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Research Progress of Intrathecal Morphine in Postoperative Analgesia

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Abstract: Postoperative pain is a common complication in the perioperative period of surgery. It not only reduces patients' quality of life, but also easily induces adverse events such as pulmonary infection and deep vein thrombosis, hindering the clinical implementation of the concept of enhanced recovery after surgery. As a hydrophilic opioid, intrathecal morphine (ITM) has the advantages of long residence time in cerebrospinal fluid and high analgesic potency, which can achieve longterm analgesia for 24–48 hours, especially with a significant effect on visceral pain control. It has become a core component of the multimodal analgesia system. This paper systematically reviews the development status, pharmacological basis and core advantages of ITM in postoperative analgesia, focuses on its clinical application optimization strategies and targeted application schemes in different types of surgery, analyzes the shortcomings of current research, and prospects future research directions, so as to provide accurate and comprehensive practice guidance for clinicians.

Keywords: Intrathecal morphine; Postoperative analgesia; Multimodal analgesia; Enhanced Recovery After Surgery (ERAS)

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1. Introduction

Postoperative pain is a series of physiological, psychological, and behavioral responses experienced by patients following surgical trauma, typically peaking within 24–72 hours post-surgery [1]. Although laparoscopic minimally invasive surgery results in less postoperative pain compared to large-incision open surgery, laparoscopic postoperative pain is predominantly visceral pain, caused by tissue manipulation, visceral dissection, abdominal distension due to pneumoperitoneum, and referred pain. According to statistics, regardless of cancer treatment modalities and tumor locations, 80% of patients report moderate to severe pain [2]. In recent years, scholars both domestically and internationally have achieved numerous breakthroughs in optimizing the clinical application of intrathecal morphine (ITM), developing individualized

dosing regimens, and constructing multimodal analgesic strategies. This article systematically reviews the current research status of ITM in postoperative analgesia, providing comprehensive and precise practical references for clinicians, while offering insights for the precise and intelligent development in the field of postoperative analgesia.

2. Development status of intrathecal morphine for postoperative analgesia

Since its first application in 1979, where six patients responded solely to morphine for analgesia with complete pain relief lasting 12–24 hours, ITM has become an integral part of postoperative pain management across multiple surgical disciplines [3]. Currently, the surgical indications for intrathecal morphine are extensive, with recommended doses being < 500 μg for cardiothoracic/abdominal surgeries, 100–200 μg for orthopedic surgeries, 50–200 μg for urological surgeries, < 300 μg for spinal surgeries, and 50–100 μg for cesarean sections. Beyond these advantages, single-dose intrathecal morphine administration is more cost-effective than catheter-based delivery techniques, making it a component of enhanced recovery after surgery protocols [4]. However, significant gaps exist in current research: the quantity and quality of data are low, statistical robustness is weak, and large-sample, multicenter studies targeting specific surgical types are lacking; the synergistic effects of combining intrathecal morphine with non-opioid analgesics remain unclear; and research on the long-term outcomes (e.g., incidence of chronic pain, quality of life) for patients is insufficient [5–7].

3. Pharmacological basis and advantages

3.1. Mechanism of action

ITM exerts analgesic effects by directly acting on μ-opioid receptors in the dorsal horn of the spinal cord, inhibiting the transmission of nociceptive impulses, while also activating descending pain inhibitory pathways in the brainstem to further enhance analgesia [8]. As a hydrophilic opioid, morphine, when administered intrathecally, maintains high concentrations in the cerebrospinal fluid, binding to μ-receptors on the cell membranes of dorsal horn neurons. Through G-protein signaling pathways, it inhibits adenylate cyclase activity, reduces calcium ion influx, and promotes potassium ion efflux, thereby inhibiting the release of nociceptive neurotransmitters (e.g., substance P, glutamate) and blocking the transmission of pain signals to the central nervous system [9].

3.2. Core advantages

3.2.1. Potent and long-lasting analgesia

ITM directly acts on spinal pain transmission pathways, blocking pain signal transmission at its source, resulting in direct and potent analgesic effects. While alleviating early postoperative pain, it reduces opioid consumption and associated adverse reactions, facilitating early patient recovery in line with the principles of enhanced recovery after surgery [10]. Its long-lasting analgesic properties stably cover the peak pain period of 24–48 hours post-surgery, reducing the frequency of postoperative rescue analgesia and avoiding blood concentration fluctuations and analgesic gaps caused by rapid metabolism of short-acting analgesics [11].

3.2.2. Minimal impact on motor function

Unlike local anesthetics, ITM primarily acts on sensory nerve fibers with no significant inhibitory effects on

motor nerve conduction [4]. Clinical studies confirm that within the recommended dose range (100–500 μg), intrathecal morphine does not cause motor dysfunction such as lower limb weakness or numbness. ITM provides superior analgesia compared to traditional anesthesia methods in spinal and thoracic surgeres [12].

3.2.3. Reduced systemic adverse reactions

Due to the minimal dosage of ITM and its predominantly local action, the concentration of drugs entering the bloodstream is extremely low, significantly reducing systemic opioid-related adverse reactions. Continuous monitoring is not clinically required for patients receiving ≤ 100 μg of intrathecal morphine [13].

3.2.4. Compatibility with multimodal analgesia concepts

Intrathecal morphine exhibits significant synergistic analgesic effects with local anesthetics, α_2-adrenergic agonists, and NSAIDs. Intrathecal morphine targets and blocks spinal pain transmission, local anesthetics directly inhibit nerve fiber impulse conduction, α_2-adrenergic agonists reduce the release of pain signals, and non-steroidal anti-inflammatory drugs inhibit inflammation-mediated pain sensitization, synergistically amplifying analgesic efficacy through multiple pathways [14].

4. Optimization strategies for clinical application

4.1. Dose refinement and personalization

The intensity, duration, and mechanisms of pain vary significantly across different surgical procedures, necessitating precise adaptation of intrathecal morphine doses based on surgical characteristics to ensure effective analgesia while minimizing safety risks. Although thoracoscopic surgery involves minimally invasive incisions, the sharp pain caused by pleural traction is prominent, peaking within the first 48 hours postoperatively, with a recommended dose of 200 μg [15]. Spinal surgeries such as lumbar fusion, which involve nerve root traction, bone tissue damage, and internal fixation implantation, have a high incidence of severe postoperative pain, warranting doses of 200–300 μg [16]. Pediatric patients, whose physiological functions are not yet fully developed and exhibit unique drug metabolism and cerebrospinal fluid circulation, are recommended a dose of 4–5 μg/kg [17]. Elderly patients, due to degenerative physiological functions and significantly reduced drug metabolism and clearance capabilities, should receive 100–200 μg of intrathecal morphine during hip replacement surgery if they are over 65 years old [13]. Patients with sleep apnea syndrome, who have congenital or acquired abnormalities in respiratory regulation, are more sensitive to the respiratory depressant effects of opioids, requiring a 30–50% reduction in intrathecal morphine dose [18].

4.2. Combination therapy strategies

Multimodal analgesia, centered on “mechanistic complementarity and synergistic enhancement”, has become the mainstream approach in the clinical application of intrathecal morphine. By combining analgesic drugs or techniques with different targets and pathways, it not only amplifies the spinal-targeted analgesic effect of intrathecal morphine but also reduces the dose of a single drug, thereby decreasing opioid-related adverse effects [19]. The combination of local anesthetics (e.g., bupivacaine, ropivacaine) with intrathecal morphine allows bupivacaine to immediately block nerve fiber impulse conduction postoperatively, precisely filling the analgesic gap from morphine onset to peak effect, effectively alleviating early postoperative sharp pain, and significantly reducing the required morphine dose and opioid-related adverse effects such as

respiratory depression and pruritus [20]. α2-adrenergic agonists (e.g., ketamine, dexmedetomidine) can inhibit neurotransmitter release by activating α2 receptors in the spinal dorsal horn, producing synergistic analgesic effects with morphine. In major abdominal surgeries, the group receiving intrathecal morphine combined with dexmedetomidine demonstrated significantly enhanced analgesia, prolonged time to first rescue analgesia, reduced PCA morphine consumption, and lower pain scores [21]. Nonsteroidal anti-inflammatory drugs (NSAIDs) specifically inhibit cyclooxygenase (COX) activity, reducing prostaglandin synthesis and release in peripheral tissue inflammation, thereby blocking pain signal transmission at its source while inhibiting postoperative pain sensitization. This mechanism precisely complements the central analgesic mechanism of intrathecal morphine, synergistically enhancing overall analgesic efficacy [22].

5. Safety management and adverse effects

Adverse effects of intrathecal morphine are primarily categorized into non-pulmonary complications and respiratory risks [23]. The former commonly manifest as nausea and vomiting, pruritus, and urinary retention; the latter's core risk is respiratory depression, which, although rare, is life-threatening and a key focus of prevention [24].

5.1. Non-pulmonary complications

5.1.1. Nausea and vomiting

Nausea and vomiting are the most common non-pulmonary adverse effects following intrathecal morphine administration. A recent meta-analysis incorporating multiple clinical studies confirmed that the incidence of postoperative nausea and vomiting in patients receiving intrathecal morphine was 1.52 times higher than that in the non-intrathecal morphine control group [24]. A multimodal preventive strategy is clinically employed, involving the combination of at least two prophylactic antiemetics with different mechanisms of action and reducing intraoperative opioid use to synergistically lower the risk of nausea and vomiting [8].

5.1.2. Pruritus

Pruritus is a highly characteristic adverse effect of intrathecal morphine, with an incidence as high as 37–61%, significantly higher than that associated with other postoperative analgesics [25]. Its pathogenesis involves morphine activating γ-aminobutyric acid (GABA)-ergic neurons in the spinal dorsal horn, upregulating the activity of gastrin-releasing peptide receptors. Abnormal activation of these receptors triggers abnormal sensory nerve signal transmission, ultimately causing generalized or localized pruritus [24]. Preoperative prophylactic use of antihistamines, such as 20 mg of diphenhydramine administered orally or intravenously, can mitigate skin pruritus by blocking histamine H1 receptors [26].

5.1.3. Urinary retention

Urinary retention is a common postoperative adverse effect of intrathecal morphine, with an incidence of approximately 6–17.3%. It not only affects patient comfort but may also delay early mobilization and rehabilitation. Its occurrence is closely related to morphine inhibiting spinal micturition reflexes and reducing acetylcholine release, leading to weak bladder detrusor muscle contractions [24].

5.2. Respiratory risks

Respiratory depression is the most severe adverse effect following intrathecal morphine administration. Although its incidence is only 1.1–5.1%, once it occurs, it can rapidly progress to respiratory failure, directly endangering patient life [22]. Continuous vital sign monitoring is strongly recommended within the first 24 hours postoperatively, focusing on three key indicators: respiratory rate, blood oxygen saturation (SpO_2), and level of consciousness [27].

5.3. Other complications

5.3.1. Hypotension

Hypotension is a prominent adverse effect in multimodal intrathecal analgesia, with an incidence as high as 42.37%. Local anesthetics directly block sympathetic nerve conduction, while α2-adrenergic agonists further inhibit sympathetic activity. This dual effect leads to vasodilation and suppressed heart rate regulation, ultimately causing blood pressure to drop [14]. Clinical prevention requires targeted interventions: intraoperative infusion of crystalloid at a dose of 10–15 mL/kg to maintain adequate blood volume; strict avoidance of rapid infusion of vasodilatory drugs to prevent abrupt blood pressure drops.

5.3.2. Puncture-related complications

Puncture-related complications such as epidural hematoma and infection are rare (incidence < 0.1%), primarily associated with improper puncture techniques and inadequate aseptic practices. Intrathecal injections should be performed under sterile conditions using a 27G pencil-point needle to avoid spinal cord injury [28].

6. Application evaluation in different surgical types

Intrathecal morphine (ITM), with its advantages of long-lasting and potent analgesia, has been widely applied in surgeries across multiple fields, including abdominal, thoracic, orthopedic, obstetric and gynecological, and pediatric surgeries. However, its application protocols need to be specifically adjusted according to the pain characteristics of different surgeries and the features of patient populations [12].

6.1. Abdominal surgery

The pain mechanism in abdominal surgery is complex, encompassing sharp incisional pain, visceral distension pain, and peritoneal traction pain. The superimposition of multidimensional pain can delay recovery. The combination of ITM and multimodal analgesia can complement mechanisms and comprehensively meet pain management needs. In laparoscopic colorectal surgery, 150 μg of ITM combined with bupivacaine reduced the postoperative 24-hour Numerical Rating Scale (NRS) score by 2.3 points, decreased opioid consumption by 35%, and did not inhibit gastrointestinal motility [29]. The use of 3 μg/kg of ITM combined with transversus abdominis plane block (TAPB) further reduced opioid consumption, improved pain scores at various time points, accelerated the recovery of gastrointestinal function and activity, and minimized adverse reactions [30]. In open living-donor liver resection, 300 μg of intrathecal morphine combined with bupivacaine significantly reduced postoperative fentanyl consumption and NRS scores for resting, activity, and shoulder pain within 12 hours ($p < 0.001$), demonstrating superior analgesic effects [31]. ITM is widely used in abdominal surgery, alleviating pain, reducing opioid use, and some studies suggest it can shorten hospital stays [32].

6.2. Cardiothoracic surgery

The pain mechanism in thoracic surgery is unique, primarily stemming from chest wall incision trauma, pleural traction caused by surgical manipulation, and intercostal nerve injury. The pain is intense and persistent, severely affecting patient comfort, limiting respiratory amplitude and cough expectoration, and increasing the risk of complications such as pulmonary infection and atelectasis [33]. For cardiac surgery, a recommended dose of 5–10 μg/kg is advised, while for thoracoscopic surgery, a dose of 10 μg/kg provides better analgesic effects. Fixed low doses (e.g., 200 μg) may lead to inadequate analgesia [34,35]. Multiple studies have confirmed that ITM can reduce postoperative 24-hour opioid consumption by 30–50%, with analgesic effects lasting over 48 hours, effectively reducing the need for rescue analgesia [36,37].

6.3. Orthopedic surgery

Pain in orthopedic surgery mainly involves bone, muscle, and nerve injury pain, and there is an urgent need for analgesic protocols that have minimal impact on motor function. In total knee arthroplasty, 100 μg of ITM combined with continuous femoral nerve block reduced the postoperative 24-hour motion pain score by 1.5 points and opioid consumption by 30%, without affecting knee joint mobility [38]. In spinal surgery, ITM can directly act on the spinal cord at the affected segment, providing precise analgesia. In lumbar fusion surgery, 100 μg of ITM reduced patient-controlled analgesia (PCA) morphine consumption and did not affect lumbar mobility, allowing patients to ambulate within 3 days postoperatively [39]. In clinical practice, strict dose control is essential, with individualized adjustments based on different surgical types. Additionally, enhanced postoperative respiratory function monitoring and the combination of multimodal analgesic strategies, such as non-steroidal anti-inflammatory drugs and local blocks, are necessary to balance analgesic effects and safety [40,41].

6.4. Obstetric and gynecological surgery

As a core adjuvant in neuraxial anesthesia for cesarean sections and other obstetric surgeries, ITM offers efficient and long-lasting analgesia. Dose optimization of ITM is crucial for balancing analgesic effects and safety. Multiple guidelines recommend an ITM dose range of 50–100 μg for elective cesarean sections. A domestic randomized controlled study involving 142 parturients confirmed that a 100 μg dose provided ideal postoperative 48-hour analgesia, making it the preferred clinical dose [42,43]. ITM is a safe and effective analgesic method for radical hysterectomy in gynecological malignancies. In radical surgeries, a single dose of ITM (100–200 μg) combined with low-concentration local anesthetics significantly reduced resting and motion pain scores 24–72 hours postoperatively and decreased intravenous opioid use by up to 50% [44,45]. Future research should focus on large-sample studies to determine the optimal dosing protocols for different surgical methods and tumor stages and optimize multimodal analgesic combinations.

6.5. Pediatric surgery

ITM is one of the core methods for multimodal analgesia in pediatric postoperative care. With its advantages of definite analgesia, small drug dosage, and long-lasting effects, it has been widely applied in various pediatric surgeries. The efficacy and safety of a low-dose protocol (2–5 μg/kg) in spinal fusion surgery have been validated, effectively reducing postoperative 24-hour PCA morphine consumption and resulting in significantly lower pain scores compared to the pure PCA group [46]. ITM also shows advantages in pediatric cardiac and

abdominal surgeries: a dose of 20 μg/kg provides 12 hours of effective analgesia after sternotomy and has an opioid-sparing effect [47]. Future research should involve multi-center prospective clinical trials to refine dosing protocols for different age groups and surgical types.

6.6. Other surgical types

The analgesic value of ITM has been validated in both high-trauma and minimally invasive urological surgeries. In open prostatectomy and nephrectomy, 250 μg of ITM significantly prolonged the time to the first analgesic requirement [48]. ITM also demonstrates advantages in percutaneous nephrolithotomy and kidney transplantation, reducing not only postoperative pain scores but also the incidence of catheter-related bladder discomfort [49].

7. Future prospects

The future research directions of ITM include conducting multi-center large-sample clinical studies for special populations and complex surgeries to develop standardized dosing guidelines; accelerating the research and development and clinical translation of novel sustained-release formulations to develop long-acting analgesic preparations; exploring the mechanisms of adverse reactions and developing targeted preventive drugs and intervention techniques; and investigating the integration of ITM with artificial intelligence technology, using machine learning algorithms to optimize analgesic protocol development and improve the precision and efficiency of clinical applications.

8. Conclusion

As an important method for postoperative analgesia, ITM exhibits significant analgesic advantages in various fields. Through fine-tuning the dose based on surgical types and individual patient characteristics, precise adaptation of analgesic effects can be achieved, providing high-quality pain management solutions for patients undergoing different surgeries.

Disclosure statement

The authors declare no conflict of interest.

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Analysis of Specialized Nursing Practices During Anti-Infective Treatment for Pediatric Brain Abscess

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Abstract: *Objective*: This paper focuses on a comprehensive analysis of the overall framework and core operational points of specialized, systematic nursing interventions for children with brain abscesses undergoing complete antimicrobial therapy, and explores the practical effects of such structured nursing models on enhancing treatment compliance, preventing related complications, and improving long-term neurological recovery. *Methods*: A cohort analysis model incorporating both retrospective and prospective features was designed. The study subjects were identified as 76 pediatric patients admitted from early 2020 to the end of 2023, diagnosed with brain abscesses, and who completed the prescribed anti-infective treatment course. Based on different clinical nursing pathways adopted, all cases were equally divided into two groups: a control group receiving standard routine care (38 cases) and a practice group applying a specialized integrated nursing protocol designed for this study (38 cases). This specialized protocol systematically integrates four dimensions: precise monitoring of intracranial pressure changes, a full-process management strategy for antimicrobial drug use, neurological function maintenance measures, and a family-centered educational support plan. The study comprehensively recorded various clinical observation indicators for both groups during treatment. *Results*: Data analysis revealed that the practice group adopting the specialized nursing protocol demonstrated superiority across multiple evaluation indicators. The effective symptom control rate during treatment (94.7% vs. 78.9%, $p < 0.05$), the incidence of adverse events induced by treatment drugs (10.5% vs. 28.9%, $p < 0.05$), and the qualification rate of primary caregivers of the children in mastering relevant knowledge and skills (92.1% vs. 71.1%, $p < 0.05$) were all significantly better than those in the routine care group. Additionally, the practice group showed statistically significant reductions in time-sensitive indicators such as the average number of days required for fever resolution, the time for relief of meningeal irritation signs, and the overall length of hospital stay (all comparisons $p < 0.05$). In the follow-up Glasgow Outcome Scale scores conducted three months after treatment completion, the proportion of cases in the practice group achieving a good prognosis (scores of 4 to 5) reached 86.8%, significantly higher than the 68.4% in the control group ($p < 0.05$). *Conclusion*: A multi-component, interlinked specialized nursing practice developed around and deeply integrated with the anti-infective treatment mainline can clearly enhance the safety level and overall efficiency of clinical management for pediatric brain abscesses.

Keywords: Pediatric brain abscess; Antimicrobial therapy; Specialized nursing; Intracranial pressure monitoring;

Online publication: Apr 30, 2026

1. Introduction

Pediatric brain abscess is a localized purulent lesion formed within the central nervous system due to endogenous infection. Its course progresses rapidly and exhibits significant heterogeneity in clinical outcomes, posing a persistent risk to the long-term survival status of affected children. The fundamental treatment involves the use of antimicrobial agents to eliminate pathogens; however, this process is typically time-consuming and may involve a combination of multiple drugs, giving rise to a series of complex management challenges. These include the distribution efficacy of drugs in the central nervous system, tracking of side effects, risk of secondary intracranial pressure changes, and difficulties in treatment compliance among young children. Traditional nursing models often focus on basic vital sign maintenance and mechanical execution of medical orders, frequently falling short in addressing the evolving details of the condition and the need for integrated management throughout the entire treatment cycle. This may lead to a turbulent treatment process, secondary complications, or even long-term neurological damage. Based on the pathological mechanisms of the disease and the principles of clinical pharmacology, this study developed and validated a comprehensive specialized nursing plan. It aims to ensure a smooth progression of the treatment phase through its prospective, structured intervention items, with the ultimate goal of promoting better overall rehabilitation outcomes for the children.

2. Materials and methods

2.1. General clinical data

The study cohort consisted of 76 children diagnosed with and treated for brain abscesses at our hospital from January 2020 to December 2023. The enrolled children were randomly divided into two groups using a random number generation method, with 38 cases in each group. The conventional nursing control group included 21 males and 17 females, with an average age of (5.4 ± 2.8) years. Among them, 29 had single abscesses, and 9 had multiple abscesses. The specialized nursing practice group included 20 males and 18 females, with an average age of (5.7 ± 3.1) years. Among them, 31 had single abscesses, and 7 had multiple abscesses. Statistical analysis revealed no statistically significant differences between the two groups in terms of gender distribution, average age, number of abscesses, types of major pathogens (with *Streptococcus* and *Staphylococcus aureus* being common), and baseline clinical characteristics such as the Glasgow Coma Scale score at admission ($p > 0.05$), indicating good comparability between the two groups.

2.2. Study design and procedure

This project implemented a non-blinded, parallel-controlled clinical practice effectiveness analysis. Members of the control group received the general nursing routines for children with brain abscesses in the pediatric neurosurgery department, covering basic condition observation, medication verification and administration, daily life assistance, and general health knowledge education. The practice group, in addition to the above

conventional items, comprehensively and systematically implemented an integrated nursing plan with multiple professional modules pre-developed by the research team, covering the entire timeline from initial assessment upon admission to regular follow-up after discharge.

2.3. Core components of the integrated specialized nursing plan

The plan consists of four interrelated and complementary core modules:

(1) Precise intracranial pressure monitoring and response module

This module goes beyond the scope of traditional vital sign monitoring. Through specialized training for nursing staff, it enables them to keenly identify early behavioral and physiological cues of increased intracranial pressure (such as changes in headache characteristics, vomiting patterns, pupillary light reflex abnormalities, subtle fluctuations in consciousness level, and prodromal manifestations of Cushing's response) and standardizes the implementation of a series of collaborative measures to reduce intracranial pressure, including maintaining a head-up position at 15 to 30 degrees, avoiding any actions that cause excessive neck flexion, implementing controlled sedation and analgesia, and accurately executing medical orders for dehydrating agents.

(2) Clinical application management module for antimicrobial agents

A closed-loop management process from drug preparation, intravenous infusion to post-administration observation has been established. Key control points include ensuring that the infusion duration of special antimicrobial agents such as vancomycin and meropenem strictly complies with regulations; closely monitoring and recording all possible adverse drug reactions, with particular attention to the "red man syndrome", signs of renal impairment, and hearing effects potentially caused by vancomycin, as well as the risk of seizure associated with meropenem; regularly assessing and maintaining intravenous infusion access to prevent phlebitis.

(3) Neurological function protective intervention module

Neurological function status is dynamically tracked through regular, brief but targeted neurological examinations (such as observing voluntary limb movements, assessing muscle strength, and checking language response ability). Early, passive limb positioning and joint range-of-motion maintenance training are implemented for the children to prevent muscle disuse and joint contractures. For children at potential risk of seizures, their families are guided on arranging a safe environment and trained on emergency response steps during seizure.

(4) Family core competency building and support system module

A structured family education curriculum has been designed to explain in detail to primary caregivers the pathogenesis of brain abscesses, the basic principles of treatment (emphasizing the necessity of long-term medication), how to identify adverse drug reactions, key points of family nursing (such as nutritional support and prevention of recurrent infections), and the importance of regular follow-up. The understanding and mastery of caregivers are assessed through knowledge questionnaires and simulated scenario exercises, while continuous emotional care and psychological support are also provided.

2.4. Effect observation indicators and assessment methods

The primary observation indicators were set as:

(1) The effective rate of symptom control during treatment (judged by normalization of body temperature and significant relief or complete disappearance of dominant symptoms such as headache and vomiting);
(2) The overall incidence of adverse reactions related to antimicrobial therapy;
(3) The qualification rate of primary caregivers of the children in mastering disease and nursing knowledge (assessed using a self-designed 100-point questionnaire, with a score of ≥80 points judged as qualified).

The secondary observation indicators included:

(1) The average time required for body temperature to return to normal;
(2) The time for relief of meningeal irritation signs (such as neck stiffness);
(3) The total number of hospital treatment days;
(4) Assessment using the Glasgow Outcome Scale at 3 months after treatment completion, with scores of 4 to 5 classified as good prognosis and scores of 1 to 3 classified as poor prognosis.

The collection and entry of all observation data were jointly completed and cross-checked by two independent researchers who did not participate in the grouping operation.

2.5. Data statistical processing strategy

All research data were entered into SPSS version 26.0 statistical software for calculation and analysis. For measurement data conforming to a normal distribution, they were described in the form of mean ± standard deviation, and the independent samples *t*-test method was selected for comparing means between the two groups; for count data, they were described in the form of the number of cases and their percentage, and the chi-square test or Fisher's exact probability test method was selected for comparing rates between the two groups. A *p*-value less than 0.05 was used as the threshold for judging statistically significant differences.

3. Results

3.1. Comparative analysis of core effect indicators during the treatment phase between the two groups of children

The practice group implementing the integrated specialized nursing plan showed statistically significant differences superior to the conventional nursing control group in the three core effect indicators of the effective rate of symptom control, the incidence ratio of adverse drug reactions, and the qualification rate of family knowledge mastery ($p < 0.05$). Detailed comparative data are shown in **Table 1**.

Table 1. Comparative analysis of core effect indicators during the treatment phase between the two groups of children

Group	Total number of cases	Effective control of clinical symptoms	Adverse drug reactions occurrence	Family members' mastery of knowledge achieved standard
Routine nursing control group	38	30 (78.9)	11 (28.9)	27 (71.1)
Specialist nursing practice group	38	36 (94.7)	4 (10.5)	35 (92.1)
Chi-square value (χ^2)	-	4.145	4.142	5.554
p value	-	0.042	0.042	0.018

3.2. Comparison of symptom resolution time and hospitalization duration parameters between the two groups of children

Data analysis indicates that the practice group exhibited shorter durations in terms of the average number of days required for fever resolution, the number of days for relief of meningeal irritation signs, and the total hospitalization days compared to the control group, with all differences reaching statistically significant levels ($p < 0.05$). This suggests that systematic specialized nursing may have facilitated the clinical recovery process. For specific numerical comparisons, refer to **Table 2**.

Table 2. Comparison of symptom resolution time and hospitalization duration parameters between the two groups of children

Group	Total number of cases	Mean days to defervescence	Days to resolution of meningeal irritation signs	Total hospitalization days
Routine care control group	38	5.8 ± 1.9	7.2 ± 2.1	28.5 ± 6.3
Specialized nursing practice group	38	4.1 ± 1.5	5.6 ± 1.8	24.2 ± 5.7
t value	-	4.434	3.556	3.143
p value	-	<0.001	0.001	0.002

3.3. Specific category distribution of adverse drug reactions in the two groups of children

A detailed breakdown of cases with recorded adverse drug reactions reveals that the practice group not only had a lower overall incidence but also experienced milder adverse reactions compared to the control group. For instance, suspected nephrotoxic reactions and new-onset seizure cases were not reported in the practice group, demonstrating the protective effect of refined management. For a detailed category distribution, see **Table 3**.

Table 3. Specific category distribution of adverse reactions to antimicrobial agents in the two groups of children

Specific category of adverse reaction	Routine nursing group (n = 11)	Specialized nursing practice group (n = 4)
Phlebitis	4	1
Rash/Red man syndrome	3	1
Diarrhea	2	1
Suspected nephrotoxicity (Elevated indicators)	1	0
New-onset seizure	1	0
Other	0	1

Note: One case in the specialized nursing practice group exhibited mild abnormalities in liver function indicators.

3.4. Comparison of short-term neurological function recovery outcomes between the two groups of children

In the follow-up assessment conducted three months after treatment completion, using the Glasgow Outcome Scale (GOS) for measurement, the proportion of cases in the practice group receiving a favorable prognosis evaluation (scores of 4–5) was significantly higher than that in the control group (86.8% vs. 68.4%, $p < 0.05$). This indicates that systematic specialized nursing may be associated with better long-term neurological function recovery. Specific data are shown in **Table 4**.

Table 4. Comparison of Glasgow Outcome Scale (GOS) results between the two groups of children three months after treatment

Group	Total cases	Favorable prognosis (GOS 4–5)	Unfavorable prognosis (GOS 1–3)
Routine nursing control group	38	26 (68.4)	12 (31.6)
Specialized nursing practice group	38	33 (86.8)	5 (13.2)
Chi-square value (χ^2)	–	3.945	–
p value	–	0.047	–

4. Discussion

This study delved into the mechanism and practical effects of an integrated specialist nursing practice protocol on optimizing the entire process of antimicrobial drug therapy for pediatric brain abscesses through its development and application [1]. The results indicated that, compared to the conventional nursing model, this integrated protocol effectively enhanced the efficiency of symptom management, reduced treatment-associated risks, accelerated clinical recovery, and was ultimately linked to superior long-term neurological function recovery. This finding opens up a new, empirically supported management pathway for improving treatment outcomes in children with such severe conditions from the perspective of specialized nursing practice [2].

The higher symptom control efficacy achieved by this specialist nursing practice may stem from the "time advancement" and "content deepening" of nursing interventions. Traditional nursing models often respond to increased intracranial pressure (ICP) after the emergence of obvious clinical symptoms. In contrast, the refined monitoring emphasized in this study's protocol requires nurses to possess the ability to proactively identify early, non-specific yet warning signs, such as abnormal restlessness, changes in crying tone, and a shift from projectile vomiting to frequent vomiting. This close, warning-oriented observation, combined with standardized and timely collaborative interventions to reduce ICP (e.g., precise head positioning adjustments and avoiding nursing procedures that could increase abdominal pressure or impede jugular venous return), plays a crucial role [3].

The significant decline in the incidence of adverse drug reactions directly reflects the practical effectiveness of the drug closed-loop management module within specialist nursing [4]. Prolonged courses, potent drugs, and multi-drug combinations are typical features of antimicrobial therapy for brain abscesses and also major sources of toxicity risks. In this practice, standardized infusion procedures minimized immediate reactions caused by inappropriate infusion rates, while systematic monitoring checklists (e.g., regular auscultation of the heart and lungs, accurate recording of fluid intake and output, and timely attention to laboratory results of electrolytes and liver and kidney function) enabled early detection of toxicity signals. Additionally, pre-education of family members facilitated the early identification and reporting of minor abnormalities [5].

5. Conclusion

Based on the above analysis, the specialist nursing practice constructed in this study, with intracranial

pressure monitoring, drug management, neurological function protection, and family capacity building as its four core pillars, is not merely a mechanical accumulation of routine nursing procedures. Instead, it represents a clinical management ecosystem where each component organically interacts and collaborates. By proactively grasping key risk points in the treatment process and systematically strengthening core support systems, it elevates the value of nursing work from an auxiliary and supportive role to a critical position that exerts a clear and positive impact on the final treatment outcomes.

Disclosure statement

The authors declare no conflict of interest.

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Investigation on the Vitamin D Nutritional Status of Neonates with Hyperbilirubinemia

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Abstract: *Objective*: This study aims to investigate the vitamin D nutritional status of neonates with hyperbilirubinemia and provide clinical evidence for guiding the scientific and rational supplementation of vitamin D in these neonates. *Methods*: This study selected neonates diagnosed with neonatal hyperbilirubinemia without other diagnoses admitted to the neonatal ward of our hospital from December 2021 to December 2023 as the research subjects. One milliliter of peripheral venous blood samples was collected from the neonates before treatment and sent to Hangzhou Qlife Precision Medical Testing Technology Co., Ltd. (Dian Diagnostics) for testing. The Sciex4500MD mass spectrometer was used as the detection instrument, and the Dicesis reagent was used as the detection reagent. The concentration of 25(OH)D in peripheral blood, namely the sum of 25(OH)D2 and 25(OH)D3 concentrations, was quantitatively detected using high-performance liquid chromatography-tandem mass spectrometry (LC-MS). According to the criteria for assessing children's vitamin D nutritional status proposed by the Institute of Medicine of the United States in 2011 and the Global Consensus on the Management of Nutritional Rickets in 2016, serum 25-(OH)D < 30 nmol/L (12 ng/mL) was defined as vitamin D deficiency; serum 25-(OH)D 30–50 nmol/L (12– < 20 ng/mL) was defined as vitamin D insufficiency; and serum 25-(OH)D ≥ 50 nmol/L (20 ng/ml) was defined as adequate. *Results*: A total of 76 neonates with hyperbilirubinemia who met the diagnostic criteria were included in this study, including 40 boys and 36 girls. The results showed that the distribution of 25-(OH)D concentrations did not conform to a normal distribution, with a median of 11.69 (8.46–14.04) ng/mL. Only 5 neonates had adequate vitamin D levels, 31 had insufficient levels, and 40 had deficient levels. The rates of adequate, insufficient, and deficient vitamin D were 6.6%, 40.8%, and 52.6%, respectively, with no statistically significant difference in vitamin D levels between boys and girls ($p > 0.05$). Additionally, there was no statistically significant difference in serum 25(OH)D levels among neonates with hyperbilirubinemia across different seasons (F value = 0.312, $p > 0.05$). *Conclusion*: Neonates with hyperbilirubinemia generally have low vitamin D levels. However, due to the small sample size and single-center nature of this study, further verification with more samples and studies are needed.

Keywords: Hyperbilirubinemia; Vitamin D; Nutritional status; Investigation and analysis

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1. Introduction

Neonatal hyperbilirubinemia, also known as neonatal jaundice, is the most common clinical issue during the neonatal period, typically manifesting as yellowing of the skin, mucous membranes, and sclera. More than two-thirds of full-term or near-term neonates develop visible jaundice shortly after birth [1]. Vitamin D is a fat-soluble vitamin that is essential for human metabolism. In addition to regulating bone metabolism, it is closely related to various diseases in the human body. Studies have shown that vitamin D deficiency is associated with hyperbilirubinemia [2]. To investigate the vitamin D nutritional status of neonates with hyperbilirubinemia, we conducted a cross-sectional survey of full-term neonates with hyperbilirubinemia admitted to Taizhou Women and Children's Hospital Affiliated to Nantong University from December 2021 to December 2023, providing clinical evidence for guiding the scientific and rational supplementation of vitamin D in neonates with hyperbilirubinemia.

2. Materials and methods

2.1. General information

Seventy-six neonates diagnosed with neonatal hyperbilirubinemia without any other diagnosis, admitted to the neonatal ward of our hospital from December 2021 to December 2023, were included in the study. Among them, there were 40 boys and 36 girls, with a gestational age ranging from 1 to 14 days and a birth gestational age of 37 to 41 + 6 weeks. This study was a retrospective study; no ethical review was required.

2.1.1. Inclusion criteria

(1) Presence of skin yellowing upon physical examination at admission, meeting the diagnostic criteria for neonatal hyperbilirubinemia;
(2) Birth weight ≥ 2500 g and < 4000 g;
(3) Gestational age ≥ 37 weeks and < 42 weeks.

2.1.2. Exclusion criteria

(1) Neonates with major diseases in other systems or severe congenital abnormalities;
(2) Severe asphyxia;
(3) Meconium aspiration syndrome;
(4) Neonatal infectious diseases such as neonatal sepsis;
(5) Endocrine diseases;
(6) Neonatal digestive disorders;
(7) Neonatal hemolytic diseases;
(8) Genetic metabolic diseases, etc.

2.2. Detection methods

Peripheral venous blood samples (1 mL) were collected from the neonates before treatment and sent to Hangzhou Chromai Precision Medical Testing Technology Co., Ltd. (Dian Diagnostics) for analysis. The detection instrument used was the Sciex4500MD mass spectrometer, and the detection reagent was the Disai Si reagent. The concentration of 25(OH)D in peripheral blood, i.e., the sum of the concentrations of 25(OH)D2 and 25(OH)D3, was quantitatively detected using high-performance liquid chromatography-tandem mass

spectrometry (LC-MS).

2.3. Evaluation criteria

According to the criteria for assessing children's vitamin D nutritional status proposed by the Institute of Medicine in 2011 and the Global Consensus on the Management of Nutritional Rickets in 2016, serum 25-(OH)D < 30 nmol/L (12 ng/mL) is defined as vitamin D deficiency; serum 25-(OH)D 30–50 nmol/L (12– < 20 ng/mL) is defined as vitamin D insufficiency; and serum 25-(OH)D ≥ 50 nmol/L (20 ng/mL) is defined as adequate [3,4] . Since neonatal serum bilirubin levels undergo dynamic changes, the diagnostic criteria for neonatal hyperbilirubinemia in this study are based on the hour-specific bilirubin nomogram at the 95th percentile recommended by the American Academy of Pediatrics (AAP) guidelines [5]. (See **Figure 1)**.

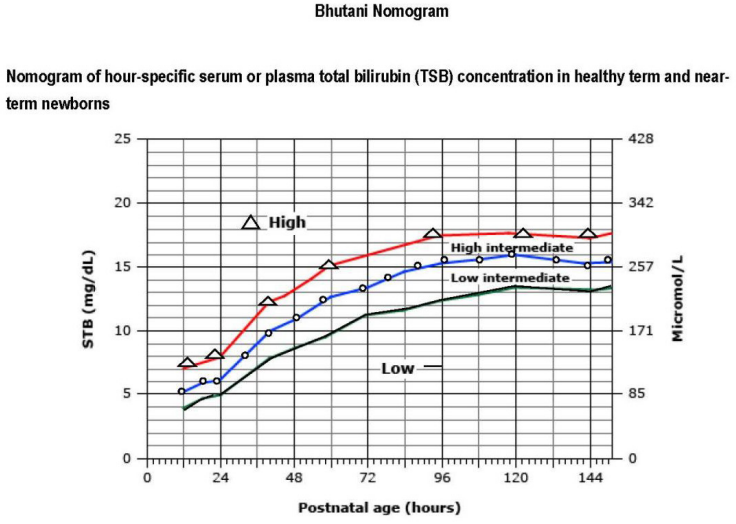


Figure 1. Postnatal age bilirubin risk assessment curve (Bhutani curve)

2.4. Statistical methods

All data analyses were conducted using SPSS 27.0 statistical software. For quantitative data, if it met the normality assumption, it was expressed as mean ± standard deviation ($\overline{x} \pm s$). Comparisons between two groups were made using the two independent samples t-test, while comparisons among three or more groups were performed using analysis of variance (ANOVA). If the data did not meet the normality assumption, it was expressed as median (M) with interquartile range (Q1–Q3). Comparisons between two groups were made using the Mann-Whitney U test, while comparisons among three or more groups were performed using the Kruskal-Wallis H test. Categorical data were expressed as n (%), and non-parametric tests were used for comparisons. A *p*-value less than 0.05 was considered statistically significant.

3. Results

3.1. Distribution of serum 25(OH)D levels in neonates with hyperbilirubinemia

This study analyzed the vitamin D nutritional status at admission of 76 neonates diagnosed with hyperbilirubinemia in the neonatal ward of our hospital. The data exhibited a non-normal distribution, with a median (interquartile range) serum 25-(OH)D concentration of 11.69 (8.46–14.04) ng/mL (as shown

in **Figure 2**). Among the 76 neonates, only 5 had adequate serum 25-(OH)D concentrations, while the remaining had insufficient (31 cases) or deficient (40 cases) levels. Specifically, 6.6% of the neonates with hyperbilirubinemia had adequate vitamin D levels, 40.8% had insufficient levels, and 52.6% had deficient levels, as depicted in **Figure 3**.

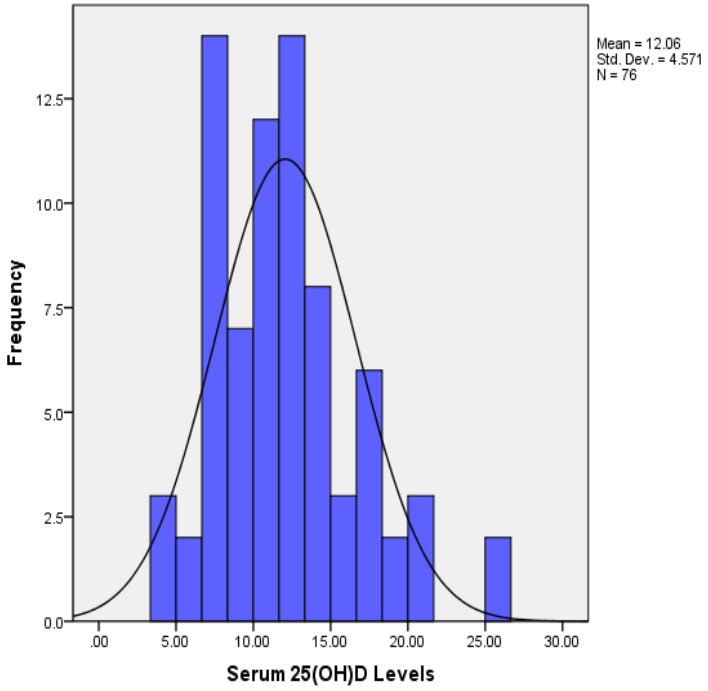


Figure 2. Histogram of serum 25-(OH)D levels in children with hyperbilirubinemia

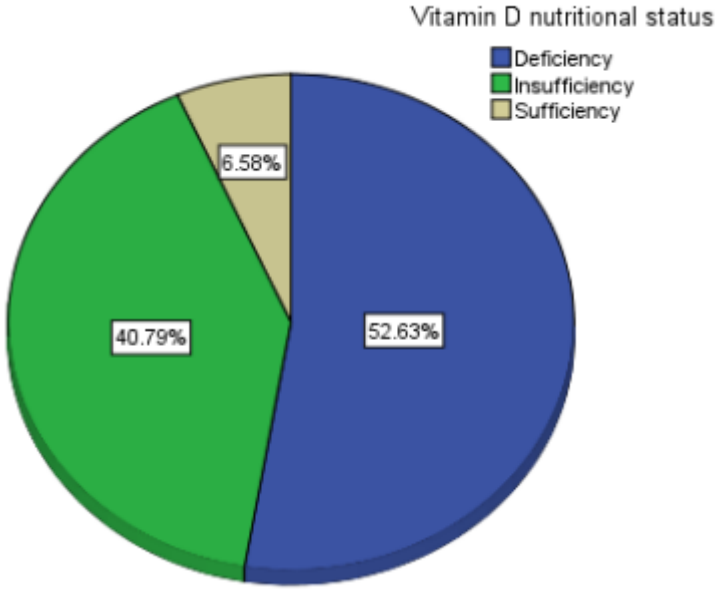


Figure 3. Pie chart of serum 25-(OH)D levels in children with hyperbilirubinemia

3.2. Distribution of serum 25-(OH)D levels in children with hyperbilirubinemia by gender

In this survey, the median serum 25-(OH)D levels in boys and girls were 11.18 (8.15–13.55) ng/mL and 12.25 (9.96–14.16) ng/mL, respectively, with boys having slightly lower levels than girls, although the difference was not statistically significant ($p < 0.05$), as shown in **Figure 4**. According to the criteria for determining vitamin D levels, serum 25-(OH)D was classified into different grades. Among those with serum 25-(OH)D levels within the normal range, there were 3 boys, accounting for 60.0%, and 2 girls, accounting for 40.0%, with boys having slightly higher levels than girls, but no statistical difference was observed between the two groups ($p > 0.05$). Meanwhile, among those with insufficient serum 25-(OH)D levels, there were 13 boys, accounting for 41.9%, and 18 girls, accounting for 58.1%. Among those with deficient serum 25-(OH)D levels, there were 24 boys, accounting for 60%, and 16 girls, accounting for 40.0%. This indicates that there were no significant differences between boys and girls in terms of insufficient and deficient serum 25-(OH)D levels, as shown in **Table 1**.

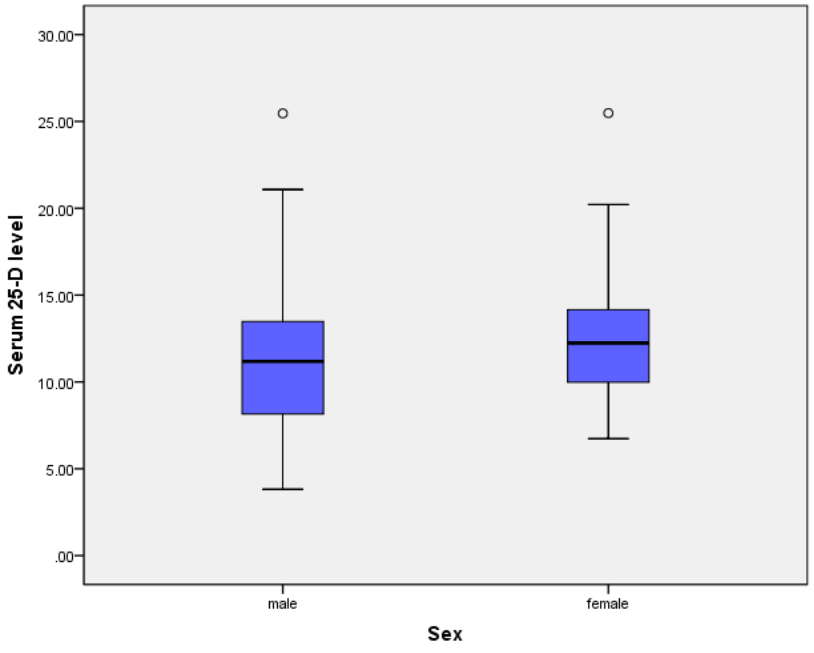


Figure 4. Box plot comparing serum 25(OH)D levels in children of different genders

Table 1. Comparison of serum 25(OH)D levels in children of different genders

Gender	n	Deficient (%)	Insufficient (%)	Sufficient (%)	25(OH)D (ng/mL) Median	*Z* value	*p* value
Male	40	24 (60.0)	13 (41.9)	3 (60.0)	11.18 (8.15–14.16)	-1.389	0.165
Female	36	16 (40.0)	18 (58.1)	2 (40.0)	12.25 (9.96–14.16)		

3.3. Comparison of serum 25(OH)D levels in hyperbilirubinemia infants born in different seasons

Among infants with hyperbilirubinemia born in different seasons, the comparison of serum 25(OH)D levels

showed no statistically significant difference (F-value = 0.312, $p > 0.05$), as shown in **Table 3** and **Figure 5**.

Table 3. Serum 25-(OH)D levels in infants born in different seasons

Variable	Number of cases(%)	Serum 25-(OH)D concentration(ng/mL)	*F* value	*p* value
Spring	21 (52.5)	12.00 ± 4.51	0.312	0.817
Summer	5 (13.2)	11.37 ± 5.13		
Autumn	19 (45.2)	11.41 ± 3.74		
Winter	31 (47.0)	12.62 ± 5.11		

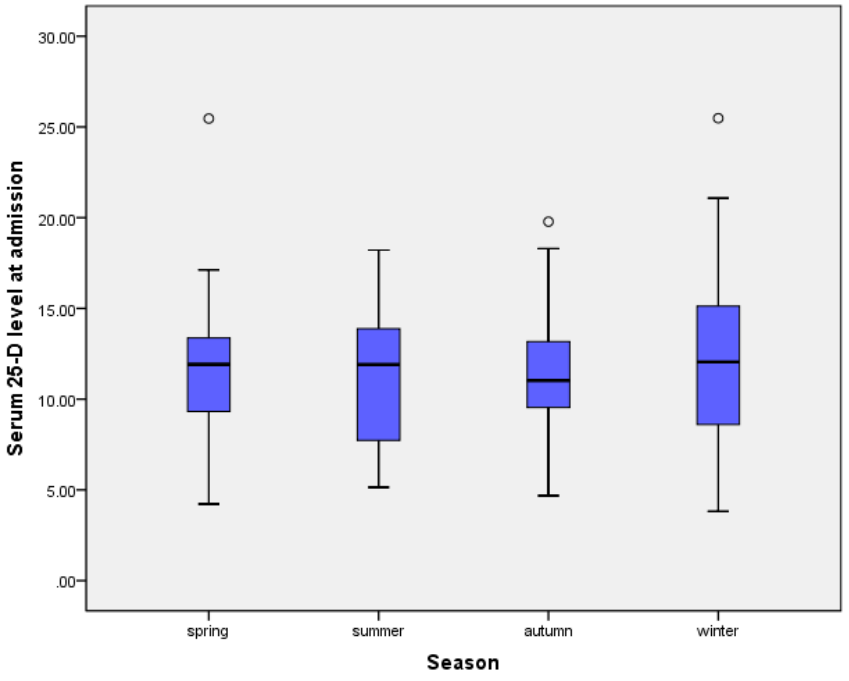


Figure 5. Box plot of serum 25(OH)D levels in children with different seasons

4. Discussion

Neonatal hyperbilirubinemia, also known as neonatal jaundice, is a common clinical issue among newborn infants. During the neonatal period, excessive bilirubin production, immature liver function, and the characteristics of the hepatoenteric circulation result in a greater production of bilirubin than its excretion, leading to the accumulation of bilirubin in the body and causing yellowing of the skin or other tissues, typically manifesting as yellowing of the skin, mucous membranes, and sclera [6]. Vitamin D is a group of steroid derivatives, primarily existing in two forms: vitamin D2 (ergocalciferol) and vitamin D3 (cholecalciferol). Vitamin D2 is mainly derived from plants, while vitamin D3 is produced through photochemical reactions in the skin of the human body under the influence of ultraviolet rays in sunlight. Both forms are converted into biologically active vitamin D after hydroxylation in the body, thereby exerting biological effects. Hydroxylated 25(OH)D is recognized as the most reasonable indicator reflecting human vitamin D status due to its stable properties [7]. Adequate vitamin D is crucial for children's health and has positive implications for early childhood development and disease prevention.

With further understanding of vitamin D, it has been discovered that its role in human health is not limited to bone or calcium-phosphorus metabolism. Instead, it participates in the proliferation, differentiation, and apoptosis of various cells throughout the body, influencing the normal functioning of the neuromuscular system and the regulation of immune function [8–10]. However, numerous epidemiological surveys have found that vitamin D insufficiency and deficiency are highly prevalent among newborns. A large-scale survey in northern United States revealed a high prevalence of vitamin D deficiency and insufficiency among newborns, at 31% and 49%, respectively [4]. In 2020, a hospital in Wuxi conducted a survey on 347 healthy full-term newborns aged ≤ 7 days [11]. The results showed that only 3 infants had adequate vitamin D levels, accounting for only 0.86%, while 28 infants had insufficient vitamin D levels, accounting for 8.07%, and 316 infants had vitamin D deficiency, accounting for 91.07%. This indicates that vitamin D insufficiency and deficiency remain a global public health issue. This study analyzed the vitamin D nutritional status of 76 hyperbilirubinemic children upon admission and found that only 5 children had adequate serum 25-(OH) D concentrations, while the rest had insufficient (31 cases) or deficient (40 cases) levels. This means that among hyperbilirubinemic children, only 6.6% had adequate vitamin D levels, while 40.8% had insufficient levels and 52.6% had deficient levels. This suggests that the vitamin D nutritional status is generally low among full-term hyperbilirubinemic children. The possible reasons for this include:

(1) Low vitamin D content in breast milk

Newborns can only obtain a small amount of vitamin D through breast milk daily, making breastfed newborns prone to vitamin D deficiency.

(2) Poor vitamin D status of the mother during pregnancy

Vitamin D can be transferred from the mother to the fetus through the placenta, and the concentration of 25-hydroxyvitamin D in the maternal plasma during pregnancy directly affects the vitamin D status of the fetus. If the mother has vitamin D deficiency during pregnancy, her plasma 25-hydroxyvitamin D concentration will be low, and the amount of vitamin D transferred to the fetus through the placenta will also be relatively insufficient, affecting the accumulation of vitamin D in the fetus during the fetal period.

(3) Immature liver function in newborns

The activation of vitamin D requires the liver, and the immature liver function in newborns makes it difficult to effectively activate vitamin D.

5. Conclusion

In conclusion, vitamin D deficiency and insufficiency are prevalent among full-term newborns with hyperbilirubinemia. It is essential to strengthen neonatal vitamin D monitoring and develop individualized supplementation plans.

Disclosure statement

The authors declare no conflict of interest.

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Research on Optimizing the Surgical Treatment Plan and Postoperative Refined Nursing Management of Keloids

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Abstract: Surgical resection is the core treatment for large, medium-sized, and refractory keloids. However, the recurrence rate of simple surgery remains high, and the standardization of perioperative nursing and postoperative management directly affects the treatment effect. Combining clinical nursing practice, this paper summarizes the key points of perioperative nursing for keloids, the optimization path of surgical plans, and multi-mode anti-recurrence nursing strategies, focusing on the core links of preoperative evaluation, intraoperative cooperation, postoperative wound care, tension control, recurrence monitoring, and psychological intervention. Research shows that refined surgical cooperation based on skin tension lines, anti-recurrence intervention within 24 hours after surgery combined with standardized nursing, and long-term dynamic follow-up can control the postoperative recurrence rate within 10%. This paper also analyzes the bottlenecks in postoperative nursing diagnosis and treatment, proposes optimization measures, and provides evidence-based reference for constructing an integrated perioperative nursing plan.

Keywords: Keloid; Surgical treatment; Perioperative nursing; Postoperative management; Recurrence prevention; Refined nursing

Online publication: Apr 30, 2026

1. Introduction

Keloids are pathological scars characterized by abnormal proliferation of dermal fibrous tissue, manifested as invasive growth beyond the scope of the original injury and continuous proliferation, accompanied by discomfort such as itching and stinging, which seriously affect the patient's appearance and quality of life, and are genetically susceptible and highly recurrent [1]. At present, the clinical consensus of "surgery as the foundation, combined treatment as the core, and postoperative nursing as the guarantee" has been formed [2]. However, the recurrence rate of single surgery is as high as 45–100% [3]. Perioperative nursing omissions, delayed anti-recurrence intervention, and insufficient patient compliance are important inducements for recurrence.

Clinical nursing runs through the entire diagnosis and treatment process of keloids. Preoperative evaluation, intraoperative cooperation, postoperative nursing, and long-term follow-up all directly affect the surgical effect and recurrence risk. Combining domestic and foreign research and nursing guidelines from 2022 to 2025, this paper sorts out the optimization of perioperative nursing and postoperative refined management strategies, providing operational basis for clinical nurses and promoting the standardized and precise development of keloid nursing.

2. Preoperative nursing evaluation and plan optimization for keloids

2.1. Comprehensive preoperative nursing evaluation

Accurate preoperative evaluation is the premise of formulating personalized plans. Nurses need to conduct evaluations from four aspects: In terms of scar characteristics, clarify the location, size, texture, etc. High-tension areas such as the chest, shoulders, and earlobes have a high recurrence risk, so enhanced nursing plans need to be formulated [4]. In terms of physical condition, focus on monitoring blood glucose. Diabetic patients need to control fasting blood glucose below 7.0 mmol/L to avoid high glucose exacerbating postoperative inflammation [5]. Use the Vancouver Scar Scale to quantify the degree of scar hyperplasia, providing a baseline for postoperative effect evaluation [6]. At the same time, evaluate the patient's psychological state and nursing compliance. Most scar patients are accompanied by anxiety and inferiority. Low compliance is an important risk factor for postoperative recurrence, so high-risk groups need to be identified in advance and guidance plans formulated [7].

2.2. Preoperative patient stratification and personalized intervention

Stratified nursing is implemented based on evaluation results. Intensive intervention is adopted for high-recurrence risk groups (high-tension areas, positive family history, diabetic patients): Conduct special health education to clarify nursing points and recurrence risks; Assist in completing serum TGF-β1 and hydroxyproline detection to provide reference for surgical timing and nursing monitoring [8]. For patients with severe anxiety, implement cognitive-behavioral intervention in conjunction with the psychology department. Routine preoperative nursing includes cleaning and skin preparation of the surgical area, position training, and informing patients of the surgical process and coping methods for discomfort to alleviate preoperative fear [9].

3. Surgical cooperation and intraoperative nursing key points for keloids

3.1. Refined surgical nursing cooperation

Minimally invasive and tension-free are the core to reducing postoperative recurrence. Nurses need to cooperate meticulously throughout the process: Prepare special instruments for minimally invasive surgery before operation to ensure sterility and precision; Cooperate with the surgeon to confirm Langer's skin tension lines during operation to ensure the incision follows the tension lines [10]. During subcutaneous tension-reducing suture, timely deliver materials and adjust tension to ensure tension-free alignment of the epidermis. For trephine volume reduction surgery, assist in controlling the depth and scope of the trephine, retain the normal superficial skin, and perform intraoperative hemostasis well to reduce surgical trauma [11].

3.2. Intraoperative trauma control and inflammation prevention

The core of intraoperative nursing is to reduce traumatic inflammation. Cooperate with the surgeon to strictly control the resection range, only resect scar tissue, and avoid damaging normal tissue; Timely clean the wound to reduce residual tissue debris and foreign body reaction; Provide moisturizing protection for large-area wounds to reduce postoperative inflammatory exudation. At the same time, monitor the patient's vital signs throughout the process, handle adverse reactions in a timely manner, and ensure the smooth progress of the operation.

4. Postoperative refined nursing and anti-recurrence intervention for keloids

4.1. Standardized postoperative wound care

Wound care is the foundation of postoperative rehabilitation. Keep the wound dry and avoid water for 6–8 hours after minimally invasive surgery; Change the dressing for the first time 1–3 days after surgical incision, cover with sterile dressing until suture removal. Suture removal is 5–7 days for the head and face, and 10–14 days for the trunk and limbs. The use of silver ion antibacterial dressings is recommended, which reduces the postoperative infection rate from 8% to 2.5% [12]. Closely observe the wound during dressing change and handle abnormalities such as redness and exudation in a timely manner. Use silicone preparations promptly after suture removal to inhibit fibroblast proliferation, guide patients to apply them regularly, and ensure uniform coverage of the drug.

4.2. Postoperative tension control and physical-chemical protection nursing

High tension is an independent risk factor for scar hyperplasia and recurrence. Immediately apply elastic bandage compression dressing after operation, maintaining a pressure of 15–25 mmHg [5]. Customize pressure garments/pressure earrings for high-tension areas. Wearing customized earrings for ear keloids can reduce the recurrence risk by more than 50% [13]. Guide patients to wear them for ≥ 20 hours a day for 3–6 months, and inform them of cleaning and maintenance methods. The 3 months after operation is the peak period of scar hyperplasia. Guide patients to apply sunscreen with SPF30 + PA +++ twice a day to do a good job in sun protection; The diet should be high in protein and vitamins, avoid spicy and irritating foods, and at the same time avoid excessive activities in the surgical area to reduce incision tension.

4.3. Nursing cooperation in postoperative combined anti-recurrence treatment

Surgery combined with anti-recurrence treatment is the key to reducing the recurrence rate. The 24 hours after operation is the "golden time" for radiotherapy and drug injection [14]. Assist doctors in completing the first intralesional hormone injection, guide patients to cooperate with radiotherapy, and observe and handle adverse reactions such as radiation dermatitis. For patients receiving hormone combined with 5-fluorouracil injection, prepare drugs strictly in accordance with medical advice, controlling the dosage and depth; For patients undergoing fractional laser treatment, clean the skin before operation, apply cold compress and moisturize after operation, and record the treatment situation throughout the process to ensure standardized completion.

4.4. Postoperative psychological nursing and health guidance

Patients still have appearance anxiety after operation, and long-term treatment is prone to burnout [7].

Continuous psychological nursing is needed: Timely feedback the wound healing situation and positively guide to alleviate anxiety; Communicate the psychological state regularly and timely counsel patients with negative emotions. Formulate personalized health guidance plans, guide patients to master skills such as wound care and pressure device wearing through oral explanation + graphic manuals + video demonstrations; Clarify early signs of recurrence (redness and itching, slight protrusion, hardening texture), and inform patients to seek medical attention immediately when signs appear [15].

5. Postoperative dynamic follow-up and early recurrence intervention for keloids

5.1. Construction of a standardized postoperative follow-up system

Dynamic follow-up is the core of early recurrence intervention. Construct a follow-up system of "1, 3, 6, 12 months", followed by annual follow-up. Adopt a combination of outpatient, telephone, and online methods: Outpatient follow-up evaluates the degree of hyperplasia through the Vancouver Scar Scale and detects serum hydroxyproline; Telephone and online follow-up focus on understanding self-care, wearing of pressure devices, and signs of recurrence. Establish exclusive follow-up files for patients, recording surgery, treatment, nursing, and follow-up results to achieve full traceability.

5.2. Early recurrence intervention and nursing adjustment

When early signs of recurrence are found during follow-up, immediately start hierarchical intervention [15]. Mild recurrence adopts hormone injection combined with fractional laser, strengthening the use of pressure and silicone preparations; Moderate recurrence adds radiotherapy and adjusts pressure device parameters; Severe recurrence assists in implementing secondary minimally invasive volume reduction surgery and re-formulates nursing plans. Analyze the inducements for recurrent patients, adjust nursing plans targeted, strengthen health guidance and psychological counseling, improve self-care ability, and reduce the risk of re-recurrence.

6. Existing problems and optimization strategies in postoperative nursing of keloids

6.1. Current bottlenecks in clinical nursing

Although refined nursing can reduce the recurrence rate, there are still shortcomings in clinical nursing: Insufficient intervention for high-recurrence risk groups, the recurrence rate of patients with chest keloids and positive family history is still 15–20% ; Patients' nursing compliance is low, and they arbitrarily interrupt nursing due to discomfort of pressure devices and cumbersome treatment; The professional ability of grass-roots nurses is uneven, and they have insufficient grasp of scar pathology and key points of anti-recurrence nursing; Lack of personalized nursing plans, most adopt unified standards, and do not formulate plans combined with patients' individual conditions.

6.2. Clinical nursing optimization strategies

First, carry out specialized nursing training, focusing on scar pathology, perioperative nursing, recurrence identification, etc., and only those who pass the assessment can engage in specialized nursing; Second, construct personalized nursing plans, formulate "one person, one plan" based on scar location, recurrence

risk, psychological state, etc., and strengthen intervention for high-risk groups; Third, innovate health guidance methods, improve patients' compliance through online check-in and regular reminders, simplify nursing processes, develop convenient tools, and reduce nursing difficulty; Fourth, establish a multi-disciplinary collaboration model, combining surgery, dermatology, and psychology to provide patients with comprehensive physical and psychological integrated diagnosis, treatment, and nursing services.

7. Conclusion

The effect of surgical treatment for keloids depends on an integrated model of "precision surgery + standardized perioperative nursing + long-term anti-recurrence management" and clinical nursing occupies a core position throughout the process. Preoperative evaluation, intraoperative cooperation, postoperative nursing, and long-term follow-up need to follow the principles of precision and standardization, and each link is interlocking to effectively reduce the recurrence rate.

At present, clinical practice needs to address nursing bottlenecks, strengthen the construction of specialized nursing capabilities, construct personalized nursing plans, improve patient compliance, and achieve continuous improvement of nursing quality through multi-disciplinary collaboration. In the future, with the development of molecular targeted therapy and intelligent diagnosis and treatment technology, clinical nursing needs to integrate new diagnosis and treatment concepts, combine precision nursing with new technologies, further reduce the postoperative recurrence rate, improve patients' quality of life, and provide a new direction for the development of clinical nursing for keloids.

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Disclosure statement

The authors declare no conflict of interest.

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Observation on the Therapeutic Effect of Budesonide Combined with Azithromycin in the Treatment of *Mycoplasma Pneumoniae* Pneumonia in Children

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Abstract: *Objective*: To investigate whether adding budesonide inhalation to the azithromycin anti-infective regimen can enhance the therapeutic effect and ensure the safety of its application in the clinical management of *Mycoplasma pneumoniae* pneumonia in children. *Methods*: This study included 120 diagnosed children who were randomly divided into two parallel groups. Among them, 60 children in the reference group received a 3-day course of oral azithromycin (single daily dose of 10 mg/kg); the study group, consisting of 60 children, received an additional twice-daily budesonide suspension inhalation (0.5 mg each time) alongside the same azithromycin treatment. The total treatment period for all children was set at 7 days. This study systematically collected and compared the time spans required for the resolution of core symptoms (body temperature, cough, and pulmonary signs) between the two groups; analyzed changes in the concentrations of C-reactive protein and interleukin-6 in the blood before and after treatment; evaluated the absorption of inflammatory shadows on chest X-rays at the end of treatment; examined changes in pulmonary ventilation function indicators in some children; and recorded and compared all adverse events that occurred during the treatment phase. *Results*: The study data indicated that children in the study group experienced faster resolution of fever, cough, and pulmonary signs compared to the reference group, with differences being statistically significant. After the treatment course, the levels of inflammatory markers in the blood of children in the study group decreased more significantly. Imaging assessment showed that the overall effective rate of pulmonary inflammation absorption in the study group reached 96.7%, higher than the 83.3% in the reference group. In terms of pulmonary function improvement, the study group also demonstrated superior results. There was no significant difference in the reported rates of treatment-related adverse events between the two groups. *Conclusion*: For children with *Mycoplasma pneumoniae* pneumonia, combining azithromycin for etiological treatment with budesonide inhalation for local anti-inflammatory intervention can accelerate the clinical recovery process, effectively suppress systemic inflammation levels, promote pulmonary lesion repair, and improve pulmonary function.

Keywords: Pediatric *Mycoplasma pneumoniae* infection; Azithromycin; Inhaled budesonide; Synergistic therapy; Therapeutic effect analysis

Online publication: Apr 30, 2026

1. Introduction

Mycoplasma pneumoniae is a significant pathogen responsible for community-acquired pneumonia in children, with *Mycoplasma pneumoniae* pneumonia being highly prevalent in clinical practice. The pathological process of this disease not only stems from the direct invasion of pathogenic microorganisms but is also closely related to the abnormal immune-inflammatory response network triggered after host infection. This excessive inflammatory response can cause extensive damage to the airway mucosa, increased secretions, and heightened reactivity, resulting in prominent clinical symptoms and slow recovery in some children. Currently, antimicrobial therapy centered around macrolide antibiotics such as azithromycin represents the standard approach targeting the pathogen. However, clinical observations have revealed that relying solely on antimicrobial agents sometimes fails to promptly alleviate respiratory symptoms dominated by a strong immune-inflammatory response, such as persistent severe cough. Therefore, how to effectively regulate local airway inflammation while combating infection has emerged as a potential breakthrough for improving treatment outcomes. Inhaled corticosteroids, due to their ability to efficiently act on airway targets with minimal systemic side effects, hold a firm position in the management of airway inflammatory diseases. Budesonide, as a representative of such drugs, is conveniently used in pediatric patients in its nebulized form. The primary objective of this study is to systematically evaluate whether the addition of nebulized budesonide to azithromycin anti-infective therapy provides incremental value in enhancing the overall treatment effectiveness for children with *Mycoplasma pneumoniae* pneumonia and to carefully examine its safety profile.

2. Subjects and methods

2.1. General information

The cases for this study were sourced from children hospitalized in the pediatric ward of our hospital from early 2022 to the end of 2023, who were definitively diagnosed with *Mycoplasma pneumoniae* pneumonia. Case selection adhered to the following criteria: children aged between 3 and 12 years; diagnosis strictly conforming to the current authoritative pediatric diagnostic and treatment guidelines for *Mycoplasma pneumoniae* pneumonia; a time interval of no more than 3 days from disease onset to enrollment in the study protocol; imaging evidence indicating the presence of definitive inflammatory lung lesions; and full informed consent and written agreement obtained from the children's guardians. Exclusion criteria encompassed individuals with a history of allergy to the drug components planned for use in the study; those who had received systemic corticosteroids or other types of macrolide therapy prior to inclusion; those with severe dysfunction of vital organs or underlying immune dysfunction; and those concurrently diagnosed with chronic respiratory diseases such as asthma. A total of 120 children who met the criteria and were ultimately enrolled in the study were randomly assigned to two groups: the conventional treatment group and the combined treatment group, with 60 children in each group. Balanced testing of baseline data, including age, gender, average disease duration, initial disease severity, and key pre-treatment inflammatory indicators, revealed no statistically significant differences in any comparison items, confirming good comparability between the two groups at the outset.

2.2. Diagnostic criteria

Establishing a diagnosis requires integrating clinical manifestations, laboratory evidence, and imaging findings. Clinically, children must exhibit signs such as fever, typical cough, and fixed rales heard on lung auscultation. Laboratory evidence is crucial, specifically indicating that serum testing reveals *Mycoplasma pneumoniae*-specific IgM antibody titers reaching the diagnostic threshold or that molecular biology techniques directly detect *Mycoplasma pneumoniae* nucleic acids in respiratory samples. Imaging evidence consists of chest X-ray or CT findings confirming the presence of exudative shadows consistent with pneumonia. A definitive diagnosis of *Mycoplasma pneumoniae* pneumonia can only be made when all three elements, clinical signs, etiological evidence, and imaging changes were present.

2.3. Treatment methods

All enrolled children received conventional symptomatic support, including antipyretic and expectorant treatments. Children in the conventional treatment group received oral azithromycin dry suspension, administered once daily for three consecutive days, with the dose calculated based on body weight at a standard of 10 mg per kilogram per day. Children in the combined treatment group, in addition to receiving the identical oral azithromycin regimen as the conventional treatment group, underwent twice-daily nebulized inhalation therapy with budesonide suspension, with each dose consisting of 0.5 mg of the drug diluted in an appropriate amount of normal saline and inhaled via a nebulizer. The total duration of the intervention process was uniformly set at seven days, with strict monitoring of medication adherence in children throughout the treatment period.

2.4. Observation indicators

Evaluation of efficacy and safety was accomplished through a series of predefined indicators. The primary efficacy endpoint focused on the timeliness of symptom relief, accurately recording the number of days required for normalization of body temperature, cessation of cough, and dissipation of lung rales. Secondary efficacy indicators were examined from multiple perspectives: venous blood samples were collected on the first day of treatment and the day after treatment completion to measure changes in C-reactive protein and interleukin-6 concentrations; chest X-rays were reviewed at the end of one week of treatment, with imaging doctors unaware of group assignments assessing the degree of absorption of lung shadows; for children of cooperative age, lung function was quantified before and after treatment using a spirometer to measure the proportion of forced expiratory volume in one second to the predicted value. Safety assessment was achieved by actively monitoring and recording any adverse events potentially related to treatment throughout the process, such as gastrointestinal symptoms, rashes, or local irritation reactions associated with nebulization, and comparing the frequency of occurrence between the two groups.

3. Results

3.1. Comparison of relief times for major clinical

Symptoms between the Two Groups of Children In terms of the relief efficiency of core clinical symptoms, the combined treatment group demonstrated a clear advantage. Statistical data showed that the average durations of fever, cough, and lung signs were all shorter in the combined treatment group than in the conventional treatment group, with statistically significant differences between groups upon hypothesis

testing. Detailed time data are summarized in the following table. See **Table 1**.

Table 1. Comparison of relief times for major clinical symptoms between the two groups of children

Group	Number of cases	Duration of fever recovery	Duration of cough	Duration of rales
Conventional treatment group	60	3.6 ± 0.7	7.3 ± 1.4	6.7 ± 1.2
Combination treatment group	60	2.3 ± 0.5	5.1 ± 1.1	4.9 ± 1.0
t value	–	9.112	8.345	8.012
p value	–	< 0.001	< 0.001	< 0.001

3.2. Comparison of serum inflammatory factor levels between the two groups of children before and after treatment

Prior to treatment, the baseline levels of inflammatory factors were comparable between the two groups. After completing one week of treatment, both groups exhibited a significant decrease in CRP and IL-6 levels compared to their pre-treatment values. Further comparison of the post-treatment levels revealed that the measured CRP and IL-6 values in the children of the combined treatment group were lower than those in the conventional treatment group. This difference passed the statistical significance test, indicating that the combined intervention regimen had a stronger effect in suppressing systemic inflammatory responses. The specific values are presented in the following table. See **Table 2**.

Table 2. Comparison of serum inflammatory factor levels between the two groups of children before and after treatment

Group	Time point	CRP concentration (mg/L)	IL-6 concentration (pg/mL)
Conventional treatment group (n = 60)	Before treatment	28.8 ± 6.0	35.9 ± 8.1
	After treatment	10.8 ± 3.0*	15.8 ± 4.5*
Combination treatment group (n = 60)	Before treatment	29.3 ± 5.7	36.8 ± 7.5
	After treatment	6.2 ± 2.2*#	9.3 ± 3.0*#

Note: Compared with the pre-treatment data within the same group, $p < 0.05$; compared with the post-treatment data of the conventional treatment group, $\#p < 0.05$*

3.3. Comparison of improvements in lung function between the two groups of children after treatment

Among the 50 children (24 in the conventional group and 26 in the combined group) who met the age criteria and were able to complete lung function tests, the predicted FEV1% values were similar between the two groups before treatment. After completing the treatment course, this indicator improved in children from both groups. Analysis of the differences before and after treatment revealed that the increase in FEV1% was significantly greater in the combined treatment group compared to the conventional treatment group, with a statistically significant difference between the groups. This indicates that the combined therapy has a more positive effect on improving respiratory function in children. See **Table 3**.

Table 3. Comparison of changes in predicted FEV1% before and after treatment between the two groups of children

Group	Number of cases	Pre-treatment value	Post-treatment value	Pre-post treatment difference
Conventional treatment group	24	78.5 ± 5.4	85.1 ± 4.9*	6.6 ± 2.7
Combination treatment group	26	78.0 ± 5.9	90.5 ± 4.7*	12.5 ± 3.2#
t value	-	0.315	4.128	6.521
p value	-	> 0.05	< 0.001	< 0.001

Note: Compared with the pre-treatment values within the same group, $p < 0.05$; compared with the difference in the conventional treatment group, $\#p < 0.05$.

3.4. Comparison of overall efficacy and safety between the two groups of children

The overall efficacy was evaluated based on the comprehensive improvement of clinical symptoms and imaging findings at the end of treatment. The combined treatment group had a higher proportion of cases achieving marked and effective outcomes, with its overall effective rate significantly superior to that of the conventional treatment group. Safety monitoring results indicated that the adverse reactions observed in both groups were mild, primarily including gastrointestinal reactions and transient hoarseness, which were relieved after treatment. Statistical analysis revealed no significant difference in the overall incidence of adverse reactions between the two groups. See **Table 4**.

Table 4. Comparison of overall efficacy and incidence of adverse reactions between the two groups of children

Group	Total cases	Markedly effective	Effective	Ineffective	Overall effective	Adverse reactions
Conventional treatment group	60	24 (40.0)	26 (43.3)	10 (16.7)	50 (83.3)	7 (11.7)
Combination treatment group	60	33 (55.0)	25 (41.7)	2 (3.3)	58 (96.7)	9 (15.0)
χ^2 value	-	-	-	-	5.926	0.327
p value	-	-	-	-	0.015	0.567

4. Discussion

The data and conclusions obtained from this study support the following viewpoint: In the treatment of *Mycoplasma pneumoniae* pneumonia in children, the combined application of budesonide inhalation and oral azithromycin can produce a synergistic effect. The underlying mechanism of this synergistic effect can be understood from the different targets of drug action. The core function of azithromycin is antibacterial; it inhibits the growth of pathogens by interfering with their protein synthesis, thereby controlling the source of infection. However, many pathological manifestations of *Mycoplasma pneumoniae* pneumonia, particularly persistent respiratory symptoms, are largely attributable to the excessive host immune-inflammatory response triggered by the pathogen. In such cases, targeting only the pathogen may not rapidly quell the already initiated inflammatory cascade [1].

Under these circumstances, budesonide demonstrates its unique therapeutic value. As a highly selective inhaled corticosteroid, budesonide can directly reach the site of airway inflammation after nebulization [2]. By

regulating gene transcription, it effectively inhibits the production and release of various pro-inflammatory factors while stabilizing inflammatory cell membranes, reducing mucosal edema and hyperresponsiveness. This study observed a more significant decrease in serum inflammatory marker levels in children in the combined treatment group, directly reflecting the stronger inhibitory capacity of this regimen on systemic inflammatory status. It is precisely this dual suppression of local and systemic inflammation that provides a biological basis for the rapid improvement of clinical symptoms [3].

The more pronounced improvement in pulmonary function indicators observed in children in the combined treatment group in this study holds significant clinical importance. *Mycoplasma pneumoniae* infection can induce inflammatory swelling and mucus plugging of the airway mucosa, leading to decreased airway patency. Budesonide, through its potent local anti-inflammatory effects, can effectively alleviate these pathological changes, thereby reducing airway resistance. The greater increase in FEV1% in **Table 3** directly confirms the additional benefits of the combined therapy in restoring normal airway ventilation function, which may have a positive impact on ensuring the long-term respiratory health of children [4].

From the perspective of objective morphological evidence of disease outcome, the significant advantage of the combined treatment group in terms of the overall effective rate of chest X-ray lesion absorption translates the improvement in clinical symptoms and laboratory indicators into the repair of pulmonary parenchymal lesions. Imaging improvement is one of the most intuitive and hard indicators for evaluating the efficacy of pneumonia treatment. A higher imaging absorption rate means that the combined treatment strategy can more effectively promote the dissipation of pulmonary inflammatory infiltration and accelerate the anatomical healing process of the disease, which has practical value in shortening the overall course of the disease and reducing medical resource consumption.

The adoption of any treatment regimen must weigh its benefits against its risks. Although there are many concerns regarding the systemic use of glucocorticoids, the budesonide inhalation therapy used in this study significantly reduces related risks due to its extremely high local activity and extremely low systemic bioavailability. The study results also clearly show that the combined treatment did not lead to a significant increase in the incidence of adverse reactions, and all reported adverse events were mild and reversible [5].

5. Conclusion

In summary, the evidence chain from this study indicates that for *Mycoplasma pneumoniae* pneumonia in children, initiating budesonide inhalation for anti-inflammatory intervention simultaneously with azithromycin anti-infective treatment at the outset is an optimized strategy that can accelerate recovery, enhance treatment benefits, and not increase additional risks. This strategy achieves more comprehensive disease management by simultaneously targeting the two core aspects of the infection source and host inflammatory response. Subsequent research directions can focus on exploring the optimal drug dosage and treatment duration for children with different clinical phenotypes in detail and evaluating their impact on children's growth and development and long-term respiratory health through long-term follow-up.

Disclosure statement

The authors declare no conflict of interest.

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Multivariate Logistic Regression Analysis of Risk Factors for Subacute Delirium Syndrome in ICU Patients

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Abstract: *Objective*: This study aimed to identify risk factors for subsyndromal delirium (SSD) in adult intensive care unit (ICU) patients using a multivariate logistic regression model. *Methods*: A total of 252 ICU patients admitted to a Grade A tertiary hospital between January 2024 and December 2025 were included in the study. General characteristics, clinical conditions, treatments and laboratory test results were compared between 174 patients who developed SSD and 78 who did not. Univariate risk factors for SSD were identified, and multivariate logistic regression analysis was performed to determine the independent risk factors for SSD. *Results*: Multivariate logistic regression analysis revealed that patient age (OR = 1.465), Acute Physiology and Chronic Health Evaluation II (APACHE II) score (OR = 1.677), Critical Care Pain Observation Tool (CPOT) score (OR = 1.899), physical restraint (OR = 3.485), sepsis (OR = 2.452) and duration of mechanical ventilation (OR = 1.635) were identified as independent risk factors for SSD in ICU patients. *Conclusion*: Elderly ICU patients are at higher risk of developing sub-delirium syndrome; early screening and timely medical intervention can reduce the risk of SSD and improve patient prognosis.

Keywords: Subsyndromal delirium (SSD); Intensive care unit (ICU); Risk factors; Multivariate logistic regression

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1. Introduction

Subacute delirium syndrome (SSD) is an acute state of brain dysfunction that does not fully meet the diagnostic criteria for delirium but is characterized by impairments in attention, cognition, mood, or sleep. Recent studies indicate that the incidence of SSD in intensive care unit (ICU) patients ranges from 17% to 86%, far exceeding that of typical delirium; however, due to its insidious symptoms and rapid progression, it poses significant challenges for clinical identification and intervention [1]. SSD represents a critical precursor to delirium; its occurrence and progression are closely associated with adverse outcomes such as long-term cognitive impairment, mechanical ventilation and prolonged hospital stays, placing a heavy burden on

patients' families and the healthcare system. Currently, both domestic and international research on SSD in ICU patients has largely focused on descriptive surveys, with a relative lack of in-depth analysis of specific risk factors, which directly limits the early identification of high-risk patients and targeted prevention [2] .Therefore, this study aims to conduct a prospective observational study to systematically analyze the risk factors associated with SSD in ICU patients and construct a multivariate logistic regression model. The objective is to provide evidence-based support for the early clinical screening of high-risk individuals and the implementation of targeted interventions, thereby improving patient outcomes.

2. Materials and methods

2.1. General information

A prospective observational study design was employed. A total of 252 patients admitted to the general ICU of a Grade A tertiary hospital between 1 January 2024 and 31 December 2025 were consecutively enrolled. Participants were categorized into a delirium group (n = 174) and a non-delirium group (n = 78) based on the occurrence of SSD during their ICU stay.

2.1.1. Inclusion criteria

(1) Age ≥ 18 years;
(2) ICU stay ≥ 24 hours;
(3) Informed consent from the patient or their legal representative.

2.1.2. Exclusion criteria

(1) History of neurological diseases with a confirmed diagnosis, such as dementia, Parkinson's disease, sequelae of stroke, or intracranial tumors;
(2) History of psychiatric or psychological disorders prior to admission;
(3) Severe visual, hearing, or speech impairments affecting cognitive assessment;
(4) Patients in a deep coma upon admission to the ICU or those expected to require deep sedation throughout their ICU stay.

2.2. Methods

2.2.1. Collection of general and clinical data

The following data were collected by reviewing electronic medical records:

(1) General information

Gender, age, educational attainment, marital status.

(2) Disease and treatment-related factors

Acute Physiology and Chronic Health Evaluation II (APACHE II) score within 24 hours of admission; Critical Care Pain Observation Tool (CPOT) score; diagnosis of sepsis (referring to the Sepsis-3.0 criteria); use of analgesics/sedatives during hospitalisation, use of physical restraints, and administration of blood products; total number of indwelling catheters; total length of stay; total duration of mechanical ventilation.

(3) Laboratory parameters

Relevant parameters collected within 24 hours of ICU admission, including serum albumin (hypoalbuminaemia: < 30 g/L), arterial blood carbon dioxide partial pressure ($PaCO_2$, hypercapnia: > 45

mmHg), and C-reactive protein (CRP, elevated > 10 mg/L) [3].

2.2.2. Richmond agitation-sedation scale (RASS)

Assesses the patient's level of consciousness and depth of sedation; the score ranges from -5 (unresponsive) to +4 (agitated), with assessments conducted twice daily. Scores of -1 to -5 indicate varying degrees of sedation; a score of 0 indicates the patient is alert and calm; scores of 1 to 4 indicate agitation and anxiety [4].

2.2.3. The ICU confusion assessment method (CAM-ICU)

The ICU Confusion Assessment Method (CAM-ICU) is widely recognized as the "gold standard" for diagnosing delirium in ICU patients [5]. This scale comprises four criteria:

(1) Acute change or fluctuation in level of consciousness;
(2) Disorientation;
(3) Change in level of consciousness as determined by the RASS;
(4) Disorganized thinking.

A diagnosis of delirium is made when the patient meets criteria (1) + (2) + (3) or (1) + (2) + (4) simultaneously. When a patient exhibits only one or several of the above characteristics but does not fully meet the diagnostic criteria for delirium, the condition is classified as SSD.

2.3. Statistical analysis

Data analysis was performed using SPSS 26.0 and R 4.3.1 software. Quantitative data conforming to a normal distribution are presented as mean ± standard deviation ($\overline{x} \pm s$), with comparisons between groups performed using the independent samples *t*-test; categorical data are presented as frequency (percentage) [n(%)], with comparisons between groups performed using the chi-square test. Variables with $p < 0.1$ in the univariate analysis were included in a multivariate binary logistic regression model (stepwise method, LR) to analyze independent risk factors for the occurrence of SSD, and odds ratios (OR) and their 95% confidence intervals (CI) were calculated. All statistical tests were two-sided; $p < 0.05$ was considered statistically significant.

3. Results

3.1. Univariate analysis of SSD occurrence in ICU patients

The results of the univariate analysis showed that there were statistically significant differences between the SSD group and the non-SSD group in terms of age, APACHE II score, CPOT score, length of hospital stay, use of sedative-analgesic drugs, physical restraint, sepsis, use of blood products, CRP levels, and duration of mechanical ventilation (all $p < 0.05$). There were no statistically significant differences between the two groups in terms of gender, educational level, marital status, hypoproteinaemia, or hypercapnia ($PaCO_2$) ($p > 0.05$); see **Table 1**.

Table 1. Univariate analysis of subdelirium syndrome in ICU patients

Item	Subdelirium group(n = 174)	Non-delirium group (n = 78)	t/χ^2 value	*p*-value
Age ($\overline{x} \pm s$, years)	60.12 ± 2.14	59.45 ± 2.17	2.288	0.023

Item		Subdelirium group(n = 174)	Non-delirium group (n = 78)	t/χ^2 value	*p*-value
Gender [n(%)]	Male	92	42	0.021	0.886
	Female	82	36		
Educational attainment [n(%)]	Primary school and below	97	35	5.052	0.080
	Lower secondary or upper secondary	52	23		
	College or above	25	20		
Marital status [n(%)]	Married	150	68	0.062	0.970
	Unmarried	9	4		
	Divorced or widowed	15	6		
APACHE II score ($\overline{x}$ ± s, points)		9.48 ± 1.36	10.12 ± 1.26	3.531	< 0.001
CPOT score ($\overline{x}$ ± s, points)		1.25 ± 0.34	1.04 ± 0.26	4.854	< 0.001
Length of stay ($\overline{x}$ ± s, days)		9.55±2.05	6.52 ± 2.11	10.749	< 0.001
Use of sedative-analgesic drugs [n(%)]	Yes	105	21	24.064	< 0.001
	No	69	57		
Constraint [n(%)]	Yes	119	15	52.274	< 0.001
	No	55	63		
Sepsis [n(%)]	Yes	35	4	9.247	0.002
	No	4	74		
Use of blood products [n(%)]	Yes	78	24	4.418	0.036
	No	96	54		
Hypoproteinaemia [n(%)]	Yes	108	40	2.586	0.108
	No	66	38		
Elevated $PaCO_2$[n (%)]	Yes	24	10	0.044	0.835
	No	150	68		
CRP [n (%)]	Normal	82	57	14.664	< 0.001
	Elevated	92	21		
Duration of mechanical ventilation ($\overline{x}$ ± s, h)		209.15 ± 7.89	198.36 ± 8.52	9.789	< 0.001

3.2. Logistic regression analysis of SSD incidence in ICU patients

The results of the multivariate logistic regression analysis showed that age, APACHE II score, CPOT score, physical restraint, sepsis and duration of mechanical ventilation were independent risk factors for SSD in ICU patients (all $p < 0.05$). Among these, physical restraint posed the highest risk (OR = 3.485), followed by sepsis (OR = 2.452) and pain (CPOT score, OR = 1.899), as shown in **Table 2**.

Table 2. Logistic regression analysis of SSD in ICU patients

Variable	Value	β	SE	Wald χ^2	*p*-value	OR	95% CI
Age (years)	Original value	0.382	0.167	5.241	0.022	1.465	1.058–2.028
APACHE II score (points)	Original value	0.517	0.189	7.396	0.007	1.677	1.152–2.441
CPOT score (points)	Original value	0.642	0.213	9.185	0.002	1.899	1.268–2.843
Length of stay (days)	Original value	0.279	0.158	3.098	0.078	1.321	0.972–1.794
Use of sedative-analgesic drugs	No = 0, Yes = 1	0.315	0.192	2.716	0.099	1.370	0.935–2.007
Constraint	No = 0, Yes = 1	1.248	0.285	19.152	< 0.001	3.485	2.079–5.832

Sepsis	No = 0, Yes = 1	0.897	0.321	7.864	0.005	2.452	1.318–4.561
Use of blood products	No = 0, Yes = 1	0.294	0.176	2.773	0.096	1.342	0.950–1.899
CRP	Normal = 0, elevated = 1	0.368	0.201	3.339	0.068	1.445	0.973–2.145
Duration of mechanical ventilation (h)	Original value	0.492	0.174	7.963	0.005	1.635	1.149–2.328

4. Discussion

ICU patients often present with complex conditions such as multiple organ dysfunction and severe infections, and frequently require invasive treatments including mechanical ventilation, analgesia and sedation, and the administration of vasoactive drugs; all such procedures and medications may interfere with the body's normal physiological state. Furthermore, given the rapid progression of ICU patients' conditions and significant individual variability, the symptoms of subacute delirium syndrome are subtle. In the early stages, they manifest only as mild inattention and sleep disturbances, which are easily masked by symptoms of severe underlying diseases. This leads to delayed clinical recognition, missed opportunities for intervention, and an increased risk of poor outcomes [6]. Subacute delirium syndrome (SSD) is an acute cerebral dysfunction lying between normal consciousness and delirium; although it does not meet the diagnostic criteria for delirium, it involves mild impairment in attention, cognition, mood and sleep, and represents an important precursor to the development of delirium [7]. Therefore, identifying the risk factors for SSD in ICU patients can, on the one hand, assist clinical staff in accurately identifying high-risk groups, establishing early screening mechanisms, and implementing targeted prevention; on the other hand, it enables the development of individualized interventions to reduce the incidence of SSD, prevent its progression to delirium, and improve the quality of care for critically ill patients.

Multivariate logistic regression analysis in this study revealed that age, APACHE II score, CPOT score, physical restraint, sepsis, and duration of mechanical ventilation are independent risk factors for SSD in ICU patients. Based on clinical practice, the reasons are analyzed as follows:

(1) As people age, the brain parenchyma undergoes degenerative changes, cerebral blood supply becomes inadequate, and the regulatory functions of the central nervous system decline. This leads to a significant reduction in tolerance to external stimuli such as pain, infection and medication. Furthermore, the presence of multiple underlying conditions often makes brain function more susceptible to damage, thereby increasing the risk of SSD.

(2) The APACHE II score reflects the severity of a patient's acute physiological injury and chronic health status. A higher score indicates a more critical condition and a more intense physiological stress response; the massive release of stress hormones can interfere with central nervous system function. Furthermore, critically ill patients often suffer from metabolic disorders and hypoxia, which further exacerbate brain damage and induce SSD.

(3) A high CPOT score indicates a more severe level of pain. Persistent pain stimuli activate the body's stress response, impairing sleep quality and leading to poor concentration and emotional disturbances. Furthermore, pain necessitates increased doses of sedative and analgesic medications, which indirectly interfere with brain function and heighten the risk of SSD.

(4) ICU patients may require physical restraints due to agitation or catheter maintenance; these restrict limb movement, impair positional changes and blood circulation, and exacerbate cognitive impairment,

leading to negative emotions such as anxiety and fear, thereby inducing SSD.

(5) In patients with sepsis, the systemic inflammatory response leads to the massive release of inflammatory mediators into the bloodstream. These cross the blood-brain barrier and damage brain tissue, causing dysfunction of the central nervous system. Furthermore, sepsis is often accompanied by fever, hypoxia and metabolic acidosis, which further exacerbate brain damage and increase the risk of SSD.

(6) Prolonged mechanical ventilation can cause airway discomfort and communication difficulties in patients, and may even lead to complications such as pulmonary infection and hypoxia. This continuously stimulates the central nervous system, disrupts the homeostasis of brain function, and induces SSD [8].

5. Conclusion

In summary, the occurrence of SSD in ICU patients is influenced by multiple factors. Clinically, targeted intervention measures should be developed to address the aforementioned risk factors, with early screening of high-risk groups and timely intervention to reduce the incidence of SSD and improve patient prognosis.

Disclosure statement

The authors declare no conflict of interest.

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Research on the Application Effect of Predictive and Targeted Nursing in Patients with Liver Cirrhosis Complicated with Upper Gastrointestinal Bleeding

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Abstract: *Objective*: To investigate the application effect of predictive and targeted nursing in patients with liver cirrhosis complicated with upper gastrointestinal bleeding, and to evaluate its impact on clinical indicators, psychological state, and quality of life of patients. *Methods*: A total of 102 patients with liver cirrhosis complicated with upper gastrointestinal bleeding who were hospitalized from January 2023 to December 2023 were selected and divided into a control group (51 cases) and an observation group (51 cases) according to the random number table method. The control group received routine care, while the observation group received further strengthening of preventive care and targeted care on the basis of routine care. Clinical indicators (time to stop bleeding, length of hospital stay, incidence of rebleeding), psychological states (Self-Rating Anxiety Scale (SAS), Self-rating Depression Scale (SDS) scores), and quality of life (Short Form SF-36 score) were compared between the two groups. *Results*: The hemostasis time and hospital stay in the observation group were shorter than those in the control group, and the incidence of rebleeding was also lower than that in the control group, which was statistically significant ($p < 0.05$). After the intervention, the SAS and SDS scores of the observation group were lower than those of the control group, and the scores of each dimension of the SF-36 scale were higher than those of the control group, and the differences were statistically significant ($p < 0.05$). *Conclusion*: The application of predictive and targeted nursing to patients with liver cirrhosis complicated with upper gastrointestinal bleeding can significantly shorten hemostasis and hospital stay, reduce the incidence of rebleeding, significantly improve patients' anxiety and depression, improve patients' quality of life, and has good clinical application value.

Keywords: Cirrhosis; Upper gastrointestinal bleeding; Predictive nursing; Targeted nursing; Quality of life

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1. Introduction

Cirrhosis is a common chronic progressive liver disease in clinical practice, caused by the long-term or repeated effects of one or more causes. Upper gastrointestinal bleeding is one of its most serious

complications, with rapid onset, severe condition and high mortality rate. Bleeding not only directly endangers the patient's life, but also the negative emotions it causes, such as fear and anxiety, as well as the risk of repeated bleeding, have adverse effects on the patient's treatment compliance and quality of life. Conventional care models focus only on observing the condition and following medical advice, fail to make forward-looking predictions about potential risks, and fail to respond to individualized needs. Predictive care involves a comprehensive assessment of the patient's condition to identify potential risks in advance and intervene; Targeted care is providing personalized care based on individual differences among patients. Combining the two enables the full, dynamic and efficient management of patients with cirrhosis combined with upper gastrointestinal bleeding. This paper mainly studies the efficacy of predictive and targeted care for this type of patients, providing some references for clinical nursing work [1].

2. Data and methods

2.1. General information

Patients with liver cirrhosis complicated with upper gastrointestinal bleeding admitted to our hospital from January 2023 to December 2023 were the subjects of study.

2.1.1. Inclusion criteria

(1) Meeting the diagnostic criteria for liver cirrhosis in the Guidelines for Diagnosis and Treatment of liver cirrhosis, and confirmed by imaging or pathology;
(2) Clinical manifestations include hematemesis, melena, etc., and upper gastrointestinal bleeding is confirmed by gastroscopy;
(3) Between 18 and 80 years old;
(4) Conscious and capable of basic communication and understanding;
(5) Informed consent and signature of the patient and his/her family.

2.1.2. Exclusion criteria

Patients with severe dysfunction of other organs such as heart, lung or kidney failure; patients with mental illness or cognitive impairment who cannot cooperate with the study; patients with upper gastrointestinal bleeding caused by other reasons such as gastric ulcer or gastric cancer; patients who refuse to participate in the study or withdraw from the study halfway [2].

A total of 102 patients who met the criteria were included. Patients were randomly divided into a control group and an observation group, with 51 cases in each group, using a random number table. There was no statistically significant difference ($p > 0.05$) between the two groups of patients in terms of general information such as gender, age, liver function classification, and degree of bleeding, and they were comparable [3].

2.2. Methods

2.2.1. Control group

Routine nursing intervention included:

(1) Disease observation

Paying attention to the changes in the patient's condition, accurately recording the inflow and outflow,

and observing the color, nature and volume of hematemesis and hematochezia.

(2) Basic care

Instruct the patient to stay in bed absolutely, keep the airway unobstructed and prevent aspiration.

(3) Medication care

Use hemostatic drugs, vasoactive drugs, etc. accurately and promptly as prescribed, and observe the efficacy and adverse reactions of the drugs.

(4) Dietary care

Strictly fast during the bleeding period. After the bleeding stops, gradually transition to liquid and semi-liquid diets as directed by the doctor.

(5) Health education

Teach patients and their families about the disease and precautions [4].

2.2.2. Observation group

Predictive and targeted care was carried out on the basis of the control group, and the specific care measures were as follows.

(1) Predictive nursing

① Risk assessment and prediction: After admission, the responsible nurse continuously assesses the patient's risk of rebleeding (blood pressure, heart rate, hemoglobin changes, ascites status, infection status, etc.) using standardized assessment tools to identify possible triggers such as severe coughing, emotional agitation, straining during defecation, etc., and then formulates prevention plans. ② Prepare first aid in advance: Anticipate the readiness of first aid supplies and medicines, three-chamber two-capsule tube, rescue vehicle, electrocardiogram monitor, oxygen inhalation device, blood products, etc., to ensure that rescue can be initiated in the shortest possible time in case of an emergency. ③ Early warning monitoring: On the basis of routine monitoring, pay special attention to those symptoms that indicate the possibility of rebleeding, that is, when the patient shows symptoms such as restlessness, thirst, palpitations, and reduced pulse pressure, immediately inform the doctor and initiate the emergency procedure. ④ Environmental and safety management: Anticipate the safety of patient activities, guide patients to defecate in bed, prevent them from getting out of bed, keep the ward quiet and clean, reduce adverse stimuli, and lower stress responses caused by environmental factors [5].

(2) Targeted care

① Targeted psychological intervention: Stratified psychological care is carried out based on the assessment results of the patient's psychological state (SAS, SDS score). For those with mild anxiety and depression, supportive psychotherapy such as listening, explaining and comforting is used, and successful cases are presented to boost their confidence; For patients with moderate to severe mood disorders, psychotherapists are invited to help them develop positive coping styles through relaxation training, cognitive behavioral therapy, etc. ② Individualized care during the bleeding period: Develop individualized care plans based on different amounts of bleeding and different causes. Patients with esophageal and gastric variceal bleeding should be treated with three-chamber two-capsule compression hemostasis care, and the pressure of the balloon should be monitored regularly to prevent improper traction or balloon slippage; For patients with peptic ulcer bleeding, pay attention to observing the nature of abdominal pain and whether there are signs of perforation. ③ Precise dietary management: Based

on the patient's bleeding control status, liver function and nutritional status, work with the nutrition department to develop personalized dietary plans. Transition from fasting to cold liquid, warm liquid, and low-residue semi-liquid to ensure nutrition supply while preventing rebleeding. Provide enteral nutrition support to those at risk of malnutrition. ④ Targeted strengthening of health education and continuing care: Provide focused guidance on health education and continuing care for patients, that is, "one-on-one" guidance. The content includes the identification of triggers, dietary restrictions, medication compliance, follow-up visit times, abnormal signal identification, etc. Health records are established after discharge, and continuous care is provided through phone calls, wechat, etc. Regular follow-ups are conducted, questions are answered, and reminders for follow-up visits are made [6].

2.3. Observation indicators

2.3.1. Clinical indicators

Compare the hemostasis time (the time from the start of treatment upon admission to the cessation of active bleeding, based on the absence of bloody fluid drawn from the gastric tube or negative fecal occult blood), length of hospital stays, and incidence of rebleeding during hospitalization between the two groups of patients.

2.3.2. Psychological status

Patients were evaluated on the Self-Rating Anxiety Scale (SAS) and the Self-Rating Depression Scale (SDS) at admission, and on discharge. Both scales have 20 items and are scored on a 4-point scale with a cut-off standard score of 50 points. The higher the score, the more severe the degree of anxiety and depression.

2.3.3. Quality of life

Assessed using the Short Form 36 Health Survey (SF-36) three months after the patient's discharge. The scale consists of eight dimensions: physical function, physical role, physical pain, overall health, vitality, social function, emotional role, and mental health. Each dimension has a score range of 0 to 100, and the higher the score, the better the quality of life.

2.4. Statistical processing

Data were processed using SPSS 26.0 statistical software. Measurement data were expressed as mean plus or minus standard deviation ($\overline{x} \pm s$), and comparisons between groups were conducted using the independent sample t-test; Count data were expressed as the number of cases and percentage (%), and the χ^2 test was used for comparison between groups. $p < 0.05$ was considered statistically significant.

3. Fruiting

3.1. Comparison of clinical indicators between the two groups

The results showed that the hemostasis time and hospital stay of patients in the observation group were significantly shorter than those in the control group, and the incidence of rebleeding was significantly lower than that in the control group. The differences were statistically significant ($p < 0.05$). See **Table 1**.

Table 1. Comparison of clinical indicators between the two groups [($\overline{x} \pm s$), d]

Groups	Number of cases	Hemostasis time (d)	Hospital stays (d)	Rebleeding rate [n(%)]
Control group	51	2.64 ± 0.83	7.58 ± 1.94	9 (17.65)
Observation group	51	1.47 ± 0.51	5.13 ± 1.36	2 (3.92)
t/χ^2 values		8.521	7.332	4.993
p value		< 0.001	< 0.001	0.026

3.2. Comparison of mental states between the two groups

Before the intervention, there was no statistically significant difference in SAS and SDS scores between the two groups ($p > 0.05$). After the intervention, the SAS and SDS scores of the observation group were significantly lower than those of the control group, and the difference was statistically significant ($p < 0.05$). See **Table 2**.

Table 2. Comparison of mental states between the two groups [($\overline{x} \pm s$), points]

Group	Number of cases	SAS score		SDS score	
		Before intervention	After intervention	Before intervention	After intervention
Control group	51	55.23 ± 4.58	46.71 ± 4.15	56.72 ± 5.13	47.68 ± 4.42
Observation group	51	55.81 ± 4.96	39.84 ± 3.62	56.08 ± 4.87	40.27 ± 3.85
t value		0.613	8.956	0.652	9.134
p value		0.541	< 0.001	0.516	< 0.001

3.3. Comparison of quality of life between the two groups

After the intervention, the scores of each dimension of the SF-36 scale in the observation group were significantly higher than those in the control group, and the differences were statistically significant ($p < 0.05$). See **Table 3**.

Table 3. Comparison of quality of life between the two groups [($\overline{x} \pm s$), points]

Dimensions	Physiological function	Physiological functions	Somatic pain	Overall health	Vitality	Social function	Emotional function	Mental health
Control group (n = 51)	64.17 ± 7.02	57.32 ± 8.45	60.54 ± 7.98	52.89 ± 8.12	55.17 ± 7.33	62.28 ± 7.56	56.84 ± 8.91	58.06 ± 8.27
Observation group (n = 51)	74.85 ± 7.68	69.46 ± 9.21	71.33 ± 8.67	67.52 ± 9.04	68.91 ± 8.52	73.49 ± 8.89	70.22 ± 9.76	72.38 ± 9.01
t value	7.367	6.902	6.558	8.572	8.673	6.836	7.192	8.313
p value	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001

4. Discussion

Cirrhosis combined with upper gastrointestinal bleeding is a critical condition in gastroenterology, with rapid disease progression and a high risk of rebleeding. Patients not only suffer from physical pain, but also experience intense anxiety and depression due to uncertainty about the prognosis of the disease, fear

of rebleeding, and concern about the financial burden. This negative mental state affects the stability of the internal environment of the body through neuroendocrine mechanisms, increases sympathetic nerve excitability, may lead to elevated blood pressure, accelerated heart rate, and even induce rebleeding, creating a vicious cycle. Therefore, how to effectively control bleeding while optimizing nursing strategies and improving patients' psychological state and quality of life has become a key and difficult point in clinical nursing work.

The results of this study showed that the hemostasis time and hospital stay of patients in the observation group were significantly shorter than those in the control group after predictive and targeted care, and the incidence of rebleeding was also significantly reduced. The results suggest that the risk assessment and pre-intervention emphasized by predictive care play a key role. By early identification of high-risk factors for rebleeding, such as increased intra-abdominal pressure, coagulation dysfunction, improper activity, etc., and taking preventive measures in advance, such as guiding effective coughing, maintaining smooth bowel movements, strict bed rest, etc., the external factors that induce rebleeding were effectively reduced. At the same time, the advance preparation of first aid supplies and medicines ensures an immediate response in case of sudden changes in the condition, buying precious time for rescue, which fundamentally improves the efficiency of treatment and shortens the course of the disease.

Targeted care is reflected in the precise understanding of individual differences among patients. In terms of psychological state, the observation group provided stratified and personalized psychological intervention for patients with different degrees of emotional disorder based on the SAS and SDS scores. For those with mild emotional disorders, positive communication and positive guidance were provided to help them build a sense of security; For those with moderate to severe emotional disorders, introduce professional psychotherapy to correct their misperceptions and catastrophizing of the disease at the cognitive level. This targeted intervention effectively alleviates patients' negative emotions, enabling them to cooperate with treatment with a more stable and positive mindset, which is of great significance for maintaining stable vital signs, reducing stress responses, and promoting recovery. The data also confirmed that the SAS and SDS scores of the observation group after the intervention were much lower than those of the control group.

Improving the quality of life is one of the ultimate goals of nursing work. The study showed that patients in the observation group scored significantly better than those in the control group in all dimensions of SF-36 three months after discharge. This was due to the predictive and targeted care throughout the course. Physiologically, individualized dietary management and nutritional support provide patients with a sufficient nutritional base and promote the recovery of bodily functions; Precise medication guidance and disease monitoring have reduced the occurrence of complications. On the psychological level, effective emotional intervention alleviates long-term psychological burden. At the social function level, continuous care, through follow-up and guidance after discharge, helps patients and their families master scientific home care methods and enhances their confidence and ability to return to the family and participate in social activities. This multi-dimensional and comprehensive intervention has contributed to the overall improvement of patients' quality of life.

5. Conclusion

In summary, the application of predictive and targeted care in patients with liver cirrhosis complicated with upper gastrointestinal bleeding, through prospective risk identification and precise intervention,

not only effectively improves clinical treatment efficiency and reduces the risk of rebleeding, but also significantly improves the psychological state and long-term quality of life of patients. This nursing model has put the patient-centered concept into practice, achieving a shift from simple disease care to holistic and individualized care, and has significant clinical promotion value.

Disclosure statement

The author declares no conflict of interest.

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Research on the Construction of a Digital and Intelligent Nursing Simulation Teaching System Based on Best Practice Standards

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Abstract: *Objective*: To construct a digital and intelligent nursing simulation teaching case library based on INACSL best practice standards, and to evaluate the effect of clinical teaching for nursing interns under this model. *Method*: The case library was established based on the best practice standards of INACSL. Sixty nursing interns were selected and divided into a control group and an experimental group. The control group received traditional teaching, while the experimental group received digital and intelligent case simulation teaching based on traditional teaching. The theoretical and operational assessment results, clinical practice ability, critical thinking ability, and teaching satisfaction of the two groups were compared. *Results*: The theoretical scores (86.52 ± 4.38) and operational scores (88.15 ± 3.96) of the experimental group were higher than those of the control group (79.63 ± 5.12, 80.24 ± 4.85) ($p < 0.05$). The total scores of clinical practice ability (178.65 ± 12.34) and critical thinking ability (298.42 ± 18.56) in the experimental group were higher than those in the control group (152.37 ± 15.68, 265.19 ± 20.43) ($p < 0.05$). The teaching satisfaction rate of the experimental group (96.7%) was higher than that of the control group (80.0%) ($p < 0.05$). *Conclusion*: The digital and intelligent nursing simulation teaching case library created based on INACSL best practice standards can improve the clinical practice ability, critical thinking ability and teaching satisfaction of nursing interns.

Keywords: Digital intelligence technology; Best practice standards; Simulation teaching; Case library; Nursing practice

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1. Introduction

In the context of high-quality development, nursing vocational education has also shifted from the previous knowledge-imparting model to a competency-based training model. Nursing practice is an important period for students to move from the classroom to the clinical setting, and it mainly cultivates students' ability to apply knowledge to solve real clinical problems and critical thinking. However, there is a disconnection between theory and practice in clinical teaching at present, and students' emergency response ability and clinical thinking are relatively lacking. The traditional "one-to-one" apprenticeship system is restricted by

various factors such as medical safety, ethical privacy, seasonal cases, and tight clinical resources, and thus fails to provide students with sufficient and diverse practical opportunities. Although case simulation teaching can achieve experiential learning through highly realistic scenarios and thereby improve clinical decision-making ability, it also has problems such as scarce case resources, non-standard case writing, disconnection from clinical practice, and lack of unified implementation standards. Therefore, this study intends to create a standardized and digitalized nursing simulation teaching system based on INACSL best practice standards and digital intelligence technology, and evaluate the impact of this system on the clinical practice ability, critical thinking, and teaching satisfaction of nursing interns [1].

2. Data and methods

2.1. General information

By convenient sampling, a survey on satisfaction with clinical practice was conducted among 60 full-time undergraduate nursing interns who were doing clinical practice at a non-directly affiliated tertiary grade A hospital in Deyang City between March 2024 and August 2025. The inclusion criteria were full-time nursing students with the highest degree of undergraduate, who voluntarily participated in the survey and signed informed consent. Exclusion criteria: Those who were absent for more than two weeks due to illness or personal leave during their internship; Those who have received the same kind of mock teaching training. Interns who entered the department from March to August 2024 were the control group (n = 30), and those who entered the department from March to August 2025 were the experimental group (n = 30). There were no statistically significant differences in general information such as gender, age, and academic performance between the two groups ($p > 0.05$), and they were comparable [2].

2.2. Methods

2.2.1. Construction of the teaching case library

Based on the INACSL best practice standards, this study formed a nursing practice simulation teaching team consisting of the deputy director of the nursing department, teaching head nurses, teaching group leaders, and clinical backbone teachers.

(1) Case themes and selection criteria

Based on textbooks such as “Internal Medicine Nursing”, “Surgery Nursing”, “Critical Care Nursing”, etc., the case themes were determined according to the “Intern Training Outline”. Case inclusion criteria: True source, representative, able to reflect the objective laws of the disease, reasonable structure, each case contains more than two nursing knowledge points and skill operation items, can prompt students to think, promote the improvement of clinical practice ability in a targeted manner, complete information, clear description of the disease development process [3].

(2) Case writing template formulation

According to the INACSL best practice standard, a unified case writing template is designed, which includes three major parts: pre-simulation preparation, scenario setting, and guiding feedback. Pre-simulation preparation includes preparations for trainees, teachers, materials, etc., with emphasis on preview tasks; The setting of scenarios should be reasonable and specific, providing guiding hints and teaching objectives; The guiding feedback should be detailed and elaborate on the guiding words and discussion points in the review opening, information collection and analysis, and summary sessions.

(3) Case review and archiving

The case is scored and reviewed by the review panel based on the evaluation index of Nursing Professional case resources, and a meeting is held for experts and authors to discuss and revise it. After approval, it is encoded and archived into the medical simulation system [4].

2.2.2. Teaching implementation

The control group used traditional clinical teaching methods. According to the requirements of the internship syllabus, students were taught one-on-one by a dedicated person in the clinical setting, with the instructor responsible for explaining specialized nursing knowledge, observing and guiding the condition, demonstrating bedside physical examination, and practicing clinical operations.

The experimental group, on the basis of traditional teaching, added the case simulation teaching method in addition to digital intelligence technology. The implementation was divided into three steps in accordance with INACSL best practice standards.

(1) Pre-simulation preparation stage

The instructor sends the case materials and preview questions to the students one week in advance. The students discuss in groups, review the relevant materials, familiarize themselves with the case background and teaching objectives.

(2) Conduct scenario exercises at the Medical Simulation Skills Center

Teachers import pre-prepared cases into the medical simulation system, operate with a computer to make the highly realistic manikins exhibit clinical symptoms and signs that match the cases, and use the virtual clinical environment to create very realistic clinical scenes. Students act as nurses based on the set scenarios and perform tasks such as condition assessment, nursing operations, and emergency treatment for the simulated patients. Teachers monitor students' performance through the system and adjust the difficulty of the situation in a timely manner.

(3) The guided feedback phase is carried out immediately after the practice is completed

The teacher guides the students to conduct a review, allowing them to reflect independently, discuss in groups, analyze their decision-making process, whether the operation is reasonable, whether the teamwork is in place, and the teacher summarizes and comments according to the INACSL standards, thereby strengthening key knowledge points and skills [5].

2.3. Observe the indicators

2.3.1. Theoretical and practical assessment results

At the end of the internship, both groups of students participated in the theoretical examination and clinical skills practical assessment organized by the nursing department. The theoretical examination covered nursing knowledge of common diseases in the internship department, with a full score of 100 points; The operation assessment randomly selects one operation from the case library, and the teachers of the operation group score it according to the scoring criteria, with a total score of 100.

2.3.2. Clinical practice ability

Clinical practice ability was evaluated using the clinical practice ability scale for undergraduate nursing students developed by Yao Pingping et al. The scale consists of seven aspects: clinical nursing, communication and coordination, health education, scientific research and innovation, emergency

cooperation, humanistic care, and clinical teaching, with a total of 44 items. Using the Likert five-point scale, the higher the total score, the stronger the clinical practice ability. The scale has good reliability and validity.

2.3.3. Critical thinking ability

Critical thinking ability was evaluated using the Chinese version of the Critical Thinking Ability Measurement Scale (CTDI-CV) translated by Peng et al. The scale consists of seven aspects: seeking truth, open mind, analytical ability, systematization ability, critical thinking confidence, thirst for knowledge, and cognitive maturity, with a total of 70 items. Using the Likert 6-point scale, the total score ranges from 70 to 420, with higher scores indicating stronger critical thinking ability.

2.3.4. Teaching satisfaction survey

Students using a self-made teaching satisfaction questionnaire after the internship ends. The survey covered teaching methods, teaching content, faculty level, learning outcomes, etc. Fill in anonymously. The options are "satisfied" and "dissatisfied", and calculate the satisfaction rate.

2.4. Statistical processing

Data analysis was performed using SPSS 23.0 statistical software. Measurement data were expressed as mean ± standard deviation ($\overline{x} \pm s$), and the independent sample *t*-test was used for comparison between groups; Count data were expressed as frequency and percentage (%), and chi-square test was used for comparisons between groups. A difference was considered statistically significant when $p < 0.05$.

3. Results

3.1. Comparison of theoretical and operational assessment results between the two groups of students

The results showed that the theoretical and operational assessment scores of students in the experimental group were significantly higher than those in the control group, and the difference was statistically significant ($p < 0.05$). Specific data are shown in **Table 1**.

Table 1. Comparison of theoretical and practical assessment scores between the two groups of students ($\overline{x} \pm s$, points)

Group	Number of cases	Theoretical assessment score	Operational assessment results
Control group	30	79.63 ± 5.12	80.24 ± 4.85
Experimental group	30	86.52 ± 4.38	88.15 ± 3.96
t value		5.634	7.112
p value		< 0.001	< 0.001

3.2. Comparison of clinical practice ability between the two groups of students

The total score of clinical practice ability and the scores of each dimension of students in the experimental group was higher than those in the control group, and the differences were particularly significant in the total score and key dimensions such as clinical nursing, emergency cooperation, and humanistic care ($p < 0.05$). Specific data are shown in **Table 2**.

Table 2. Comparison of clinical practice scores between the two groups of students ($\overline{x} \pm s$, points)

Dimensions	Clinical care	Communication and coordination	Health education	Research and innovation	Emergency coordination	Humanistic care	Clinical teaching	Total score
Control group (n = 30)	38.21 ± 5.62	25.63 ± 3.89	20.15 ± 3.27	12.84 ± 2.56	18.42 ± 4.01	20.93 ± 3.68	16.19 ± 2.95	152.37 ± 15.68
Experimental group (n = 30)	46.85 ± 4.17	28.92 ± 3.51	23.48 ± 2.96	15.37 ± 2.88	25.16 ± 3.74	25.41 ± 3.12	18.46 ± 2.70	178.65 ± 12.34
t value	6.762	3.451	4.122	3.558	6.847	5.067	3.110	7.293
p value	< 0.001	0.001	< 0.001	0.001	< 0.001	< 0.001	0.003	< 0.001

3.3. Comparison of critical thinking ability between the two groups of students

The total score of critical thinking ability of the students in the experimental group was significantly higher than that in the control group ($p < 0.05$), especially showing obvious advantages in analytical ability, systematization ability and cognitive maturity dimensions. Specific data are shown in **Table 3**.

Table 3. Comparison of critical thinking scores between the two groups ($\overline{x} \pm s$, points)

Dimensions	Seeking the truth	Open mind	Analytical ability	Systematic ability	Critical thinking self-confidence	Thirst for knowledge	Cognitive maturity	Total score
Control group (n = 30)	35.62 ± 5.34	38.95 ± 4.76	36.84 ± 5.12	35.17 ± 5.43	34.26 ± 5.05	41.53 ± 4.89	42.82 ± 5.31	265.19 ± 20.43
Experimental group (n = 30)	39.28 ± 4.91	42.17 ± 4.52	44.36 ± 4.38	42.85 ± 4.69	38.92 ± 4.73	44.78 ± 4.51	49.06 ± 4.17	298.42 ± 18.56
t value	2.745	2.683	6.176	5.935	3.662	2.706	5.086	6.574
p value	0.008	0.010	< 0.001	< 0.001	0.001	0.009	< 0.001	< 0.001

3.4. Comparison of teaching satisfaction between the two groups of students

The teaching satisfaction survey showed that the overall satisfaction rate with the teaching method was 96.7% (29/30) in the experimental group and 80.0% (24/30) in the control group. There was a statistically significant difference between the two groups ($\chi^2 = 4.043$, $p = 0.044$).

4. Discussion

This study successfully constructed a digital and intelligent nursing simulation teaching case library based on INACSL best practice standards, and verified through empirical research its significant effect in enhancing the clinical practice ability and critical thinking of nursing interns. The core of the teaching system lies in the deep integration of internationally recognized practice standards with cutting-edge digital intelligence technologies, thereby achieving innovation and optimization of the traditional clinical teaching model.

The case library constructed in this study effectively addresses the pain points of the scarcity and uneven quality of case resources in traditional simulation teaching. Based on the INACSL best practice standards, it not only standardizes the process and content elements of case writing, but more importantly, it structurally integrates key teaching links such as teaching objectives, pre-simulation preparation, scenario design, and guided feedback. This standardized template ensures that each case has a clear teaching orientation and

operability, avoiding fluctuations in teaching quality due to differences in the level of the writers. The results showed that students in the experimental group performed significantly better than those in the control group in both theoretical and operational assessments, which directly demonstrated that teaching based on a standardized case library could more effectively promote students' systematic mastery of knowledge and standardized application of clinical skills. The simulated teaching scenarios based on digital intelligence technology greatly enhanced the sense of reality and immersion in learning. Through the medical simulation system, students can repeatedly deal with various clinical situations in a safe and controllable environment, especially acute and critical cases or rare cases that are difficult to encounter in traditional internships. This high-fidelity experiential learning breaks the limitations of time and space and compensates for the lack of clinical practice opportunities. In the study, the experimental group scored significantly higher in the "emergency coordination" dimension of clinical practice ability, which confirmed this. Students went through the complete process of "error–reflection–improvement" in a virtual context, and their clinical decision-making ability and psychological quality were effectively exercised.

Guided feedback is the core of the simulation teaching and the key to internalizing the ability. In this study, the process strictly adheres to INACSL standards, emphasizing student-centered review and reflection. Through teacher-guided self-analysis and group discussions, students are no longer passively accepting knowledge but actively analyzing the logic behind their actions and decisions. This contrasts sharply with the traditional teaching model of "the teacher does, the student sees". The significant superiority of the students in the experimental group in the total score of critical thinking ability and the scores of each dimension fully demonstrates the irreplaceable role of this structured and deep reflection process in cultivating students' analytical ability, systematization ability and cognitive maturity.

5. Conclusion

In conclusion, the digital and intelligent nursing simulation teaching system constructed based on the INACSL best practice standards provides a scientific, standardized and efficient new paradigm for clinical nursing teaching. It has not only effectively enhanced the clinical practice ability and critical thinking ability of nursing interns, but also received high recognition from students. This teaching model, which combines standards and techniques, has successfully transformed classroom knowledge into practical skills to meet clinical challenges, achieving a deep shift in nursing education from "knowledge imparting" to "ability development".

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A Study on Evidence-Based Nursing Practice for Perioperative Pain Management in Thoracoscopic Lung Cancer Surgery

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Abstract: *Objective*: To evaluate the efficacy of a perioperative pain management protocol based on evidence-based nursing principles in patients undergoing thoracoscopic surgery for lung cancer. *Methods*: A total of 112 patients undergoing thoracoscopic lung cancer surgery in the Department of Thoracic Surgery at a specific hospital between August 2025 and March 2026 were selected and randomly assigned to either a control group or an observation group, with 56 patients in each group. The control group received standard pain management, while the observation group received a pain management protocol based on evidence-based nursing. *Results*: At various postoperative time points, the observation group demonstrated significantly lower pain scores, both at rest and during activity, compared to the control group. Furthermore, within the first 48 hours post-surgery, the observation group consumed fewer opioids, mobilized out of bed earlier, experienced shorter postoperative hospital stays, and had a lower overall incidence of complications than the control group; all these differences were statistically significant ($p < 0.05$). *Conclusion*: A perioperative pain management protocol established upon evidence-based nursing principles can effectively alleviate postoperative pain in patients undergoing thoracoscopic lung cancer surgery, reduce opioid consumption, facilitate postoperative recovery, lower the incidence of complications, and enhance patient satisfaction with nursing care.

Keywords: Thoracoscopic surgery; Lung cancer; Pain management; Evidence-based nursing; Perioperative nursing

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1. Introduction

Lung cancer is a malignant tumor with high incidence and mortality rates worldwide, and surgical resection remains its primary treatment modality. Due to its minimally invasive nature, rapid recovery, and lower complication rates, thoracoscopic lobectomy has become the preferred surgical approach for early-stage non-small cell lung cancer; however, intraoperative incision of the intercostal muscles and traction on the intercostal nerves can still result in significant postoperative pain. Inadequate pain control not only hinders

early patient mobilization and respiratory function exercises but also increases the risk of complications, such as pulmonary infection and atelectasis, delays the removal of drainage tubes and prolongs hospital stays, and may even lead to the development of chronic pain. Currently, perioperative pain management has evolved from a sole reliance on opioids toward a multimodal, individualized approach to analgesia; nevertheless, clinical practice still frequently exhibits issues such as inconsistent pain assessment, unsystematic intervention strategies, and insufficient utilization of non-pharmacological interventions. Evidence-based nursing is a methodology for making nursing decisions that integrates the best available evidence with clinical expertise and patient needs. When applied to perioperative pain management in patients undergoing video-assisted thoracoscopic surgery (VATS) for lung cancer, it serves to standardize nursing practices and enhance analgesic efficacy. Based on a systematic search and evaluation of relevant evidence, an evidence-based nursing practice protocol was established; its clinical efficacy was subsequently validated through a controlled clinical trial to provide a reference for clinical nursing practice [1].

2. Materials and methods

2.1. General data

A total of 112 patients undergoing VATS for lung cancer in the Department of Thoracic Surgery between August 2025 and March 2026 were selected for this study.

2.1.1. Inclusion criteria

(1) Postoperative pathological confirmation of primary lung cancer;
(2) Undergoing video-assisted thoracoscopic lobectomy or wedge resection;
(3) Age between 18 and 80 years;
(4) American Society of Anesthesiologists (ASA) physical status classification I–III; and
(5) Provision of informed consent and voluntary participation in the study.

2.1.2. Exclusion criteria

(1) Patients with a history of chronic pain or long-term analgesic use prior to surgery;
(2) Patients with severe concurrent cardiac, hepatic, or renal insufficiency;
(3) Patients with allergies to the analgesic medications used in the study;
(4) Patients with psychiatric disorders or cognitive impairments precluding cooperation with pain assessments; and patients whose procedures required conversion to open thoracotomy.

2.1.3. Study groups

Patients were randomly assigned to either a control group or an observation group using a random number table, with 56 patients in each group There were no statistically significant differences ($p > 0.05$) between the two groups regarding general demographic and clinical data, including gender, age, pathological type, and surgical approach, indicating that the groups were comparable [2].

2.2. Methods

The control group received standard perioperative pain management. Preoperatively, the assigned nurse provided routine health education to patients, informing them of potential postoperative pain and common

analgesic methods. Postoperatively, pain intensity was assessed every four hours using a Numerical Rating Scale (NRS). When the NRS score reached ≥ 4, analgesics were administered according to physician orders (via patient-controlled analgesia pumps or on-demand opioid administration); pain assessment results and analgesic interventions were duly recorded [3].

The observation group implemented a perioperative pain management protocol based on evidence-based nursing principles, the specific details of which are outlined below.

(1) Formation of an evidence-based nursing practice team

Led by the Head Nurse of Thoracic Surgery, the team comprises thoracic surgeons, anesthesiologists, evidence-based nursing trainers, and primary care nurses. Adhering to the principles of evidence-based nursing, the team conducted a comprehensive literature search regarding key issues in perioperative pain management; by integrating prior clinical nursing experience with the actual needs of patients, they formulated an evidence-based nursing protocol. Concurrently, all nursing staff received training in evidence-based pain management, covering topics such as pain assessment, multimodal analgesia, adverse reaction monitoring, and non-pharmacological interventions. Participation in the study was contingent upon successful completion of this training, thereby ensuring the scientific rigor and consistency of the research protocol.

(2) Assessment of preoperative risk factors and individualized education

Within 24 hours of admission, an assessment of high-risk factors for pain was completed. This assessment covered the patient's history of pain, history of opioid use, anxiety and depressive states, and their cognitive understanding of, and attitudes toward pain. Patients identified as high-risk, such as those with a history of chronic pain, high anxiety levels, or low pain tolerance were singled out, and individualized pain management plans were formulated based on their assessment results. Simultaneously, structured health education was provided preoperatively to ensure patients possessed an accurate understanding of the characteristics of postoperative pain, the use of the Numerical Rating Scale (NRS), and the potential efficacy and risks associated with their prescribed analgesia regimen.

(3) Standardized pain assessment

Postoperatively, the NRS was utilized to dynamically assess pain intensity in patients under various conditions, specifically at rest, as well as during coughing, deep breathing, turning over, and ambulation. Assessments were conducted every two hours during the first 24 hours post-surgery, and every four hours thereafter; the results were recorded immediately on the pain nursing record sheet. If an NRS score reached 4 or higher, the analgesia intervention protocol was initiated immediately. A subsequent assessment was performed 30 minutes later; this process continued until the pain subsided to a mild level or lower, at which point a second nurse performed an independent verification to ensure the accuracy of the assessment.

(4) Nursing support for multimodal pharmacological analgesia

Postoperatively, a multimodal analgesia regimen consisting of patient-controlled intravenous analgesia (PCIA) pumps combined with non-steroidal anti-inflammatory drugs (NSAIDs) was routinely employed. The primary care nurse was responsible for closely monitoring the operation of the analgesia pump, periodically recording the cumulative dosage of fentanyl administered, and evaluating both the efficacy of the analgesia and the presence of any adverse reactions, such as nausea and vomiting, respiratory depression, or excessive sedation. For patients experiencing poorly controlled pain, whether

at rest or during activity, rescue analgesia is administered in accordance with physician orders. The medication regimen is adjusted based on the patient's hepatic and renal function, as well as their gastrointestinal tolerance, while guidance on the proper use of patient-controlled analgesia (PCA) pumps is reinforced.

(5) Non-pharmacological pain interventions

In addition to pharmacological analgesia, measures such as proper positioning, breathing exercises, music therapy, distraction techniques, and cold therapy are implemented. Nursing staff assist patients in adopting a semi-Fowler's position to minimize pressure on surgical incisions and drainage tubes; they instruct patients on diaphragmatic breathing, pursed-lip breathing, and effective coughing techniques; and prior to procedures such as dressing changes, turning, or tube removal, they employ conversation or guided imagery to distract the patient and alleviate pain. During the first 24 hours post-operatively, cold compresses are applied around the incision site to reduce local inflammatory responses and enhance the overall efficacy of pain management.

(6) Long-term pain management

Prior to discharge, patients receive education on pain management, covering topics such as proper techniques for using home analgesics, methods for self-assessing pain levels, appropriate physical activity guidelines, and scheduled follow-up appointments. This ensures that patients can maintain effective pain control and continue their functional recovery after returning home. A dedicated WeChat group is established for follow-up care; the assigned nurse conducts remote monitoring on the 3rd, 7th, and 14th days post-discharge to assess the patient's pain status, analgesic usage, and rehabilitation progress. The nurse promptly addresses patient inquiries and provides appropriate guidance, thereby enhancing the quality of continuity of care.

2.3. Outcome measures

(1) Pain scores

The Numerical Rating Scale (NRS) is used to assess the intensity of the patient's pain both at rest and during activity at 6, 12, 24, and 48 hours post-operatively.

(2) Opioid consumption

The total opioid dosage administered within the first 48 hours post-operatively is recorded. All administered opioids are converted into fentanyl-equivalent doses using a pre-established conversion formula.

(3) Post-operative recovery indicators

The time to first ambulation, the duration of chest tube placement, and the total length of post-operative hospitalization are recorded.

(4) Incidence of complications

The occurrence of post-operative complications, including nausea and vomiting, respiratory depression, pulmonary infection, atelectasis, urinary retention, and constipation is documented.

(5) Nursing satisfaction

Patient satisfaction with the nursing care provided is assessed. Upon discharge, nursing satisfaction was evaluated using a questionnaire developed in-house by the hospital. This questionnaire comprised 20 items across four dimensions: effectiveness of pain management, nursing communication, health

education, and overall service. A 5-point Likert scale was employed, yielding a total score ranging from 20 to 100 points; a higher score indicated a higher level of satisfaction [4].

2.4. Statistical analysis

Data analysis was performed using SPSS 26.0 statistical software. Measurement data conforming to a normal distribution were expressed as ($\overline{x} \pm s$), and inter-group comparisons were conducted using an independent-samples *t*-test. Count data were expressed as the number of cases (percentage), and inter-group comparisons were performed using the χ^2 test or Fisher's exact test. A *p*-value of < 0.05 was considered to indicate a statistically significant difference.

3. Results

3.1. Comparison of NRS scores at various postoperative time points between the two groups

At 6 h, 12 h, 24 h, and 48 h postoperatively, the patients in the observation group demonstrated significantly lower NRS scores for both resting and active states, compared to those in the control group; all differences were statistically significant ($p < 0.05$). See **Table 1**.

Table 1. Comparison of NRS scores at different time points after surgery between the two groups ($\overline{x} \pm s$, scores)

Group	Number of cases	Resting state				Active state			
		6 h Post-op	12 h Post-op	24 h Post-op	48 h Post-op	6 h Post-op	12 h Post-op	24 h Post-op	48 h Post-op
Control group	56	3.52 ± 0.84	3.08 ± 0.76	2.65 ± 0.68	2.12 ± 0.55	5.86 ± 1.02	5.23 ± 0.95	4.58 ± 0.87	3.86 ± 0.72
Observation group	56	2.46 ± 0.71	2.05 ± 0.63	1.68 ± 0.52	1.34 ± 0.43	4.25 ± 0.86	3.68 ± 0.79	3.12 ± 0.65	2.45 ± 0.58
t-value		7.206	7.754	8.432	8.195	9.015	9.364	9.902	11.346
p-value		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001

3.2. Comparison of postoperative opioid consumption between the two groups

Within 48 hours postoperatively, the fentanyl-equivalent consumption in the observation group was (168.35 ± 32.67) μg compared to (245.82 ± 41.53) μg in the control group; the consumption in the observation group was significantly lower than that in the control group ($t = 11.103$, $p < 0.001$. The proportion of patients in the observation group requiring rescue analgesia due to inadequate pain control was 10.71% (6/56), which was lower than 23.21% (13/56) observed in the control group; this difference was statistically significant ($\chi^2 = 4.206$, $p = 0.040$).

3.3. Comparison of postoperative recovery indicators between the two groups

In the observation group, the time to first ambulation, the duration of chest tube drainage, and the length of postoperative hospital stay were all significantly shorter than those in the control group ($p < 0.001$); see **Table 2**.

Table 2. Comparison of postoperative recovery indicators between the two patient groups ($\overline{x} \pm s$)

Group	Number of cases	Time to first ambulation (h)	Chest tube duration (d)	Postoperative hospital stays (d)
Control group	56	22.36 ± 4.58	4.12 ± 1.08	8.86 ± 1.95
Observation group	56	14.58 ± 3.21	3.25 ± 0.94	6.92 ± 1.58
t-value		10.316	4.562	5.744
p-value		< 0.001	< 0.001	< 0.001

3.4 Comparison of complication rates between the two patient groups

The overall incidence of postoperative complications in the observation group was 8.93% which was significantly lower than that in the control group (19.64%) ($\chi^2 = 4.206$, $p = 0.040$); see **Table 3**.

Table 3. Comparison of postoperative complication rates between the two patient groups [cases (%)]

Group	Number of cases	Nausea/ Vomiting	Pulmonary infection	Atelectasis	Urinary retention	Constipation	Total incidence
Control group	56	4 (7.14)	2 (3.57)	2 (3.57)	2 (3.57)	1 (1.79)	11 (19.64
Observation group	56	2 (3.57)	1 (1.79)	1 (1.79)	1 (1.79)	0 (0.00)	5 (8.93)
χ^2 Value							4.206
p Value							0.040

3.5 Comparison of nursing satisfaction between the two groups

The nursing satisfaction score in the observation group was (94.28 ± 3.51) which was significantly higher than that in the control group (86.75 ± 5.23); the difference was statistically significant ($t = 8.802$, $p < 0.001$).

4. Discussion

Perioperative pain management for thoracoscopic lung cancer surgery constitutes a vital component of Enhanced Recovery After Surgery (ERAS) protocols. Utilizing an evidence-based nursing approach, this study systematically searched for and synthesized relevant evidence to establish a comprehensive, full-cycle nursing regimen. This regimen encompasses preoperative assessment of high-risk factors and health education, standardized postoperative pain assessment, multimodal pharmacological analgesia support, non-pharmacological pain interventions, and post-discharge continuity of care. Clinical application results demonstrate that this regimen significantly alleviates the severity of postoperative pain, both at rest and during activity, reduces opioid consumption, and facilitates the recovery of postoperative functional capacity. These findings underscore the clinical efficacy of systematic pain management guided by evidence-based nursing principles, while also providing a clear practical pathway for optimizing perioperative care for patients undergoing thoracoscopic lung cancer surgery [5].

5. Conclusion

The study results indicate that, at every postoperative time point assessed, the Numerical Rating Scale (NRS) scores of patients in the observation group were lower than those in the control group, demonstrating that systematic pain interventions can effectively improve patients' postoperative pain experience. The integration of multimodal pharmacological analgesia serves as the foundational basis for enhancing analgesic efficacy.

By combining non-steroidal anti-inflammatory drugs (NSAIDs) with patient-controlled intravenous analgesia (PCIA), different mechanisms of action are leveraged to potentiate pain relief and mitigate dependence on opioid medications. In this study, the observation group demonstrated a significant reduction in the fentanyl-equivalent dose consumed within the first 48 hours postoperatively; consequently, the demand for rescue analgesia also decreased, a result of substantial clinical significance for thoracic surgery patients. Excessive opioid use is associated with adverse effects such as respiratory depression, delayed recovery of gastrointestinal function, nausea, and vomiting; conversely, a combined pharmacological approach allows for effective pain management while simultaneously minimizing these adverse reactions, thereby facilitating early respiratory training and physical mobilization among patients.

Non-pharmacological pain management measures also played a significant role in this study. The implementation of a comprehensive strategy, including postural adjustments, breathing exercises, music therapy, distraction techniques, and cold compresses, enhanced patients' coping mechanisms regarding pain stimuli, thereby exerting a synergistic effect when combined with pharmacological analgesia. With improved pain control, patients' initial mobilization time is significantly advanced; consequently, the duration of chest tube placement and the length of postoperative hospitalization are reduced. Furthermore, the incidence of complications, such as pulmonary infections and atelectasis, also declines. This demonstrates that enhanced pain management fosters a virtuous cycle characterized by "improved analgesia, increased physical activity, accelerated functional recovery, and reduced complications". From an evidence-based nursing perspective, the establishment of a perioperative pain management protocol is highly feasible and widely applicable, offering robust support for the postoperative rehabilitation of patients undergoing video-assisted thoracoscopic surgery for lung cancer, as well as for the enhancement of nursing quality.

Disclosure statement

The authors declare no conflict of interest.

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Value Evaluation of Applying the Concept of Enhanced Recovery After Surgery in the Reengineering of Operating Room Service Processes

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Abstract: *Objective*: To investigate the clinical value of the concept of enhanced recovery after surgery in the reengineering of operating room service processes. *Methods*: 260 patients scheduled for elective surgery in a tertiary grade A hospital from January 2023 to December 2023 were randomly divided into a control group and an observation group, with 130 cases in each group. The control group used the traditional operating room service process, while the observation group used the process reengineering plan integrated with the ERAS concept. Perioperative indicators, postoperative recovery, complication rates, and patient satisfaction were compared between the two groups. *Results*: The observation group had shorter preoperative fasting and fluid deprivation time, surgical waiting time, first postoperative ambulation time, first anal exhaust time and hospital stay than the control group, lower intraoperative hypothermia, postoperative nausea and vomiting and total complication rates than the control group, and higher patient satisfaction than the control group. The differences were statistically significant. *Conclusion*: ERAS concept for operating room service process reengineering can improve perioperative management, accelerate postoperative recovery speed, reduce the incidence of complications, enhance patients' medical experience, and has good clinical application value.

Keywords: Enhanced recovery after surgery; Operating room; Service process reengineering; Perioperative care; Postoperative recovery

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1. Introduction

With the development of modern surgery and the increasing demands of patients for the quality of medical services, how to shorten hospital stays, reduce surgical stress and lower medical costs while ensuring surgical safety has become a clinical concern. Enhanced Recovery after surgery is a systematic treatment model that relies on evidence-based medical evidence and integrates multiple perioperative optimization measures. Its aim is to reduce the physical and psychological stress caused by surgery and anesthesia to the body, reduce

the occurrence of complications, and speed up postoperative recovery. The operating room is an important part of perioperative management, and its service process will directly affect the safety of the surgery and the postoperative condition. The traditional operating room service process also has problems such as long waiting times for preoperative preparation, intraoperative management, and postoperative connection, inconsistent measures and standards, and low synergy efficiency, which reduce the overall management efficiency. In recent years, the ERAS concept has been applied to operating room nursing and has achieved results in temperature control, multimodal analgesia and process improvement, but there are few systematic studies on the reengineering of operating room service processes. This paper uses a randomized controlled design to evaluate the clinical value of service process reengineering in operating rooms under the ERAS concept, providing some reference for the improvement of operating room quality [1].

2. Data and methods

2.1. General information

A total of 260 patients who underwent elective surgery in a tertiary grade A hospital from January 2023 to December 2023 were selected as the study subjects.

2.1.1. Inclusion criteria

(1) 18–75 years old
(2) American Society of Anesthesiologists (ASA) grade I–III
(3) Undergoing elective general anesthesia surgery
(4) Basically, normal preoperative examination indicators
(5) Conscious
(6) Cooperative with the investigator

2.1.2. Exclusion criteria

(1) Those with severe heart, lung, liver or kidney insufficiency
(2) Those with severe preoperative infection or fever
(3) Those who underwent emergency surgery
(4) Those with abnormal coagulation function
(5) Those with a history of mental illness or communication disorders
(6) Women who are pregnant or lactating.

2.1.3. Study design

A total of 260 patients were randomly divided into a control group and an observation group, with 130 cases in each group, using a random number table. There was no statistically significant difference ($p > 0.05$) between the two groups of patients in terms of general information such as gender, age, BMI, ASA classification, and surgical type, and they were comparable [2].

2.2. Methods

The control group used the traditional operating room service process. Routine fasting for 12 hours and abstaining from water for 8 hours before the operation; Routine bowel preparation (with laxatives in some

patients); A gastric tube and catheter are routinely placed in the morning of the operation; Analgesics are not routinely used before the operation; Routine heat preservation (covering with a blanket) during the operation; After being transferred from the anesthesia recovery room to the ward after the operation, analgesia was administered as directed by the doctor; Postoperative routine fasting until the anus is vented before resuming diet; Catheters and drainage tubes are removed at the traditional time limit; Encourage patients to get out of bed and move around 24 to 48 hours after the operation [3].

The observation group adopted an operating room service process reengineering program that incorporated the ERAS concept. The program systematically improved the traditional process in three aspects: preoperative, intraoperative and postoperative.

(1) Preoperative

A multidisciplinary team is formed, with the participation of surgeons, anesthesiologists, operating room nurses, nutritionists, rehabilitation therapists, etc. Before the operation, provide systematic health education to the patient, explaining the surgical process, anesthesia methods, and key points of postoperative rehabilitation to the patient in the form of illustrated manuals, video explanations, etc., to reduce the patient's anxiety. The preoperative fasting period was shortened to 6 hours, the no-drink period to 2 hours, and patients were given 400 mL of 12.5% carbohydrate drinks 2 hours before the operation. Bowel preparation is generally not done except for colorectal surgery. Selective indwelling of gastric tubes and catheters is not routinely performed.

(2) Intraoperative procedures

Operating room nurses should make adequate preparations of surgical instruments and equipment in advance, minimize unnecessary installation and removal of instruments, and ensure smooth transitions during the operation. Intraoperative composite insulation measures include adjusting the operating room temperature to 23–25 ℃, using inflatable heating blankets, infusing heating fluids (37 ℃), and heating intraoperative irrigation fluids to 37 ℃, etc. Goal-directed fluid therapy was implemented, with the volume and speed of fluid infusion precisely adjusted according to the hemodynamic indicators of the patient. A variety of analgesic methods were promoted. Non-steroidal anti-inflammatory drugs were administered for prophylactic analgesia before the operation, and regional block methods such as incision infiltration anesthesia and nerve block were used in combination during the operation to reduce the use of opioids. Strictly control the operation time, reduce unnecessary operation steps during the operation, and perform fine operations to minimize tissue damage.

(3) Postoperative procedures

Operating room nurses and ward nurses make standardized handows to patients to ensure the continuity of perioperative information. After anesthesia recovery, the patient's state of consciousness and swallowing function were evaluated. Within 2 to 4 hours, a small amount of water was administered, gradually transitioning to liquid, semi-liquid, and normal diets. Multimodal analgesia was used after the operation, mainly patient-controlled analgesia combined with non-steroidal anti-inflammatory drugs, supplemented by non-pharmacological analgesia methods such as local cold compress, and the pain score was dynamically adjusted (NRS score) to be kept below 3.4 to 6 hours after the operation, the patient sat up with the assistance of an assistant; 6 to 8 hours after the operation, the patient stood beside the bed with the assistance of an assistant; 12 to 24 hours after the operation, the patient got out of bed with the assistance of an assistant. The catheter was removed within 24 hours after the operation,

and the abdominal drainage tube was removed early depending on the volume and shape of the drainage [4].

2.3. Observation indicators

(1) Perioperative indicators

Preoperative fasting time, preoperative fluid deprivation time, surgical waiting time (time from entering the operating room to the start of surgery), incidence of intraoperative hypothermia (core body temperature < 36 ℃), intraoperative infusion volume.

(2) Postoperative recovery indicators

Time to first get out of bed after surgery, time to first anal exhaust, time to first oral feeding, length of hospital stays.

(3) Occurrence of complications

Incidence of complications such as postoperative nausea and vomiting, incision infection, urinary tract infection, deep vein thrombosis, pulmonary infection, etc.

(4) Patient satisfaction

A self-made operating room nursing service satisfaction questionnaire was used for assessment before discharge, with a full score of 100. A score of ≥ 90 was considered very satisfied, 70–89 was considered basically satisfied, and < 70 was considered dissatisfied [5].

2.4. Statistical processing

Data analysis was conducted using SPSS 26.0 statistical software. Measurement data were expressed as mean ± standard deviation ($\overline{x} \pm s$), and the independent sample t-test was used for comparison between the two groups. Count data were expressed as frequency and percentage (%), and the χ^2 test was used for comparison between the two groups. A difference was considered statistically significant when $p < 0.05$.

3. Results

3.1. Comparison of perioperative indicators between the two groups

In the observation group, the preoperative fasting time, fluid deprivation time, and surgical waiting time were shorter than those in the control group, and the incidence of intraoperative hypothermia was lower than that in the control group, with statistically significant differences ($p < 0.05$). There was no statistically significant difference in the intraoperative infusion volume between the two groups ($p > 0.05$), as shown in **Table 1**.

Table 1. Comparison of perioperative indicators between the two groups

Indicators	**Preoperative fasting time (h, $\overline{x} \pm s$)**	**Preoperative fasting time (h, $\overline{x} \pm s$)**	**Surgical waiting time (min, $\overline{x} \pm s$)**	**Intraoperative infusion volume (mL, $\overline{x} \pm s$)**	**Intraoperative hypothermia [cases (%)]**
Control group (n = 130)	11.24 ± 1.52	7.56 ± 1.18	45.32 ± 12.64	1520.35 ± 245.68	16 (12.31)
Observation group (n = 130)	6.38 ± 0.85	2.15 ± 0.46	28.46 ± 8.37	1485.62 ± 231.47	4 (3.08)
t/χ^2 values	31.970	48.824	12.679	1.157	8.090
p value	< 0.001	< 0.001	< 0.001	0.249	0.005

3.2. Comparison of postoperative recovery indicators between the two groups

The first time to get out of bed, the first time to exhaust gas through the anus, the first time to eat orally, and the length of hospital stay in the observation group were all shorter than those in the control group, and the differences were statistically significant ($p < 0.05$), as shown in **Table 2**.

Table 2. Comparison of postoperative recovery indicators between the two groups ($\bar{x} \pm s$)

Indicators	First time out of bed (h)	First anal exhaust time (h)	Time of first oral feeding (h)	Length of stay (d)
Control group (n = 130)	36.42 ± 8.56	32.18 ± 7.42	28.35 ± 6.84	10.52 ± 2.86
Observation group (n = 130)	18.35 ± 5.27	20.56 ± 5.18	12.47 ± 4.26	7.18 ± 1.92
t value	20.307	14.857	22.627	11.015
p value	< 0.001	< 0.001	< 0.001	< 0.001

3.3. Comparison of postoperative complications between the two groups

The total incidence of postoperative complications such as nausea and vomiting, incision infection, urinary tract infection, and deep vein thrombosis in the observation group was lower than that in the control group, and the difference was statistically significant ($p < 0.05$), as shown in **Table 3**.

Table 3. Comparison of postoperative complications between the two groups [cases (%)]

Complication types	Postoperative nausea and vomiting	Incision infection	Urinary tract infection	Deep vein thrombosis	Pulmonary infection	Total complications
Control group (n = 130)	20 (15.38)	6 (4.62)	8 (6.15)	4 (3.08)	5 (3.85)	43 (33.08)
Observation group (n = 130)	8 (6.15)	2 (1.54	2 (1.54)	1 (0.77)	1 (0.77)	14 (10.77)
χ^2 value	6.052	2.105	4.000	1.831	2.666	19.025
p value	0.014	0.147	0.046	0.176	0.103	< 0.001

3.4. Comparison of patient satisfaction between the two groups

The overall satisfaction rate of patients in the observation group with operating room nursing services was 95.38%, which was higher than 83.08% in the control group, and the difference was statistically significant ($\chi^2 = 10.429$, $p = 0.001$).

4. Discussion

While the traditional operating room service process has played a fundamental safeguarding role in clinical practice, its shortcomings have gradually emerged with the development of concepts such as evidence-based medicine and enhanced recovery after surgery. Prolonged fasting and abstinence before surgery can exacerbate discomfort such as hunger and thirst in patients, and increase insulin resistance and catabolism, thereby exacerbating postoperative stress response; Insufficient insulation during the operation can lead to hypothermia, interfere with coagulation function, and increase the risk of incision infection and delayed anesthesia recovery; A single postoperative analgesic method, delayed feeding recovery and activity guidance also have an impact on overall recovery. Therefore, in this study, the ERAS concept was systematically integrated into the reengineering of operating room service processes, starting with the integration and

optimization of various aspects such as preoperative education, diet management, anesthesia optimization, intraoperative heat preservation, fluid therapy, analgesia management, early postoperative activity, early feeding, and early extubation. The results showed that the observation group had shorter preoperative fasting, water deprivation, and surgical waiting times than the control group, and the incidence of intraoperative hypothermia was significantly lower, indicating that process reengineering can reduce unnecessary waiting, physiological stress, and improve the refinement of perioperative management.

In terms of postoperative recovery, the observation group had better first time out of bed, first anal exhaust, first oral feeding, and hospital stay than the control group. In particular, the first time out of bed was much earlier than in the traditional mode, indicating that optimizing the process has a direct promoting effect on accelerating functional recovery. Early activity can improve lung function, gastrointestinal peristalsis, reduce the occurrence of deep vein thrombosis and pulmonary infection, and also enhance patients' confidence in recovery. Early oral feeding can reduce the adverse effects of long-term fasting on nutritional status and intestinal barrier function. The length of hospital stay is significantly shortened, which, on the one hand, reduces the economic burden on patients and, on the other hand, increases the turnover rate of hospital beds and the utilization rate of medical resources. In terms of complication control, the total incidence of postoperative complications in the observation group was significantly lower than that in the control group. Complications such as nausea and vomiting and urinary tract infection were reduced, which was closely related to multimodal analgesia with reduced opioid dosage, selective indwelling catheterization with early extubating, and combined heat preservation with goal-directed fluid therapy. The ERAS process reengineering has significant benefits for the prognosis of patients.

The results of patient satisfaction once again demonstrated the clinical value of the model. The overall satisfaction rate of the observation group with the operating room nursing service was higher than that of the control group, indicating that process reengineering, in addition to alleviating patients' physical discomfort, can also relieve perioperative anxiety and enhance recognition of the entire diagnosis and treatment process. The smooth implementation of the plan relied on close cooperation among various departments such as surgery, anesthesiology, operating room nursing, nutrition, and rehabilitation, with standardized handover procedures and continuous quality feedback to ensure the implementation of all measures. There was no statistically significant difference in intraoperative infusion volume between the two groups, indicating that the reengineering of operating room processes under the ERAS concept does not increase the medical burden and has good safety and feasibility. Applying the concept of enhanced recovery after surgery (ERAS) to the reengineering of operating room service processes can systematically improve perioperative management, promote postoperative recovery, reduce the incidence of complications, shorten hospital stays, increase patient satisfaction, and has strong clinical promotion value.

5. Conclusion

In summary, the traditional operating room service process is no longer sufficient to meet the modern clinical needs of evidence-based medicine and enhanced recovery after surgery. Problems such as unreasonable preoperative fasting and drinking, insufficient intraoperative heat preservation, and delayed postoperative rehabilitation intervention can exacerbate the stress response of patients, increase the risk of complications, and delay the recovery process. In this study, the ERAS concept was systematically integrated into the reengineering of the operating room service process. Through the full-process integration and improvement of preoperative education and diet management optimization, intraoperative precise heat preservation and fluid therapy, postoperative multimodal analgesia, early feeding, early activity and early extubating, the deficiencies of the traditional model were effectively compensated.

The research results confirm that process reengineering based on the ERAS concept can significantly shorten preoperative fasting and fluid deprivation as well as the waiting time for surgery, reduce the incidence of intraoperative hypothermia, and improve the refined level of perioperative management. At the same time, it effectively promotes postoperative functional recovery, significantly advances the time of getting out of bed, anal exhaust and oral feeding, significantly shortens the length of hospital stay, reduces the economic burden on patients, and improves the efficiency of medical resource utilization. In terms of complication control and patient safety, this model can significantly reduce the total incidence of postoperative complications, and there is no statistically significant difference in intraoperative infusion volume, demonstrating good safety and feasibility. In addition, the optimized service process effectively alleviated patients' perioperative anxiety, significantly enhanced the satisfaction of nursing services, and achieved a dual improvement of physical rehabilitation and psychological comfort.

The smooth implementation of ERAS operating room process reengineering relies on the efficient collaboration and standardized quality control of multiple disciplines including surgery, anesthesiology, nursing, nutrition and rehabilitation. The comprehensive application of the concept of enhanced recovery after surgery (ERAS) to the optimization of operating room processes can systematically improve the quality of perioperative management, accelerate postoperative recovery, reduce complications, shorten hospital stays and increase patient satisfaction. It is in line with the development direction of modern surgical nursing and has significant clinical application value and wide promotion significance.

Disclosure statement

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Clinical Application and Research of Telemetry Electrocardiographic Monitoring in Pediatric Patients

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Abstract: Pediatric patients have a wide age range, weak independent cooperation ability, rapid disease changes, and obvious individual differences in physiological indicators. Traditional bedside electrocardiographic monitoring has problems such as multiple wires, limited mobility, easy data interference, and poor patient compliance. Telemetry electrocardiographic monitors, with characteristics such as wireless transmission, continuous monitoring, real-time early warning, and portability, have been increasingly widely used in pediatric clinical practice.

Keywords: Telemetry electrocardiographic monitoring; Pediatric patients; Wireless monitoring; Intensive care; Clinical nursing; Arrhythmia

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1. Introduction

Telemetry electrocardiographic monitoring has emerged as a valuable tool in pediatric clinical practice, addressing the limitations of traditional bedside monitoring, such as restricted mobility, wire-related discomfort, and poor patient compliance. By enabling wireless, continuous, and real-time transmission of cardiac signals, telemetry systems are particularly suitable for children, who often have wide age ranges, rapid disease progression, and limited cooperation. This paper reviews the technical characteristics, clinical applications, nursing strategies, and existing challenges of telemetry electrocardiographic monitoring in pediatric patients, highlighting its role in improving diagnostic accuracy, patient safety, and overall quality of care.

2. Overview of telemetry electrocardiographic monitors

2.1. Basic structure and working principle

The telemetry electrocardiographic monitoring system is mainly composed of four parts: a portable electrocardiographic acquisition terminal, a wireless transmission module, a central monitoring workstation,

and a data storage and alarm device. Electrode patches collect weak electrocardiographic signals from the human body surface. After amplification, filtering, noise reduction, and analog-to-digital conversion, the data is transmitted in real-time to the nurse's station or doctor's terminal via Bluetooth, Wi-Fi, or mobile networks. The system can automatically analyze indicators such as heart rate, rhythm, ST segment, QT interval, and respiratory rate. When the data exceeds the preset range, it immediately activates an audio-visual alarm to remind medical staff to handle it in a timely manner. Compared with traditional monitoring, the telemetry mode breaks free from cable constraints and can achieve continuous monitoring in a mobile state within a certain range, making it more suitable for the special group of children.

2.2. Technical characteristics

First, wireless and portable, reducing constraints. Children can move freely, eat, play, and undergo examinations in the ward, significantly improving comfort and cooperation, and reducing monitoring interruptions caused by crying and restlessness. Second, long-term continuous monitoring. It can achieve uninterrupted recording for hours to days, improving the detection rate of transient and paroxysmal electrocardiographic abnormalities, and making up for the shortcomings of conventional electrocardiograms with short time and limited information. Third, real-time early warning and rapid response. The central monitoring platform can monitor multiple beds simultaneously, with immediate prompts for abnormal situations, shortening the rescue response time and improving the level of medical safety. Fourth, traceable data for easy evaluation. The system automatically stores waveforms and trend graphs, supporting playback, comparison, and export, providing an objective basis for curative effect judgment, disease analysis, teaching, and scientific research. Fifth, expandable multi-parameter monitoring. High-end equipment can synchronously integrate monitoring of blood oxygen, respiration, body temperature, body position, etc., to meet the comprehensive monitoring needs of critically ill children [1].

2.3. Principles for selecting pediatric equipment

For neonates and infants, priority is given to small, lightweight acquisition equipment with hypoallergenic electrodes and firm fixation to reduce skin irritation and compression. For preschool and school-age children, models that are easy to wear, anti-interference, and have gentle alarm sounds are selected to reduce fear. For critically ill and post-operative children, models with stable transmission, strong battery life, and support for synchronous multi-parameter monitoring are used to ensure continuous and reliable monitoring.

3. Main clinical applications of telemetry electrocardiographic monitoring in pediatrics

3.1. Perioperative monitoring of congenital heart disease

Children with congenital heart disease have significant differences in preoperative cardiac function and are prone to complications such as arrhythmia, pericardial effusion, and low cardiac output syndrome after surgery. Telemetry electrocardiographic monitoring can continuously observe changes in heart rate, rhythm, and ST segment, early identify dangerous signals such as supraventricular tachycardia, ventricular premature beats, and atrioventricular block, providing a basis for adjusting medication, volume management, and early intervention, reducing the incidence of postoperative malignant cardiac events and promoting recovery. For children after complex congenital heart disease surgery, long-term and continuous electrocardiographic

monitoring is particularly important, which can promptly detect early signs of hemodynamic instability and improve the success rate of treatment [2].

3.2. Screening and definite diagnosis of arrhythmia

Common pediatric arrhythmias include supraventricular tachycardia, premature beats, atrioventricular block, long QT syndrome, and Wolff-Parkinson-White syndrome. Most of them occur paroxysmally, and conventional electrocardiograms are prone to missed diagnosis. Telemetry monitoring can capture abnormal electrocardiographic events over a long period, recording the onset, termination, frequency, duration, and inducing factors, providing objective evidence for drug treatment, radiofrequency ablation surgery, and pacemaker implantation. For children with unexplained syncope, palpitations, and chest tightness, telemetry electrocardiographic monitoring can significantly improve the detection rate of the cause and provide key support for clinical diagnosis.

3.3. Continuous monitoring of critically ill children

Children with neonatal asphyxia, premature infants, severe pneumonia, septic shock, respiratory failure, etc., are often accompanied by myocardial injury, heart rate fluctuations, apnea, and other problems. Telemetry monitoring can maintain uninterrupted monitoring during transportation, examinations, and nursing operations, promptly detect the trend of disease deterioration, and improve the success rate of critical care. In the neonatal intensive care unit, telemetry monitoring can reduce the constraints of wires on children, facilitate skin care and position changes, and at the same time achieve continuous electrocardiographic and respiratory monitoring, early identifying apnea and heart rate abnormalities, and reducing the incidence of adverse events in critically ill children [3].

3.4. Whole-process monitoring of children with myocarditis and cardiomyopathy

Children with viral myocarditis are prone to severe arrhythmia and decreased cardiac function in the acute phase; children with hypertrophic cardiomyopathy, dilated cardiomyopathy, etc., require long-term monitoring of QTc interval, ST-T changes, and rhythm stability. Telemetry monitoring can dynamically reflect the degree of myocardial injury and changes in the condition, early warn of high-risk events, and ensure the safety of treatment. For children in the recovery phase of myocarditis, outpatient telemetry monitoring can help doctors evaluate the myocardial repair situation, guide the adjustment of activity levels and medication, and achieve whole-process management from the acute phase to the recovery phase [4].

3.5. Postoperative rehabilitation monitoring in surgery

After pediatric cardiothoracic, abdominal, and orthopedic surgeries, anesthetic drug metabolism, pain stimulation, and stress responses can all lead to increased heart rate, arrhythmia, or hypoxemia. Telemetry monitoring supports early ambulation of children, accelerates the rehabilitation process under the premise of ensuring safety, and reduces bedridden complications such as pulmonary infection and venous thrombosis. Compared with traditional monitoring, the telemetry mode is more conducive to the implementation of the enhanced recovery after surgery (ERAS) concept, improving children's mobility and shortening the length of hospital stay.

3.6. Monitoring of drug cardiotoxicity

Some clinical drugs such as digitalis, antiarrhythmic drugs, and certain chemotherapeutic drugs have potential cardiotoxicity, and close monitoring of heart rate and QT interval changes is required during use. Telemetry electrocardiographic monitoring can reflect drug effects and adverse reactions in real-time, helping doctors adjust doses in a timely manner and avoid drug-related cardiac damage. For children who have long-term use of drugs that affect cardiac conduction, continuous electrocardiographic monitoring can reduce the risk of malignant arrhythmia and improve medication safety [5].

3.7. Post-discharge home telemonitoring

Children with complex congenital heart disease, post-arrhythmia surgery, pacemaker implantation, etc., still face the risk of condition fluctuations after discharge. Home telemetry equipment can upload monitoring data to the hospital platform, realizing continuous post-discharge management, reducing unnecessary re-consultations, early detecting abnormalities and intervening in a timely manner, and reducing the readmission rate. Home telemetry monitoring not only improves the quality of life of children but also reduces the pressure and economic burden of family care, and is an important supplement to the pediatric chronic disease management model.

4. Clinical advantages of telemetry electrocardiographic monitoring in pediatrics

4.1. Significantly improve patient compliance

The wireless design reduces entanglement, compression, and discomfort, lowers the incidence of crying and restlessness, and is particularly suitable for infants and active children. Children can move and play normally under monitoring, with less psychological pressure and higher cooperation, which is conducive to improving the accuracy and continuity of monitoring data [6].

4.2. Improve the detection rate of electrocardiographic abnormalities

Long-term continuous monitoring can greatly improve the detection probability of paroxysmal and asymptomatic arrhythmias, which has obvious advantages over conventional electrocardiograms. A large number of clinical studies have shown that the detection rate of transient arrhythmia, myocardial ischemia, and other events by telemetry electrocardiographic monitoring is significantly higher than that of conventional electrocardiographic examinations, which can effectively reduce missed diagnoses and misdiagnoses.

4.3. Strengthen safety early warning capabilities

Centralized central monitoring and real-time alarm for abnormalities help medical staff quickly identify dangerous situations, improving the success rate of rescue and the level of medical safety. In multi-bed wards, the telemetry system can achieve centralized management and unified early warning, optimize the allocation of human resources, and improve the efficiency of emergency response.

4.4. Optimize nursing work efficiency

It reduces repetitive work such as wire arrangement and electrode re-fixation, lowers the pressure of nurses' bedside rounds, and improves the overall quality of nursing. Nurses can observe the electrocardiographic conditions of multiple children in real-time through the central station, and spend more time on condition observation, basic nursing, and health guidance, improving the level of nursing services.

4.5. Support individualized precision medicine

Monitoring data can form trend curves and complete waveform records, facilitate the evaluation of disease changes, treatment effects, and prognosis, and providing support for individualized plans. Doctors can adjust medications and formulate rehabilitation plans according to continuous monitoring results, realizing the transformation from empirical treatment to precision treatment [7].

4.6. Adapt to children's physiological characteristics

The equipment can set different alarm thresholds according to age, weight, and condition, which is more in line with the physiological differences of neonates, infants, children, and adolescents. Compared with the unified standards for adults, the individualized alarm settings for pediatrics can reduce false alarms and missed alarms, and improve the effectiveness of monitoring.

5. Operational points and nursing strategies of telemetry electrocardiographic monitoring in pediatrics

5.1. Skin care and electrode placement

Clean the skin before placing electrodes to remove sweat, oil, and fine hair to ensure signal quality. For neonates and children with sensitive constitutions, use hypoallergenic electrodes and regularly change positions to prevent redness, damage, and dermatitis. For restless children, breathable films or special fixing vests can be used to strengthen fixation and reduce electrode detachment. Nursing staff should be proficient in the electrode placement positions for children of different ages to ensure clear waveforms and minimal interference [8].

5.2. Individualized alarm settings

Set reasonable upper and lower limits according to age, disease type, and basic heart rate to avoid false alarms or missed alarms caused by unified standards and reduce alarm fatigue. The normal values of heart rate vary greatly among neonates, infants, and school-age children, so hierarchical settings must be carried out. At the same time, the alarm sensitivity can be adjusted according to the severity of the condition to reduce invalid alarms under the premise of ensuring safety.

5.3. Reduce signal interference

Keep away from electromagnetic equipment such as mobile phones, microwave ovens, and monitors; mark children during severe crying and activities to facilitate waveform interpretation. Nursing staff should master common interference sources and elimination methods to ensure stable and reliable electrocardiographic signals. For transient waveform interference during movement, it should be identified and recorded in a timely manner to avoid misjudgment as abnormal rhythm.

5.4. Health education for family members

Explain the purpose, precautions, and emergency handling methods of monitoring to parents, alleviate anxiety, and improve cooperation and care capabilities. Guide parents to correctly protect the acquisition equipment to avoid collision, water ingress, and excessive pulling. Through health education, family members can actively participate in the monitoring process and jointly ensure the safety of children.

6. Existing problems and improvement measures

6.1. Existing problems

First, the skin of young children is delicate, and long-term wearing of electrodes is prone to local irritation, redness, and even damage. Second, children's hyperactivity and crying are likely to cause electrode loosening and signal interruption, affecting the continuity of monitoring. Third, unreasonable alarm parameter settings led to a high false alarm rate, which is likely to cause alarm fatigue among medical staff. Fourth, some equipment lacks special algorithms for children, with limited waveform recognition accuracy and weak ability to judge complex arrhythmias. Fifth, there is a lack of unified standards for the transmission, interpretation, and management of home monitoring data, and the connection between in-hospital and out-of-hospital data is not smooth. Sixth, the procurement and maintenance costs of equipment are relatively high, which to a certain extent limits the popularization and application in primary hospitals [9].

6.2. Improvement countermeasures

Promote hypoallergenic flexible electrodes and hydrocolloid dressings to reduce skin irritation and damage and improve wearing comfort. Optimize the fixing method, adopt an integrated wearing design, elastic straps, or special vests to improve equipment stability. Establish an age-stratified alarm system for pediatrics, refine parameters combined with disease types and conditions, and reduce invalid alarms. Introduce AI intelligent analysis algorithms to improve the accuracy of automatic arrhythmia recognition and reduce the burden of manual interpretation. Formulate operating specifications for pediatric telemetry monitoring and home monitoring processes, unify data standards, and realize seamless connection between in-hospital treatment and home management. Strengthen equipment maintenance and personnel training, extend service life, improve use efficiency, gradually reduce application costs, and promote the popularization of technology in primary hospitals [10].

7. Development trends

First, wearable and non-invasive monitoring. In the future, telemetry monitoring equipment will develop in the direction of being smaller, lighter, and softer, adopting flexible sensors and non-invasive attachment technology to achieve almost non-invasive long-term monitoring. Second, artificial intelligence-assisted diagnosis. AI automatically identifies arrhythmia, myocardial ischemia, and risk early warning, improving diagnostic efficiency and accuracy, and reducing the workload of medical staff. Third, integration of 5G telemedicine. It supports cross-regional real-time monitoring, remote consultation, and home follow-up, expanding the coverage of high-quality medical services, especially benefiting children in remote areas. Fourth, multi-parameter integrated monitoring. Integrated analysis of electrocardiography, respiration, blood oxygen, blood pressure, body temperature, and other data to achieve comprehensive evaluation and early warning. Fifth, full-cycle health management. Extend from in-hospital monitoring to long-term post-discharge management, building an integrated child's cardiac health protection model of screening–diagnosis–treatment–rehabilitation–follow-up.

8. Conclusion

With the core advantages of being wireless, continuous, real-time, and mobile, telemetry electrocardiographic

monitors are highly consistent with the clinical characteristics of pediatric patients, such as a wide age range, low cooperation, and rapid disease changes. They have important application value in congenital heart disease, arrhythmia, intensive care, postoperative rehabilitation, drug monitoring, and home follow-up. It can not only improve the detection rate of electrocardiographic abnormalities, reduce the risk of adverse events, and enhance medical safety but also improve children's comfort and nursing efficiency, which has significant clinical significance. At present, pediatric telemetry monitoring still faces problems such as skin tolerance, signal interference, false alarms, and algorithm adaptation, which require continuous improvement in equipment research and development, process standardization, nursing optimization, and intelligent technology application. With the continuous development of wearable devices, artificial intelligence, and telemedicine, telemetry electrocardiographic monitoring will become more accurate, intelligent, and convenient, serving as an indispensable important tool in pediatric cardiovascular safety management and providing more reliable protection for children's health.

Disclosure statement

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Research Review on Early Diagnostic Markers and Intervention Strategies for Liver Fibrosis

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Abstract: Liver fibrosis represents a pivotal intermediate pathological stage in the progression from various chronic liver diseases to cirrhosis and hepatocellular carcinoma, characterized primarily by persistent hepatocyte injury leading to the activation of hepatic stellate cells, which subsequently results in excessive extracellular matrix deposition and hepatic tissue structural remodeling. Early-stage liver fibrosis is fully reversible; however, once it advances to late-stage fibrosis or cirrhosis, the difficulty of reversal significantly increases. Therefore, early and accurate diagnosis, coupled with timely intervention, is crucial for improving the prognosis of patients with chronic liver diseases and reducing mortality from end-stage liver diseases. This article systematically reviews current markers for the early diagnosis of liver fibrosis and summarizes mainstream intervention strategies, providing theoretical references and clinical practice evidence for the early diagnosis and treatment of liver fibrosis.

Keywords: Liver fibrosis; Early diagnosis; Biomarkers; Non-invasive diagnosis; Intervention strategies; Anti-fibrotic therapy

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1. Introduction

Chronic liver disease is a hepatic condition resulting from chronic injury caused by various factors, characterized by hepatocyte damage, often accompanied by abnormal liver function, and typically persisting for more than six months. The later stages of the disease are primarily marked by liver fibrosis and cirrhosis [1]. According to global disease burden statistics, over 80% of deaths from cirrhosis and hepatocellular carcinoma annually are closely associated with the persistent progression of liver fibrosis [2]. Liver fibrosis is not an independent disease but rather a pathological repair response of the liver to chronic injury. Under physiological conditions, the synthesis and degradation of the extracellular matrix in the liver are in dynamic equilibrium. However, under chronic injury conditions, this balance is disrupted, and activated hepatic stellate cells become the primary cells secreting collagen. Large amounts of extracellular matrix, including type I and type III collagen and fibronectin, abnormally deposit in the liver, gradually destroying the normal lobular structure of the liver and ultimately leading to cirrhosis [3]. In recent years, with the rapid development of molecular biology, imaging, and omics

technologies, the early diagnostic system for liver fibrosis has been continuously improved, and targeted intervention methods have gradually transitioned from basic research to clinical application. This article provides a comprehensive review of research progress in this field.

2. Early diagnostic markers

2.1. Traditional serological markers

Traditional serological markers are the earliest indicators used in clinical non-invasive assessment of liver fibrosis, categorized into extracellular matrix metabolism and indirect liver function markers. They are convenient to detect, low-cost, and suitable for primary screening at the grassroots level. However, the sensitivity and specificity of a single marker are insufficient, necessitating combined use [4].

Markers related to extracellular matrix metabolism are core indicators reflecting the fibrotic process. The clinically common "four markers of liver fibrosis" include hyaluronic acid (HA), type III procollagen N-terminal peptide (PIIINP), type IV collagen (CIV), and laminin (LN) [5]. HA is metabolized by the liver, and its level is positively correlated with the degree of fibrosis, increasing early on. PIIINP directly reflects the rate of collagen synthesis, rising significantly early and declining in the late stage when synthesis slows. CIV is a core component of the hepatic basement membrane, with its level rapidly increasing early after basement membrane degradation, showing high specificity. LN can assist in evaluating the degree of hepatic sinusoidal capillarization, increasing in the progressive stage. Combined detection of these markers improves accuracy, but false positives may occur due to inflammation or connective tissue diseases, requiring clinical exclusion. Indirect liver function markers rely on routine test results to construct assessment models without additional detection.

Classic examples include the APRI and FIB-4 indices [6]. The FIB-4 index integrates four indicators, age, AST, ALT, and platelets, and is easy to calculate. It has high sensitivity for early significant fibrosis and is recommended as a first-line primary screening tool by domestic and international guidelines, suitable for patients with fatty liver and chronic hepatitis B.

2.2. Emerging specific molecular markers

In recent years, with the continuous development of molecular biology techniques, a batch of highly sensitive and specific emerging markers for liver fibrosis have been gradually discovered. Most of these markers are directly related to the activation of hepatic stellate cells and inflammatory fibrotic pathways, accurately capturing the early fibrotic process and effectively compensating for the diagnostic shortcomings of traditional markers.

Chitinase 3-like protein 1 (CHI3L1/YKL-40) is currently the most well-researched indicator, primarily secreted by activated hepatic macrophages and hepatic stellate cells. It specifically increases early in fibrosis and is not affected by liver inflammation, biliary obstruction, or other factors, showing superior early diagnostic specificity compared to traditional markers [7]. Clinical studies have confirmed a significant positive correlation between serum CHI3L1 levels and fibrosis staging in patients with chronic hepatitis B and non-alcoholic fatty liver disease. Combined detection with FIB-4 can significantly improve the detection rate of early mild fibrosis and has been listed as a supplementary diagnostic indicator in some liver disease treatment guidelines [8].

Golgi protein 73 (GP73) is lowly expressed in hepatocytes under physiological conditions but is extensively released into the blood during hepatocyte damage and early fibrosis. Serum concentration is

highly correlated with fibrosis progression, showing prominent value in the early diagnosis of viral hepatitis-related fibrosis and the ability to distinguish liver fibrosis from simple liver inflammation [9].

2.3. Non-invasive imaging diagnostic techniques

Imaging examinations can visually observe liver structure and measure liver tissue stiffness, enabling non-invasive, quantitative, and dynamic assessment of liver fibrosis. They are important methods for clinical early diagnosis, primarily divided into elastography and functional imaging [10].

Transient elastography is simple, non-invasive, reproducible, and has a short detection time. It judges the degree of fibrosis based on liver stiffness and has good diagnostic performance for moderate to severe fibrosis and early cirrhosis, becoming the preferred non-invasive examination for chronic liver disease staging [11]. Shear wave elastography and acoustic radiation force impulse imaging, developed on this basis, are less affected by obesity, ascites, and bile stasis, have a broader application range, and exhibit stronger detection capabilities for mild fibrosis. Functional imaging includes magnetic resonance elastography (MRE) and CT perfusion imaging.

MRE is close to non-invasive liver biopsy, with sensitivity and specificity exceeding 90%, providing accurate grading and suitable for patients in whom elastography fails. However, it is expensive and has a long examination time, limiting its grassroots popularity [12]. CT perfusion imaging reflects hepatic sinusoidal microcirculation injury through blood flow changes and is often used in combination with morphological examinations to assist in judging early liver fibrosis [13].

2.4. Multi-omics combined diagnostic models

A single marker or technique is insufficient to meet the demands of early and accurate diagnosis. Multi-omics combined diagnostic models based on transcriptomics, metabolomics, and proteomics have become a new direction for the early diagnosis of liver fibrosis. These models integrate multiple serum markers, imaging parameters, and clinical indicators, constructing diagnostic formulas through machine learning algorithms, significantly improving the diagnostic accuracy of early fibrosis. For example, a model combining bile acids and lipid metabolite profiles selected based on metabolomics with elastography stiffness values improves the diagnostic sensitivity for early mild fibrosis by more than 30% compared to a single indicator [14]. Although multi-omics models have broad prospects, they are currently in the clinical validation stage, with complex detection processes and high costs. Future efforts should focus on simplifying processes, reducing costs, and achieving clinical translation and application.

3. Early intervention strategies

The core of liver fibrosis intervention lies in blocking chronic liver injury, inhibiting the activation of hepatic stellate cells, promoting extracellular matrix degradation, and achieving fibrosis reversal [15].

3.1. Etiological intervention

Etiological intervention is the primary step in liver fibrosis treatment. Only by completely removing or controlling the causative factors can the activation of hepatic stellate cells and fibrogenesis be blocked at the source, which is also crucial for the reversal of early fibrosis. Well-established clinical guidelines have been developed for intervention plans targeting different etiologies: for patients with viral hepatitis, timely

initiation of standardized antiviral therapy is necessary. Chronic hepatitis B patients require long-term oral administration of nucleoside (nucleotide) analogs, while chronic hepatitis C patients are treated with direct-acting antiviral drugs to continuously suppress viral replication, rapidly alleviate liver inflammation, and reverse early fibrosis [16]. For patients with alcoholic liver disease, strict abstinence from alcohol is essential, along with supplementation of B vitamins, proteins, and other nutrients to repair liver cell damage [17]. For patients with non-alcoholic fatty liver disease, the focus is on controlling metabolic disorders through weight loss, blood glucose and lipid control, and improvement of insulin resistance to alleviate liver fat deposition and inflammation; for patients with autoimmune liver disease and cholestatic liver disease, long-term administration of immunosuppressants and choleretic drugs is required to control autoimmune reactions and cholestasis, preventing ongoing liver damage [18].

3.2. Targeted anti-fibrotic drug therapy

The mechanisms of action of anti-fibrotic drugs mainly include inhibiting the activation of hepatic stellate cells, promoting the apoptosis of activated stellate cells, inhibiting collagen synthesis, and promoting extracellular matrix degradation. Currently, drugs used clinically fall into two categories: Western medicines and traditional Chinese medicines (TCMs), most of which serve as adjuvant therapies and need to be combined with etiological treatment.

In terms of Western medicines, there are currently no specifically approved anti-fibrotic drugs. Clinically, drugs with anti-inflammatory and anti-fibrotic effects are often used for symptomatic treatment. For example, pirfenidone can inhibit the TGF-β1 pathway, reduce collagen synthesis, and exert anti-inflammatory effects, showing certain intervention effects on mild to moderate liver fibrosis [19]. Obeticholic acid can regulate bile acid metabolism and improve insulin resistance, making it suitable for fibrosis associated with non-alcoholic fatty liver disease; ursodeoxycholic acid can promote bile excretion and protect the liver, alleviating cholestatic liver injury [20]. These drugs require long-term administration, and some patients may experience gastrointestinal reactions, abnormal liver function, and other side effects, necessitating close monitoring.

TCMs are widely used in liver fibrosis treatment, offering advantages such as multi-target effects and fewer side effects, which meet the treatment needs of chronic liver disease patients in China. Classic TCM formulas such as Compound Biejia Ruangan Tablets, Anluo Huaxian Pills, and Fuzheng Huayu Capsules have been clinically validated to effectively inhibit collagen synthesis, promote fiber degradation, and improve liver fibrosis staging, especially suitable for early fibrosis associated with viral hepatitis and non-alcoholic fatty liver disease. Combined with etiological treatment, they can significantly enhance the reversal rate [21]. TCM treatment emphasizes holistic regulation, combining liver protection, anti-inflammatory, and anti-fibrotic effects, making it suitable for long-term intervention. However, it requires syndrome differentiation and treatment to avoid blind medication.

3.3. Lifestyle and comprehensive intervention

Lifestyle intervention is an important component of early liver fibrosis intervention, particularly suitable for patients with fibrosis associated with non-alcoholic fatty liver disease and alcoholic liver disease, and can assist in improving treatment outcomes [22]. The core measures include: a reasonable diet following the principles of low fat, low sugar, high protein, and high dietary fiber, reducing the intake of refined

carbohydrates, fried foods, and sugary beverages, increasing the intake of vegetables, high-quality proteins, and whole grains, and controlling daily calorie intake; regular exercise, with a weekly commitment of 150 minutes of moderate-intensity aerobic exercise such as brisk walking, jogging, and swimming, combined with resistance training to control weight and reduce liver fat deposition [23]. Avoiding liver-damaging factors, strictly abstaining from alcohol, avoiding the misuse of drugs and health supplements, and reducing additional liver cell damage; regular follow-up, with liver function tests, liver fibrosis markers, and liver elastography performed every 3–6 months to dynamically monitor fibrosis progression and adjust intervention plans in a timely manner.

3.4. Novel intervention approaches: Translation from basic research to clinical practice

With in-depth research on the molecular mechanisms of liver fibrosis, a series of novel intervention approaches have entered clinical trial stages, providing new directions for refractory early fibrosis [24]. Targeted stem cell therapy, through the infusion of mesenchymal stem cells, can inhibit liver inflammation, promote liver cell regeneration, and degrade extracellular matrix. Preliminary clinical studies have confirmed its effectiveness in improving liver fibrosis staging [25]. Gene therapy and RNA interference technology target and silence pro-fibrotic genes such as TGF-β1 and connective tissue growth factor to block fibrogenesis pathways, currently in animal experimental and early clinical stages [26]. Intestinal microecological regulation, through the use of probiotics and prebiotics to modulate the intestinal microbiota, reduces the absorption of intestinal-derived endotoxins, alleviating liver inflammation and fibrosis, and has become a hotspot for intervention in fibrosis associated with non-alcoholic fatty liver disease. Although these novel approaches hold great promise, they still require large-sample, long-term clinical studies to verify their safety and effectiveness and have not yet entered routine clinical practice.

4. Summary and outlook

Early diagnosis and intervention of liver fibrosis are core components of the prevention and treatment of chronic liver diseases. Currently, non-invasive diagnostic systems have been gradually improved, with traditional serological markers combined with elastography meeting the needs of preliminary clinical screening. Emerging molecular markers and multi-omics models have significantly enhanced early and accurate diagnostic capabilities, hopefully gradually replacing liver biopsy as the mainstream diagnostic method. Future research directions should focus on: developing highly specific and sensitive single-molecule early diagnostic markers, simplifying multi-omics diagnostic models for grassroots popularization; developing targeted and low-side-effect anti-fibrotic drugs, clarifying the molecular mechanisms of TCMs; promoting the clinical translation of novel stem cell and gene therapies, and constructing a standardized "screening-diagnosis-intervention-follow-up" full-process management system. Through multidisciplinary collaboration, early detection, diagnosis, and treatment of liver fibrosis can be achieved, ultimately reducing the incidence of liver cirrhosis and liver cancer and improving the long-term prognosis of chronic liver disease patients.

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Analysis of the Effectiveness of Evidence-Based Multidimensional Nursing Interventions in Preventing Deep Vein Thrombosis in Patients with Lower Limb Fractures

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Abstract: Lower limb fractures are common orthopedic injuries in clinical practice. Due to factors such as prolonged bed rest, immobilization, and vascular injury, patients are at a higher risk of developing deep vein thrombosis (DVT), which can lead to pulmonary embolism in severe cases, endangering their lives and affecting their prognosis and quality of life. Evidence-based nursing, guided by clinical problems, integrates high-quality clinical evidence, nursing expertise, and individual patient needs to develop scientific and standardized nursing plans, offering greater effectiveness compared to traditional empirical nursing. Evidence-based multidimensional nursing interventions break through the limitations of single nursing approaches by constructing a comprehensive prevention system from multiple dimensions, including physiology, medication, rehabilitation, psychology, and health education, precisely targeting the risk factors for DVT formation. This article reviews the implementation content of multidimensional nursing interventions for patients with lower limb fractures and analyzes their application effectiveness in DVT prevention, providing a reference for optimizing clinical DVT prevention nursing plans, improving nursing quality, and enhancing patient prognosis for those with lower limb fractures.

Keywords: Evidence-based; Multidimensional nursing; Lower limb fractures; Deep vein thrombosis

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1. Introduction

Lower limb fractures are a common type of orthopedic trauma in clinical practice, primarily caused by factors such as external impact, falls from heights, and accidental slips. After surgery, patients experience restricted mobility and are required to rest in bed, leading to a slower blood flow and an increased risk of developing deep vein thrombosis (DVT) [1,2]. Once DVT forms, it can cause limb swelling and severe pain, and in severe cases, may progress to venous gangrene, shock, or even be life-threatening. During the acute phase, if a

thrombus detaches and triggers a pulmonary embolism, patients may experience symptoms such as chest pain and dyspnea [3]. Scientific and efficient preventive interventions are the core focus of perioperative nursing for lower limb fractures. Evidence-based nursing, guided by clinical problems, involves retrieving, screening, and integrating high-quality clinical evidence, and combines this with individual patient needs and the professional experience of nursing staff to develop tailored nursing plans. Compared to traditional empirical nursing, it is more scientific, standardized, and effective [4]. Evidence-based multidimensional nursing interventions break through the limitations of a single nursing model by constructing a comprehensive and systematic nursing system from multiple dimensions, including physiological, psychological, behavioral, and rehabilitation aspects, demonstrating significant advantages in preventing DVT in patients with lower limb fractures.

2. Implementation content

2.1. Physiological nursing

Physiological nursing focuses on promoting venous return and alleviating blood stasis, serving as a fundamental aspect of DVT prevention. All measures are developed based on the evidence-based conclusion that "insufficient limb movement leads to blood stasis". In terms of positional care, nursing staff instruct patients to elevate the affected limb at an angle of 15° to 30° above heart level, avoiding compression or lowering of the limb to facilitate venous return. Patients are also encouraged to avoid prolonged periods in the same position, with regular assistance in turning to prevent localized vascular compression [5]. For bedridden patients, turning is assisted every 2 hours, with gentle movements to avoid pulling on the affected limb and causing vascular injury [6]. Regarding skin and pressure care, based on evidence, appropriate medical elastic stockings or intermittent pneumatic compression devices are selected for patients. Elastic stockings are worn from the toes to the upper thigh, put on before getting out of bed in the morning and removed before bedtime at night. Intermittent pneumatic compression devices are used 2 to 3 times daily for 30 to 60 minutes each session to promote venous blood flow and reduce blood stasis through external pressure. Additionally, skin care of the affected limb is strengthened, with observations of skin color, temperature, and swelling to maintain cleanliness and dryness, preventing skin breakdown and subsequent infection, thereby indirectly reducing thrombotic risk [7]. In terms of daily life care, patients are guided to maintain a reasonable diet rich in high-protein, high-fiber, low-fat, and high-vitamin foods such as lean meat, vegetables, fruits, and whole grains, while avoiding spicy, high-fat, and high-sugar foods to prevent increased blood viscosity. Patients are encouraged to drink plenty of water, with a daily intake of no less than 2000 mL, to promote blood circulation, dilute blood, and reduce thrombotic risk. Maintaining regular bowel movements is also emphasized to prevent increased abdominal pressure during straining, which could hinder venous return.

2.2. Pharmacological nursing

Pharmacological intervention is a crucial means of preventing DVT in patients with lower limb fractures, particularly for high-risk patients. Anticoagulant drugs effectively inhibit hypercoagulability, and their use must strictly adhere to evidence-based guidelines while balancing anticoagulant effects with bleeding risks [8]. Based on evidence, the nursing team selects appropriate anticoagulant drugs for patients at different risk levels. Low-to-moderate-risk patients may receive subcutaneous injections of low molecular weight heparin

calcium or low molecular weight heparin sodium, while high-risk patients may be prescribed oral rivaroxaban or dabigatran in combination. Dosage and timing strictly follow medical advice to avoid unauthorized dose adjustments or discontinuation. During medication administration, nursing staff closely monitor for signs of bleeding, such as skin bruising, gum bleeding, nosebleeds, hematuria, or melena, and regularly assess coagulation function (e.g., prothrombin time, activated partial thromboplastin time) to adjust medication regimens accordingly [9]. Patients are instructed on proper injection site compression after subcutaneous low molecular weight heparin injections, pressing for 5 to 10 minutes with moderate pressure without rubbing to prevent bleeding or hematoma at the injection site. Patients are also advised to avoid strenuous exercise, trauma, and medications affecting coagulation (e.g., aspirin) during treatment to minimize bleeding risks.

2.3. Rehabilitation nursing

Functional exercise effectively promotes limb blood circulation and improves venous return, serving as a key measure in preventing DVT. Exercise regimens are developed based on evidence, considering the patient's fracture type, surgical approach, and recovery status, following the principles of "gradual progression and individualization" [10]. In the early postoperative period (days 1–3), with limited limb movement, patients are guided to engage in a combination of passive and active exercises. Passive exercises, assisted by nursing staff or family members, involve massaging the affected limb muscles (from the dorsum of the foot to the thigh, proximally to distally) for 10 to 15 minutes, 3 to 4 times daily, to prevent muscle atrophy and promote blood flow. Active exercises include toe flexion and extension and ankle dorsiflexion and plantarflexion, with each movement held for 5 to 10 seconds and repeated 10 to 15 times, 3 to 4 times daily, based on patient tolerance and without exacerbating pain. In the mid-postoperative period (days 4–14), as pain subsides, exercise intensity is gradually increased. Patients are guided to perform knee flexion and extension, mild hip movements, and isometric quadriceps contractions, holding contractions for 10 seconds and relaxing for 5 seconds, repeated 20 to 30 times, 3 times daily. Rehabilitation equipment may also be used to facilitate limb movement and gradually restore limb function, promoting venous return. In the late postoperative period (2 weeks and beyond), based on fracture healing, patients are guided to ambulate, progressing from standing beside the bed and slow walking to normal activities. Elastic stockings are worn during walking to avoid prolonged standing or walking. Patients are closely monitored for dizziness or limb pain during activity, with adjustments made to activity intensity as needed. Through scientific exercise, the fundamental issue of blood stasis due to insufficient limb movement is addressed [11].

2.4. Psychological nursing

Patients with lower limb fractures often experience negative emotions such as anxiety, depression, and fear due to sudden trauma, limited limb function, and concerns about prognosis. These emotions can lead to sympathetic nervous system excitation, vasoconstriction, increased blood viscosity, and indirectly elevate DVT risk. Additionally, negative emotions reduce patient compliance with nursing interventions, affecting prevention outcomes. Therefore, psychological nursing is an essential component of multidimensional intervention. Nursing staff actively communicate with patients, patiently listening to their concerns and assessing their psychological state. For anxious patients, the healing process of fractures, the importance of DVT prevention, and the effectiveness of intervention measures are explained to instill confidence in recovery [12]. For fearful patients, successful case studies are shared to alleviate concerns about disease

prognosis. Family members are encouraged to provide companionship and support, offering psychological comfort and creating a positive rehabilitation environment. Furthermore, before implementing nursing measures, nursing staff thoroughly explain the purpose, process, and precautions to patients, ensuring understanding and active cooperation. For example, patients are informed about the significance of wearing elastic stockings and engaging in functional exercise to prevent resistance and ensure the effective implementation of prevention measures, enhancing DVT prevention outcomes [13].

2.5. Health education

Health education aims to enhance patients' and their families' understanding of DVT, enabling patients to master self-monitoring and self-care skills and strengthen self-management capabilities, serving as an important guarantee for long-term DVT prevention. Education content is developed based on clinical issues related to insufficient patient knowledge about DVT [14]. Diversified educational methods are employed, including one-on-one explanations, distribution of health manuals, playing educational videos, and conducting group lectures, to ensure comprehension by patients and their families. Education content covers three aspects: first, DVT-related knowledge, including high-risk causes, clinical manifestations (limb swelling, pain, increased skin temperature, purplish skin color), and harms (risk of pulmonary embolism) of DVT in patients with lower limb fractures, enabling early symptom recognition and timely notification of healthcare staff; second, prevention measures, including positional care, dietary requirements, functional exercise methods, elastic stocking wearing techniques, and precautions for anticoagulant drug use, encouraging active patient cooperation with nursing and continued adherence to prevention measures after discharge; third, self-monitoring points, guiding patients to observe limb swelling and pain daily after discharge, regularly review coagulation function, and seek medical attention promptly for abnormalities to avoid delayed treatment.

3. Application effects

3.1. Reducing the incidence of deep vein thrombosis

Multiple clinical studies have confirmed that evidence-based multidimensional nursing interventions can significantly reduce the incidence of DVT in patients with lower limb fractures [15]. Under traditional nursing models, nursing measures often lack systematicity and scientific rigor, primarily focusing on single aspects such as positional care and verbal education, with insufficient attention to individual patient differences, leading to a relatively high incidence of DVT. In contrast, multidimensional nursing interventions address DVT risk factors from multiple dimensions, including physiological, pharmacological, rehabilitation, psychological, and educational aspects. By promoting venous return, standardizing anticoagulant medication use, and implementing scientific functional exercises, these interventions reduce the conditions conducive to thrombus formation at the source. Relevant data indicate that implementing multidimensional evidence-based nursing not only effectively reduces the incidence of pressure injuries and lower limb deep vein thrombosis in patients after tibiofibular fracture surgery but also alleviates patient pain and improves nursing satisfaction [7].

3.2. Improving clinical indicators and rehabilitation progress in patients

Multidimensional nursing interventions can effectively improve clinical indicators in patients and accelerate the rehabilitation process [16]. Through measures such as positional care and functional exercises, the time

for swelling resolution and pain relief in the affected limb is significantly shortened, and limb mobility recovers more rapidly. Standardized anticoagulant medication nursing maintains stable coagulation function in patients, avoiding hypercoagulability while reducing the risk of bleeding and minimizing treatment delays caused by bleeding. Simultaneously, psychological nursing alleviates negative emotions in patients, enhancing their enthusiasm for rehabilitation. Health education equips patients with self-care skills, enabling them to actively cooperate with rehabilitation training, further shortening hospital stays, reducing medical costs, and improving rehabilitation efficiency [17].

3.3. Enhancing patient nursing satisfaction and health literacy

Evidence-based multidimensional nursing interventions, centered on patients and addressing both their physiological and psychological needs, offer more targeted and humane nursing measures, significantly improving patient nursing satisfaction [18]. Through proactive communication and meticulous care, nursing staff establish a positive nurse-patient relationship, making patients feel cared for. Additionally, diversified health education enables patients and their families to comprehensively grasp DVT prevention knowledge and rehabilitation skills, enhancing patients' health literacy. This not only facilitates cooperation with nursing during hospitalization but also ensures sustained implementation of preventive measures after discharge, reducing the long-term risk of thrombus recurrence. Furthermore, standardized nursing procedures improve nursing quality, reduce nursing disputes, and further enhance recognition of nursing work among patients and their families [15].

4. Conclusion

Patients with lower limb fractures are at high risk of developing deep vein thrombosis (DVT) due to factors such as prolonged bed rest and vascular injury. Therefore, DVT prevention represents a core task in perioperative nursing care for lower limb fractures. In the future, clinical nurses should further strengthen the concept of evidence-based nursing, continuously monitor the latest clinical evidence, and optimize multidimensional nursing plans based on individual patient differences. Nursing interventions should extend beyond hospital discharge to establish an integrated in-hospital and post-discharge DVT prevention and nursing system. This approach aims to provide higher-quality, scientific, and efficient nursing services for patients with lower limb fractures, facilitating their swift recovery.

Disclosure statement

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Research Progress on Nurse-Driven Warning Tools for Early Recognition of ICU Sepsis

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Abstract: Sepsis is the primary cause of deterioration and death in patients in the intensive care unit (ICU). Early identification and timely intervention are crucial for improving prognosis. Nurses, as frontline personnel providing bedside continuous monitoring, play a pivotal role in the early recognition of sepsis. This article systematically reviews the evolution, research progress, current challenges and shortcomings of nurse-driven early warning tools for sepsis in the ICU, and looks forward to future development directions, aiming to provide a reference for related research and clinical practice.

Keywords: Sepsis; Early recognition; Intensive care; Nurse-driven; Warning tools; Review

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1. Introduction

As a global healthcare challenge, sepsis and septic shock are the main causes of death for patients in the ICU [1]. According to the 2020 Global Burden of Disease Study, there were 48.9 million cases of sepsis worldwide in 2017, resulting in 11 million deaths and accounting for nearly 20% of all global deaths that year [2]. A multicenter cross-sectional study conducted in Asia revealed that patients with sepsis accounted for 22.4% of all ICU admissions, with a 90-day mortality rate of 36.6%. The study further revealed the critical effect of the "golden 3-hour" treatment time window, highlighting that early identification and timely intervention are the key to improving the prognosis of sepsis patients [3]. Nurses, as the frontline personnel who have the closest contact with patients and conduct continuous observation in the ICU, play an irreplaceable core role in the early identification of sepsis. This review aims to systematically explore the research progress and application status of such tools in the early identification of sepsis in the ICU, providing theoretical support and practical references for promoting the early identification of sepsis and nursing intervention, and thereby optimizing the management of sepsis in the ICU.

2.The core role and strategies of nurses in the early identification of sepsis

2.1. The challenges of sepsis in the ICU and the importance of early identification

Sepsis is a life-threatening organ dysfunction caused by the dysregulated response of the host to infection [4]. As a clinical unit dedicated to the treatment of critically ill patients, the intensive care unit (ICU) serves as both a key setting for infection prevention and control and a setting with a high prevalence of sepsis. Studies indicate that approximately 20%–30% of deaths among ICU patients are attributed to sepsis or septic shock placing infected patients admitted to the ICU at extremely high risk of developing sepsis [5].

Kumar et al. reported in 2004 that each hour of delay in antibiotic administration was associated with an approximately 7.6% decrease in survival, underscoring the critical importance of time-dependent treatment [6]. In 2018, the Surviving Sepsis Campaign (SSC) Guidelines based on the Sepsis-3.0 definition underwent key updates, integrating the original 3-hour and 6-hour treatment targets into "1-hour bundled treatment", emphasizing the urgency of immediately initiating standardized intervention after the identification of sepsis [7]. In October 2021, SSC issued the latest version of the guidelines, providing new guidance and opinions for the management of sepsis [8].

Therefore, establishing an early-warning system that can accurately and promptly identify the risk of sepsis holds significant clinical importance for optimizing clinical practice and improving patient outcomes.

2.2. The core role of nurses in the early identification of sepsis

ICU nurses, as the core practitioners of 24-hour continuous monitoring of patients, are responsible for critical tasks such as dynamic monitoring of vital signs, real-time recording, and clinical status assessment. Studies have shown that through continuous close contact with patients, nurses can detect subtle fluctuations in vital signs. This experience-based assessment can detect abnormalities at an early stage and often precedes machine alerts. Moreover, this "contextual awareness" ability based on practice is something that current automated monitoring systems cannot fully replace [9]. The literature further indicates that nurse-led screening is often more sensitive than purely electronic alert systems. The nurse-driven model not only means that screening tasks are carried out by nurses, but also emphasizes granting nurses the power and responsibility to initiate subsequent diagnostic and treatment procedures, thereby shortening the time from detection to intervention and securing the critical window for improving patient outcomes [10].

3. The evolution and current status of the early warning tools driven by ICU sepsis nurses

3.1. Evolution of traditional identification tools and scoring systems for ICU sepsis

3.1.1. Identification model based on the comprehensive systemic inflammatory response (SIRS)

In the era when sepsis was defined primarily as a systemic inflammatory response triggered by infection, identification tools were largely constructed based on the criteria for systemic inflammatory response syndrome (SIRS). As the cornerstone of early screening, the identification of SIRS relied on the abnormal physiological parameters such as body temperature, heart rate, respiratory rate, and white blood cell count to indicate potential severe infection and inflammatory conditions. However, this model has limitations. Studies have shown that while SIRS is highly sensitive for sepsis screening, its specificity is extremely low, often leading to misdiagnosis of non-infectious inflammation. Moreover, it fails to directly reflect organ

dysfunction or patient prognosis, resulting in limited warning value in high-risk settings such as the ICU [11].

3.1.2. The era of SOFA and qSOFA under the definition of Sepsis-3

With the release of the "International Consensus on the Definition of Sepsis-3" in 2016, sepsis was redefined as "life-threatening organ dysfunction caused by infection". This fundamental change gave rise to the second-generation identification tools centered around the Sequential Organ Failure Assessment (SOFA) and its rapid bedside version, the Quick Sequential Organ Failure Assessment (qSOFA). The SOFA score quantifies the severity of organ dysfunction through an objective assessment of six organ systems: respiratory, renal, liver, cardiovascular, hematological, and nervous. The qSOFA, based on criteria such as changes in consciousness, systolic blood pressure ≤ 100 mmHg, respiratory rate ≥ 22 breaths per minute, and Glasgow Coma Scale (GCS) < 15 points, rapidly identifies high-risk patients with suspected sepsis [4]. The design of these tools shifted from "searching for inflammation" to "evaluating organ function", significantly enhancing the specificity of early warnings and the ability to predict mortality risk.

3.1.3. The widespread application of early warning score (EWS)

The clinical application of SOFA is limited by its reliance on laboratory results, which precludes rapid use in critical situations [12]. In contrast, qSOFA serves as a convenient screening tool outside intensive care settings, but its sensitivity may be insufficient for early detection of all critically ill patient, particularly those in the ICU requiring immediate intervention, where reliance on qSOFA alone could lead to missed diagnoses [13]. To address these limitations, the screening strategy has further evolved to comprehensively integrate and optimize various early warning scores (EWS), and to link them with standardized response processes. Current tools, such as NEWS, MEWS, and their infection-adapted versions, are widely used to identify patients at risk of deterioration and offer higher sensitivity and practicality in early detection [14].

3.2. Current development status and tool types

3.2.1. Paper-based screening scale and flowchart

This stage is characterized by the introduction and promotion of a standardized screening model centered on structured assessment tools. Core forms include the qSOFA scorecard, NEWS/MEWS record sheets, and accompanying clinical decision flowcharts. Nursing staff perform bedside vital sign monitoring and manual data entry, calculate scores based on preset algorithms, determine risk categories using standardized flowcharts, and activate the corresponding tiered reporting mechanisms. This approach offers advantages such as low cost and simple training requirements [15]. However, this highly manual characteristic also leads to efficiency bottlenecks, with problems such as record delays and calculation errors, making it difficult to meet the extremely high requirements for timeliness in critical illness early warning.

3.2.2. The deep integration of early warning tools with electronic health record systems

In the context of the accelerated informatization process of medical institutions, the clinical decision support system (CDSS) integrates electronic health records (EHR) with Internet of Things (IoT) technology to achieve real-time automatic capture and dynamic calculation of vital signs, laboratory indicators, and imaging data. This system automates the calculation of core scores such as SOFA and NEWS. When parameters reach preset thresholds, it triggers graded warning responses through pop-up windows, audio-visual alerts, or mobile terminal task push notifications [16]. Empirical studies have shown that the automated warning

system significantly shortens the time for clinical decision-making. Research indicates that the early warning system (EWS) can reduce the antibiotic administration time by approximately 30% and significantly lower the incidence of complications; however, alarm fatigue is the core challenge of current ICU informatization. In an ICU environment with dense monitoring equipment, healthcare workers need to handle up to 700 alerts daily, with 80% of them being false alarms, resulting in an increase of approximately 18% in the response delay rate of critical alerts [17].

3.2.3. Nurse-driven standardized bundled intervention protocol

The core of this approach is to closely integrate the early warning score with the evidence-based medical-based sepsis bundle response protocol [18,19]. For instance, when the system identifies a combination of indicators that meet the criteria for "suspected sepsis", it will simultaneously trigger a task set with time constraints, such as completing blood culture, lactate measurement, and antibiotic administration within one hour. Under this framework, the role of nurses shifts from traditional screening executors to multidisciplinary coordinators, treatment drivers, and process supervisors. For example, after Ferguson et al. introduced the "Sepsis Care Bundle", the 3-hour bundle treatment compliance rate in the medical institution increased from 40.5% to 73.7%, and the rate of drug administration within one hour also significantly improved [20].

3.2.4. Development and application of an intelligent early warning model based on machine learning

Traditional rule-based scoring systems can only identify existing physiological disorders, while machine learning models, by analyzing patient data, can predict more subtle changes before the onset of the disease [21]. For example, the TREWScore model, developed using the MIMIC-II database, can provide early warnings approximately 28 hours before the clinical diagnosis of septic shock, with validated discriminative performance [22]. This technological evolution introduces new demands on the role of nurses, who are no longer merely data entry personnel but are now expected to integrate AI-derived risk predictions with clinical presentations to formulate comprehensive assessments.

4. The integration and application of innovative technologies

4.1. Clinical applications of artificial intelligence and machine learning

With its powerful data analysis and pattern recognition capabilities, AI and machine learning technologies are driving a revolutionary transformation in early warning tools for sepsis. Li et al. pointed out in their review that artificial intelligence has the potential for transformation in the management of sepsis, especially in the aspects of early identification and prognosis prediction [23]. By analyzing complex clinical data, machine learning and deep learning models can capture subtle pattern. This significantly improves the timeliness of early intervention and helps reduce mortality rates. Hu et al. based on the MIMIC-IV database and using the XGBoost algorithm, constructed an early prognosis prediction model for sepsis [24]. This study also emphasized the importance of interpretable machine learning methods (such as SHAP), which helps clinicians understand the key features behind the model's predictions. It not only proved the superiority of artificial intelligence in prediction performance but also demonstrated its practical value in clinical decision support. The systematic review by Islam et al. further evaluated the application of machine learning in the prediction of sepsis, indicating that artificial intelligence models have significant advantages in integrating

multi-source heterogeneous data and can achieve high-precision early warning in various clinical scenarios such as emergency departments and intensive care units [25].

Currently, such systems have been put into practical use in several top medical centers in North America, such as the "Sepsis Watch" developed by Duke University Hospital and the similar system implemented by Johns Hopkins Hospital. Both achieve early warning for sepsis through real-time analysis of electronic health record data [26]. These practical applications have preliminarily indicated that AI-based early warning tools are expected to further improve patient prognosis by enhancing the early recognition rate and timeliness of intervention for sepsis.

4.2. The application of the internet of things (IoT) and wearable devices

Traditionally, ICU nurses spent a lot of time manually measuring, recording and transcribing vital signs. However, the system based on the Internet of Things integrates wearable biological sensors and intelligent connected bedside monitoring equipment, achieving automatic, high-frequency and continuous collection of patients' vital signs [27]. This transformation not only reduces the repetitive labor of nurses, but also provides data density and dynamic trend information far superior to the traditional intermittent measurement methods, thereby laying a more comprehensive and real-time data foundation for AI prediction models.

Further research has further verified the potential of this technology: A study by Johns Hopkins University demonstrated that combining wearable biosensors with machine learning models can capture subtle physiological signals that traditional monitoring systems might miss, thereby enhancing the early identification of sepsis and creating conditions for earlier intervention [28]. Bignami et al. pointed out in their review that the integration of the Internet of Things monitoring system is conducive to continuous data collection and analysis, thereby reducing human errors and improving the accuracy of clinical decision-making [27]. A prospective observational study conducted by Garbern et al. continuously recorded heart rate, respiratory rate, and body temperature measurements using wearable biosensors and compared them with intermittent manual collection of vital signs [29]. This study confirmed that wearable biosensor devices can provide accurate continuous monitoring of heart rate and respiratory rate.

5. The existing limitations and challenges of nurse-driven early warning tools in the early identification of sepsis in the ICU

5.1. Alarm fatigue and the crisis of clinical disbelief

One of the most common and severe challenges faced by electronic warning systems in clinical applications is the clinical trust crisis caused by alarm fatigue. Numerous studies have confirmed that the majority of the alarms issued by ICU monitoring systems are ineffective. Statistical data show that up to 85% to 99% of the alarms are caused by improper equipment settings, normal physiological fluctuations of patients, or interference factors, and do not require immediate clinical intervention. Due to these high-frequency ineffective alarms, nurses in actual work have developed a "numb" state towards alarms, resulting in approximately 60% of the alarms being ignored or delayed responses, and approximately 85% of the nurses admitting to experiencing great psychological and work pressure due to the frequent alarms. The research further indicates that this noisy environment not only increases the risk of medical errors but also may cause patients' sleep quality to decline due to frequent ringing sounds, thereby affecting recovery [30].

5.2. Data quality and core technical bottlenecks

Clinical data often suffer from issues such as scattered sources, inconsistent standards, and discontinuous collection. Moreover, the insufficient data interoperability among various internal information systems within hospitals makes it difficult to construct high-quality, integrated, and standardized data sets. This situation severely hinders the development and performance optimization of advanced early warning models. Additionally, a qualitative study indicates that many advanced artificial intelligence models, especially deep learning algorithms, with their decision-making logic lacking transparency and clinical interpretability. This directly affects the trust and acceptance of medical staff in the system's outputs [31].

5.3. The human factors of the nurses themselves

Research indicates that some nurses have insufficient understanding of the latest definition of sepsis, its pathophysiological mechanisms, early identification criteria, and treatment guidelines. They also experience lag in knowledge update and fragmented understanding. Multiple studies have found that the cognitive level of nurses regarding the "Guidelines for Treating Sepsis and Septic Shock" is generally low, with scores typically ranging from 10 to 18, and they are not precise in identifying high-risk groups such as the elderly [32]. The lack of systematic and continuous training further hinders nurses from accurately grasping the warning logic when using early warning tools and integrating system prompts with specific clinical situations effectively, thereby affecting the effective transformation of knowledge into practice. Additionally, ICU nurses generally face high workloads, continuous physical and mental stress, and an unbalanced ratio of nurses to patients [33].

5.4. Resource and cost constraints

Health economics analysis indicates that the total life cycle cost of clinical decision support systems is high. Their development, integration and continuous optimization impose continuous pressure on the financial and operational resources of medical institutions, which poses a real economic burden for many hospitals [34].

6. Conclusion

The nurse-driven early warning tools have significant clinical value in the management of sepsis in the ICU. Their development reflects the trend of evolving from rule-based scoring systems to data-driven intelligent prediction models. The core role of nurses in early identification cannot be replaced. Future research should focus on conducting high-quality clinical validation, developing assessment tools that are intelligent, interpretable, and clinically applicable, and deepening the integration of emerging technologies and nursing processes, thereby constructing a nurse-centered, human-machine collaborative sepsis management loop, and improving patient prognosis.

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Disclosure s tatement

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Research on the Effect of Operating Room Nursing on Perioperative Body Temperature Protection of Patients and the Improvement Methods

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Abstract: *Objective*: To investigate the application effect of comprehensive thermoprotective nursing strategies in preventing unplanned hypothermia in surgical patients during the perioperative period, and to analyze the weak links and improvement directions in the temperature management process. *Methods*: A total of 286 patients undergoing elective surgery in a tertiary grade A hospital from January 2024 to June 2025 were selected and randomly divided into an observation group and a control group, with 143 cases in each group. The control group received routine temperature care, while the observation group carried out comprehensive measures such as preoperative risk assessment and pre-insulation, intraoperative active insulation and dynamic monitoring, and postoperative continuous insulation on this basis. Core body temperature changes, incidence of hypothermia, incidence of shivering, intraoperative blood loss, postoperative recovery time, and incidence of surgical site infection were compared between the two groups. *Results*: The results showed that the core body temperature of the observation group was higher than that of the control group at 30 minutes, 60 minutes after the start of the operation, at the end of the operation and when entering the recovery room. The incidence of perioperative hypothermia and postoperative chills was significantly lower than that of the control group. The incidence of intraoperative blood loss, postoperative recovery time and surgical site infection was better than that of the control group, and the differences were statistically significant. *Conclusion*: Comprehensive body temperature protection nursing measures can effectively maintain stable body temperature during the perioperative period, reduce the occurrence of hypothermia and hypotheria-related complications, promote postoperative recovery of patients, and provide a reference for the optimization of the operating room body temperature management process.

Keywords: Operating room nursing; Perioperative period; Hypothermia; Body temperature protection; Insulation strategies

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1. Introduction

Unplanned hypothermia during the perioperative period refers to an abnormal state where a patient's core

body temperature is below 36 ℃ during surgery. It is a common perioperative complication and has a higher incidence in the absence of effective preventive measures. It can lead to adverse outcomes such as coagulation dysfunction, increased risk of surgical site infection, increased cardiovascular adverse events, and delayed anesthesia recovery. It is associated with a variety of factors such as anesthesia inhibition of body temperature regulation, low-temperature exposure in the surgical environment, open body cavity for heat dissipation, and cold fluid infusion. As the concept of enhanced recovery after surgery progresses, body temperature management has shifted from passive heat preservation to a systematic protection model covering the entire process before, during and after surgery. Evidence-based studies have shown that the bundled heat preservation strategy can reduce the incidence of hypothermia and improve the effectiveness of nursing execution. However, there are still problems such as inaccurate risk assessment, inadequate implementation of insulation measures, and incomplete collaboration mechanisms in clinical practice. Therefore, a more standardized management plan needs to be established. This study uses a randomized controlled trial to evaluate the application effect of the comprehensive body temperature protection nursing strategy, providing a basis for optimizing the body temperature management process in the operating room [1].

2. Data and methods

2.1. General information

Patients who underwent elective surgery in the operating room of a tertiary grade A hospital from January 2024 to June 2025 were selected as the study subjects.

2.1.1. Inclusion criteria

(1) Age 18 to 75 years;
(2) American Society of Anesthesiologists Class I to III;
(3) Undergoing elective surgery under general anesthesia or intraspinal anesthesia with an estimated operation time of ≥ 60 minutes;
(4) Patients' informed consent and voluntary participation in this study.

2.1.2. Exclusion criteria

(1) Those with preoperative fever (body temperature ≥ 38.0 ℃) or preoperative core body temperature < 36.0 ℃;
(2) Preoperative hyperthyroidism or hypothyroidism, adrenal cortical insufficiency or other systemic diseases that affect body temperature regulation;
(3) Patients undergoing emergency surgery or day surgery;
(4) Those who need cardiopulmonary bypass during the operation;
(5) Pregnant patients.

2.1.3. Study design

A total of 286 patients who met the criteria were included and randomly divided into the observation group and the control group using the random number table method, with 143 cases in each group. There were no statistically significant differences ($p > 0.05$) between the two groups in terms of general information such as gender, age, body mass index, anesthesia method, type of surgery and duration of surgery, and they were

comparable. **Table 1** shows the comparison of general data between the two groups [2].

Table 1. Comparison of general data of the two groups of patients

Items	Gender (male/ female)	Age (years, $\overline{x} \pm s$)	Body mass index (kg/m^2, $\overline{x} \pm s$)	Anesthesia method (general anesthesia/ intraspinal anesthesia)	Surgical type (Abdominal surgery/ orthopedic surgery/ others)	Operation duration (min, $\overline{x} \pm s$)
Observation group (n = 143)	78/65	52.36 ± 12.48	23.82 ± 3.15	96/47	64/51/28	118.46 ± 35.27
Control group (n = 143)	82/61	53.17 ± 11.92	23.56 ± 3.28	101/42	68/48/27	121.38 ± 33.96
t value	0.253	0.568	0.692	0.488	0.286	0.719
p value	0.615	0.571	0.489	0.485	0.867	0.473

2.2. Methods

2.2.1. Nursing measures for the control group

The control group received routine operating room temperature care measures. After entering the operating room, patients were covered with conventional quilts, and whether to add quilts was determined based on the subjective judgment of the nursing staff. The ambient temperature in the operating room is generally controlled at 21 to 24 degrees Celsius, and the humidity is controlled at 40 to 60 percent. The fluid transfused during the operation is at room temperature (about 22 ℃), and no liquid heating device is used. The patient was covered with a regular cotton quilt in the recovery room for warmth after the operation [3].

2.2.2. Nursing measures for the observation group

The observation group adopted comprehensive body temperature protection measures on the basis of routine care as follows.

(1) Preoperative stage

① Risk assessment: Before entering the room, patients were evaluated by operating room nurses using the Hypothermia risk assessment scale. High-risk patients (aged ≥ 65 years, body mass index < 18.5 kg/ m^2 or expected operation time ≥ 120 min) were identified and managed. ② Pre-warming: Immediately after entering the preoperative preparation room, the patient is pre-warmed with an inflatable heating blanket at a temperature of 38 ° C for a duration of ≥20 minutes. ③ Environmental preparation: Set the operating room temperature to 24-25 ° C before the patient enters the room, and adjust it to 22-23 ° C after the patient enters the room according to the progress of the operation.

(2) During the operation

① All patients in the observation group used inflatable heating blankets throughout the operation. The appropriate covering method was selected based on the surgical site, and the temperature of the heating device was set at 38–43 ℃ and adjusted dynamically. ② Fluid heating: During the operation, all intravenously infused crystalloid fluid, colloid fluid, and blood products were heated to 37 ℃ by a thermostatic infusion heater before infusion. The body cavity irrigation fluid was preheated to 38 ° C to 40 ℃ in a constant temperature box. ③ Body temperature monitoring: Continuously monitor core body temperature using a nasopharyngeal temperature probe from the start of anesthesia induction until the end of the patient leaving the recovery room. Record every 5 minutes after anesthesia induction, every

15 minutes during the stable period of surgery, and increase monitoring frequency when the body cavity is exposed or when there is a large volume of fluid infusion. ④ Reduce heat loss by covering non-surgical areas with cotton blankets or thermal blankets and applying thermal surgical membranes around surgical incisions to reduce the area of body surface exposure and heat loss [4].

(3) Postoperative stage

① Continue to insulate. When the patient is transferred to the anesthesia recovery room and in the recovery room, continue to use inflatable heating blankets for insulation to maintain core body temperature above 36.0 ℃. ② Handover management: Operating room nurses and recovery room nurses have a special handover of body temperature management, recording the trajectory of body temperature changes during the operation and the insulation measures taken. ③ Shivering management: When shivering is detected in the patient, immediately assess the core body temperature and take measures such as increasing coverage, raising the temperature of the heating blanket, and administer medication as directed by the doctor if necessary.

2.3. Observation of indicators

(1) Core body temperature

Core body temperatures were recorded in both groups of patients after anesthesia induction (at the time of entering the room), 30 minutes after the start of surgery, 60 minutes after the start of surgery, immediately after the end of surgery, and when entering the recovery room after surgery.

(2) Incidence of perioperative hypothermia

A core body temperature of less than 36.0 ° C at any monitoring point during the perioperative period is considered hypothermia.

(3) Incidence of postoperative chills: Chills are defined as visible muscle tremors or generalized tremors in patients according to the Wrench classification criteria.

(4) Intraoperative blood loss

A combined calculation using a negative pressure suction bottle and gauze weighing.

(5) Postoperative recovery time

The time from the end of the surgery to the recovery from anesthesia, the eyes open upon call, and the ability to perform commanded actions.

(6) Incidence of surgical site infection

Redness, swelling, heat, pain or purulent discharge at the surgical incision within 30 days after surgery, or positive pathogen culture, in accordance with the diagnostic criteria for nosocomial infections.

(7) Length of stay in the recovery room.

2.4. Statistical processing

Data analysis was performed using SPSS 26.0 statistical software. Measurement data were expressed as mean ± standard deviation ($\overline{x} \pm s$), independent sample t-test was used for comparison between groups, and repeated measures analysis of variance was used for comparison of body temperature at different time points. Count data were expressed as percentages, and the χ^2 test was used for comparison between groups. A difference was considered statistically significant when $p < 0.05$.

3. Results

3.1. Comparison of perioperative core body temperature between the two groups of patients

The core body temperatures of the observation group were significantly higher than those of the control group at 30 minutes, 60 minutes after the start of surgery, immediately after the end of surgery, and when entering the recovery room after surgery, and the differences were statistically significant ($p < 0.05$). There was no significant difference in core body temperature between the two groups after anesthesia induction (at the time of entering the room) ($9 > 0.05$). **Table 2** shows the comparison of core body temperatures at each time point during the perioperative period between the two groups.

Table 2. Comparison of core body temperatures during the perioperative period between the two groups (℃, $\overline{x} \pm s$)

Monitoring time points	After anesthesia induction (when entering the room)	30 minutes after the operation begins	60 minutes after the operation begins	Immediately after the operation ends	When entering the recovery room after surgery
Observation group (n=143)	36.58 ± 0.23	36.42 ± 0.28	36.35 ± 0.31	36.38 ± 0.29	36.45 ± 0.26
Control group (n=143)	36.54 ± 0.25	35.96 ± 0.34	35.82 ± 0.39	35.78 ± 0.41	35.92 ± 0.36
t value	1.420	12.554	12.815	14.201	14.381
p value	0.157	<0.001	<0.001	< 0.001	< 0.001

3.2. Comparison of the incidence of perioperative hypothermia between the two groups of patients

There were 16 cases of perioperative hypothermia in the observation group, with an incidence rate of 11.19%; There were 49 cases of perioperative hypothermia in the control group, with an incidence rate of 34.27%. The incidence of hypothermia in the observation group was significantly lower than that in the control group, and the difference was statistically significant ($\chi^2 = 21.732$, $p < 0.01$).

3.3. Comparison of postoperative chills and other clinical indicators between the two groups

The incidence of postoperative chills in the observation group was 9.79%, significantly lower than 28.67% in the control group ($p < 0.01$). The intraoperative blood loss, postoperative recovery time and recovery room stay time in the observation group were all better than those in the control group, and the differences were statistically significant ($p < 0.05$). The incidence of surgical site infection was 2.10% in the observation group and 6.99% in the control group, and the difference was statistically significant ($p < 0.05$). The comparison of clinical indicators between the two groups is shown in **Table 3**.

Table 3. Comparison of postoperative chills and other clinical indicators between the two groups of patients

Observation indicators	Postoperative chills occur [cases (%)]	Intraoperative blood loss (mL, $\overline{x} \pm s$)	Postoperative recovery time (min, $\overline{x} \pm s$)	Recovery room stay time (min, $\overline{x} \pm s$)	Surgical site infection [cases (%)]
Observation group (n = 143)	14 (9.79)	185.46 ± 68.33	28.46 ± 10.27	52.37 ± 15.46	3 (2.10)

Control group (n = 143)	41 (28.67)	226.71 ± 75.48	36.58 ± 12.34	64.28± 18.37	10 (6.99
t value	16.261	4.865	6.111	6.015	4.114
p value	< 0.001	< 0.001	< 0.001	< 0.001	0.043

4. Discussion

4.1. Mechanisms and hazards of perioperative hypothermia

Perioperative hypothermia is caused by a combination of factors. Anesthetic drugs inhibit hypothalamic thermoregulatory function, causing blood vessels to dilate and core heat to redistribute to the periphery. The low-temperature environment in the operating room, the opening of body cavity, the expansion of skin exposure range, the infusion of cold fluid and cold rinse fluid, etc. all accelerate heat dissipation, causing patients to experience a decrease in core body temperature within a short period of time during the operation. The harm of hypothermia is not just cold discomfort. It also inhibits platelet function and thrombin activity, increases intraoperative blood loss, weakens the body's immune defense ability, raises the risk of surgical site infection and adverse cardiovascular events, and delays the metabolism of anesthetic drugs and the recovery process after surgery. In this study, the incidence of hypothermia in the control group was 34.27%, indicating that perioperative hypothermia is still relatively common in patients with an average operation duration of 120 minutes, and there is still a need to further strengthen clinical temperature management.

4.2. Core elements and effects analysis of comprehensive body temperature protection strategies

The integrated body temperature protection strategy focuses on the entire perioperative management, with the core being the organic combination of preoperative prevention, intraoperative intervention, and postoperative continuous heat preservation. Preoperative risk assessment of high-risk patients and pre-warming measures can increase peripheral heat reserves and reduce the drop in body temperature caused by the redistribution of core heat after anesthesia induction; The continuous use of inflatable heating blankets, fluid heating, dynamic temperature monitoring, etc. during the operation can reduce the impact of surface heat dissipation and cold fluid input, and maintain core temperature stability in multiple aspects; Continuing to insulate after the operation can prevent hypothermia again during the transfer and recovery phases. The results of this study show that the body temperature of the observation group was higher than that of the control group at 30 minutes, 60 minutes after the start of the operation, at the end of the operation and when entering the recovery room. The indicators such as perioperative hypothermia, postoperative chills, intraoperative blood loss, postoperative recovery time and infection incidence were also better than those of the control group, indicating that the comprehensive body temperature protection strategy has good clinical application value.

4.3. Weak links in current body temperature management and methods for improvement

Although the effectiveness of the integrated body temperature protection strategy has been established, there are still weak links in body temperature management in practical application. Some nursing staff are not fully aware of the dangers of hypothermia, preoperative risk assessment lacks the support of quantitative tools, and high-risk patients are not identified in a timely manner; Active heat preservation equipment is underconfigured in some operating rooms, or has a low usage rate due to unskilled operation and inadequate

maintenance; There are also discontinuous records and untimely interventions in intraoperative temperature monitoring, which cannot achieve the purpose of dynamic management throughout the entire process. The coordination among anesthesiologists, surgeons, operating room nurses and recovery room nurses also needs to be strengthened. In response to these issues, hypothermia risk assessment should be incorporated into the standard process of preoperative visits, the configuration and maintenance system of active heat preservation equipment should be improved, continuous core temperature monitoring technology should be promoted, and standardized handover forms and multidisciplinary collaboration mechanisms should be established to continuously improve perioperative temperature management to be more standardized and efficient.

The comprehensive body temperature protection care strategy, which includes preoperative pre-warming, intraoperative active warming and fluid heating, and postoperative continuous warming, can effectively reduce the incidence of perioperative hypothermia and complications, accelerate postoperative recovery, and improve patient safety. Operating room nursing staff should, based on the actual clinical situation, continuously improve risk assessment, temperature monitoring, active heat preservation technology application and multidisciplinary collaboration system, thereby enhancing perioperative temperature management and facilitating postoperative recovery of patients.

5. Conclusion

In conclusion, unplanned hypothermia during the perioperative period is an important risk factor affecting surgical safety and postoperative recovery of patients, which can significantly increase the risk of adverse events such as chills, increased intraoperative bleeding, delayed awakening, and surgical site infections. This study confirmed that compared with conventional body temperature care, the integrated comprehensive body temperature protection care strategy of preoperative precise risk assessment and pre-insulation, intraoperative active insulation combined with dynamic body temperature monitoring, and postoperative continuous insulation can effectively maintain the stability of core body temperature in patients during the perioperative period and significantly reduce the incidence of hypothermia and related complications. Shortening postoperative recovery time, reducing intraoperative blood loss and lowering the risk of surgical site infection are of significant clinical value in improving surgical safety and accelerating postoperative recovery.

At the same time, this study also identified the weak links in the traditional temperature management process in the operating room and pointed out the direction for improvement in subsequent temperature protection work. In clinical nursing practice, the concept of full-process, proactive and individualized body temperature protection should be integrated into the entire operating room nursing process, continuously optimize the perioperative body temperature management process, improve the preoperative assessment system, standardize the intraoperative heat preservation operation, strengthen the postoperative heat preservation connection, and construct a standardized and systematic body temperature protection nursing model. In the future, it is necessary to further promote comprehensive body temperature protection nursing measures, continuously refine nursing plans, improve nursing quality, effectively ensure the body temperature safety of surgical patients during the perioperative period, and provide solid nursing support for the rapid recovery of patients after surgery.

Disclosure statement

The author declares no conflict of interest.

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Clinical Efficacy and Safety Analysis of Reversed Flap Turnover Layered Minimally Invasive Surgery for the Treatment of Bromhidrosis

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Abstract: *Objective*: To explore the clinical efficacy and safety of reverse skin flap turnover and stratified minimally invasive surgery for the treatment of bromidrosis, and compare it with traditional bromidrosis excision surgery, providing a reference for optimizing clinical surgical plans for bromidrosis. *Methods*: A total of 100 patients with bromidrosis admitted to the Vascular Surgery Department of our hospital from January 2024 to December 2025 were selected as the study subjects. They were randomly divided into an observation group and a control group using a random number table method, with 50 cases in each group. The control group was treated with traditional fusiform excision surgery, while the observation group was treated with reverse skin flap turnover and stratified minimally invasive surgery. Surgical-related indicators, the overall clinical treatment response rate, the incidence of postoperative complications, scar scores at 6 months postoperatively, and recurrence rates were compared between the two groups. Patient postoperative satisfaction was also recorded. *Results*: The observation group showed significantly better results than the control group in terms of operative time, intraoperative blood loss, and incision healing time (all $p < 0.001$). The overall response rate in the observation group was significantly higher than that in the control group ($\chi^2 = 5.005$, $p = 0.025 < 0.05$). The overall incidence of complications in the observation group was significantly lower than that in the control group ($\chi^2 = 6.353$, $p = 0.012 < 0.05$). At 6 months postoperatively, the Vancouver Scar Scale (VSS) scores and recurrence rates in the observation group were significantly lower than those in the control group, while overall patient satisfaction was significantly higher in the observation group (all $p < 0.05$). *Conclusion*: Reverse skin flap turnover and stratified minimally invasive surgery is effective for the treatment of bromidrosis. Compared with traditional surgical methods, it offers advantages such as less trauma, reduced bleeding, faster healing, a lower incidence of complications, minimal scarring, and a lower recurrence rate. It is safer and more acceptable to patients, making it suitable for clinical promotion and application.

Keywords: Bromidrosis; Reverse skin flap turnover and stratified minimally invasive surgery; Traditional fusiform excision surgery; Clinical efficacy; Safety

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1. Introduction

Bromidrosis, also known as fox odor or axillary osmidrosis, is a common clinical dermatological accessory disease primarily caused by abnormal secretion from the apocrine glands in the axillary region. The secretions are decomposed by bacteria on the skin surface, producing unsaturated fatty acids and ammonia, resulting in a distinctive pungent odor. It is more prevalent among young adults, particularly women [1]. Although bromidrosis does not cause organic damage to internal organs, it significantly affects patients' daily social interactions, mental health, and quality of life. Some patients may even develop psychological issues such as low self-esteem, anxiety, and social avoidance, making it necessary to actively pursue effective treatment methods. Currently, surgical treatment is the primary approach for bromidrosis, with the core principle being the complete removal of the axillary apocrine glands to block the source of the odor [2]. Traditional fusiform excision surgery was commonly used in clinical practice in the past. Although it can partially remove the sweat glands, it has drawbacks such as large incisions, significant trauma, obvious postoperative scarring, restricted upper limb movement due to traction, a relatively high incidence of complications, and poor controllability of recurrence rates, making it difficult to meet patients' demands for aesthetics and postoperative comfort [3]. With the development of minimally invasive surgical techniques, various minimally invasive surgical methods for bromidrosis have gradually replaced traditional methods. Reverse skin flap turnover and stratified minimally invasive surgery, through precise positioning, small incision design, and stratified dissection and turnover of skin flaps, allows for the complete removal of apocrine glands under direct vision while maximally preserving normal skin tissue, balancing efficacy and aesthetics. This study selected 100 patients with bromidrosis and conducted a grouped comparative analysis of the clinical efficacy, safety, and prognosis of reverse skin flap turnover and stratified minimally invasive surgery versus traditional surgical methods, aiming to provide objective data support for selecting the optimal surgical plan for bromidrosis in clinical practice. The report is as follows.

2. Materials and methods

2.1. General information

A total of 100 patients with bromidrosis admitted to the Vascular Surgery Department of our hospital from January 2024 to December 2025 were selected as the study subjects.

2.1.1. Inclusion criteria

(1) Met the clinical diagnostic criteria for bromidrosis, with moderate to severe odor and poor response to conservative treatment;
(2) Aged 18–45 years, with unilateral or bilateral bromidrosis, and voluntarily accepted surgical treatment;
(3) No surgical contraindications, normal coagulation function, no local skin infection, ulceration, or scar-prone constitution;
(4) Patients and their families provided informed consent, signed the surgical informed consent form, and cooperated with postoperative follow-up.

2.1.2. Exclusion criteria

(1) Severe dysfunction of the heart, liver, kidneys, or other organs;

(2) Pregnant or lactating women;
(3) Previous history of axillary surgery or local injection therapy;
(4) Patients with mental illness or cognitive impairment unable to cooperate with treatment;
(5) Patients lost to follow-up or with incomplete data postoperatively.

2.1.3. Study design

Patients were randomly divided into an observation group and a control group using a random number table method, with 50 cases in each group. Observation group: 18 males and 32 females; aged 19–43 years, with an average age of (26.58 ± 4.26) years; disease duration of 1–12 years, with an average of (5.32 ± 2.14) years; 46 cases with bilateral bromidrosis and 4 cases with unilateral bromidrosis. Control group: 20 males and 30 females; aged 18-45 years, with an average age of (27.12 ± 4.53) years; disease duration of 1-11 years, with an average of (5.18 ± 2.07) years; 45 cases with bilateral bromidrosis and 5 cases with recurrent bromidrosis. There were no statistically significant differences in general information such as gender, age, disease duration, and side of bromidrosis between the two groups ($p > 0.05$), indicating comparability.

2.2. Surgical methods

The control group underwent traditional fusiform excision surgery. Patients were placed in a supine position with their upper limbs abducted at 90 °. The axillary skin was routinely disinfected with iodophor, and a sterile surgical drape was placed. Local infiltration anesthesia was administered. A fusiform incision was designed along the distribution area of axillary hair. The skin and subcutaneous tissue were incised, and the skin and subcutaneous adipose tissue containing the apocrine glands in the axillary region were completely excised. After thorough hemostasis, the subcutaneous tissue and skin were sutured layer by layer. Postoperatively, gauze compression bandaging was applied, and routine anti-infective treatment was given for 3 days. Sutures were removed 10–12 days postoperatively.

The observation group underwent reverse skin flap turnover and stratified minimally invasive surgery, performed by the same group of senior vascular surgeons according to a standardized protocol to ensure uniformity of operations.

(1) Preoperative positioning

Before surgery, with the patient's upper limb abducted, the axillary hair area was positioned using a sterile marking pen, extending 0.5–1 cm beyond the boundary of the axillary hair to completely cover the apocrine glands and reduce the possibility of recurrence.

(2) Incision design

A 1.0–1.5 cm arc-shaped incision was made along the axillary sulcus, avoiding major skin lines and balancing operational space with minimally invasive aesthetics.

(3) Anesthesia protocol

Local tumescent anesthesia was administered using 0.5% lidocaine with 1:200,000 epinephrine to reduce bleeding and prolong the analgesic effect.

(4) Skin flap dissection and turnover

After anesthesia, the skin was incised to the superficial fascia layer. A reverse skin flap was bluntly dissected and turned over, clearly exposing and stratified dissecting the sweat glands and fat while avoiding damage to deep blood vessels and nerves.

(5) Hemostasis and drainage

Intraoperative electrocoagulation hemostasis was performed, with the single-point action time not exceeding 0.5 seconds. Negative pressure drainage or fenestrated drainage was placed according to the degree of bleeding.

(6) Suture and bandaging

After confirming no bleeding, the subcutaneous tissue was sutured with absorbable sutures, and the skin was sutured with cosmetic sutures. Postoperatively, an "8-figure" bandage was applied for moderate compression bandaging for 72 hours to prevent hematoma and scar hyperplasia.

After surgery, both groups of patients received routine anti-infective, anti-swelling, and analgesic treatment. Patients were instructed to avoid strenuous upper limb activities, raising their arms, or lifting heavy objects within 1 week postoperatively, keep the local skin clean and dry, change dressings regularly, and were followed up for 6 months postoperatively.

2.3. Observation indicators

(1) Surgical-related indicators

The operative time, intraoperative blood loss, and incision healing time were recorded for both groups, with measurement data retained to two decimal places.

(2) Clinical efficacy determination

Patients were followed up at 6 months postoperatively, and efficacy was determined based on the elimination of axillary odor. Cure: Complete disappearance of axillary odor, with no odor at close range; Marked response: Significant reduction in odor, with only slight odor at close range that does not affect social interactions; Effective: Reduction in odor, but still present to some extent, requiring daily masking; Ineffective: No improvement or worsening of odor. The overall response rate = (number of cured + markedly responsive + effective cases) / total number of cases × 100.00%.

(3) Postoperative complications

The occurrence of postoperative complications such as subcutaneous hematoma, skin necrosis, incision infection, scar hyperplasia, and upper limb traction discomfort was statistically analyzed in both groups, and the overall incidence of complications was calculated.

(4) Scar score

At 6 months postoperatively, the Vancouver Scar Scale (VSS) was used to assess scar conditions, with a total score ranging from 0 to 15. A lower score indicates a milder scar and more aesthetically pleasing appearance [4].

(5) Recurrence rate and satisfaction

The number of bromidrosis recurrence cases was statistically analyzed at 6 months postoperatively, and the recurrence rate was calculated. A self-made satisfaction questionnaire was used to assess patient postoperative satisfaction, which was divided into very satisfied, satisfied, and dissatisfied. The overall satisfaction rate = (number of very satisfied + satisfied cases) / total number of cases × 100.00%.

2.4. Statistical methods

Data analysis was performed using SPSS 22.0 statistical software. Measurement data were expressed as ($\overline{x} \pm s$), and comparisons between groups were made using independent sample t-tests. Count data were expressed as [n (%)], and comparisons between groups were made using χ^2 tests. $p < 0.05$ was considered

statistically significant.

3. Results

3.1. Comparison of surgical-related indicators between the two groups

The observation group showed significantly better results than the control group in terms of operative time, intraoperative blood loss, and incision healing time (all $p < 0.001$). See **Table 1**.

Table 1. Comparison of surgical-related indicators between the two groups

Group	Operation time (min)	Intraoperative blood loss (mL)	Wound healing time (d)
Observation group (n = 50)	42.36 ± 5.28	8.25 ± 1.36	7.12 ± 1.05
Control group (n = 50)	58.74 ± 6.35	22.68 ± 3.42	11.36 ± 1.82
t	14.037	35.395	14.255
p	< 0.001	< 0.001	< 0.001

3.2. Comparison of clinical efficacy between the two groups

The overall response rate in the observation group was significantly higher than that in the control group ($\chi^2 = 5.005$, $p = 0.025 < 0.05$), as shown in **Table 2**.

Table 2. Comparison of clinical efficacy between the two groups of patients

Group	Cured	Markedly effective	Effective	Ineffective	Total effective rate (%)
Observation group (n = 50)	36	9	3	2	48 (96%)
Control group (n = 50)	22	11	8	9	41 (82%)
χ^2					5.005
p					0.025

3.3. Comparison of the incidence of postoperative complications between the two groups

The overall incidence of complications in the observation group was significantly lower than that in the control group ($\chi^2 = 6.353$, $p = 0.012 < 0.05$), as shown in **Table 3**.

Table 3. Comparison of the incidence of postoperative complications between the two groups

Group	Subcutaneous hematoma	Scar hyperplasia	Incisional infection	Skin necrosis	Upper limb discomfort from traction	Overall incidence rate (%)
Observation group (n = 50)	1	1	1	-	-	3 (6%)
Control group (n = 50)	4	2	2	2	2	12 (24%)
χ^2						6.353
p						0.012

3.4. Comparison of postoperative scar scores, recurrence rates, and satisfaction between the two groups

At 6 months postoperatively, the VSS scores and recurrence rates in the observation group were significantly lower than those in the control group, while the overall patient satisfaction was significantly higher in the

observation group (all $p < 0.05$). See **Table 4**.

Table 4. Comparison of postoperative scar scores, recurrence rates, and satisfaction between the two groups

Group	VSS score (points)	Recurrence rate [n (%)]	Overall satisfaction rate [n (%)]
Observation group (n = 50)	2.15 ± 0.42	1 (2.00)	47 (94.00)
Control group (n = 50)	6.84 ± 1.26	7 (14.00)	40 (80.00)
t/χ^2	25.023	4.891	4.332
p	< 0.001	0.027	0.037

4. Discussion

The core pathogenesis of bromhidrosis lies in the excessive secretion of apocrine sweat glands in the axillary region. The key to surgical treatment is the complete removal of apocrine sweat glands while minimizing surgical trauma, reducing the risk of complications, and ensuring postoperative aesthetic appeal [5]. Traditional fusiform excision involves directly removing skin tissue containing sweat glands, which is a simple procedure but results in significant trauma. It is challenging to precisely control the excision range, often leading to residual sweat glands or excessive removal of normal tissue. Postoperatively, patients not only exhibit wide and prominent scars that affect the appearance of the axillary region but may also experience discomfort due to skin defects that restrict upper limb movement. Additionally, the incidence of complications such as subcutaneous hematoma and skin necrosis is relatively high, and the recurrence rate remains elevated, making it difficult to meet the modern patient's demands for minimally invasive, aesthetically pleasing, and comfortable treatment [6,7].

Reversed skin flap turnover and stratified minimally invasive surgery is a minimally invasive technique optimized based on the anatomical structure of bromhidrosis. In this study, this technique achieved precise, minimally invasive, and efficient therapeutic effects through standardized preoperative localization, incision design, anesthesia, and hemostatic drainage procedures. Expanding the preoperative marking of the boundary of axillary hair distribution ensures comprehensive coverage of potential areas where apocrine sweat glands may be located, preventing postoperative residue and recurrence. Designing a 1.0–1.5 cm arc-shaped small incision along the axillary fold avoids major skin lines, ensuring sufficient surgical space while minimizing postoperative scar formation, aligning with cosmetic surgery principles. Local tumescent anesthesia combined with epinephrine effectively constricts local blood vessels, significantly reducing intraoperative blood loss. In this study, the intraoperative blood loss in the observation group was significantly lower than that in the control group. Additionally, tumescent anesthesia separates tissue spaces, facilitating skin flap dissection and reducing the risk of tissue damage.

During surgery, the reversed skin flap turnover allows for stratified removal of apocrine sweat glands under direct visualization, ensuring more thorough removal compared to the blind excision in traditional techniques, thereby effectively improving the treatment efficiency [8]. Strict control of electrocoagulation hemostasis time, combined with microporous negative pressure drainage or small fenestration drainage, and standardized postoperative "8-figure" bandage compression can effectively prevent complications such as subcutaneous hematoma and skin necrosis [9]. In this study, the overall complication rate in the observation group was significantly lower than that in the control group, highlighting the safety advantages of this technique. Furthermore, the minimally invasive small incision combined with cosmetic suturing results in

minimal postoperative scarring, with a VSS score significantly lower than that of traditional techniques. Patients experience no significant discomfort or restriction in upper limb movement, leading to a marked improvement in quality of life. The recurrence rate was only 2.00%, and patient satisfaction reached 94.00%, significantly superior to traditional techniques.

The results of this study indicate that reversed skin flap turnover and stratified minimally invasive surgery significantly outperforms traditional fusiform excision in terms of surgical trauma, treatment efficiency, complication control, scar aesthetics, recurrence rate, and patient satisfaction, aligning with conclusions from domestic studies on related minimally invasive bromhidrosis techniques. The core advantages of this technique are as follows: first, it is minimally invasive, with small incisions, minimal trauma, and reduced blood loss, leading to faster postoperative healing; second, it is precise, allowing for stratified operation under direct visualization, thorough removal of sweat glands, and reduced recurrence risk; third, it is aesthetically pleasing, with concealed incisions and minimal scarring, meeting patients' cosmetic needs; fourth, it is safe, with standardized hemostasis and drainage, a low complication rate, and smooth postoperative recovery.

However, when applying this technique clinically, the following points should be noted: precise preoperative marking to avoid inadequate coverage leading to residual sweat glands; gentle intraoperative manipulation and strict control of electrocoagulation intensity and duration to prevent skin burns and necrosis; uniform postoperative compression bandaging, close observation of local blood supply, and guidance for patients in postoperative care to avoid strenuous upper limb activity and reduce complication incidence [10]. Additionally, this technique requires a certain level of proficiency from the surgeon and should be performed after standardized training to ensure surgical effectiveness and safety.

5. Conclusion

In conclusion, reversed skin flap turnover and stratified minimally invasive surgery demonstrates significant clinical efficacy in treating bromhidrosis. Compared to traditional fusiform excision, it offers multiple advantages, including shorter surgical time, minimal trauma, reduced blood loss, faster incision healing, a low complication rate, minimal postoperative scarring, a low recurrence rate, and high patient satisfaction. It is safe and balances therapeutic effects with aesthetic needs, effectively improving patients' bromhidrosis symptoms and mental health while enhancing their quality of life. This technique is the preferred option for treating bromhidrosis and warrants promotion in vascular surgery clinics. Future studies could further expand the sample size, extend follow-up periods, and delve into the long-term efficacy and refined criteria for suitable patient populations to provide more comprehensive clinical references.

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Experience in Treating Atherosclerosis Based on Professor Guo Shuwen's Theory of "Qi Deficiency and Turbid Stasis"

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Abstract: Atherosclerosis is the pathological basis leading to various chronic internal diseases, such as peripheral atherosclerosis, coronary heart disease, cerebral infarction, etc. Professor Guo Shuwen, based on the pathophysiological characteristics of atherosclerosis and plaque formation, believes that the gradual decline in physical function and metabolic function in middle-aged and elderly people leads to the formation of pathological products, which in turn cause the occurrence and development of diseases. Therefore, clinical practice emphasizes the key pathological links of "gradual deficiency" or "intrinsic deficiency". Qi deficiency is the root cause of the formation of pathological products such as turbidity, phlegm, blood stasis, and toxicity. That is, Qi deficiency does not circulate, turbid phlegm is diffuse, and blood stasis is the main pathological characteristics. The theory of "Qi deficiency, turbidity, and blood stasis" is proposed to treat atherosclerosis. Clinically, the method of nourishing Qi to resolve turbidity and promoting blood circulation to clear the meridians is applied, and the therapeutic effect is satisfactory.

Keywords: Atherosclerosis; Guo Shuwen; Experience of renowned veteran Chinese medicine practitioners; Qi deficiency and turbid stasis

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1. Introduction

Atherosclerosis (AS) is the pathological basis for a variety of chronic internal medical diseases, including carotid atherosclerosis, lower extremity atherosclerosis/lower extremity atherosclerotic occlusive disease/lower extremity atherosclerotic gangrene, coronary heart disease, ischemic cardiomyopathy, cerebral infarction, among others. Modern medicine posits that atherosclerosis is a systemic disease characterized by degenerative and proliferative lesions of the arterial intima, mediated by lipid metabolism disorders and chronic inflammatory responses [1]. The initiating factors include endothelial dysfunction and lipid infiltration. Risk factors for atherosclerosis encompass hypertension, hyperlipidemia, diabetes, smoking, obesity, etc.

Key events involve increased permeability of damaged endothelium, allowing low-density lipoproteins (LDL) in the blood to enter and accumulate beneath the arterial intima, where they are oxidatively modified into ox-LDL, a potent pro-inflammatory substance. The core process involves inflammatory responses and plaque formation, where ox-LDL attracts monocytes into the intima, differentiating them into macrophages that engulf lipids and transform into foam cells, forming early lesions known as fatty streaks. During the plaque development phase, smooth muscle cells migrate and proliferate, synthesizing collagen fibers that, together with the lipid core and necrotic cell debris, constitute mature fibrous atherosclerotic plaques. Plaques can be classified as stable or unstable. Stable plaques have a thick fibrous cap, a small lipid core, and mild inflammation; unstable plaques have a thin fibrous cap, a large lipid core, active inflammation, and significant macrophage infiltration, making them prone to rupture or erosion, leading to secondary platelet aggregation, thrombosis, and acute cardiovascular and cerebrovascular events such as myocardial infarction and cerebral infarction. Currently, therapeutic targets for atherosclerosis primarily focus on controlling risk factors, including blood pressure reduction, lipid regulation, glycemic control, anti-inflammatory stabilization of plaques, antiplatelet therapy, and vascular reconstruction.

Professor Guo emphasizes the importance of addressing the key pathological link of "gradual deficiency" or "fundamental deficiency" in atherosclerosis, proposing that Qi deficiency is the root cause of pathological products such as turbidity, phlegm, blood stasis, and toxins, with the primary pathological characteristics being Qi deficiency failing to disperse, turbid phlegm pervading, and blood stasis obstructing the vessels. He advocates for the "Qi-Supplementing and Turbidity-Resolving, Blood-Activating and Meridian-Unblocking" method as the primary treatment for this condition, achieving satisfactory therapeutic effects.

2. Treating atherosclerosis from the perspective of the spleen and stomach

Classic ancient TCM texts do not mention the modern term "atherosclerosis", but descriptions of its clinical manifestations such as chest pain, dizziness, and limb numbness, as well as its pathological essence such as sluggish pulse channels and obstruction, are scattered among records of conditions like "chest obstruction", "true heart pain", "pulse obstruction", "vertigo", "phlegm retention" and "blood stasis". The core understanding of its syndrome differentiation and treatment can be summarized as follows:

2.1. Core etiology and pathogenesis of atherosclerosis

2.1.1. Dietary and labor-induced injury to the spleen and stomach, leading to internal generation of turbid phlegm

"Su Wen · Jing Mai Bie Lun" states, "Food Qi enters the stomach, turbid Qi goes to the heart, and the essence permeates the vessels", indicating that dietary essence can transform into nutrient blood, but excessive rich and greasy foods generate "turbid Qi", akin to modern lipid metabolism disorder products. "Dan Xi Xin Fa" explicitly proposes, "Phlegm entwined with blood stasis forms nests", recognizing that turbid phlegm and blood stasis intertwine to form tangible pathogenic factors, similar to modern medical plaques, obstructing the channels.

2.1.2. Emotional internal injury, leading to Qi stagnation and blood stasis

"Su Wen · Ju Tong Lun" states, "All diseases arise from Qi". Prolonged worry, anger, and frustration lead to Qi stagnation, which in turn causes blood stasis, obstructing the heart vessels. This aligns with "Zheng Zhi

Zhun Sheng", which says, "Depression and anger injure the liver, causing Qi reversal and blood stasis".

2.1.3. Aging and decline, leading to kidney essence deficiency

"Ling Shu · Ying Wei Sheng Hui" states, "The elderly have declining Qi and blood, with withered muscles and sluggish channels", indicating that aging leads to reduced Qi and blood, making the channels sluggish and providing an internal basis for disease. The kidney is the root of primordial Qi; kidney deficiency leads to insufficient Qi, resulting in weak propulsion and easy formation of phlegm and blood stasis.

2.1.4. Invasion of cold pathogens, leading to stagnant blood

"Su Wen · Ju Tong Lun" states, "Cold Qi enters the channels, causing delay and stagnation...lodging in the vessels obstructs Qi flow". Cold's contracting and stagnating nature can induce or exacerbate vessel obstruction and pain, explaining why such conditions often worsen in cold seasons or after exposure to cold.

2.2. Therapeutic principles for atherosclerosis

Although classic ancient texts do not have dedicated sections, they establish therapeutic principles and herbal formulas targeting the core pathogenesis, deficiency, phlegm, blood stasis, and stagnation, laying the framework for later differentiation and treatment. Based on in-depth study and analysis of classic TCM texts, Professor Guo Shuwen proposes the "Qi Deficiency, Turbidity and Blood Stasis" theory, establishing the "Qi-Supplementing and Turbidity-Resolving, Blood-Activating and Meridian-Unblocking" method for treating this condition.

2.2.1. General therapeutic principles

Combine tonification and dredging, with dredging as the priority.

2.2.2. "Dredging" method

Targets tangible pathogenic factors such as phlegm, blood stasis, and Qi stagnation, including blood-activating and stasis-resolving, phlegm-resolving and turbidity-eliminating, and Qi-moving and channel-unblocking approaches. As stated in "Su Wen · Zhi Zhen Yao Da Lun", "Dredge the blood and Qi to make them harmonious and unobstructed".

2.2.3. "Tonification" method

Targets fundamental deficiencies such as Qi deficiency, yang deficiency, and kidney deficiency, focusing on Qi-supplementing and yang-warming, kidney-tonifying and primordial Qi-nourishing approaches.

2.3. Herbal formula composition ideas

Professor Guo Shuwen's self-created "Lipid-Regulating and Meridian-Unblocking Formula" consists of: Raw Astragalus 30 g, Angelica Sinensis 15 g, Raw Hawthorn 20 g, Alisma 12 g, Cassia Seed 30 g, Earthworm 15 g, Notoginseng Powder 6 g. In this formula, Astragalus and Angelica Sinensis, drawing from Angelica Blood-Supplementing Decoction, supplement Qi to generate blood, addressing fundamental deficiency and promoting new blood while resolving stasis; Angelica Sinensis enters the heart, liver, and spleen channels, supplementing and activating blood, serving as a sovereign medicine for blood supplementation, and when paired with Astragalus to supplement Qi and strengthen the spleen, it prioritizes strengthening the body

before eliminating pathogens. Stagnant blood leads to blood stasis, which over time obstructs the channels, generating turbid phlegm and blood stasis. Ye Gui said, "I often use swift-moving insects and ants to promote blood circulation, making ascending substances rise and descending substances fall, preventing blood stagnation and promoting Qi circulation", hence Earthworm is used to unblock the channels and guide other herbs to their respective channels; Notoginseng Powder is used to activate blood and resolve stasis, unblock the channels and promote blood circulation, while Hawthorn promotes blood and Qi circulation; Alisma and Cassia Seed, which eliminate dampness and resolve phlegm, activate blood and resolve stasis, work together to achieve the effects of supplementing Qi, resolving turbidity, activating blood, and unblocking the channels.

Modern pharmacological studies have confirmed that Astragalus polysaccharides can significantly reduce serum levels of total cholesterol, malondialdehyde, triglycerides, and endothelin, alleviating endothelin-induced vascular damage [2]. The active components of Angelica Sinensis can increase the absorption of intracellular oxygen free radicals, inhibit platelet aggregation and vascular smooth muscle proliferation [3]. Angelica Blood-Supplementing Decoction, originating from Li Gao's "Nei Wai Shang Bian Huo Lun" and composed of Astragalus and Angelica Sinensis, has been found through network pharmacology and molecular docking studies [4] that its core active components such as quercetin, kaempferol, and isorhamnetin can regulate pathways related to inflammation, oxidative stress, and lipid metabolism by acting on relevant hub targets such as TNF, IL1B, IL6, and AKT1, thereby achieving therapeutic effects on atherosclerosis. The active components of Earthworm can reduce blood lipids and enhance cholesterol conversion and excretion [5]. The active component of Notoginseng, notoginsenoside, can alleviate endothelial cell damage caused by harmful factors, while notoginseng flavonoids can significantly increase high-density lipoprotein in the blood, neutralizing "toxins" in the blood and softening blood vessels [6]. Hawthorn leaf flavonoids can reduce serum levels of nitric oxide, C-reactive protein, and tumor necrosis factor in rabbits, increase superoxide dismutase and glutathione peroxidase levels, achieving anti-atherosclerotic effects [7]. Alisma-containing serum can increase superoxide dismutase (SOD) levels in vascular endothelial cells after action, indicating that Alisma may protect vascular endothelial cells by increasing SOD to counteract oxygen free radicals [8]. The anthraquinone glycosides in Cassia Seed are the main components that increase cholesterol absorption; additionally, the phenolic compounds in Cassia Seed can exhibit antioxidant effects, preventing the aggregation of oxidized low-density lipoproteins [9].

Previous studies have shown that the Lipid-Regulating and Meridian-Unblocking Formula can significantly reduce blood lipids, improve vascular endothelial damage, alleviate plaque lesions, and reduce the formation of atherosclerosis; it can reduce serum levels of IL-6, CRP, and IL-17, repair the structure and function of damaged vascular endothelial cells, and reduce lipid deposition in the arterial intima; it can lower levels of MMP-1, MMP-2, PD-ECGF, and UA, increase TIMP-1 levels, thereby affecting vascular remodeling in atherosclerosis and improving the condition; it can reduce levels of endothelial cell markers endothelin (ET-1) and thromboxane A2 (TXA2), increase expression of nitric oxide synthase (eNOS) and prostacyclin I2 (PGI2), improving vascular endothelial cell damage and alleviating atherosclerosis [10–12].

"The channels must be unobstructed for Qi and blood to flow" is a fundamental physiological principle. The essence of atherosclerosis is summarized as "obstructed channels", with its key pathological products being "turbid phlegm" and "blood stasis", which intertwine and are difficult to resolve. Syndrome differentiation indicates a "fundamental deficiency with superficial excess". Deficiency of yang Qi (or primordial Qi) in the heart, spleen, and kidney is the root, while turbid phlegm, blood stasis, Qi stagnation,

and cold congealing are the manifestations. Treatment must balance deficiency and excess, considering urgency and chronicity. This provides a source for the modern concept of "treating from the perspective of toxin-damaged collateral vessels". Concepts such as "turbid Qi" and "nests" in ancient texts already contain the embryonic idea of "toxicity" causing disease and damaging collateral vessels, aligning with modern research on inflammatory responses and oxidative stress damaging the endothelium.

In summary, TCM, from the perspective of overall functional imbalance, reveals that the core pathogenesis of atherosclerosis is fundamental deficiency with intertwined turbid phlegm and blood stasis obstructing the channels as the manifestations, establishing a basic treatment strategy of supplementing deficiency, resolving turbidity, activating blood, and unblocking the channels, achieving good clinical effects, especially with significant advantages in improving symptoms and adjusting constitution.

3. Stage-based treatment of atherosclerosis

Early-stage atherosclerosis: Focus on "strengthening the spleen and supplementing Qi to aid digestion and transportation", using a modified Lipid-Regulating and Meridian-Unblocking Formula. This formula combines attack and tonification, treating both the root and manifestations, with Astragalus and Angelica Sinensis supplementing Qi and nourishing blood to address the root, while Hawthorn, Alisma, and Cassia Seed resolve phlegm and eliminate turbidity to treat the manifestations, considering the pathogenesis of fundamental deficiency with superficial excess in this condition.

Middle-stage coronary heart disease, cerebral artery stenosis, peripheral atherosclerotic stenosis or occlusion: Adopt the method of "supplementing Qi and activating blood, unblocking the channels and relieving pain", using a modified combination of the Lipid-Regulating and Meridian-Unblocking Formula and a Qi-supplementing and blood-activating formula. At this stage, patients experience further aggravation of channel obstruction, presenting with symptoms such as chest pain, chest tightness, dizziness, lower limb numbness, pain, and intermittent claudication. The treatment focus is on reversing the disease trend and preventing acute cardiovascular and cerebrovascular events and ischemic gangrene, supplementing the spleen and strengthening the kidney, resolving blood stasis and unblocking the channels to prevent transmission and transformation. In conjunction with TCM treatment, modern minimally invasive interventional therapies such as coronary interventional therapy, cerebral artery interventional therapy, and peripheral artery interventional therapy can be considered based on the actual condition to avoid acute myocardial infarction, acute cerebral infarction, and atherosclerotic gangrene.

Late-stage heart failure after myocardial infarction or heart failure caused by ischemic cardiomyopathy, cerebral infarction, atherosclerotic gangrene: Supplement the spleen and strengthen the kidney to prevent transmission and transformation, using modified formulas such as Buyang Huanwu Decoction, Zhenwu Decoction, Fangji Huangqi Decoction, Tingli Dazao Xiefei Decoction, and Danggui Sini Decoction. At this stage, patients are critically ill with complex etiology and pathogenesis, requiring careful syndrome differentiation in clinical practice to turn the tide and restore stability.

4. Sharing of medical records

Mr. Zhao, male, aged 73, first visited on December 12, 2024. Chief complaint: bilateral lower limb soreness after activity for half a year. Present condition: bilateral lower limb soreness after activity, with the right

side more severe than the left, significantly limited activity, and symptoms appearing after walking 200–300 meters. The skin color of both lower limbs is slightly dark, with normal skin temperature, and weakened pulse of the right dorsal artery of the foot. The tongue is dark with a white and greasy coating, and the pulse is deep. On December 4, a lower extremity vascular ultrasound at Beijing Tsinghua Changgung Hospital revealed atherosclerotic plaque formation in both lower extremity arteries, with multiple segmental stenoses (moderate to severe) in the lumen of the right superficial femoral artery, and intervention therapy was recommended. The disease was identified as arterial obstruction, and the syndrome differentiation was Qi deficiency, blood stasis, and phlegm obstruction. The treatment aimed to replenish Qi, resolve turbidity, promote blood circulation, and unblock the meridians, using a modified Danggui Sini Decoction + Lipid-Regulating and Meridian-Unblocking Formula: Danggui (*Angelica sinensis*) 30 g, Guizhi (*Cinnamomum cassia*) 15 g, Chishao (*Paeonia lactiflora*) 15 g, Xixin (*Asarum heterotropoides*) 10 g, Zhigancao (*Glycyrrhiza uralensis*) 10 g, Xiaotongcao (*Tetrapanax papyriferus*) 6 g, Huangqi (*Astragalus membranaceus*) 30 g, Dilong (*Pheretima*) 15g, Wugong (*Scolopendra*) 2 pieces, Gualou (*Trichosanthes kirilowii*) 10 g, Xiebai (*Allium macrostemon*) 25 g, Fabanxia (*Pinellia ternata*) 9 g, Fuling (*Poria cocos*) 15 g, Zexie (*Alisma orientale*) 15 g, Chaojuemingzi (*Cassia obtusifolia*) 15 g, Jiaoshanzha (*Crataegus pinnatifida*) 15 g, 7 doses, decocted in water and taken orally, one dose per day, divided into morning and evening servings, 150 mL each time.

On the second visit on December 19, 2024, after taking the above prescription, the soreness in both lower limbs decreased, and activity tolerance increased. Currently, he could walk 400–500 meters slowly with rare episodes of lower limb soreness, and the feeling of coldness in the lower limbs significantly decreased. The modified Danggui Sini Decoction + Lipid-Regulating and Meridian-Unblocking Formula was continued: Danggui 30 g, Guizhi 15 g, Chishao 15 g, Xixin 10 g, Zhigancao 10 g, Xiaotongcao 6 g, Huangqi 50 g, Dilong 15 g, Wugong 2 pieces, Gualou 10 g, Xiebai 25 g, Fabanxia 9 g, Fuling 15g , Zexie 15 g, Chaojuemingzi 15 g, Jiaoshanzha 15 g, Jingshanzha (Crataegus pinnatifida var. major) 10g, 7 doses, decocted in water and taken orally, one dose per day, divided into morning and evening servings, 150ml each time. Subsequently, he returned for follow-up every two weeks.

After more than four months of treatment, the soreness in the lower limbs disappeared. On April 17, 2025, a follow-up lower extremity vascular ultrasound at Beijing Tsinghua Changgung Hospital revealed atherosclerotic plaque formation in both lower extremity arteries, with mild to moderate stenosis in the lumen of the right superficial femoral artery. Both the patient's subjective symptoms and objective examinations indicated significant improvement in the condition.

Comment: With the improvement of people's living standards and the influence of unhealthy lifestyles, the number of patients with lower extremity vascular occlusion caused by atherosclerosis is on the rise. Currently, Western medicine treatment mainly focuses on lipid regulation, plaque stabilization, and control of high-risk factors, with peripheral vascular intervention therapy being the main treatment for severe stenosis or occlusion. However, the current treatment efficacy is not satisfactory and has certain limitations. The etiology of atherosclerosis is complex, and modern research has only revealed part of the causes. How to combat atherosclerosis and achieve plaque reversal is an urgent problem to be solved. In traditional Chinese medicine, "lower extremity atherosclerotic stenosis" falls under the categories of "arterial obstruction" and "blood obstruction". Professor Guo Shuwen believes that in the clinical treatment of atherosclerotic diseases, attention should be paid to syndrome differentiation from the aspects of Qi and blood, phlegm turbidity, and

blood stasis. The application of traditional Chinese medicine in treating such diseases has certain advantages. The Lipid-Regulating and Meridian-Unblocking Formula is an empirical formula created by Professor Guo Shuwen, which has the effects of lowering blood lipids and combating atherosclerosis, and has shown plaque reversal effects in clinical applications. Further research is needed to elucidate its mechanism of action, improve efficacy, and promote its large-scale clinical application.

Danggui Sini Decoction originates from "Treatise on Febrile Diseases · Differentiation and Treatment of Jueyin Meridian Disease Based on Pulse and Syndrome", which has the effects of warming the meridians, dispelling cold, nourishing blood, and unblocking the meridians. It is mainly used for treating blood deficiency and cold extremity syndrome, with typical manifestations of cold extremities, or pain in the waist, thighs, legs, feet, shoulders, and arms, no thirst, pale tongue with a white coating, and a deep, thin, or faint pulse. The clinical manifestations of blood deficiency and cold extremity syndrome are similar to those of lower extremity atherosclerotic occlusion in modern medicine. Therefore, the author combined Danggui Sini Decoction with Professor Guo Shuwen's Lipid-Regulating and Meridian-Unblocking Formula in treating this disease to warm the meridians, dispel cold, promote blood circulation, remove blood stasis, nourish blood, and unblock the meridians, aiming to treat both the symptoms and the root cause and further improve efficacy. Practice has proven that the combination of the two formulas has indeed achieved plaque reversal, improved clinical symptoms, and objective examinations also indicate a reduction in lower extremity arterial stenosis, avoiding the trauma caused by surgery and reducing medical costs. During the apprenticeship, the author applied Danggui Sini Decoction combined with the Lipid-Regulating and Meridian-Unblocking Formula to treat multiple patients with lower extremity atherosclerotic stenosis, all achieving satisfactory efficacy, which is worthy of further research and clinical promotion.

5. Summary

Professor Guo Shuwen emphasizes treating atherosclerotic diseases from the perspective of the spleen and stomach, revealing the core role of spleen dysfunction in the pathogenesis of atherosclerosis. "Su Wen · Jing Mai Bie Lun" states: "When food Qi enters the stomach, turbid Qi goes to the heart and nourishes the meridians with essence". It points out that dietary essence can be transformed into nutrient blood or generate "turbid Qi", which is similar to the products of lipid metabolism disorders referred to in modern medicine. "Dan Xi Xin Fa" clearly proposes: "Phlegm combined with blood stasis forms a nest". It recognizes that phlegm turbidity and blood stasis combine to form tangible pathogenic factors, similar to plaques in modern medicine, which block the meridians. Professor Guo Shuwen has deeply studied the classics, comprehensively understood the etiology, pathogenesis, course, progression, and clinical outcomes of atherosclerotic diseases, and emphasized early prevention and treatment. Early intervention in atherosclerosis can effectively reduce the incidence of myocardial infarction and cerebral infarction, which is of great clinical significance.

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Disclosure statement

The authors declare no conflict of interest.

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Research Progress on the Mechanisms and Management Strategies of Pneumonia in Patients with Schizophrenia

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Abstract: Patients with schizophrenia are at high risk of developing pneumonia, with significantly higher incidence and mortality rates than the general population, a public health issue that warrants urgent attention. This article systematically reviews the epidemiological characteristics of pneumonia susceptibility in schizophrenia patients, deeply explores the multifaceted risk factors, including disease-specific features, antipsychotic medication effects, behavioral and lifestyle factors, and immune dysfunction. Based on this, the article further analyzes the core pathophysiological mechanisms underlying this susceptibility and comprehensively summarizes strategies for pneumonia prevention, early identification, and treatment. By integrating the latest research evidence, this review aims to provide a theoretical basis for developing targeted comprehensive management strategies in clinical practice, thereby improving the physical health status and long-term prognosis of patients with schizophrenia.

Keywords: Schizophrenia; Pneumonia; Risk factors; Antipsychotics; Comprehensive management

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1. Introduction

The risk of pneumonia in patients with schizophrenia is significantly higher than in the general population, and this susceptibility is collectively driven by disease-specific factors, medications, behaviors, and biological factors [1]. Monotherapy is associated with a dose-dependent increase in pneumonia risk; high-dose quetiapine (≥ 440 mg/d), medium-to-high-dose clozapine (≥ 180 mg/d), high-dose olanzapine (≥ 11 mg/d), and medications with high anticholinergic burden pose particularly prominent risks; clozapine, quetiapine, and olanzapine are associated with increased rates of hospital-acquired pneumonia infection [2,3]. Concomitant use of benzodiazepines, mood stabilizers (e.g., sodium valproate), or modified electroconvulsive therapy (MECT) further increases the risk of hospital-acquired pneumonia [4,5]. Advanced age, male sex, prolonged

hospitalization, malnutrition (low serum albumin), sarcopenia (assessed by Ishii test, calf circumference, or SARC-CalF), and smoking and alcohol consumption are all risk factors [6–9]; the severity of sarcopenia is positively correlated with pneumonia risk [10]. The anticholinergic effects of clozapine lead to excessive salivation, dysphagia, and increased aspiration risk; excessive sedation suppresses cough reflex and airway clearance function; it may cause neutropenia, weakening host defenses [6,11]. Schizophrenia (especially first episode) is associated with intestinal barrier disruption, bacterial translocation (e.g., *Klebsiella pneumoniae*), and immune complex formation, linked to systemic inflammation and increased susceptibility to infection [12]. Patients with schizophrenia spectrum disorders have a higher risk of severe illness and death after SARS-CoV-2 infection [13,14], and long-term antipsychotic treatment may exert certain effects on inflammatory responses [15]. Leptin receptor (*LEPR*) gene polymorphisms are associated with pneumonia risk in clozapine-treated patients; the role of host microbiota in clozapine-induced ileus and pneumonia is being explored [16,17].

2. Analysis of multiple risk factors for pneumonia susceptibility in patients with schizophrenia

2.1. Intrinsic disease factors and behavioral lifestyle risks

Patients with schizophrenia have a significantly increased risk of developing pneumonia, with intrinsic disease factors and behavioral lifestyle factors forming a complex and intertwined risk network. First, the psychiatric symptoms themselves pose a direct threat to the patient's physiological defense mechanisms. Negative symptoms, such as avolition and social withdrawal, severely impair patients' self-care abilities, leading to poor oral hygiene and increased colonization and proliferation of oral pathogens [6]. Concurrently, cognitive impairments affect swallowing coordination and the cough reflex, significantly raising the risk of silent aspiration, a key trigger for aspiration pneumonia [6]. Positive symptoms, such as delusions, may lead patients to refuse medical care or non-compliance with preventive treatments, delaying early intervention. Second, patients with schizophrenia have a very high smoking rate, reaching 50–80% [6]. Tobacco smoke directly damages the mucociliary clearance function of the respiratory tract and inhibits alveolar macrophage activity, disrupting the first line of defense against pathogens in the lungs. Additionally, substance abuse, such as alcohol and drugs, further depresses the central nervous system, weakens protective reflexes, and causes immune system dysfunction, making patients more susceptible to severe infections [6]. Malnutrition and obesity are other significant risk factors. Due to irregular eating habits, metabolic disorders induced by antipsychotics, and other reasons, patients often suffer from malnutrition or obesity. Studies have shown that decreased serum albumin levels are significantly associated with an increased risk of pneumonia in female patients with stable schizophrenia [8]. Whether it is insufficient immune protein synthesis due to malnutrition or the chronic low-grade inflammatory state caused by obesity, immune function is compromised. Finally, socioeconomic factors, such as low income, poor living conditions, and weak social support systems, limit patients' access to timely, high-quality medical care and the ability to maintain healthy living conditions, indirectly increasing infection risk [6].

2.2. Direct effects of antipsychotic medications

While controlling psychiatric symptoms, antipsychotic medications also directly increase the risk of pneumonia in patients through their pharmacological effects, with this association being dose-dependent and drug-specific. The primary risk stems from the sedative effects of these drugs. Especially first-generation and

certain second-generation antipsychotics with strong sedative properties can cause excessive sedation and reduced level of consciousness, significantly increasing the risk of aspiration, a key precipitant of aspiration pneumonia [6]. Second, anticholinergic side effects represent one of the core mechanisms increasing pneumonia risk. Many antipsychotics possess anticholinergic properties, leading to reduced salivation (dry mouth) and directly affecting the swallowing center, causing swallowing dysfunction [2]. A large cohort study clearly indicated that only the use of antipsychotics with a high anticholinergic burden was associated with an increased risk of pneumonia [2]. This "silent aspiration" allows oral secretions and food debris to more easily enter the lower respiratory tract. Regarding specific drug risks, clozapine stands out as the most prominent. Research confirms that clozapine use is significantly associated with an increased risk of upper respiratory infections progressing to pneumonia [18]. This risk exhibits a dose-dependent pattern, with both medium and high doses of clozapine associated with an increased risk of pneumonia (adjusted hazard ratios of 1.43 and 1.44, respectively) [2]. Furthermore, although rare, clozapine can cause severe agranulocytosis, leading to the collapse of the body's first line of defense against bacterial infections, making severe pneumonia highly likely [11]. Other drugs, such as high-dose quetiapine (≥ 440 mg/d) and high-dose olanzapine (≥ 11 mg/d), have also been confirmed to be associated with an increased risk of pneumonia[2]. Finally, the metabolic side effects of antipsychotics, such as weight gain, elevated blood glucose, and dyslipidemia, create a chronic low-grade inflammatory state, indirectly weakening the body's immune response to acute infections [6]. Notably, the combined use of antipsychotics, especially with benzodiazepines and mood stabilizers, further increases the risk of hospital-acquired pneumonia [4].

2.3. Underlying state of immune system dysfunction

Patients with schizophrenia have an inherent state of immune system dysfunction, which constitutes the biological basis for their susceptibility to pneumonia. This dysfunction exists even in medication-naïve patients. First, innate immune abnormalities are a core feature. Studies show alterations in immune markers in patients with schizophrenia, such as elevated levels of pro-inflammatory cytokines (e.g., IL-6, TNF-α), suggesting underlying immune activation or dysregulation [12]. This chronic, non-specific inflammatory background may impair effective immune responses against specific pathogens, preventing the body from mounting a precise and robust defense when facing bacterial or viral infections. Second, adaptive immune responses may also be impaired. Some studies have found that patients with schizophrenia exhibit weaker antibody responses to vaccines (e.g., influenza vaccine, pneumococcal vaccine) compared to healthy controls, suggesting potential defects in B cell function or helper T cell function [19]. A preclinical study also found that the antipsychotic risperidone disrupts antibody responses to pneumococcal vaccine in mice, which may have similar implications in clinical patients. This weakening of adaptive immune responses makes it difficult for patients to gain adequate protection through vaccination and also affects the production of specific antibodies post-infection. Furthermore, alterations in immune cell function have been widely reported. For instance, functional abnormalities in macrophages and natural killer (NK) cells suggest inherent deficiencies in immune surveillance and pathogen clearance [19]. Such functional defects in immune cells prevent the effective recognition and elimination of pathogens in the early stages of invasion, creating conditions conducive to the establishment and spread of infection. Additionally, genetic factors play a role. Research indicates that specific polymorphisms in the leptin receptor (*LEPR*) gene are associated with a significantly increased risk of pneumonia in Taiwanese schizophrenia patients treated with clozapine, with

individuals carrying certain genotypes facing a nearly 15-fold increased risk [16]. This reveals how individual genetic differences interact with the underlying immune state under drug exposure to collectively determine susceptibility to pneumonia.

3. Exploration of core pathophysiological mechanisms of pneumonia in patients with schizophrenia

3.1. Cascade mechanism from aspiration to infection

In the pathophysiology of pneumonia in patients with schizophrenia, the cascade from aspiration to infection is a central component. First, patients' defense reflex systems are often compromised due to the disease itself and pharmacological treatments. Multiple studies confirm that antipsychotics, particularly those with a high anticholinergic burden, are significantly associated with an increased risk of pneumonia [2]. Anticholinergic effects inhibit the cough reflex and swallowing reflex, allowing oropharyngeal secretions or gastric contents to easily enter the lower respiratory tract without being effectively cleared, which is a direct cause of aspiration pneumonia [6]. Second, aspirated material contains oral flora. After these bacteria colonize the lungs, the patients' impaired local immune defenses cannot effectively clear the pathogens. Studies show that patients with schizophrenia often suffer from malnutrition and sarcopenia, which can lead to decreased systemic and local immune function [7,8]. For example, decreased serum albumin level is an independent factor associated with pneumonia risk in female patients with stable schizophrenia [8]. Finally, the underlying chronic low-grade inflammatory state present in patients with schizophrenia may lead to an imbalance in the inflammatory response in the lungs upon infection. This imbalance may manifest as insufficient response, leading to pathogen dissemination, or excessive response, causing severe tissue damage and even acute respiratory distress syndrome (ARDS). Some research suggests that in patients with schizophrenia, cytokines released during infection may affect the central nervous system, exacerbate psychiatric symptoms and forming a vicious cycle [6].

3.2. Dysregulation of the neuro-immune-endocrine network

The susceptibility of patients with schizophrenia to pneumonia is closely related to the dysregulation of their intrinsic neuro-immune-endocrine network. Hypothalamic-pituitary-adrenal (HPA) axis dysfunction is a key component. Patients with schizophrenia often exhibit HPA axis hyperactivity, leading to chronically elevated cortisol levels. This long-term high-cortisol environment exerts widespread immunosuppressive effects, particularly inhibiting cellular immunity and appropriate inflammatory responses, thereby reducing resistance to intracellular pathogens (e.g., viruses, *Mycobacterium tuberculosis*) [6]. Autonomic nervous system dysfunction, particularly altered vagal tone, is another important factor. Vagal dysfunction may affect the function of immune cells like macrophages and interfere with the fine-tuning of systemic inflammatory responses via the cholinergic anti-inflammatory pathway. This dysregulation of neuroimmune interaction may partially explain why patients on antipsychotics with high anticholinergic burden have a higher risk of pneumonia [2]. Furthermore, there is a bidirectional relationship between infection and psychiatric symptoms. Pro-inflammatory cytokines (e.g., IL-1β, IL-6) released during infection can cross the blood-brain barrier or affect the brain via vagal afferents, potentially exacerbating existing psychiatric symptoms [6]. The worsening of psychiatric symptoms further impairs patients' self-care abilities, such as neglecting personal hygiene or inability to effectively expectorate sputum, thus increasing the risk of pneumonia occurrence or

worsening, forming a vicious cycle of "infection – worsening psychiatric symptoms – further decline in self-care ability". This complex network dysregulation highlights the particular challenges and complexities of managing pneumonia in patients with schizophrenia.

3.3. Disruption of respiratory barrier structure and function

Disruption of the structure and function of the respiratory barrier is an important pathological basis for pulmonary susceptibility in patients with schizophrenia. First, dysfunction of the mucociliary clearance system is a common issue. The prevalent smoking habit among patients, along with the potential effects of certain antipsychotics, may lead to decreased mucociliary motility in the respiratory tract, preventing inhaled pathogens from being promptly cleared by the mucus [6]. Second, the integrity of the airway epithelial barrier may be compromised. The chronic inflammation and oxidative stress present in patients with schizophrenia may disrupt tight junctions between airway epithelial cells, increasing the risk of pathogen invasion into submucosal tissues. Studies suggest that different immune and oxidative stress pathway abnormalities exist in first-episode and multi-episode schizophrenia patients, which may extend systemically, including the respiratory barrier [12]. Finally, the alveolar surfactant system may be abnormal. Surfactant proteins play a critical role not only in reducing alveolar surface tension but also possess essential immune defense functions. It is hypothesized that certain genes associated with schizophrenia might affect the expression or function of pulmonary surfactant proteins, and their abnormalities could increase susceptibility to pneumonia [20]. Additionally, sarcopenia, a common comorbidity in patients with schizophrenia, is directly related to pneumonia risk, with its severity correlating with increased risk [10]. Muscle function decline, particularly respiratory muscle weakness, directly affects cough efficiency and airway clearance capability, further compromising the physical barrier function. These disruptions in barrier function collectively constitute structural vulnerabilities for pathogen colonization and infection development.

4. Comprehensive management strategies for pneumonia in patients with schizophrenia

4.1. Prevention strategies: Tiered intervention and active surveillance

Prevention of pneumonia in patients with schizophrenia requires a tiered intervention strategy. The core of primary prevention lies in universal measures. Given that patients with schizophrenia are at high risk for pneumonia, with a significantly higher prevalence than the general population, routine vaccination is crucial [1]. Evidence suggests that pneumococcal vaccination coverage is inadequate, and unvaccinated individuals may face severe consequences of invasive pneumococcal disease (e.g., bacteremia) [21]. Therefore, vigorously promoting and routinely administering influenza and pneumococcal vaccines to all patients with schizophrenia, and monitoring antibody responses, constitutes a fundamental public health measure to reduce infection risk. Concurrently, given the prevalent risks of malnutrition and sarcopenia in patients, nutritional support is indispensable. Studies indicate that decreased serum albumin levels and reduced calf circumference are associated with increased pneumonia risk, highlighting the importance of early nutritional assessment and intervention [8,22]. Furthermore, conducting health education for patients and caregivers to enhance awareness of early pneumonia symptoms (e.g., fever, cough, dyspnea) facilitates early identification and medical consultation.

Secondary prevention focuses on targeted interventions for high-risk patients. Identifying high-risk

factors is key, including advanced age, use of specific antipsychotics (especially clozapine, olanzapine, quetiapine, particularly at high doses), concomitant use of benzodiazepines or mood stabilizers, receiving modified electroconvulsive therapy (MECT), and presence of dysphagia or sialorrhea symptoms [2,5,6]. For these patients, routine swallowing function assessment should be conducted. If abnormalities are found, consider adjusting antipsychotic medication (e.g., switching to drugs with fewer anticholinergic side effects) and implementing physical interventions such as postural adjustments during eating and modification of food consistency. Enhancing oral care interventions to reduce oropharyngeal pathogen colonization is also an important aspect of preventing aspiration pneumonia [2].

Tertiary prevention aims to prevent complications, primarily targeting patients with schizophrenia who already have chronic respiratory diseases (e.g., chronic obstructive pulmonary disease). This patient group inherently has a high prevalence of respiratory diseases[1] and requires enhanced chronic disease management to ensure regular medication and reduce acute exacerbations. In psychiatric inpatient settings, strict implementation of infection control protocols is particularly important. Hospitalization duration is an independent risk factor for hospital-acquired pneumonia, and polypharmacy during hospitalization (including antipsychotics combined with MECT, benzodiazepines, mood stabilizers) significantly increases pneumonia risk [3,4]. Therefore, optimizing the inpatient environment, shortening unnecessary hospital stays, carefully evaluating the necessity of combination therapies, and strictly enforcing infection control measures such as hand hygiene and environmental disinfection are crucial for reducing nosocomial infection risk.

4.2. Treatment strategies: Multidisciplinary collaboration and individualized medication

The treatment of pneumonia in patients with schizophrenia presents unique challenges and requires multidisciplinary collaboration and individualized medication. Early identification and diagnosis are primary challenges. Due to potential communication difficulties or atypical symptom presentation, healthcare professionals must maintain a high index of suspicion for non-typical manifestations. For instance, sudden worsening of psychiatric symptoms, lethargy, or refusal to eat may be the initial or sole symptoms of pneumonia [6]. Therefore, for any patient with unexplained deterioration in health status, timely detailed physical examination and chest imaging should be performed to avoid delayed diagnosis.

The choice of anti-infective therapy requires special consideration. Given the high aspiration risk in patients with schizophrenia, empirical antibiotic selection should cover aspiration-related anaerobes and Gram-negative bacteria. Close monitoring for drug interactions is particularly important. Certain antibiotics (e.g., fluoroquinolones, macrolides) can prolong the QTc interval, and co-administration with many antipsychotics may synergistically increase the risk of arrhythmias [2]. Additionally, the inhibition of antipsychotic-metabolizing enzymes (e.g., CYP1A2) can lead to drug toxicity and increase pneumonia risk, so the impact on liver enzymes should be considered when selecting antibiotics [16].

Adjustment of psychiatric medications is a core component of treatment. During severe pneumonia, it is necessary to assess whether to temporarily reduce the dose or switch to antipsychotics with weaker sedative effects and fewer anticholinergic side effects to reduce aspiration risk due to excessive sedation and improve ventilatory function[2]. However, this decision requires careful balancing against the risk of psychiatric symptom relapse. Studies show that antipsychotic monotherapy, especially with high anticholinergic burden drugs, is associated with increased pneumonia risk [2]. For patients on clozapine, considering dose reduction during upper respiratory tract infections may help prevent progression to pneumonia [18]. However, any

adjustments should be made under the guidance of a psychiatrist with close monitoring of psychiatric status.

Supportive care and rehabilitation are crucial for prognosis. Ensuring adequate oxygenation, meticulous fluid management, and nutritional support is fundamental. Given the strong association of malnutrition and sarcopenia with pneumonia occurrence and poor outcomes [8–10], active nutritional intervention is indispensable. Early implementation of respiratory rehabilitation training, such as deep breathing exercises, effective coughing, and postural drainage, can help improve lung function and promote sputum clearance. Concurrently, active management of comorbidities, such as glycemic control and management of chronic cardiopulmonary diseases, is essential. For elderly or critically ill patients, multidisciplinary team collaboration can be considered, and the potential of combining antipsychotics with traditional Chinese medicine may be explored, as the latter may help shorten hospital stays when used in combination [23].

4.3. System optimization and future research directions

Optimizing the management of pneumonia in patients with schizophrenia requires systemic innovation and promotion of cutting-edge research. The primary task is to establish integrated care models. The current fragmentation between physical and mental health services must be addressed by actively promoting deep collaboration between mental health institutions and respiratory, infectious disease, and geriatric departments in general hospitals. Establishing dedicated physical health management pathways for patients with severe mental illness can ensure they receive timely, equitable, and high-quality medical care for physical illnesses. This model facilitates the systematic implementation of preventive strategies and early detection for treatment.

Drug development should focus on novel targets. Existing antipsychotics, especially clozapine, olanzapine, and quetiapine, whose sedative and anticholinergic effects, along with potential impacts on immune function, are important factors increasing pneumonia risk [2,11]. Future research and development should aim to create novel antipsychotics with fewer effects on immune function and metabolism, or that do not impair protective reflexes like cough and swallowing. Concurrently, in-depth research into the mechanisms of interaction between antipsychotics and the immune system, for example, their effects on immune responses via muscarinic receptors, may provide clues for repurposing old drugs or mitigating risks [24].

Identifying reliable biomarkers for risk prediction is key to precision prevention. Future research should focus on discovering biomarkers capable of predicting pneumonia risk in patients with schizophrenia. Potential directions include specific inflammatory cytokine profiles, such as leptin receptor gene polymorphisms associated with clozapine-induced pneumonia; salivary or gut microbiome characteristics, as research suggests host microbiota may be related to clozapine-associated ileus and pneumonia; and easily measurable physical indicators, such as sarcopenia screening tool (SARC-CalF, SARC-F+EBM) scores or calf circumference [9,16,17,22]. These markers could be used for early identification of high-risk individuals to implement intensive prevention.

Immunomodulatory interventions represent a potentially promising yet cautiously explored area. Basic research shows activation of neuroimmune and oxidative pathways in schizophrenia, and pneumonia itself is an intense inflammatory process [12]. Theoretically, using anti-inflammatory drugs or immunomodulators (e.g., inhibitors targeting cytokines like IL-6) could potentially improve immune function while addressing core psychiatric pathology. However, such interventions must be evaluated with extreme caution regarding the potential increased risk of infection. Future translational research, under rigorous monitoring, is needed

to explore the safety and efficacy of specific immunomodulatory strategies in defined patient subgroups, avoiding further increasing infection susceptibility due to inappropriate interventions.

5. Conclusion

The high incidence of pneumonia in patients with schizophrenia represents a complex clinical challenge stemming from a combination of intrinsic disease pathophysiology, external therapeutic interventions, and broad psychosocial factors. From an expert perspective, the core of this issue lies in understanding that schizophrenia is not an isolated brain disorder but a systemic health crisis involving multi-system dysregulation. The disease itself may impair respiratory defenses through neuroimmune and neuroendocrine pathways; antipsychotics, while managing psychiatric symptoms, may suppress cough reflexes, increase sedation and metabolic side effects, indirectly elevating aspiration and infection risks; and patients often have concomitant cognitive impairment, diminished self-care capacity, unhealthy lifestyle habits (e.g., smoking), and potential barriers to accessing medical care and social support, collectively creating conditions conducive to pneumonia.

Therefore, future clinical practice and research must resolutely move towards integration and precision. In terms of management, prevention is far superior to treatment. Establishing an integrated preventive system encompassing vaccination, oral care, smoking cessation, and nutritional support is crucial, requiring deep collaboration among psychiatry, pulmonology, general practice, and community nursing. During treatment, a high index of suspicion is needed to recognize pneumonia that may present atypically with apathy or delirium, and careful management of complex interactions between anti-infective and psychiatric medications is essential.

Disclosure statement

The author declares no conflict of interest.

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Research Advances in Return-to-Work Readiness Among Young and Middle-Aged Hospitalized Patients: A Review

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Abstract: This review synthesizes current evidence on return-to-work (RTW) readiness among young and middle-aged adults hospitalized for acute or chronic conditions. We clarify the conceptual foundations of RTW readiness, critically evaluate existing assessment instruments, including their psychometric properties and clinical applicability, and delineate the multilevel determinants shaping readiness: disease-related factors, individual attributes, workplace characteristics, and sociocultural supports. This study further assess the empirical basis and implementation feasibility of prevailing interventions, namely, integrated vocational rehabilitation, cognitive-behavioral support, and condition-specific health literacy programs. While substantial progress has been made in identifying correlates of RTW readiness, critical gaps persist in longitudinal measurement, cross-cultural validation of tools, and theory-driven, scalable interventions. This synthesis aims to inform evidence-based practice and policy aimed at strengthening sustainable RTW outcomes in this high-need population.

Keywords: Return-to-work readiness; Hospitalized patients; Assessment tools; Influencing factors

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1. Introduction

With advancements in medical technology and demographic shifts, the issue of return-to-work among young and middle-aged hospitalized patients has garnered increasing attention [1]. Return-to-work is not only related to patients' economic independence and quality of life but also significantly impacts socio-economic development. However, due to the effects of illness and treatment, many young and middle-aged hospitalized patients face numerous challenges upon returning to work [2]. The World Health Organization (WHO) has repeatedly emphasized the importance of work for personal health, considering work a core component of people's lives; it not only provides financial resources but also gives meaning to life, promotes personal

growth, and facilitates social integration [3]. Disease recovery involves not merely the restoration of physical function but comprehensive biopsychosocial recovery. Return-to-work readiness refers to the degree of preparation a patient feels to re-enter the workplace and effectively perform job duties after experiencing illness or trauma. This process encompasses not only physical recovery but also psychological adjustment, access to social support, and adaptation to the work environment across multiple dimensions. The biopsychosocial model provides a comprehensive perspective for understanding return-to-work readiness [4]. This model emphasizes that returning to work depends not only on the patient's physiological recovery status but is also influenced by psychological state, social support, work environment, and other factors. Therefore, studying return-to-work readiness holds significant practical importance.

This article aims to systematically review recent research advances on return-to-work (RTW) readiness among hospitalized young and middle-aged adults. Specifically, it examines four key domains: validated assessment tools for RTW readiness; current prevalence and patterns of RTW readiness in this population; individual, clinical, occupational, and psychosocial factors influencing RTW readiness; and evidence-informed intervention strategies. By synthesizing extant literature, consolidating empirical findings, critically identifying persistent knowledge gaps, and proposing concrete directions for future research, this review seeks to inform clinical practice and support the development of targeted, theory- and evidence-based RTW interventions.

2. Assessment tools for return-to-work readiness in young and middle-aged hospitalized patients

A wide range of validated tools is available to assess return-to-work readiness, broadly categorized into self-report scales, clinician-administered assessments, and work ability evaluations. Widely used self-report instruments include the Readiness for Return-to-Work Scale (RRTW), the Return-to-Work Self-Efficacy Questionnaire (RTW-SE), the Lam Assessment of Stages of Employment Readiness (LASER), and the Work Ability Support Scale (WSS). Collectively, these instruments evaluate key domains, including physical functioning, psychological well-being, work motivation, and environmental adaptability providing complementary, multi-dimensional insights into patients' readiness for sustained employment.

2.1. The readiness for return-to-work scale (RRTW)

The Readiness for Return-to-Work Scale (RRTW), developed by Canadian researcher Ronald L. Franche and colleagues on the theoretical foundations of the Stages of Change Model and the Readiness for Return-to-Work Model, was culturally adapted and validated for use in China by Chinese scholar Cao Huili [5]. The core 13-item subscale comprises four theoretically grounded dimensions: Precontemplation (items 1, 2, and 13), Contemplation (items 9, 11, and 12), Preparedness for Action–Self-Evaluation (items 4, 7, 8, and 10), and Action (items 3, 5, and 6), specifically intended for patients who remain absent from work due to illness or hospitalization. Psychometric evaluation supports its robust internal consistency, with Cronbach's α coefficients ranging from 0.78 to 0.831 across dimensions. Responses are rated on a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree), and the dimension yielding the highest mean score identifies the patient's predominant stage of readiness. Empirical evidence confirms the RRTW's clinical utility and feasibility in hospitalized patient populations.

2.2. Return-to-work self-efficacy questionnaire (RTW-SE)

The Return-to-Work Self-Efficacy Questionnaire (RTW-SE), developed by Dutch researcher S. E. Lagerveld and colleagues in 2010, is a theoretically grounded instrument rooted in Bandura's social cognitive theory and the transtheoretical model of behavior change [6]. The original version has undergone rigorous cross-cultural adaptation and psychometric validation in diverse populations worldwide, establishing its robust reliability and construct validity. In 2021, Gao Yaxin and colleagues conducted a comprehensive cultural adaptation and validation study specifically for mainland Chinese cancer patients, confirming measurement invariance and clinical utility in this population [7]. The RTW-SE comprises 11 items, three of which are reverse-scored (items 2, 6, and 9) assessing confidence in performing work-related tasks despite illness-related barriers. Respondents rate each item on a 6-point Likert scale (1 = completely disagree, 6 = completely agree), and the mean item score (range: 1–6) serves as the primary indicator of return-to-work self-efficacy; scores ≥ 4.5 reflect high self-efficacy, consistent with empirically established clinical thresholds. In young and middle-aged Chinese cancer patients, the scale demonstrated excellent internal consistency (Cronbach's $\alpha = 0.932$), strong split-half reliability ($r = 0.925$), and satisfactory test–retest reliability ($r = 0.827$) across treatment phases, from active therapy to survivorship, thereby substantiating its reliability, structural validity, and practical applicability in oncology rehabilitation settings.

2.3. Lam assessment of stages of employment readiness (LASER)

The Lam Assessment of Stages of Employment Readiness (LASER), developed by American researcher M. K. Lam and colleagues in 1997, is a stage-theoretic instrument grounded in the Transtheoretical Model of Behavior Change. The original scale was subsequently adapted and validated for Cantonese-speaking populations in Hong Kong in 2006, yet its applicability to mainland Chinese patients was constrained by linguistic variation, sociocultural norms surrounding work disability, and structural differences in vocational rehabilitation systems. To address this gap, Xu Yanwen and colleagues (2014) undertook a systematic cultural adaptation and rigorous psychometric validation of the LASER specifically for mainland Chinese injured workers recovering from work-related limb fractures [8]. The revised 18-item version preserves the core four-stage structure, Precontemplation, Contemplation, Preparation, and Action, while ensuring conceptual equivalence and item relevance within the mainland Chinese occupational health context. Items are rated on a 5-point Likert scale (1 = no confidence, 5 = full confidence), and dimensional mean scores determine readiness classification: confident (≥ 4.0), intermediate (3.0–3.9), or non-confident (≤ 2.9). Empirical evaluation confirmed acceptable internal consistency across dimensions (Cronbach's $\alpha = 0.696–0.768$), supporting the scale's reliability and structural validity for use in early-phase vocational rehabilitation among young and middle-aged Chinese workers.

2.4. Work-ability support scale (WSS)

The Work Ability Support Scale (WSS), developed in 2015 by J. K. Fadyl and K. M. McPherson, is a theoretically informed, multi-stakeholder instrument designed to capture the complex interplay between individual capacity and environmental support in return-to-work processes following stroke [9]. Grounded in in-depth qualitative interviews with stroke survivors, employers, and rehabilitation professionals and integrating conceptual elements from the Work Ability Index (WAI) and the Occupational Role Questionnaire, the WSS uniquely bridges clinical assessment and vocational contextualization. Its Chinese adaptation (Guo Yawen et al., 2020) underwent rigorous cross-cultural translation, cognitive debriefing, and

psychometric validation among community-dwelling young and middle-aged stroke survivors, confirming strong measurement equivalence and clinical relevance [10]. The scale comprises two complementary modules: Part A (16 items) assesses perceived support for work ability across three empirically derived domains, Physical Functioning, Thinking and Communication, and Social Behavior, rated on a 7-point Likert scale (1 = lowest independence, 7 = highest independence); Part B (12 items) evaluates modifiable facilitators and barriers to return-to-work readiness across three contextual domains, Personal Factors, Work Environment Factors, and Barriers to Return-to-Work, scored on a 3-point bipolar scale (−1 = unlikely, 0 = uncertain, +1 = likely). Psychometric evaluation demonstrated acceptable to excellent internal consistency (Cronbach's $\alpha = 0.645–0.933$), robust test–retest reliability (ICC = 0.86), and strong convergent validity with the WAI ($r = 0.72$, $p < 0.001$), supporting its utility as a comprehensive, context-sensitive measure of return-to-work readiness.

Critically, no single tool comprehensively captures all dimensions of return-to-work readiness. While the RTW-SE excels in measuring domain-specific self-efficacy beliefs, and the LASER delineates behavioral stages of readiness, the WSS distinguishes itself by explicitly quantifying the environmental and interpersonal supports essential for translating capacity into actual work participation. Consequently, tool selection should be purpose-driven: the RTW-SE is optimal for evaluating psychological readiness interventions; the LASER best informs stage-matched counseling; and the WSS is uniquely suited for assessing and targeting modifiable workplace and systemic barriers, particularly in early-phase vocational rehabilitation for physically impaired populations.

3. Current status analysis of return-to-work readiness in young and middle-aged hospitalized patients

Empirical evidence consistently indicates that return-to-work readiness among young and middle-aged hospitalized patients remains suboptimal, with prevalence estimates ranging from 32% to 47% across recent cohort studies. Marked heterogeneity is observed across diagnostic categories: patients diagnosed with malignancies or cardiovascular conditions demonstrate significantly lower readiness levels than those with orthopedic injuries, particularly spinal or major joint impairments, reflecting differential impacts of disease chronicity, symptom burden, and functional prognosis. Beyond clinical diagnosis, sociodemographic determinants, including younger age (within the 18–45 range), female gender, and lower educational attainment exert independent and statistically significant effects on readiness scores, underscoring the multifactorial nature of this construct. Longitudinally, readiness exhibits a nonlinear but generally progressive trajectory during inpatient and early outpatient rehabilitation; however, interindividual variability is substantial, driven by factors such as comorbidity load, psychosocial support, and workplace accommodation availability. While some patients achieve functional work capacity within 3–6 months post-discharge, others require ≥ 12 months of structured vocational rehabilitation to attain sustainable employment outcomes [11]. Critically, both premature return-to-work, before achieving minimum functional safety thresholds and delayed re-entry beyond evidence-based recovery windows, pose dual risks: exacerbating physical deconditioning or symptom recurrence, and undermining occupational identity, skill retention, and long-term career mobility.

Internationally, theoretical frameworks of return-to-work readiness emerged from interdisciplinary research investigating how macro-level structural factors, including healthcare policy, workplace accommodations, and social insurance design, interact with individual biopsychosocial determinants to shape injured workers' return-to-work trajectories [12]. Empirical evidence robustly links readiness

levels to a constellation of theoretically coherent, empirically validated constructs: physical health status, functional capacity (e.g., mobility, endurance), pain intensity and interference, mental health functioning, clinically significant depressive symptoms, and fear-avoidance cognitions specifically related to work tasks and physical exertion. Wisenthal et al. applied the LASER staging model to identify distinct behavioral phenotypes: individuals in the active maintenance stage demonstrated superior physical functioning, lower kinesiophobia, and greater engagement in vocational goal-setting, whereas those classified in the rumination and uncertainty maintenance stages exhibited heightened depressive symptomatology, maladaptive illness perceptions, and reduced self-efficacy for work-related activities [13]. Jarvis et al. reported that among young adult stroke survivors (aged 18–45 years), 44% remained unemployed or on permanent disability at 2-year post-stroke follow-up, contributing to an estimated £1.9 billion in annual UK productivity losses, equivalent to 0.07% of national GDP [14]. Collectively, these findings underscore that the persistent work disability burden among young adult stroke survivors reflects not merely residual impairment, but a complex systems failure spanning clinical rehabilitation, occupational health services, and socioeconomic policy; thus, effective solutions must be multilevel, evidence-informed, and developmentally tailored to this life-stage.

Domestically, a study by Chen Xiaoping et al. on factors influencing return-to-work (RTW) among 228 postoperative renal cancer patients revealed statistically significant associations with educational level, surgical approach, anxiety, depression, and self-efficacy [15]. These findings are consistent with those reported by Zhang Gengzan et al. [16]. In a qualitative investigation, Zeng Qingwei et al. explored the experiences of adolescents with cancer returning to school and found that successful reintegration into the educational setting is critical not only for clinical recovery but also for enhancing overall quality of life in this population. Gong Aiping's study of 425 hemodialysis patients indicated that 105 (24.7%) had resumed employment; among these, 75.2% were classified in the "uncertain maintenance" stage of the transtheoretical model (TTM), suggesting fragile or unstable RTW status [17]. Conversely, among those not yet returned to work, the majority were situated in the "precontemplation" stage, indicating low RTW readiness. Similarly, Zhao Xinna's investigation of 103 young and middle-aged patients who had undergone percutaneous coronary intervention (PCI) but had not resumed work found that, among the 212 non-RTW cases assessed, the highest mean score was observed in the "contemplation" stage, further supporting the conclusion that most patients remain in early stages of behavioral change and exhibit limited RTW readiness [18]. Notably, a substantial proportion of participants across these studies lacked adequate disease-related knowledge and demonstrated poor understanding of self-care management strategies.

Return-to-work serves as a key indicator of patients' successful reintegration into society following illness. Numerous factors influence return-to-work outcomes, yet readiness for return-to-work remains suboptimal among certain patient populations.

4. Factors influencing return-to-work readiness in young and middle-aged hospitalized patients

4.1. Personal factors

Personal factors encompass age, gender, educational attainment, average monthly family income, and place of residence. These variables significantly shape patients' perceptions of their illness and their capacity to cope with it. Zhao Yajie et al. reported higher return-to-work (RTW) readiness among young and middle-aged lung cancer patients aged 18–44 years, a finding corroborated by Zhao Xinna et al. [19,20]. This trend

may be attributable to the central familial role assumed by individuals in this age group, coupled with heightened occupational demands and greater perceived family responsibilities, which collectively foster proactive engagement in rehabilitation and a stronger motivation for early societal reintegration and RTW. In contrast, younger patients, particularly those who are unmarried or live independently, may exhibit lower RTW readiness due to diminished awareness of familial obligations or greater adaptation to solitary living arrangements. Wang Yujie et al. identified substantial economic strain as a key barrier, reporting that higher average monthly family income was associated with "lower" RTW readiness, an inverse relationship also observed in the present study [21,22]. Specifically, limited capacity to cover medical expenses contributed to prolonged hospitalization and an elevated risk of job loss, consistent with findings among nasopharyngeal carcinoma survivors reported by Wang Juan et al. [23]. This paradox may reflect structural inequities: low-income patients often lack both stable financial reserves and access to workplace-based social support services, leading to treatment delays secondary to insufficient medical funding, factors that ultimately impede timely RTW. Furthermore, marital status emerged as a salient predictor: unmarried patients demonstrated significantly lower RTW readiness compared with their married counterparts. This disparity may stem, in part, from the psychosocial buffering afforded by spousal support; however, marriage may also entail added pressures related to caregiving responsibilities (e.g., childcare or eldercare). Importantly, robust family support can facilitate favorable living conditions, enhance adherence to rehabilitation regimens, and promote broader health-related outcomes conducive to successful RTW.

4.2. Disease characteristics

Disease characteristics, including disease severity, treatment modality, functional exercise capacity, and comorbid complications, directly influence patients' physical functioning. In Wang Liangliang's study on return-to-work outcomes among patients with myasthenia gravis, 198 individuals had not resumed employment; of these, 51.8% remained in the precontemplation or contemplation stages of behavioral change and had not advanced to the action stage [24]. Owing to the pathophysiological nature of myasthenia gravis, patients frequently experience proximal limb weakness, which impairs their ability to sustain standard working hours. Moreover, exposure to complex or physically demanding work environments, particularly without adequate symptom monitoring or workplace accommodations, may precipitate myasthenic crises, thereby posing a significant threat to patient safety and survival.

4.3. Psychological factors

Psychological state encompasses a range of psychological factors, including sense of coherence, positive coping, perceived stigma, anxiety, and depression. Positive coping and self-efficacy have been identified as protective factors for return-to-work (RTW) readiness among patients with cirrhosis who had not yet resumed employment [25]. Among young and middle-aged lung cancer patients who had not returned to work, family resilience exerted a direct effect on RTW readiness and an indirect effect mediated by sense of coherence; in contrast, among those who had already resumed work, sense of coherence influenced RTW readiness only indirectly. Healthcare professionals should therefore enhance disease-related health literacy, reduce illness uncertainty, and strengthen patients' self-efficacy, thereby facilitating adaptive coping strategies and supporting non-returned patients in advancing toward higher levels of RTW readiness. In breast cancer survivors who had successfully returned to work, positive coping was positively associated with RTW readiness [26]. Adaptive coping styles enable patients to confront illness with greater resilience, maintain a

constructive outlook on life, and proactively pursue early reintegration into social and occupational roles. To sustain high levels of RTW readiness among those who have resumed work, healthcare professionals should actively mobilize family support, guide the adoption of positive coping strategies, mitigate illness uncertainty, and reinforce psychosocial resources. Arends et al. conducted a cluster randomized controlled trial evaluating a problem-solving intervention among individuals with common mental disorders (CMD) who had returned to work (N = 158) [27]. Information on anxiety and depressive symptoms, work functioning, and return-to-work (RTW) status was collected at baseline and at 3-, 6-, and 12-month follow-ups. Latent class growth analysis identified three distinct recovery trajectories:

(1) Slow recover

Characterized by persistently high levels of anxiety and depressive symptoms, moderate-to-low work functioning, and rapid RTW;

(2) Rapid recovery

Marked by low anxiety and depressive symptoms, high work functioning, and rapid RTW; and

(3) Gradual recovery

Defined by declining anxiety and depressive symptoms, variable (i.e., increasing or decreasing) work functioning, and rapid RTW.

Participants reporting higher baseline work engagement and greater willingness to continue working were significantly more likely to be classified in the rapid recovery trajectory. Notably, many individuals with common mental disorders (CMDs) continue to experience elevated mental health symptoms and substantial work functioning difficulties throughout the first year following RTW. Therefore, establishing realistic, evidence-informed recovery expectations, shared jointly by patients, clinicians, employers, and other stakeholders is essential to support successful, sustained recovery and long-term work participation.

4.4. Work-environment factors

Work-environment factors, including job demands, schedule flexibility, and employer support, also significantly influence patients' readiness to return to work. A supportive work environment can facilitate the provision of necessary accommodations and allow adequate time for role adaptation and functional recovery. Social support encompassing familial, peer, and community-based resources plays a critical role in both rehabilitation and the return-to-work process [28]. These interrelated factors collectively shape patients' return-to-work readiness.

5. Intervention measures to enhance return-to-work readiness in young and middle-aged hospitalized patients

Researchers have proposed a range of evidence-informed interventions to enhance return-to-work (RTW) readiness among hospitalized young and middle-aged adults. Vocational rehabilitation represents one of the most widely implemented approaches, encompassing structured work ability assessments, individualized vocational training, and workplace accommodations. Collectively, these components aim to restore functional work capacity and strengthen occupational adaptability [29]. Psychological support constitutes another critical intervention domain, particularly cognitive-behavioral therapy and stress management techniques, which helps patients effectively navigate the psychosocial challenges inherent in the RTW transition.

Health education constitutes another evidence-based intervention strategy, which enhances patients'

self-management capacity and work-related confidence through the provision of disease-specific knowledge, evidence-informed rehabilitation techniques, and occupation-relevant information training. Moreover, multidisciplinary team collaboration and structured case management have demonstrated efficacy as intervention approaches. These strategies may be implemented independently or synergistically, with selection guided by individual patient characteristics, functional status, and psychosocial needs [30].

Cognitive Work Hardening (CWH) is a multifactorial, work-focused intervention grounded in empirical evidence and designed to support successful return-to-work (RTW) following depressive episodes. Wisenthal documented the application of CWH to prepare an individual for RTW after a disability leave attributable to major depression [13]. The participant engaged in a structured 4-week CWH program targeting key functional barriers, including fatigue and diminished physical endurance, cognitive inefficiencies (e.g., impaired attention, processing speed, and working memory), outdated digital literacy, and elevated anxiety. Through graduated, ecologically valid work simulations, the program facilitated the systematic rebuilding of cognitive capacities while concurrently enhancing work tolerance and stamina. Task-based mastery experiences bolstered self-confidence and perceived self-efficacy, whereas targeted instruction in adaptive coping strategies, particularly stress regulation and assertive interpersonal communication, addressed critical psychosocial needs. At program completion, the participant reported clinically meaningful improvements in perceived work capacity, alongside significant reductions in both fatigue severity and core depressive symptoms. Objective clinical assessments of occupational functioning indicated readiness for resumption of pre-disability employment duties. At the 3-month follow-up, the participant maintained full-time employment, consistently managing full workdays with sustained energy and focused attention. This case illustrates the pragmatic utility of CWH as an evidence-informed, functionally oriented intervention to optimize RTW outcomes following depression.

6. Conclusion

This paper provides a comprehensive review of recent research on return-to-work (RTW) readiness among hospitalized young and middle-aged adults. The analysis reveals that RTW readiness is a multidimensional construct shaped by interrelated biomedical, psychological, social, and occupational factors. While extant literature has advanced understanding in three key domains, namely, the development and validation of assessment instruments, identification of salient determinants, and design and evaluation of targeted interventions, several critical gaps persist. Notably, the field lacks consensus on standardized, psychometrically robust assessment criteria; longitudinal studies tracking RTW trajectories beyond six months remain scarce; and cross-cultural comparative research, particularly across diverse healthcare systems and socioeconomic contexts, is markedly underdeveloped.

Future research should prioritize the development of more comprehensive and psychometrically robust assessment tools, the implementation of longitudinal follow-up studies to rigorously evaluate the sustained efficacy of interventions, and the conduct of cross-cultural comparative investigations. Furthermore, fostering multidisciplinary collaboration and systematically integrating medical, psychological, vocational, and social support resources is critical to delivering holistic, patient-centered care. Sustained investment in both empirical research and evidence-informed practice will deepen our understanding of return-to-work readiness among young and middle-aged hospitalized patients, thereby advancing their vocational rehabilitation and facilitating successful social reintegration.

Disclosure statement

The authors declare no conflict of interest.

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Molecular Genetics Etiology Research on a Typical Case of Unexplained Sudden Death in Yunnan Based on Whole Exome Sequencing

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Abstract: *Objective*: To explore the etiology of a typical case of unexplained sudden death in Yunnan (referred to as "Yunnan sudden death"), correlate genotypes with phenotypes to identify high-risk populations, and provide a basis for intervention measures. *Methods*: Epidemiological and clinical investigation data, as well as blood biochemical test results, were collected from three cases of Yunnan sudden death. Whole exome sequencing (WES) was performed on blood samples, using GRCh38/HG19 as the reference sequence. Mutation sites were screened based on genetic heart disease-related gene variants and subjected to filtering, annotation, and analysis. Protein function prediction analysis of mutated genes was conducted using SIFT, Mutation Taster, and PolyPhen2 software. *Results*: After screening, harmful and ambiguous mutation sites were retained, involving 18 mutation site information from four genetic heart disease-related genes (DMD, SIDT1, CSRP3, DSG2). Among them, 17 were predicted by software to have harmful, harmful, or pathogenic protein functions. Deceased 2 carried six mutation sites in DMD, deceased 2 and deceased 4 jointly carried nine mutation sites in SIDT1, and deceased 3 carried two mutation sites in CSRP3. *Conclusion*: The causes of death in the three cases of Yunnan sudden death in this study are highly likely related to mutations in genetic heart disease-related genes.

Keywords: Unexplained sudden death in Yunnan; Genetic heart disease; Gene mutation; Whole exome sequencing

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1. Introduction

Unexplained sudden death in Yunnan (referred to as "Yunnan sudden death") is a special type of endemic disease that primarily occurs in some impoverished rural areas in central and western Yunnan Province. The onset time is concentrated from June to September, exhibiting significant temporal, geographical, familial,

and village clustering characteristics, posing a severe threat to the health of the affected population. Since its first occurrence in 1975, a total of 421 cases have been reported as of 2023, but the etiology remains incompletely understood [1]. The cardiac health status of the population in the affected areas is generally poor, with high detection rates of abnormal electrocardiograms and echocardiograms, and diverse types of abnormal changes [2–4]. Meanwhile, there are obvious specificities in gene mutations among different populations, as well as familial and regional clustering phenomena of gene mutations, suggesting a possible genetic predisposition to Yunnan sudden death [2]. Not all genetic heart disease-related pathogenic genes lead to severe phenotypes, and most carriers have normal hearts [5]. Therefore, genetic and clinical evaluations of relatives are necessary to expand the analysis. Based on the characteristics of onset and death, clinical manifestations, abnormal changes in electrocardiograms and myocardial enzymes, autopsy, and pathological histological examination results of Yunnan sudden death, it is speculated that the etiology of some cases of Yunnan sudden death may be related to genetic heart diseases.

To explore the etiological relationship between gene mutations in genetic heart diseases and Yunnan sudden death, this study, building on previous research, utilized whole exome sequencing technology for the first time to detect mutations in pathogenic genes of genetic heart diseases in a family of four who experienced unexplained sudden death in a severely affected area of Yunnan in 2009. The aim was to find associations between genotypes and phenotypes, identify high-risk populations, provide precise health interventions, and thereby improve the health status of the affected population.

2. Objects and methods

2.1. Study objects

From 11:00 on August 3, 2009, to 03:00 on August 4, 2009, four members of a family in HQSGZ Village, Dali Prefecture, suddenly died consecutively within 24 hours and were determined to be cases of "unexplained sudden death in Yunnan" after investigation. This study used the four deceased individuals from this family as study samples and performed whole exome sequencing analysis on the well-preserved heart cavity blood from three autopsied cases.

2.2. Research methods

2.2.1. Epidemiological investigation and pathological analysis

At 18:00 on August 4, a joint investigation team from the Yunnan Provincial Institute for Endemic Disease Control and Prevention, the Chinese Center for Disease Control and Prevention, the Dali Prefecture Center for Disease Control and Prevention, and the Dali Prefecture People's Hospital arrived at the scene to conduct investigations and response measures. With the consent of the deceased's relatives, autopsies were performed on Deceased 2 (approximately 16 hours post-mortem), Deceased 3 (approximately 17 hours post-mortem), and Deceased 4 (approximately 18 hours post-mortem) among the four cases. Specimens such as the heart, cardiac blood, and liver were obtained and sent to Fuwai Hospital in Beijing for pathological examination and testing. The first deceased, deceased 1, had been deceased for 32 hours, so an autopsy was not performed. Instead, a cardiac puncture was performed, but cardiac blood was not obtained; liver tissue was taken for testing.

2.2.2. Ethical approval

This study has obtained informed consent from the control population and the deceased's relatives and has been approved by the Medical Ethics Committee of the Yunnan Provincial Institute for Endemic Disease Control and Prevention (Yunnan Institute for Endemic Disease Medical Ethics [2024] No. 04). Additionally, the "Implementation Rules for the Regulation on the Administration of Human Genetic Resources" has been strictly enforced.

2.3. Experimental testing

2.3.1. Whole exome sequencing process

(1) Sample preparation

Blood samples that were well-preserved and met the sequencing company's requirements were sent to Sangon Biotech (Shanghai) Co., Ltd.

(2) DNA fragmentation

The genomic DNA from the blood was physically fragmented, and the target DNA fragments were recovered.

(3) End repair and A-tailing

The target DNA fragments underwent end repair and were adenylated with deoxyadenosine (A).

(4) Adapter ligation

The adenylated DNA fragments were ligated with sequencing adapters.

(5) Fragment selection and library enrichment

DNA fragments with successfully ligated sequencing adapters at both ends were recovered to construct the pre-capture library, which was then enriched through PCR amplification.

(6) Hybridization capture

The genomic exonym regions were captured using the Agilent SureSelect Human All Exon V6 exome capture chip.

(7) Library amplification

The captured library underwent PCR amplification for enrichment.

(8) Library quality control

The library underwent quality inspection.

(9) Sequencing

High-throughput sequencing was performed on the diluted and pooled library using the Illumina PE150 sequencing platform.

2.3.2. Data processing and quality control

(1) Raw data filtering

Adapter sequences were removed from the reads using Fastp software. Single-end sequencing reads containing more than 40% low-quality bases (quality threshold ≤ 20) or more than 10% undetermined bases were removed. Sliding window quality trimming was performed with a window size of 4 bp, and reads with an average quality below 20 were trimmed.

(2) Data alignment and processing

The clean data was aligned with the reference genome hg19 or hg38. Non-coding region gene mutations and synonymous mutations were removed, and mutation sites unrelated to inherited cardiac ion channel

diseases and cardiomyopathies were excluded. The GATK software was used for sorting, deduplication, and obtaining sequencing depth and coverage.

2.3.3. Bioinformatics analysis

(1) Variant site screening

ANNOVAR annotation software was used to screen for variant sites in genes previously reported to be associated with cardiomyopathies and cardiac ion channel diseases.

(2) Database comparison

Sites with a minor allele frequency ≤ 0.01 were screened from the 1000 Genomes Project, the Single Nucleotide Polymorphism Database, and the National Heart, Lung, and Blood Institute Exome Sequencing Project database. Diversity sites among individuals were removed, and rare variants were retained.

(3) Pathogenicity prediction

Bioinformatics software SIFT and MutationTaster were used to predict the pathogenicity of the screened gene mutation sites. When the results were inconsistent, PolyPhen-2 software was used for further analysis. A mutation was considered harmful if at least two methods predicted it to be harmful.

3. Results

3.1. Epidemiological investigation

3.1.1. This incident was a case of familial clustered sudden death, as detailed in the genetic pedigree chart

By referring to **Figure 1** of the Genetic Pedigree Chart of the Case's Family, following results were recorded.

(1) Sudden death victim 1 (ZLS0)

Female, 55 years old, of Yi ethnicity, a farmer, mother of Victims 2 and 4, mother-in-law of Victim 3. On August 3, 2009, at 6:30 AM, she went to the cornfield to cut pig fodder and returned home at 10:30 AM without any discomfort. As the family was preparing to eat, she suddenly tilted her head back, gasped for breath, then let her head droop, with clear secretions flowing from the corners of her mouth. She died suddenly at home from unknown causes five minutes later.

(2) Sudden death victim 2 (ZLS2)

Female, 29 years old, of Yi ethnicity, the third daughter of Victim 1 and the younger sister of Victim 4. On the morning of August 3, 2009, she delivered breakfast to her father and returned home at 11:30 AM to find her mother (Victim 1) had died suddenly. She fainted five times in grief before waking up. At 10:00 PM, she went to her room to rest. At 1:45 AM on August 4, she woke up, tilted her head back, gasped for breath, let her head droop, and vomited oral secretions. She died after approximately three minutes of emergency treatment.

(3) Sudden death victim 3 (ZZX)

Male, 32 years old, of Yi ethnicity. His mother-in-law and younger sister-in-law (Victim 2) died suddenly one after another. He and his wife (Victim 4) were in grief and fear. At 2:15 AM on August 4, while the couple was resting in the corridor, he suddenly clenched his hands, convulsed, tilted his head back, gasped for breath, let his head droop, and vomited oral secretions. Despite emergency measures such as artificial respiration and chest compressions, he died approximately five minutes later.

(5) Sudden death victim 4 (ZLS1)

Female, 32 years old, of Yi ethnicity. Between August 3 and 4, 2009, her mother, sister, and husband died successively, leaving her deeply saddened and frightened, and she cried continuously. After returning to her room to rest, at 3:00 AM on August 4, she suddenly tilted her head back, gasped for breath, then let her head droop and vomited clear oral secretions. Despite emergency measures such as artificial respiration, she died suddenly at home from unknown causes approximately five minutes later.

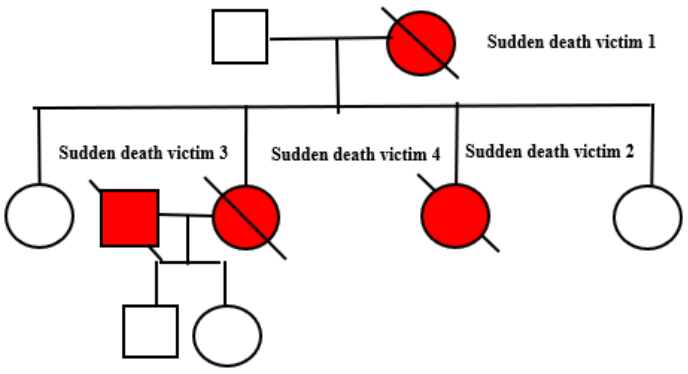


Figure 1. Genetic pedigree chart of the case's family

Note: □ represents male; ○ represents female; ⊠ ⊗ represents cases of sudden death in Yunnan.

3.2. Investigation of related risk factors

The family members enjoyed harmonious relationships and were generally in good health on a daily basis. Within the month preceding the sudden deaths, they had not consumed spoiled, unfamiliar, or cold-mixed foods. Although fresh "Xiaobai Mushrooms" were found in the deceased's home, it could not be confirmed that the incident was related to these mushrooms, and the exact cause of death has not yet been determined.

3.3. Pathological examination results

Beijing Fuwai Hospital conducted pathological examinations on the deceased. The hearts of the three cases showed no abnormalities in shape, size, or color, and no clearly characteristic lethal lesions were identified. Deceased 2: Congenital heart disease with patent foramen ovale; focal lymphocytic myocarditis. Deceased 3: Lymphocytic myocarditis, focal lymphocytic infiltration in the liver, superficial gastritis, acute pulmonary edema, with the main lesions being multifocal necrosis in the heart accompanied by lymphocytic and eosinophilic infiltration. Deceased 4: Eccentric fibrous thickening of the intima of the atrioventricular nodal artery leading to lumen stenosis; focal lymphocytic myocarditis.

3.4. Whole exome sequencing results

3.4.1. Sequencing data quality

The sequencing data quality was good, meeting the requirements for subsequent analysis. 95.85% of the target sites were covered at least 30 times. The central value of the insert size distribution for the samples was around 200 bp, conforming to a normal distribution, as shown in **Table 1**.

Table 1. Summary of whole exome sequencing data

Details	ZLS2	ZZX	ZLS1
Raw data volume	70,907,264	80,338,536	66,222,666
Data volume after QC	69,915,548	79,250,574	65,470,090
Capture rate of exonic regions	99.71%	99.75%	99.52%
Proportion of bases with quality > Q30	90.68%	89.49%	89.60%
Proportion of regions with coverage depth ≥ 10X	95.83%	95.69%	96.02%
Number of reads mapped to reference genome	69,838,081	79,150,888	65,409,298
Ratio of mapped reads to filtered reads	99.71%	99.75%	99.52%
Average sequencing depth of exonic regions	163.12	186.67	157.00

3.4.2. Genetic variation detection

Whole exome sequencing yielded an average of 217,468,466 total reads. After quality control of the results, a total of 23,605 mutation sites were identified, including single nucleotide polymorphisms (SNPs), insertions, and deletions. Among these, there were 22,830 SNPs and 775 INDELs. The vast majority of mutation sites occurred in exonic regions, totaling 23,313 (98.7%), as shown in **Table 2**.

Table 2. Statistics on SNP/InDel variation information in the sample

Sample	Single nucleotide polymorphism	Insertions and deletions	Frameshift deletion	Frameshift insertion	In-frame deletion	In-frame insertion	Missense mutation	Nonsense mutation	Homozygous mutation	Heterozygous mutation	Total mutations
ZLS2	22371	803	117	94	176	153	10729	114	392	402	11495
ZZX	22261	842	138	101	180	148	10548	119	380	462	11343
ZLS1	22632	794	109	89	159	154	10723	106	382	461	11452

3.5. Potential pathogenic gene variations and inherited heart diseases

Using existing databases and software, the variant results were further screened and analyzed to retain harmful mutations and those with uncertain significance. This process identified 18 mutation sites involving four genes associated with inherited heart diseases (DMD, SIDT1, CSRP3, DSG2). Predictions for these 18 variants were made using SIFT, MutationTaster, and PolyPhen2, with 17 mutation sites predicted to be harmful, harmful, or pathogenic. Deceased individual 2 carried six mutation sites in the DMD gene; deceased individuals 2 and 4 (sisters) jointly carried nine mutation sites in the SIDT1 gene; deceased individual 3 carried two mutation sites in the CSRP3 gene. By consulting databases and literature, the heart diseases associated with these mutated genes were identified as long QT syndrome (LQTS), dilated cardiomyopathy (DCM), Duchenne muscular dystrophy (DMD), hypertrophic cardiomyopathy (HCM), and arrhythmogenic right ventricular cardiomyopathy (ARVC). See **Table 3**.

Table 3. Mutation genes carried by the cases

Gene	Mutation site information	Decedent	SIFT	Mutation Taster	Polyphen2	Heart-related diseases
DMD	NM_004011:exon21:c.C3128A:p.S1043Y, NM_004012:exon21:c.C3119A:p.S1040Y, NM_000109:exon49:c.C7127A:p.S2376Y, NM_004006:exon49:c.C7151A:p.S2384Y, NM_004009:exon49:c.C7139A:p.S2380Y, NM_004010:exon49:c.C6782A:p.S2261Y	ZLS2	D	D	D	LQTS, DCM, DMD
SIDT1	NM_001322296:exon21:c.A2023G:p.K675E, NM_001322295:exon22:c.A2125G:p.K709E, NM_001322297:exon22:c.A1756G:p.K586E, NM_001322298:exon22:c.A1666G:p.K556E, NM_001322299:exon22:c.A1453G:p.K485E, NM_001322300:exon22:c.A928G:p.K310E, NM_017699:exon22:c.A2194G:p.K732E, NM_001308350:exon23:c.A2209G:p.K737E, NM_001322294:exon23:c.A2212G:p.K738E	ZLS2, ZLS1	D	D	D	LQTS
CSRP3	NM_001369404:exon2:c.G16A:p.G6R, NM_003476:exon2:c.G16A:p.G6R	ZZX	D	D	D	DCM, HCM
DSG2	NM_001943:exon15:c.C2470T:p.R824C	ZZX	D	P	B	ARVC, DCM, HCM

Note: The prediction results of SIFT are Tolerated (harmless) and Deleterious (harmful); the prediction results of MutationTaster are A, D, N, or P: “A” (“Disease_causing_automatic”), “D” (“Disease_causing”), “N” (“Polymorphism”), and “P” (“Polymorphism_automatic”), with both A and D indicating that the site may be harmful. The prediction results of PolyPhen-2 are Benign (benign), Possibly damaging (possibly pathogenic), and Probably damaging (highly likely pathogenic).

4. Discussion

Since 1984, over 10 similar sudden death incidents have occurred in this region, resulting in nearly 40 deaths, classifying it as a high-risk area for sudden death in Yunnan. In this study, four sudden death victims came from the same family, with the following relationships: 1 was the mother of 2 and 4, 2 and 4 were sisters, and 3 and 4 were husband and wife. The four victims lived with their relatives before death, had no special dietary or lifestyle history, and were previously healthy. They died within 20 hours, with a rapid onset from illness to death, sudden onset and death, and no specific clinical symptoms. This incident exhibited characteristics of familial clustering and cardiogenic sudden death, with victims 1, 2, and 4 being females from two generations of the same family, possibly related to genetic factors.

In recent years, studies have found that the cause of death in some Yunnan sudden death cases may be related to genetic heart disease gene mutations [2,6,7]. On July 21-22, 2015, three Yunnan sudden death cases occurred within 24 hours in a family in Qingshuihe Village, Qingshui Village Committee, Renxing Town, Lufeng City. The victims were the mother, daughter, and granddaughter. Whole-genome resequencing was performed on blood samples from the daughter, granddaughter, and surviving father of the sudden death victims using the BGI research platform. A highly pathogenic mutation was found in the atrial fibrillation-related gene NUP155, which was shared by the daughter and granddaughter but not present in the father [6]. Jia et al. also conducted gene sequencing on immediate family members of 25 Yunnan sudden death cases and found highly pathogenic mutation sites in genes such as SCN5A, IRX4, MYH6, and TTN [7]. Cheng Xue et al. found that the population in the affected area carried 52 site mutations in 36 exons of the ARVC

desmosomal protein gene, with a gene mutation rate of up to 37.1%, approaching the level of clinically reported ARVC patients (39.2%), confirming from a molecular genetics perspective that ARVC is the main cause of some Yunnan sudden deaths [2]. These studies suggest that some Yunnan sudden deaths are related to genetic heart disease gene mutations.

Detecting pathogenic gene variations in genetic heart diseases is an important direction for exploring the causes of unexplained sudden death. Most genetic heart diseases require a comprehensive diagnosis combining clinical and genetic test results. There are hundreds of reported pathogenic genes and thousands of mutation sites for genetic heart diseases, with differences in pathogenic mutations among different populations. Although exons account for less than 2% of the human gene sequence, they contain approximately 85% of known pathogenic variations and have significant advantages in disease gene screening and detection rates [8]. Compared with transcriptome and whole-genome sequencing, whole-exome sequencing covers a smaller genomic range but is more precise, effective, economical, and has high coverage in detecting exon regions, making it the best method for detecting pathogenic gene mutations in genetic heart diseases [9].

4.1. Analysis of gene mutation results

In this study, victim 2 carried six mutation sites in the dystrophin gene (DMD). The prediction results of SIFT, MutationTaster, and PolyPhen-2 for these six variations were all harmful, harmful, and pathogenic, respectively. The DMD gene is one of the largest known human genes, with a high mutation frequency. It is located on the X chromosome at Xp21.2-21.1, spans 2.4 Mb, and encodes a 14 kb mRNA transcript and a 427 kDa dystrophin protein through 79 exons. Due to the special inheritance pattern of the X chromosome, this linkage and co-inheritance phenomenon exhibits different inheritance patterns between males and females. Females carrying DMD generally have no obvious symptoms [10]. It has been reported that DMD gene variations can cause X-linked dilated cardiomyopathy, a unique muscular dystrophy phenotype without any obvious skeletal muscle disease, characterized by preferential involvement of the heart and leading to fatal heart failure [11,12]. When the expression of dystrophin protein encoded by the DMD gene is impaired in the heart, cardiac enlargement and circulatory failure rapidly occur [12]. For patients suspected of having DMD-related genetic heart diseases, gene testing is an important diagnostic method. For DMD-related genetic heart diseases, both muscle and heart aspects need to be comprehensively considered. Drug treatment may include drugs to improve myocardial function (such as angiotensin-converting enzyme inhibitors and β-receptor blockers for treating heart failure) and drugs targeting DMD muscle lesions (such as some gene therapy drugs and exon skipping therapy under development) [13]. In this study, victim 2 was female, had rapid disease progression, slight cardiac lesions, and carried six pathogenic mutation sites in the DMD gene. It is speculated that the cause of death of victim 2 may be related to X-linked dilated cardiomyopathy caused by DMD gene mutations.

In this study, the two sisters, victims 2 and 4, jointly carried nine mutation sites in the SIDT1 gene. It has been reported that this gene is a pathogenic gene associated with long QT syndrome, and mutations in this gene may play a key role in regulating cardiac electrophysiological activity [14,15]. Long QT syndrome is a heart disease characterized by prolonged QT interval on electrocardiogram, which can lead to arrhythmias and even sudden death. The protein encoded by the SIDT1 gene may be involved in regulating ion channels in cardiac cell membranes or interact with other proteins related to cardiac electrophysiology. By studying its intracellular localization, expression level, and interaction network with other proteins, its specific role in the

pathogenesis of long QT syndrome can be revealed [14].

In this study, victim 3 carried two mutation sites in the CSRP3 gene. Huang H et al. studied a family with three generations affected by hypertrophic cardiomyopathy (HCM) and used whole-exome sequencing to sequence the genes of the probands and performed gene mutation validation analysis [16]. This variation was predicted to be pathogenic and would cause protein truncation. At the same time, combined with pathological and imaging examinations, the first case of CSRP3 (p.Arg122*) variation in an HCM family in Asia was confirmed, proving that CSRP3 gene mutations can cause HCM or dilated cardiomyopathy (DCM) [16]. HCM is a common genetic heart disease determined by genes, with mild symptoms and echocardiographic manifestations of symmetric, asymmetric, focal left ventricular hypertrophy or ventricular wall thickening. Patients are at risk of arrhythmias and sudden cardiac death, which is an important and common cause of sudden death in young people [17]. For symptomatic patients, various drug treatments and septal reduction therapy have been proven to relieve symptoms and improve function [18]. Maron B et al. found mutations in cysteine and glycine-rich protein 3 (CSRP3), which encodes muscle LIM protein (MLP) [17]. This protein has complex and diverse functions in myocardial physiology and pathology, including cell fate determination, transcriptional regulation, cell adhesion and movement, signal transduction, and cytoskeletal organization. Sun L et al. found that CSRP3-deficient mice exhibited severe cardiac dysfunction [19]. When CSRP3 was knocked out, mice were born with dilated cardiomyopathy, accompanied by myocardial hypertrophy and heart failure. In this study, victim 3 was a 32-year-old young adult male who died suddenly without specific prodromal symptoms. There was multifocal lymph and eosinophil infiltration in the right ventricle and myocardial necrosis. Through gene testing, two mutation sites in the CSRP3 gene were detected in victim 3. The prediction results of SIFT, MutationTaster, and PolyPhen-2 for these two variations were all harmful, harmful, and pathogenic, respectively. Therefore, it is speculated that his death may be related to dilated cardiomyopathy or hypertrophic cardiomyopathy caused by CSRP3 gene mutations.

In this study, victim 3 also carried one mutation in the desmoglein-2 (DSG2) gene, which is associated with arrhythmogenic right ventricular cardiomyopathy (ARVC). This gene mutation affects the basic structure of the protein, altering the structure and size of glycoproteins, thereby affecting normal myocardial function. Cheng Xue found 10 mutation sites in the DSG2 gene in Yunnan sudden death cases, case relatives, and the population in the affected area [2]. Among them, the c.2470C > T heterozygous missense mutation and c.2930A>G heterozygous missense mutation in exon 15 of the DSG2 gene were only found in Yunnan sudden death cases, while case relatives, the population in the affected area, and the control population did not carry them. ARVC is a genetic cardiomyopathy mainly characterized by the replacement of ventricular myocardial cells with adipose tissue and fibrous tissue, resulting in right ventricular dysfunction and a tendency to develop heart failure, arrhythmias, and sudden death. It is also related to mutations in genes encoding desmosomal proteins [1,20]. Qiu Z et al. conducted animal model studies on genetic cardiomyopathy using DSG2 gene knockout mice and wild-type mice without DSG2 gene knockout as controls [21]. They found that DSG2 gene knockout mice had significantly increased myocardial fibrosis and observed PPARα deficiency. Their studies showed that activating PPARα could improve cardiac fibrosis in patients with arrhythmogenic cardiomyopathy lacking DSG2. ARVC, HCM, and DCM all belong to genetic cardiomyopathies. Gene mutations affect the connections between myocardial cells, making myocardial tissue fragile and prone to arrhythmias, and even leading to sudden death. Therefore, it is speculated that the cause of death of victim 3 may be related to genetic cardiomyopathy.

Gene mutations increase the susceptibility to genetic heart diseases. Although some gene mutations alone are not sufficient to directly cause genetic heart diseases, they increase the risk of an individual developing heart disease. Gene mutations can interact with environmental factors to jointly influence the occurrence and development of genetic heart diseases. In this study, 18 mutation sites in four genes were found in three cases. It is speculated that the four Yunnan sudden death cases may have developed lethal arrhythmias on the basis of gene mutations due to factors such as grief, ultimately leading to cardiac dysfunction and death. This study provides new clues for Yunnan sudden death research. Although the pathogenic mechanism of the mutant genes is currently unclear, in the future, we can construct animal models carrying pathogenic gene mutations, observe changes in their cardiac electrophysiological characteristics, and whether symptoms of genetic heart diseases appear. This will help us better understand the role of pathogenic genes in the body and the impact of their mutations on cardiac function.

4.2. Analysis of intervention measures

For people carrying mutant genes for genetic heart diseases, corresponding intervention measures can be taken [22]. First, long-term follow-up monitoring of patients should be carried out, including arrhythmias, treatment response, and disease progression. Based on this study, whole-exome sequencing and genetic counseling should be conducted on relatives of Yunnan sudden death cases and the population in the affected area to reduce the risk of recurrence in patients with the same gene mutations. At the same time, it can provide a reference for screening high-risk pathogenic mutation genes for sudden death in people in need and detect potential disease risks. Second, behavioral interventions and health education should be carried out. In areas where conditions permit, regular health check-ups mainly consisting of dynamic electrocardiogram, cardiac ultrasound, and magnetic resonance imaging should be conducted to assess cardiac health and prevent sudden death, thereby achieving the goals of disease prevention and control and health promotion.

For relatives of people who died suddenly due to genetic heart gene mutations, measures can be taken from two aspects: medical monitoring and lifestyle intervention [23,24]. In terms of medical monitoring, comprehensive cardiac examinations such as electrocardiogram and echocardiogram should be performed regularly, and the examination frequency should be increased for high-risk relatives. Dynamic electrocardiogram monitoring should be carried out to detect arrhythmias that are easily missed in conventional examinations. Cardiac magnetic resonance imaging should be performed to detect potential heart diseases at an early stage. Gene testing should be actively recommended to determine whether they carry sudden death-related gene mutations, and genetic counseling services should be provided to explain the meaning of the test results and answer family genetic questions. In terms of lifestyle intervention, personalized exercise plans should be formulated according to cardiac conditions to avoid strenuous exercise. A balanced diet is recommended, reducing the intake of high-oil, high-salt, and high-sugar foods, and appropriately increasing foods rich in magnesium and potassium. Stress management techniques such as deep breathing and meditation can be taught, and maintaining good social life and psychological state should be encouraged to reduce psychological stress.

5. Conclusion

This study identifies multiple harmful mutations in genetic heart disease-related genes (DMD, SIDT1, CSRP3, and DSG2) in three cases of Yunnan unexplained sudden death from a single family. These

mutations are predicted to be pathogenic and are associated with conditions such as long QT syndrome, dilated cardiomyopathy, hypertrophic cardiomyopathy, and arrhythmogenic right ventricular cardiomyopathy. The findings suggest that genetic heart disease mutations are highly likely to be the underlying cause of death in these cases. Whole exome sequencing proves to be an effective tool for etiological exploration, and the results highlight the importance of genetic screening, counseling, and long-term cardiac monitoring for at-risk family members and populations in affected areas.

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Disclosure statement

The authors declare no conflict of interest.

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The Application Effect of Nursing Interventions Based on Failure Mode and Effect Analysis in Non-invasive Positive Pressure Ventilation Therapy for Patients with Chronic Obstructive Pulmonary Disease Complicated by Type II Respiratory Failure

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Abstract: *Objective*: To investigate the application effect of nursing intervention based on Failure Mode and Effects Analysis (FMEA) in Non-Invasive Positive Pressure Ventilation (NPPV) treatment for patients with Chronic Obstructive Pulmonary Disease (COPD) complicated by Type II respiratory failure. *Methods*: Eighty patients with COPD complicated by Type II respiratory failure admitted from January 2024 to December 2025 were selected and randomly divided into a control group receiving conventional nursing and a study group receiving FMEA-based nursing intervention, with 40 cases in each group. Blood gas indicators, the incidence of adverse events, and quality of life scores were compared between the two groups after intervention. *Results*: After intervention, the blood gas indicators in the study group [PaO_2 (69.58 ± 5.21) mmHg, $PaCO_2$ (46.83 ± 4.56) mmHg, SaO_2 (93.87 ± 2.75) %] were significantly better than those in the control group [PaO_2 (63.12 ± 5.07) mmHg, $PaCO_2$ (52.15 ± 4.89) mmHg, SaO_2 (90.36 ± 2.89) %] ($p < 0.05$). The incidence of adverse events in the study group was significantly lower than that in the control group ($p < 0.05$). After intervention, the scores of all dimensions of the St. George's Respiratory Questionnaire (SGRQ) in the study group were significantly lower than those in the control group ($p < 0.05$), indicating a more significant improvement in quality of life. *Conclusion*: The FMEA-based nursing intervention constructed in this study can effectively improve blood gas indicators during NPPV treatment for patients with COPD complicated by Type II respiratory failure, reduce the incidence of adverse events, and significantly improve patients' quality of life, providing a widely applicable prospective risk prevention and control plan for specialized nursing management in clinical NPPV treatment.

Keywords: Chronic obstructive pulmonary disease; Type II respiratory failure; Non-invasive positive pressure ventilation; Failure mode and effects analysis; Nursing intervention; Quality of life

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1. Introduction

Chronic Obstructive Pulmonary Disease (COPD) is a progressive respiratory disease characterized by persistent airflow limitation, with a long course and high recurrence rate. In advanced stages, it often complicates with Type II respiratory failure, seriously threatening patients' lives and health [1]. Non-Invasive Positive Pressure Ventilation (NPPV) treatment, as a first-line treatment for COPD complicated by Type II respiratory failure, can improve pulmonary ventilation function and correct blood gas disorders through positive pressure ventilation, avoiding complications such as airway injury and infection caused by invasive ventilation, and significantly reducing patient mortality [2]. However, clinical practice has found that the clinical efficacy of NPPV treatment highly depends on the quality of nursing. Conventional nursing mainly focuses on symptomatic intervention and passive monitoring, lacking prospective prediction and systematic prevention and control of potential risks throughout the treatment process, which can easily lead to adverse events, treatment interruption, and decreased ventilation efficiency, affecting patient prognosis [3]. Failure Mode and Effects Analysis (FMEA) is a prospective risk assessment and quality improvement tool that systematically identifies potential failure modes in processes, quantifies risk levels, and formulates targeted improvement measures to achieve the nursing goal of "prevention first, whole-process control". It has been widely applied in fields such as critical care nursing, surgical nursing, and medical device operation, showing significant effects in reducing adverse events such as nursing catheter slippage and medical device-related pressure injuries [4]. Based on this, this study explores the effect of FMEA-based nursing intervention in patients with COPD complicated by Type II respiratory failure, compensating for the lack of prospective risk prevention and control in conventional nursing, and providing evidence-based support for optimizing nursing plans and improving the safety and effectiveness of NPPV treatment in clinical practice.

2. Materials and methods

2.1. General information

Eighty patients with COPD complicated by Type II respiratory failure admitted from January 2024 to December 2025 were selected and randomly divided into a control group and a study group, with 40 cases in each group. The sample size in this study was calculated using a clinical research sample size estimation formula, determining that at least 38 cases were required in each group. With 40 cases in each group in this study, the statistical requirements were met. There was no statistically significant difference in general information between the two groups ($p > 0.05$), indicating comparability, as shown in **Table 1**.

Table 1. Comparison of general information between the two groups [n, (%) / ($\overline{x} \pm s$)]

Group	Number of cases	Gender (n, %)		Age (years, $\overline{x} \pm s$)	Disease duration (years, ± s)	COPD classification (n, %)	
		Male	Female			Grade III	Grade IV
Control group	40	23 (57.50)	17 (42.50)	62.35 ± 7.12	8.62 ± 3.25	18 (45.00)	22 (55.00)
Study group	40	25 (62.50)	15 (37.50)	63.18 ± 6.89	9.05 ± 3.11	20 (50.00)	20 (50.00)
Statistical value (χ^2/t)		0.208		0.530	0.605	0.202	
p-value		0.648		0.598	0.547	0.654	

Note: Comparison between the two groups showed $p > 0.05$, indicating comparability.

2.2. Inclusion and exclusion criteria

2.2.1. Inclusion criteria

(1) Meeting the diagnostic criteria for COPD and confirmed with type II respiratory failure through arterial blood gas analysis [5];
(2) No restriction on gender, aged between 45 and 75 years;
(3) Having clear consciousness and able to cooperate with NPPV treatment and nursing procedures;
(4) Patients and their families providing informed consent and signing the informed consent form.

2.2.2. Exclusion criteria

(1) Having severe organ failure in vital organs such as the heart, liver, or kidneys;
(2) Having absolute contraindications to non-invasive positive pressure ventilation (e.g., facial deformities, severe upper airway obstruction, massive gastrointestinal bleeding);
(3) Having mental disorders or cognitive dysfunction that prevent cooperation with nursing care;
(4) Transferring to another hospital during the study period, voluntarily withdrawing from the study, or being lost to follow-up.

2.3. Methods

The control group received routine NPPV nursing care: dynamic monitoring of patients' vital signs, regular blood gas analysis, daily inspection and maintenance of non-invasive ventilators, guidance on proper mask fitting and adjustment, assistance in assuming semi-recumbent or sitting positions for comfortable ventilation, enhanced respiratory tract humidification management, guidance on effective coughing and sputum expulsion, symptomatic supportive care for underlying comorbidities, and concurrent health education on related diseases along with routine psychological intervention.

The study group received FMEA-based nursing intervention in addition to the routine care. Specific measures were as follows:

(1) Establishment of an FMEA nursing team

The team was led by the head nurse of the respiratory department and included 2 supervisor nurses, 5 registered nurses, and 1 respiratory therapist. Each member had at least five years of clinical nursing experience in the respiratory department and was proficient in non-invasive ventilator operation and the FMEA method. The team received specialized training in FMEA theory and practice, achieving a 100% pass rate. The team was responsible for reviewing the entire NPPV treatment nursing process, comprehensively identifying potential failure modes at each step, conducting risk grading and quantification, and developing and implementing targeted prevention and control measures. The team dynamically tracked intervention effects and continuously improved quality.

(2) Identification of potential failure modes

Through brainstorming, review of clinical adverse event cases, and consultation of relevant domestic and international literature, combined with the entire NPPV nursing process, the team identified potential failure modes. Five high-risk potential failure modes were ultimately identified: mask leakage/displacement, improper ventilator parameter settings, patient intolerance, retention of respiratory secretions, and pressure injuries on the nasal and facial skin.

(3) Risk assessment and prioritization

Using a 1–10 scale, each failure mode was scored across three dimensions: severity (S), occurrence

frequency (O), and detection difficulty (D). The risk priority number (RPN = S × O × D) was calculated for each failure mode, and they were ranked from highest to lowest RPN to identify high-risk failure modes as priorities for nursing intervention.

(4) Development and implementation of improvement measures

① Mask leakage/displacement: Select masks precisely based on the patient's facial contour, ensuring appropriate size. When wearing, allow one finger's width of slack. Apply hydrocolloid or foam dressings on the nasal bridge to reduce friction. Assist in protecting the mask when the patient turns over or moves. ② Improper parameter settings: Conduct special training on adjusting non-invasive ventilator parameters. Adjust parameters dynamically based on the patient's body weight, blood gas analysis, respiratory rate, and clinical symptoms to ensure ventilation effectiveness. ③ Patient intolerance (including physiological and psychological aspects): Comprehensively assess psychological status and provide targeted psychological intervention. Use videos, images, and written materials to explain the principles, necessity, and key cooperation points of NPPV treatment, and invite recovered patients to share experiences to enhance treatment confidence. Address discomfort during ventilation promptly. ④ Retention of respiratory secretions: Develop individualized sputum evacuation plans based on the patient's condition, including regular turning and back tapping. Turn patients to semi-recumbent or lateral positions with the head of the bed elevated 30–45°, and use the hollow palm tapping method to assist sputum expulsion, with intensity tolerable to the patient. Use a mechanical vibration sputum evacuation device as prescribed when necessary. Instruct patients in respiratory function training, such as pursed-lip breathing and abdominal breathing exercises. ⑤ Nasal and facial pressure injuries: Prioritize soft, well-ventilated silicone masks. Apply prophylactic dressings to pressure points for pressure relief. Loosen the mask every 2–3 hours for 10–15 minutes, during which low-flow oxygen (2–3 L/min) is administered via nasal cannula. Regularly inspect nasal and facial skin, focusing on pressure points, and address any signs of pressure injury promptly.

(5) Effect monitoring and continuous improvement

Convene weekly FMEA team quality control meetings to inspect and evaluate the implementation of intervention measures, recalculate the RPN values for each potential failure mode, analyze causes for unresolved or newly emerging issues, and adjust and optimize intervention measures accordingly. Both groups were intervened for 7 days, starting from the day the patient began NPPV treatment.

2.4. Observation indicators

2.4.1. Blood gas indicators

Radial artery blood was collected, and a blood gas analyzer was used to measure the levels of arterial partial pressure of oxygen (PaO_2), arterial partial pressure of carbon dioxide ($PaCO_2$), and oxygen saturation (SaO_2).

2.4.2. Adverse events

The occurrence and severity of adverse events during the intervention period were recorded. The severity was classified into levels I to IV according to the Nursing Adverse Event Grading Standards.

2.4.3. Quality of life

Assess using the Chinese version of the St. George's Respiratory Questionnaire (SGRQ) (Chinese version with good reliability and validity), which includes three dimensions: symptom dimension, activity limitation dimension, and disease impact dimension, with a total of 50 items. Each dimension is scored from 0 to 100, with higher scores indicating worse quality of life for the patient.

2.5. Statistical methods

Data analysis was performed using SPSS 26.0 statistical software. Measurement data were expressed as mean ± standard deviation ($\overline{x} \pm s$), and independent sample *t*-tests were used for comparisons between groups, while paired t-tests were used for comparisons within groups before and after intervention. Count data were expressed as frequency and percentage [n (%)], and χ^2 tests were used for comparisons between groups. A *p*-value < 0.05 was considered statistically significant.

3. Results

3.1. Comparison of blood gas indicators between the two groups before and after intervention

Before the intervention, there were no statistically significant differences in PaO_2, $PaCO_2$, and SaO_2 between the two groups of patients ($p > 0.05$). After the intervention, PaO_2 and SaO_2 in both groups increased significantly compared to those before the intervention, while $PaCO_2$ decreased significantly compared to that before the intervention ($p < 0.05$). Moreover, the extent of improvement in each blood gas indicator in the study group was significantly better than that in the control group ($p < 0.001$). See **Table 2**.

Table 2. Comparison of blood gas indicators between the two groups before and after intervention ($\overline{x} \pm s$)

Group	Number of cases	PaO_2 (mmHg)		$PaCO_2$ (mmHg)		SaO_2 (%)	
		Before intervention	After intervention	Before intervention	After intervention	Before intervention	After intervention
Control group	40	52.36 ± 4.18	63.12 ± 5.07	58.63 ± 5.24	52.15 ± 4.89	84.25 ± 3.16	90.36 ± 2.89
Study group	40	52.89 ± 4.32	69.58 ± 5.21	59.07 ± 5.31	46.83 ± 4.56	84.68 ± 3.21	93.87 ± 2.75
t value		0.568	5.620	0.373	5.032	0.604	5.565
p value		0.572	< 0.001	0.710	< 0.001	0.548	< 0.001

Note: Compared with the same group before intervention, $p < 0.05$; compared with the control group after intervention, $p < 0.001$.

3.2. Comparison of the incidence of adverse events between the two groups

The total incidence of adverse events in the study group was 5.00% (2/40), which was significantly lower than that in the control group at 22.50% (9/40), with a statistically significant difference ($\chi^2 = 5.165$, $p = 0.023$). The two adverse events in the study group were both nasal-facial pressure injuries, and no serious adverse events occurred. See **Table 3**.

Table 3. Comparison of the incidence of adverse events between the two groups [n, (%)]

Group	Number of cases	Mask leakage/ displacement	Nasofacial pressure injury	Respiratory tract infection	Ventilator-associated pneumonia	Unplanned extubation	Total occurrence
Control group	40	3 (7.50)	2 (5.00)	2 (5.00)	1 (2.50)	1 (2.50)	9 (22.50)
Study group	40	0 (0)	1 (2.50)	0 (0)	0 (0)	0 (0)	2 (5.00)
χ^2 value							5.165
p value							0.023

3.3. Comparison of quality of life scores between the two groups before and after intervention

Before the intervention, there were no statistically significant differences in the scores of each dimension of the St. George's Respiratory Questionnaire (SGRQ) between the two groups ($p > 0.05$). After the intervention, the scores of each dimension of the SGRQ in both groups decreased significantly compared to those before the intervention ($p < 0.05$). Moreover, the scores of each dimension in the study group were significantly lower than those in the control group ($p < 0.001$), with the largest decrease observed in the symptom dimension score, indicating a more significant improvement in quality of life. See **Table 4**.

Table 4. Comparison of quality of life scores between the two groups before and after intervention (± s, points)

Group	Number of cases	Symptom dimension		Activity limitation dimension		Disease impact dimension	
		Before intervention	After intervention	Before intervention	After intervention	Before intervention	After intervention
Control group	40	58.76 ± 4.23	45.89 ± 3.54	62.34 ± 4.56	48.76 ± 3.67	56.89 ± 4.31	43.25 ± 3.48
Study group	40	59.12 ± 4.35	32.14 ± 3.26	62.56 ± 4.68	35.65 ± 3.42	57.12 ± 4.42	30.23 ± 3.15
t value		0.375	18.071	0.213	16.528	0.236	17.543
p value		0.709	< 0.001	0.832	< 0.001	0.814	< 0.001

Note: Compared with the same group before intervention, $P<0.05$; compared with the control group after intervention, $p < 0.001$.

4. Discussion

COPD complicated with type II respiratory failure is a common critical illness in respiratory medicine. As a first-line intervention, NPPV treatment can effectively improve patients' ventilation function, correct hypoxia and carbon dioxide retention, but its therapeutic effect is significantly influenced by the quality of nursing care [6]. Conventional nursing care mainly focuses on symptomatic interventions, lacking forward-looking risk prevention and control awareness, making it difficult to effectively avoid potential safety hazards during NPPV treatment, such as mask leakage, nasal and facial pressure injuries, and patient intolerance, thereby affecting treatment outcomes [7]. As a forward-looking risk assessment tool, FMEA achieves closed-loop optimization of nursing processes by systematically identifying failure modes in the process, quantifying risk levels, and formulating targeted improvement measures, and has been widely applied in the field of critical care nursing [8]. Through the closed-loop management of "identification-evaluation-intervention-monitoring", FMEA transforms nursing risk prevention and control from "post-event handling" to "pre-event prevention and in-event control", meeting the needs of refined nursing care for NPPV treatment and is the core reason for the significant intervention effect in this study.

The results of this study show that after intervention, the blood gas indicators of patients in the study group were significantly better than those in the control group. The reason is that the FMEA team identified "inappropriate ventilator parameter settings" as a high-risk failure mode by combing through the entire NPPV nursing process, formulated personalized parameter adjustment plans, and dynamically optimized ventilation parameters based on patients' weight, blood gas results, and clinical symptoms, avoiding ventilation insufficiency or excess caused by standardized parameter settings in conventional nursing care, effectively improving ventilation efficiency, and correcting patients' hypoxia and carbon dioxide retention. At the same time, by optimizing the nursing process, empirical nursing was transformed into standardized and standardized nursing, reducing human operational errors, further improving the effectiveness of

nursing operations and intervention effects, and ultimately achieving significant improvements in blood gas indicators. Adverse events during NPPV treatment are mostly related to deficiencies in the nursing process and insufficient risk anticipation, such as mask leakage often caused by inappropriate model selection and improper fixation, and nasal and facial pressure injuries related to prolonged local pressure and insufficient protective measures [9]. Liu Litian and others showed that nursing interventions using FMEA can significantly reduce nasal and facial medical device-related pressure injuries through forward-looking risk prevention and control, and the results of this study are consistent with that research, further verifying the clinical value of FMEA in preventing medical device-related pressure injuries [10]. The results of this study show that the incidence of adverse events in the study group was significantly lower than that in the control group, and no serious adverse events occurred, because FMEA comprehensively and systematically identified potential failure modes in the entire NPPV treatment process through team brainstorming, quantified risks through S, O, and D scores, and identified high-priority intervention targets, avoiding the drawback of "emphasizing treatment over prevention" in conventional nursing care. Targeted intervention measures formulated for each high-risk failure mode prevented adverse events from occurring at the source, effectively improving the safety of NPPV treatment. After intervention, the SGRQ scores in all dimensions of patients in the study group were significantly lower than those in the control group, with a more significant improvement in quality of life and the largest decrease in symptom dimension scores. Nursing interventions based on FMEA reduce patients' physiological pain by accurately avoiding adverse events, significantly improve patients' respiratory function through personalized parameter settings and airway management, enhance respiratory function reserve, and increase patients' daily activity capabilities. In addition, personalized psychological counseling and health education conducted for patients' intolerance effectively alleviate negative emotions such as anxiety and fear towards NPPV treatment, reducing the impact of psychological factors on patients' living conditions. FMEA interventions improve patients' living conditions comprehensively from both physiological and psychological dimensions, thus achieving a significant improvement in quality of life.

5. Conclusion

In summary, nursing interventions based on FMEA can effectively improve blood gas indicators and pulmonary ventilation function during NPPV treatment in patients with COPD complicated with type II respiratory failure, reduce the incidence of adverse events, and improve patients' quality of life from both physiological and psychological dimensions, with high clinical application value. This study has certain limitations. Firstly, it is a single-center study with a small sample size, which may lead to biased results. Subsequent studies can conduct multi-center, large-sample, prospective cohort studies to further verify the long-term effects of FMEA nursing interventions. Secondly, the observation period of this study was relatively short, only focusing on the effects within 7 days of intervention, and the impact on patients' long-term prognosis needs further follow-up observation. Subsequent studies will extend the follow-up period to 3 months or 6 months to explore the impact of FMEA interventions on patients' long-term pulmonary function, readmission rates, and mortality rates. At the same time, this study did not conduct an economic analysis of nurses' workload or nursing costs, and subsequent studies can conduct health economics research to evaluate the cost-effectiveness ratio of FMEA interventions and provide economic evidence for clinical promotion. In addition, this study did not conduct subgroup analysis on the intervention effects of patients with different COPD severity levels (Grade III/Grade IV), and subsequent studies can further explore the application differences of FMEA interventions in patients with different severity levels to provide more precise evidence-based support for the formulation of individualized nursing plans.

Disclosure statement

The authors declare no conflict of interest.

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A Visualization Study on the Nursing of Female Menopausal Syndrome Based on CiteSpace

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Abstract: *Background*: With the accelerating global population aging, health issues related to menopausal syndrome in women are becoming increasingly prominent. Although related research and guidelines continue to enrich, problems such as fragmented knowledge and dispersed research efforts constrain the improvement of nursing quality.*Objective*: To analyze and summarize current research trends and hot topics in women's health concerning menopausal syndrome, and to explore the forefront development directions in this field.*Methods*: Based on literature retrieved from the China National Knowledge Infrastructure (CNKI) and Web of Science (WOS) databases from their inception to December 2024, this study ultimately included 639 articles (256 in Chinese, 383 in English). Using CiteSpace software, a bibliometric and visual analysis was conducted to construct knowledge maps of countries, institutions, authors, and keywords. *Results*: The overall publication volume of both Chinese and English literature showed an upward trend. English publications reached 53 in 2024, while Chinese publications peaked at 30 in 2019. The United States led in publication output (117 articles, 21.91%). Among Chinese institutions, the highest publication count was only 2 articles. Keyword analysis revealed that "menopausal syndrome" and "psychological care" were hot topics in Chinese literature (frequencies 51, 40), whereas "symptoms" and "quality of life" were high-frequency keywords in English literature (frequencies 98, 78). The cluster structures were significant ($Q > 0.53$, $S > 0.78$), and burst term analysis indicated an evolution in research focus from symptomatic care towards personalized interventions. *Conclusions*: Knowledge graph visualization can clearly present the development context and hotspot differences in research on nursing care for women with menopausal syndrome, providing a reference for subsequent studies.

Keywords: Menopausal syndrome; Climacteric syndrome; Perimenopausal syndrome; Women's health; Nursing; Citespace; Visual analysis

Online publication: Apr 30, 2026

1. Introduction

Menopausal syndrome represents a pivotal phase for women transitioning from their reproductive years to

their senior years, typically occurring between the ages of 40 and 65 and marked by menopause [1]. During this period, women experience significant hormonal changes, which can trigger a range of physical and psychological symptoms such as hot flashes, insomnia, and mood swings, severely impacting their quality of life [2]. According to statistics, the number of women in China experiencing menopausal syndrome is projected to reach 210 million by 2030, with over 85% experiencing varying degrees of symptoms, and approximately 5% to 10% suffering from severe symptoms requiring medical intervention [3].

In recent years, there has been increasing attention both domestically and internationally on the care of menopausal syndrome, with a growing body of clinical guidelines and research. China has successively released the "Chinese Guidelines for Menopause Management and Menopausal Hormone Therapy (2023 Edition)" [1] and the "Guidelines for Integrated Traditional Chinese and Western Medicine Diagnosis and Treatment of Menopausal Syndrome (2023 Edition)" [4]. Internationally, nursing norms centered around hormone therapy have also been established. However, research findings in this field are scattered and lack systematic integration, and the research hotspots, collaboration networks, and development trends both domestically and internationally remain unclear.

CiteSpace, a globally renowned visualization software developed and promoted by Professor Chaomei Chen's team, can visually present digital information in a research field, enabling readers to more clearly and intuitively access cutting-edge academic information or predict future research trends and hotspots [5,6]. As a powerful knowledge visualization tool, knowledge graphs can effectively integrate fragmented information and reveal the knowledge structure and development dynamics of a field. This study conducted a visual analysis of literature related to the care of female menopausal syndrome using CiteSpace software, based on the China National Knowledge Infrastructure (CNKI) and Web of Science (WOS) databases. The aim was to systematically review the research status, hot topics, and development trends in this field, providing a reference for future research and clinical practice.

2. Materials and methods

2.1. Data sources

This study selected the CNKI database and the Web of Science (WOS) Core Collection database as sources for Chinese and English literature, respectively. The search time range was set from the establishment of each database until December 2024. The Chinese search formula was: (Topic = menopausal syndrome OR menopausal syndrome syndrome OR perimenopause OR perimenopausal syndrome) AND (Topic = female) AND (Topic = nursing). The corresponding English search formula was: (Ts = ("menopausal syndrome" OR menopause OR "perimenopausal syndrome" OR "perimenopausal period" OR perimenopause)) AND (Ts = (female OR woman OR women)) AND (Ts = (nursing OR care OR caring)). The literature screening criteria were as follows: exclude non-research literature such as conference papers and theses; conduct an initial screening by reading titles and abstracts, followed by a further review of the full text to exclude irrelevant and redundantly published literature. A total of 639 qualified articles were included, comprising 256 Chinese articles and 383 English articles. The bibliographic information of the finally qualified articles was exported in Refworks format (CNKI) and plain text format (WOS), stored in "download_XXX.txt" format for subsequent analysis.

2.2. Research methods

The bibliographic information of the included Chinese and English articles was imported into CiteSpace 6.3.R1 software, respectively, and the literature was formatted. The time span (time slicing) was set from the establishment of the database to December 2024, with a time partition (years per slice) of 3 years; node types (node types) were selected as country, institution, author, cited journal, cited literature, and keywords, etc.; the node selection method was g-index, with k = 25, Top N = 50, Top N% = 10%; the pruning method selected pathfinder and show merged network; the remaining parameters were set to default values for analysis and generation of visual knowledge graphs to scientifically present the research results.

3. Results

3.1. Temporal analysis of publication volume

Both Chinese and English literature showed a significant upward trend in annual publication volume (**Figure 1**). Chinese research experienced a slow start between 1995 and 2008, with an average annual publication of less than 2 articles; it entered a rapid growth phase after 2009, with the average annual publication volume rising to 18 articles and reaching a peak of 30 articles in 2019. English research, after its first publication in 1996, developed slowly until 2006; it entered a steady growth phase from 2007 to 2019 (averaging 12 articles per year); the growth rate accelerated significantly after 2020, with the highest publication volume of 53 articles in 2024.

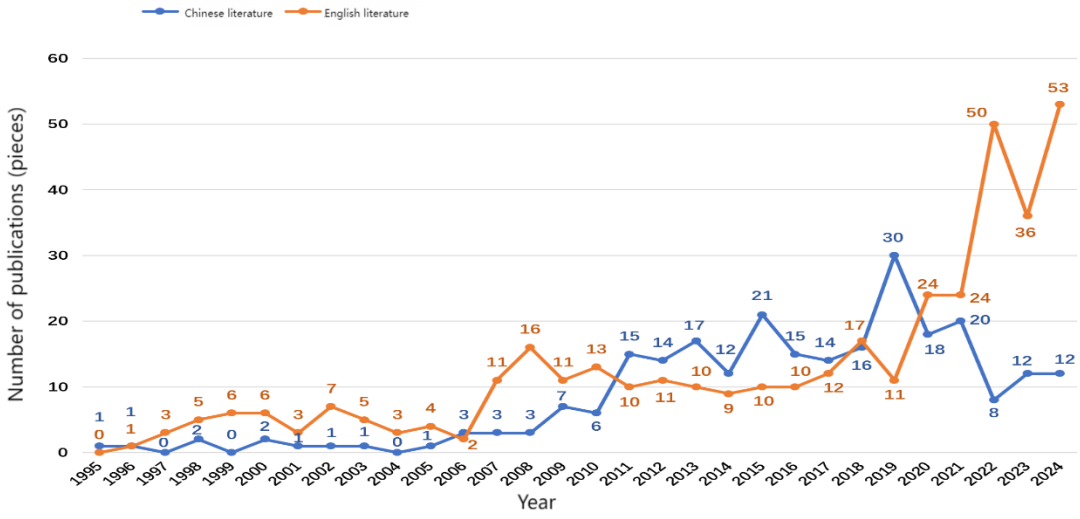


Figure 1. Analysis of the number of Chinese and English publications related to nursing research on female menopausal syndrome.

3.2. Country distribution and collaboration network

CiteSpace only supports country analysis for English literature. A total of 68 countries were included in the analysis, with 182 connections between nodes and a network density of 0.0799. Countries with a higher number of publications and stronger centrality exhibited closer collaboration relationships (see **Figure 2**). The top 10 countries in terms of publication volume (see **Table 1**) accounted for 68.54% of the total publications. The top three countries were the United States with 117 publications (21.91% of the total output), Australia

with 39 publications (7.30%), and England with 38 publications (7.12%). The United States had an absolute advantage in terms of publication volume. The United States, England, Italy, and South Korea demonstrated strong centrality (> 0.1), with the United States (0.23) having the most prominent academic influence.

Table 1. Top 10 countries by number of English publications related to nursing research on female menopausal syndrome

No.	Country	Number of publications	Percentage (%)	Centrality
1	USA	117	21.91	0.23
2	AUSTRALIA	39	7.30	0.08
3	ENGLAND	38	7.12	0.13
4	ENGLAND/IRAN	24/24	4.49/4.49	0.01/0
5	PEOPLES R CHINA	20	3.75	0.04
6	TURKEY	19	3.56	0.01
7	BRAZIL	18	3.37	0
8	SPAIN/INDIA	15/15	2.81/2.81	0.05/0
9	ITALY/SOUTH KOREA	13/13	2.43/2.43	0.11/0
10	POLAND	11	2.06	0

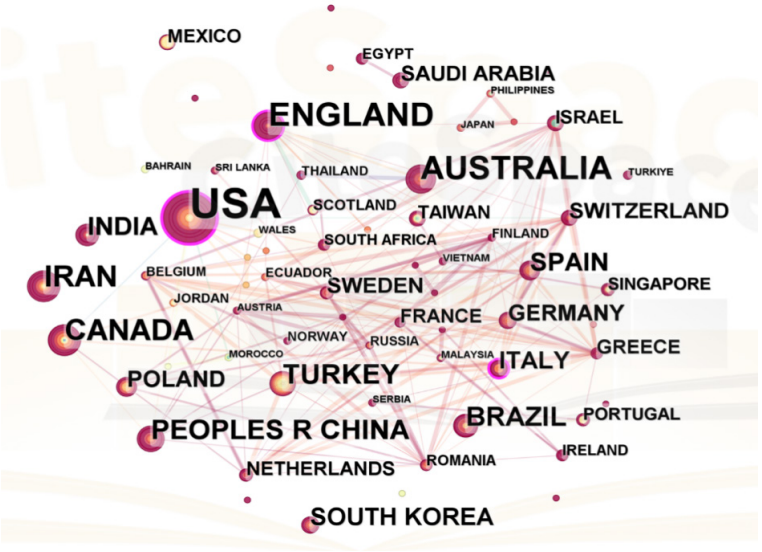


Figure 2. Country analysis of English literature related to nursing research on female menopausal syndrome.

3.3. Analysis of institutional and author collaboration

Institutional analysis indicates that research efforts are relatively dispersed both domestically and internationally. Chinese literature involves 225 institutions, with 97.78% of them publishing only one paper each, resulting in a low network density of 0.0011 and sparse collaborative connections (**Figure 3**). Among English literature, institutions such as Monash University (16 papers, 3.74%), University College London (UCL) (12 papers, 2.80%), University of Toronto (7 papers, 1.64%), and Harvard Medical School (7 papers, 1.64%) have published a relatively large number of papers, but the collaborative network among institutions remains weak (network density of 0.0087) (**Figure 4**).



Figure 3. Analysis of institutions in Chinese literature related to nursing research on female menopausal syndrome.

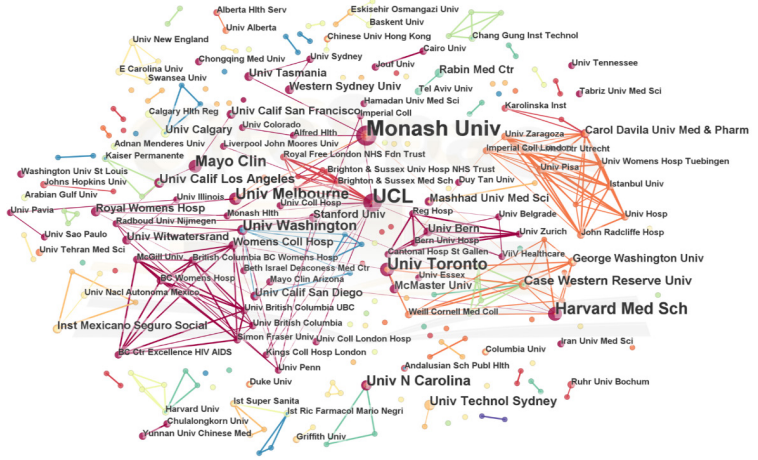


Figure 4. Analysis of institutions in English literature related to nursing research on female menopausal syndrome.

3.4. Author publication and collaboration

There is a total of 285 authors in Chinese literature, with 6 authors (4.21%) having the highest publication count of 2 papers each, and the remaining 279 authors having published only 1 paper each. All authors have a centrality of 0, indicating relatively low influence. However, several closely collaborating teams have begun to emerge. In English literature, there are 294 authors, with Stute, Petra being the most prolific contributor with 6 papers, followed by Hickey, Martha with 4 papers. Stute, Petra also has the highest degree value of 18, indicating a relatively high influence. No authors have a centrality greater than 0.1. Several actively collaborating teams have formed.

The maps illustrate the core authors, collaboration networks, and their strengths. Larger nodes represent authors with a higher number of publications, while thicker lines indicate closer collaborative relationships. In Chinese literature (see **Figure 5**), there are 346 connections with a network density of 0.0088. In English literature (see **Figure 6**), there are 425 connections with a network density of 0.0049. Both suggest that there is room for improvement in the number of publications and the level of collaboration among authors.

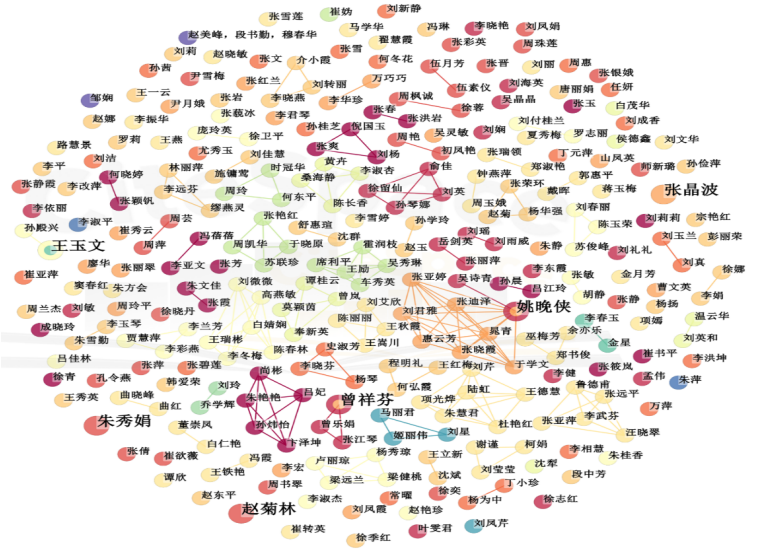


Figure 5. Analysis of authors in chinese literature related to nursing research on female menopausal syndrome.

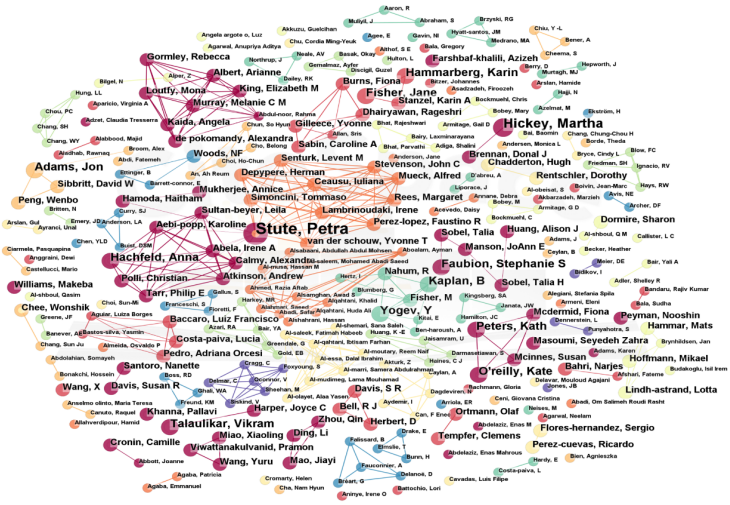


Figure 6. Analysis of authors in English literature related to nursing research on female menopausal syndrome.

3.5. Keyword co-occurrence

In Chinese literature, there are a total of 10 keywords with a frequency of occurrence ≥ 10, with the top three being menopausal syndrome (51), perimenopause (42), and psychological care (40). The top three keywords in terms of centrality are perimenopause (0.52), nursing (0.37), and psychological care (0.29), representing the core content and hot topics of the research (see **Table 2**). In English literature, there are 38 keywords with a frequency of occurrence ≥ 10, with "symptoms" being the most frequent (98) and "vasomotor symptoms" having the highest centrality (0.16) (see **Table 3**), fully reflecting their importance and influence. The co-occurrence map for Chinese literature has 181 nodes and 389 connections, with a network density of 0.0239; the map for English literature has 270 nodes and 773 connections, with a network density of 0.0213 (see **Figures 7** and **8**).

Table 2. Top 10 keywords by frequency of occurrence in Chinese literature related to nursing research on female menopausal syndrome

No.	Keyword	Frequency (times)	Centrality	No.
1	Menopausal Syndrome	51	0.4	1
2	Perimenopause	42	0.52	2
3	Psychological Nursing	40	0.29	3
4	Nursing	35	0.37	4
5	Nursing Intervention	31	0.15	5
6	Women	25	0.12	6
7	Quality of Life	20	0.14	7
8	Anxiety	18	0.09	8
9	Depression/Sleep Quality	17/17	0.11/0.02	9
10	Health Education/Depressive Disorder	15/15	0.08/0.07	10

Table 3. Top 10 keywords by frequency of occurrence in English literature related to nursing research on female menopausal syndrome

No.	Keyword	Frequency	Centrality
1	symptoms	98	0.12
2	postmenopausal women	81	0.10
3	quality of life	78	0.13
4	health	69	0.06
5	hormone replacement therapy	60	0.14
6	vasomotor symptoms	51	0.16
7	women	49	0.14
8	women's health	41	0.07
9	hormone therapy	40	0.06
10	prevalence	39	0.06



Figure 7. Keyword analysis of Chinese literature related to nursing research on female menopausal syndrome.

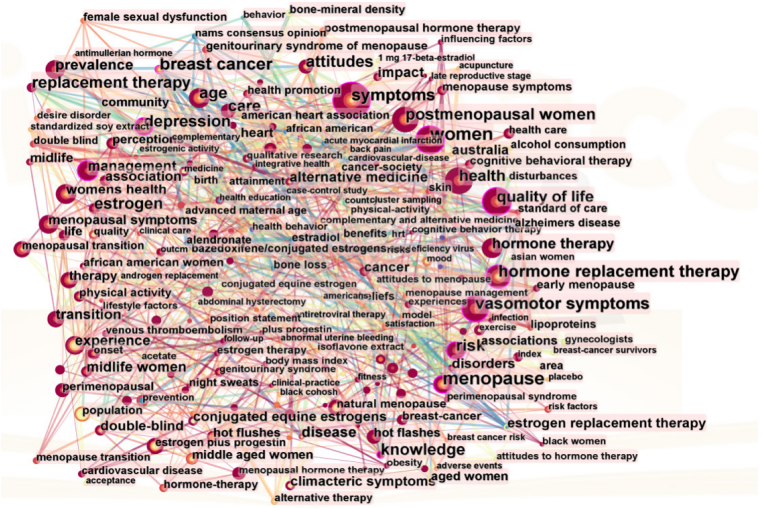


Figure 8. Keyword analysis of English literature related to nursing research on female menopausal syndrome.

3.6. Keyword clustering

The modularity Q value represents the network map structure, while the average silhouette S value indicates the clarity of clustering. A Q value greater than 0.3 signifies a significant clustering structure, and an S value greater than 0.5 indicates reasonable clustering, while an S value greater than 0.7 suggests high clustering credibility [7]. The Chinese literature generated eight clusters (see **Figure 9**), with smaller cluster label numbers indicating a larger number of included keywords, reflecting research hotspots relatively clearly. The Q value is 0.5482 (> 0.3), and the S value is 0.8376 (> 0.7), indicating that the research themes among clusters are well-defined, with a significant structure and high credibility. The English literature clustering analysis generated 12 clusters (see **Figure 10**), with Q = 0.5347 and S = 0.7803, indicating a reasonable and credible clustering structure.

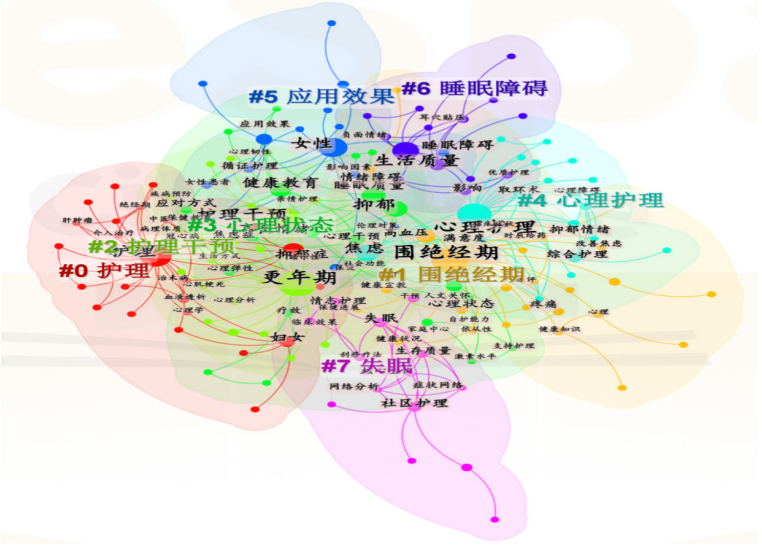


Figure 9. Cluster analysis of keywords in Chinese literature related to nursing research on female menopausal syndrome.



Figure 10. Cluster analysis of keywords in English literature related to nursing research on female menopausal syndrome.

3.7. Keyword bursts

Figure 11 shows that 24 burst terms (γ = 0.4) were generated in Chinese literature, with "nursing" (3.02), "application effectiveness" (2.86), "psychological state" (2.47), and "psychological care" (2.24) demonstrating strong burst intensities. "Nursing" and "menopausal syndrome" have persisted for over a decade since their first appearance in 1996, representing the longest duration. From 2005 onwards, ten burst terms, including "women", "depression" and "community care", emerged as the second tier, appearing sequentially. In 2018, seven burst terms, such as "application effectiveness", "female patients" and "hypertension" formed the third tier, receiving concurrent attention and persisting until 2022. Starting from 2019, burst terms from the fourth tier, including "negative emotions" "psychological state" "health knowledge" "compliance" and "coping strategies" have emerged and persisted to the present. **Figure 12** illustrates that 25 burst terms (γ = 0.2) were generated in English literature. "Hormone replacement therapy" first appeared in 1996 and persisted for the longest duration of six years. From 1997 to 1998, five burst terms, including "estrogen replacement therapy", "prevention" and "knowledge", emerged as the second stage. The third stage, spanning from 2002 to 2016, saw the sequential emergence of ten burst terms, such as "midlife", "hot flushes", and "postmenopausal hormone therapy". Since 2016, the fourth stage has witnessed the sequential appearance of nine burst terms, including "risk factors", "menopause transition" and "hormone therapy", with five burst terms, namely "menopause symptoms", "prevalence", and "menopausal hormone therapy", persisting to the present.

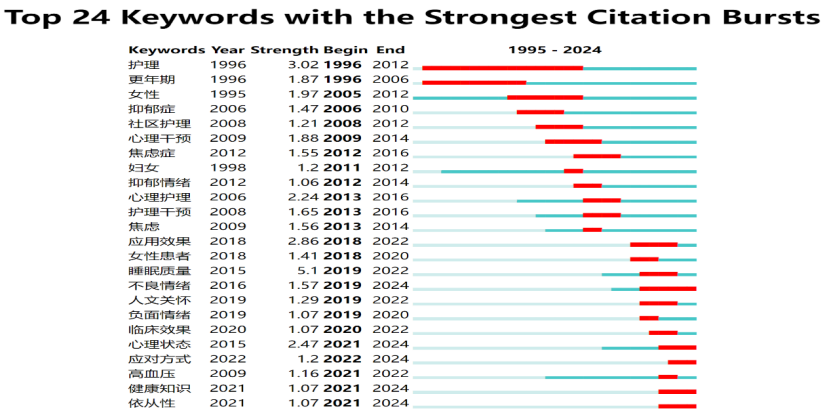


Figure 11. Burst analysis of keywords in Chinese literature related to nursing research on female menopausal syndrome.

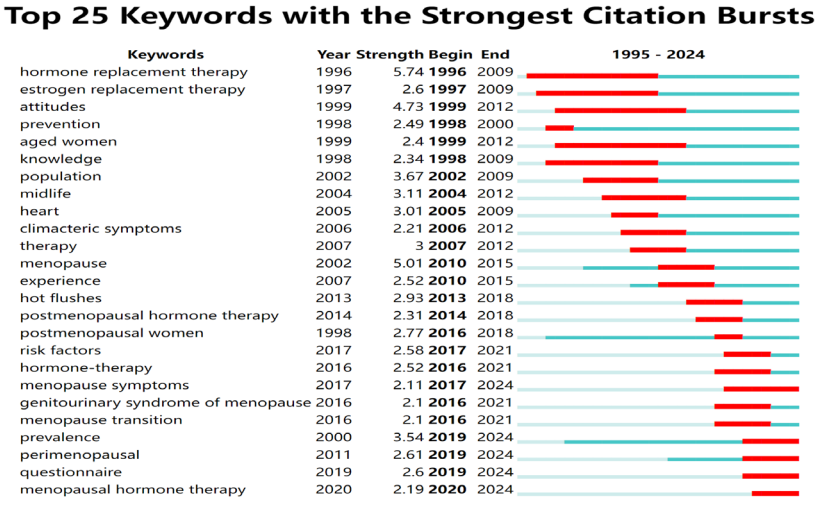


Figure 12. Burst analysis of keywords in English literature related to research on nursing for female menopausal syndrome.

4. Discussion

4.1. Uneven distribution of research strength with emerging international collaboration patterns

This study visually reveals the uneven distribution of global research strength in the field of nursing for female menopausal syndrome through knowledge mapping. The United States holds an absolute dominant position in terms of both publication volume and academic influence. In contrast, China, despite a relatively late start in this field, has witnessed rapid growth since 2009, possibly attributed to the goals and commitments outlined in the United Nations' "Future Compact (2024)", and the implementation of a series of plans and programs such as the "Healthy China Initiative (2019–2030)", the "Maternal and Child Safety Enhancement Plan (2021–2025)", the "Reproductive Health Promotion Action Plan (2023–2025)", and the "Outline for the Development of Chinese Women (2021–2030)" [8–15]. However, domestic research institutions are characterized by their small scale and scattered distribution, with sparse collaborative networks among institutions and a scarcity of high-producing author teams, severely constraining the output of high-quality research outcomes and the enhancement of academic influence. In the future, it is imperative to strengthen

collaboration among domestic institutions and actively integrate into the international collaboration network centered around the United States to facilitate knowledge exchange and resource sharing.

4.2. Divergent research hotspots reflecting different nursing philosophies

Keyword clustering, which extracts cluster label words using the log-likelihood ratio (LLR) sorting algorithm based on the intrinsic similarity of keywords, serves as a core summary and highly condensed representation of research papers [16,17]. The frequency of these keywords reflects the hot topics of concern among scholars in the field [18]. The research method of dividing keywords into multiple network clusters represents a further in-depth exploration of keyword co-occurrence. The results of keyword and cluster analysis reveal significant differences in research hotspots between Chinese and English literature, reflecting distinct nursing philosophies and cultural backgrounds. Chinese research highly focuses on practical topics such as “psychological nursing” and “nursing interventions”, forming characteristic clusters like “traditional Chinese medicine (TCM) conditioning” and “community nursing”, highlighting the importance of traditional medicine in symptom relief and the role of primary healthcare services in China, consistent with the orientation of the “International Clinical Practice Guidelines for Traditional Chinese Medicine” [19]. In contrast, English research places greater emphasis on pathological mechanisms and precise treatment plans such as “vasomotor symptoms” and “hormone replacement therapy”, focusing on “quality of life” and long-term health outcomes, aligning closely with the “personalized hormone therapy” and “whole-cycle health management” concepts advocated by the International Menopause Society [20]. These differences suggest that future research should strengthen dialogue and complementarity between Western and traditional Chinese medicine, leveraging the holistic conditioning advantages of TCM while deepening evidence-based research on the effectiveness and safety of modern medical treatment plans.

4.3. Research frontiers shifting towards personalization and long-term management

Burst words, which refer to vocabulary that experiences a sudden increase in frequency within a specific time period, reflect the cutting-edge dynamics in a research field during that period [21]. Burst word analysis clearly demonstrates the dynamic evolution of research frontiers in this field. In recent years, terms such as “application effectiveness” and “compliance” have emerged as burst words in Chinese research, indicating a shift from descriptive studies to in-depth evaluations of the effectiveness, feasibility, and patient self-management efficacy of interventions. In English research, burst words like “risk factors” and “menopause transition” mark a forward-looking shift from mere symptom treatment to health risk prediction and management throughout the entire process of menopausal syndrome at the international frontier. Notably, although artificial intelligence and digital health technologies have not directly become high-frequency burst words, their concepts are implicitly embedded in trends such as intelligent assessment and remote monitoring, suggesting that combining information technology to achieve personalized and intelligent health management for menopausal syndrome will be an important future development direction [22].

5. Prospects and limitations

This study systematically reveals the research status and frontiers in the field of nursing for female menopausal syndrome through knowledge mapping but also acknowledges certain limitations. Firstly, the data sources are limited to the CNKI and WOS core collection databases, potentially failing to fully cover

important materials such as gray literature. Secondly, the semantic parsing depth of CiteSpace software for Chinese vocabulary is limited, possibly affecting the precision of cluster labels. Based on the findings of this study, future research in this field can be further expanded in the following aspects:

(1) Deepening research content

Future research should strengthen interdisciplinary collaboration, particularly the deep integration of Western and traditional Chinese medicine, promote the standardization and evidence-based development of TCM nursing plans, and conduct in-depth research on long-term health outcomes throughout the entire cycle of menopausal syndrome.

(2) Innovating research methods

Explore the application of artificial intelligence, big data, and digital health technologies in nursing for menopausal syndrome. For example, develop intelligent risk assessment models and construct personalized health management platforms to achieve a transition from "group-based" nursing to "precision" management.

(3) Expanding data dimensions

Subsequent research can incorporate more diverse data sources (such as clinical data, patient-reported outcomes, etc.) and combine advanced text mining techniques like natural language processing for deeper knowledge discovery, constructing a dynamically updated knowledge system to provide more robust support for clinical practice and policy formulation. In conclusion, promoting the development of nursing research for female menopausal syndrome towards collaboration, intelligence, and precision is an inevitable trend to enhance the health level of women with menopausal syndrome globally.

Disclosure statement

The authors declare no conflict of interest.

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An Empirical Study on the Quality Assessment and Improvement of Outpatient Prescriptions in Tertiary-Grade Class-A Hospitals under Multi-Policy Coordination

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Abstract: *Objective*: To evaluate the quality of outpatient prescriptions for Western and proprietary Chinese medicines in a tertiary hospital under the coordinated implementation of DRG/DIP payment reform, the Tertiary Hospital Evaluation Standards (2025 Edition), and the National Performance Assessment of Tertiary Public Hospitals, and to examine the effectiveness of a policy-embedded management model. *Methods*: A triple stratified random sampling approach (disease category–department–month) was used to collect 4,996 outpatient prescriptions from January 2024 to September 2025. A four-dimensional framework (compliance, economy, efficacy, and risk) was established. Prescription quality was assessed using a risk-scoring model and Apriori association rule analysis. *Results*: The overall qualification rate was 96.2% (4,807/4,996). The mean number of drugs per prescription was 2.6 ± 0.8; antimicrobial use rate was 16.8%; essential medicines accounted for 62.5%; and drug cost proportion for key DRG/DIP disease groups was 28.3%, all meeting policy targets. Among 189 unqualified prescriptions, inappropriate medication use (38.5%) and minor omissions (48.7%) were the main issues. Association rules identified junior physicians in chronic disease management as a key risk factor (confidence > 40%). *Conclusion*: The policy-embedded model effectively improved core prescription quality indicators to required standards. Further optimization is needed for special populations, junior physician prescribing, and intelligent system support. The proposed Assessment–Insight–Intervention closed-loop model provides a practical framework for advancing refined prescription management.

Keywords: Outpatient prescription quality; DRG/DIP payment reform; National Performance Assessment; Antimicrobial stewardship; Association rule analysis

Online publication: Apr 30, 2026

1. Background

Outpatient prescriptions represent both the culmination of clinical decision-making and the starting point of

drug utilization, and are widely recognized as a core indicator of healthcare quality and hospital management performance [1]. Their quality is directly associated with patient safety, rational drug use, and efficient allocation of medical resources [2].

In recent years, China's healthcare system has undergone a transition toward coordinated policy governance. The implementation of DRG/DIP-based payment reform, the Tertiary Hospital Evaluation Standards (2025 Edition), and the National Performance Assessment of Tertiary Public Hospitals has established an integrated regulatory framework emphasizing quality, efficiency, and cost control [3–5]. Within this framework, key indicators, including prescription qualification rate (≥ 95%), proportion of essential medicines (≥ 60%), antimicrobial use rate (≤ 20%), and disease-specific drug expenditure, have become critical benchmarks for hospital evaluation and continuous quality improvement [6].

Tertiary hospitals, particularly large regional medical centers, manage a high volume of patients with complex and chronic conditions, where polypharmacy is prevalent and prescription appropriateness is more difficult to ensure [7]. Although previous studies have reported improvements in prescription qualification rates through routine prescription review and administrative interventions, most remain limited to descriptive analyses and lack systematic evaluation under multi-policy coordination [8,9]. As policy requirements evolve, merely achieving compliance is no longer sufficient; there is an increasing need to advance toward refined (lean) prescription management.

Therefore, this study, based on real-world data from a tertiary hospital that has already met core policy indicators, aims to evaluate prescription quality under coordinated policy constraints, identify potential risk patterns using data-driven methods, and develop a policy-embedded continuous improvement model for outpatient prescription management.

2. Methods

2.1. Study design and data source

This was a cross-sectional study. Data were extracted from the Hospital Information System (HIS) from January 1, 2024 to September 30, 2025.

2.1.1. Inclusion criteria

(1) Complete prescription information;

(2) Diagnoses corresponding to high-weight disease categories in the local DRG/DIP database (e.g., hypertension, diabetes).

2.1.2. Exclusion criteria

(1) Emergency prescriptions, inpatient medical orders, and prescriptions for anesthetic or Category I psychotropic drugs.

2.2. Sampling method

A triple stratified random sampling strategy (disease category–department–month) was applied to enhance representativeness. First, ten core disease categories were identified. Second, prescriptions were stratified across eight major outpatient departments. Third, monthly stratification (21 months) was performed, followed by random sampling within each stratum. A total of 4,996 prescriptions were included. The Kolmogorov–

Smirnov test indicated no significant difference between the sample and the overall population structure ($p > 0.05$).

2.3. Evaluation framework

A four-dimensional evaluation system was developed based on policy requirements and clinical guidelines.

(1) Compliance

Prescription qualification rate, antimicrobial use rate, and proportion of essential medicines.

(2) Economy

Proportion of drug costs for DRG/DIP disease groups and average drug cost per visit.

(3) Efficacy

Appropriateness rate of prescriptions, adjustment rate for special populations, and compliance rate of long-term prescriptions for chronic diseases.

(4) Risk

Prescriptions were classified into low-, medium-, and high-risk categories according to a pre-defined risk-scoring model based on error type, clinical impact, and regulatory sensitivity.

2.4. Statistical analysis

Descriptive statistics were conducted using SPSS 26.0. Categorical variables were expressed as frequency (percentage), and continuous variables as mean ± standard deviation. Apriori association rule analysis was applied to identify patterns among department, physician seniority, disease diagnosis, and types of inappropriate prescriptions (minimum support: 5%; minimum confidence: 30%). A two-sided $p < 0.05$ was considered statistically significant.

3. Results

3.1. Basic prescription characteristics and multi-policy conformity

Analysis of 4,996 outpatient prescriptions revealed that all core indicators met or exceeded national policy benchmarks (**Table 1**). The prescription qualification rate was 96.2%, the average number of drugs per prescription was 2.6 ± 0.8, the antimicrobial use rate was 16.8%, the proportion of essential medicines was 62.5%, the chronic disease long-term prescription compliance rate was 92.7%, and the drug cost proportion for key DRG/DIP disease groups was 28.3%. These results demonstrate substantial effectiveness in the coordinated multi-policy pharmaceutical governance of this institution.

Table 1. Conformity analysis of core prescription metrics with national policy benchmarks

Evaluation indicator	Study result	National policy / Industry standard	Conformity
Prescription qualification rate (%)	96.2	≥ 95 (2025 Tertiary Hospital Reaccreditation)	Yes
Number of drugs per prescription	2.6 ± 0.8	1.6–2.8 (WHO Recommendation)	Yes
Antimicrobial use rate (%)	16.8	≤ 20 (Antimicrobial Stewardship Guidelines)	Yes
Proportion of essential medicines (%)	62.5	≥ 60 (National Performance Assessment of Tertiary Public Hospitals)	Yes
Proportion of drug costs for DRG/DIP key diseases (%)	28.3	≤ 30 (DIP Payment Rules)	Yes

3.1.1. Patient demographics and disease spectrum

Patients aged 45–59 years constituted the largest age group (47.9%, 2392/4996). The predominant disease categories were cardiovascular and cerebrovascular diseases (23.4%), respiratory diseases (18.8%), and digestive diseases (15.2%), consistent with the institution's role as a regional medical center.

3.2. In-depth analysis and risk stratification of non-conforming prescriptions

Among the 189 non-conforming prescriptions (3.8%), minor omissions (e.g., missing contact information) were most common (48.7%, 92/189), followed by inappropriate medication prescriptions (38.5%, 73/189). Risk stratification using the prescription risk scoring model revealed no high-risk prescriptions; medium-risk prescriptions were entirely concentrated in the inappropriate medication category, while low-risk prescriptions consisted primarily of minor omissions and non-standardized prescriptions (**Table 2**). These findings indicate that managerial focus has shifted from intercepting critical errors toward optimizing clinical decision-making and refining prescribing details.

Table 2. Types and risk grading statistics of non-conforming prescriptions (n = 189)

Type of non-conformity	Number of prescriptions (n)	Proportion (%)	Risk level	Typical case
Non-standardized prescriptions	24	12.8	Low risk	
Exceeding 7-day supply without annotation	15	7.9	Low risk	Antihypertensive medication prescribed for 30 days without selecting "chronic disease"
Incomplete diagnosis information	9	4.9	Low risk	Diagnosis recorded only as "dizziness" without confirming etiology
Inappropriate medication prescriptions	73	38.5	Medium risk	
Inappropriate indications	28	14.8	Medium risk	Rosuvastatin prescribed to a hypertensive patient without indications for hyperlipidemia
Inappropriate dosage and administration	25	13.2	Medium risk	Caltrate D prescribed as "twice daily" instead of the recommended once at bedtime
Inappropriate drug selection	12	6.3	Medium risk	Ibuprofen, which may elevate blood pressure, prescribed to a hypertensive patient
Inappropriate dosage form or route	8	4.2	Medium risk	Nasal spray mistakenly prescribed for oral administration
Prescriptions with minor omissions	92	48.7	Low risk	Missing non-critical information such as patient occupation and contact number
Total	189	100.0		

3.3. Association rule mining and risk prediction of irrational prescriptions

Association rule analysis (Apriori algorithm; minimum support 5%, minimum confidence 30%) identified three high-confidence rules that precisely delineated the structural weak points in prescribing quality:

(1) Rule 1

Prescriptions issued for hypertension by physicians with less than five years of practice in the Cardiovascular Department are highly associated with the error of exceeding a 7-day medication supply

without proper annotation (support 6.8%, confidence 42.3%).

(2) Rule 2

Prescriptions issued by attending physicians in the Endocrinology Department for type 2 diabetes mellitus are significantly associated with errors in dosing regimens (support 5.5%, confidence 40.1%).

(3) Rule 3

Prescriptions issued by resident physicians in the Respiratory Medicine Department for acute bronchitis are closely linked to inappropriate antibiotic selection (support 5.1%, confidence 38.7%).

4. Discussion

4.1. Synergistic effects and value of the policy-embedded management model

The findings of this study indicate that by systematically embedding the requirements of tertiary hospital re-accreditation, DRG/DIP payment reform, and the National Performance Assessment (National Performance Assessment) into the pharmacy management workflow, hospitals can achieve coordinated goals across prescription quality, operational efficiency, and cost containment. A prescription qualification rate of 96.2% and a compliance rate of 92.7% for chronic disease long-term prescriptions reflect steady improvement in healthcare quality [9]. Meanwhile, maintaining the drug cost proportion for key DRG/DIP diseases at 28.3% demonstrates refined management capability under prospective payment reform, providing assurance for the safe and efficient use of medical insurance funds [10]. An essential medicines proportion of 62.5% and an antimicrobial use rate of 16.8% not only meet the National Performance Assessment benchmarks, but also promote a profound shift in clinical medication philosophy toward value-based healthcare [11].

4.2. Lean risk insight and early warning under a standards-met context

On the basis of overall compliance, this study integrated a risk scoring approach with association rule mining, enabling management to move from macro-level qualification rates to micro-level risk points. The results show that unqualified prescriptions exhibited a clear structural pattern, with inappropriate medication (38.5%) and minor omissions (48.7%) as the dominant issues. Although such problems may not markedly reduce the overall qualification rate, they represent persistent and potentially amplified risk sources under increasingly stringent policy and quality governance requirements.

Notably, the association rule analysis further identified that prescribing by junior physicians in chronic disease management constituted a key risk node for irrational prescriptions (confidence > 40%). This suggests that, in tertiary hospitals with a heavy chronic disease burden, prescribing risk is not merely driven by isolated errors, but is closely related to clinician experience, disease characteristics, and specific outpatient service scenarios. Therefore, establishing an early warning mechanism targeting key populations, key departments, and key prescriber groups is essential to achieve the transition from compliance-oriented management to lean, risk-preventive management [12].

4.3. Continuous optimization pathways: From compliance to excellence

(1) System empowerment upgrade

Strengthening Intelligent Review and Human–Machine Collaborative Governance. With the progressive application of intelligent systems in prescription review, it is recommended to further optimize clinical decision support rules, enhance the accuracy of automatic alerts, and reduce alert fatigue, thereby

improving the real-world effectiveness of intelligent review + pharmacist intervention. In addition, the review system should be more deeply integrated with DRG/DIP payment rules and the National Performance Assessment indicator system to support refined, scenario-based management, achieving a leap from post-prescription correction to pre-prescription prevention [13].

(2) Management mechanism restructuring

Establishing Data-Driven Precision Performance Management. Based on the association rule findings, a targeted empowerment program on standardized long-term prescriptions for chronic diseases and DRG/DIP policies should be implemented for junior physicians. Advanced indicators such as prescription risk grading and essential medicines utilization effectiveness should be incorporated into the performance appraisal system, guiding clinical behaviors toward higher quality and higher value.

(3) Deepening clinical services

Expanding the Scope and Depth of Pharmacy Services. A patient-centered deprescribing strategy should be promoted, particularly for older adults with polypharmacy [14,15]. Meanwhile, drug therapy pathways (Clinical Pathway) for DRG/DIP disease categories should be optimized, and patient education on medication adherence and policy communication should be strengthened to build a collaborative medication safety ecosystem.

5. Conclusion

This study shows that the systematic implementation of a "policy-embedded" management model enables tertiary hospitals to achieve strong alignment between outpatient prescription quality and national policy requirements. However, compliance is not the endpoint but the starting point for lean management. This study establishes a closed-loop model of "evaluation–insight–intervention" and applies data mining to accurately identify and predict potential risks. The proposed lean management pathways provide both a theoretical framework and practical guidance for improving pharmaceutical management efficiency and advancing high-quality development. Future research should focus on long-term evaluation of intervention effects and the feasibility of scaling this model to hospital-wide quality management systems.

Disclosure statement

The authors declare no conflict of interest.

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Content and Effects of Hand Function Exercises in Patients with Rheumatoid Arthritis: A Scoping Review

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Abstract: *Objective*: This study aimed to systematically review and synthesize the current research status, core components of intervention protocols, and outcome measures of hand function exercises in patients with rheumatoid arthritis, in order to provide references for healthcare professionals in developing and implementing related interventions. *Methods*: Following the scoping review framework, a systematic search was conducted in PubMed, Embase, Web of Science, the Cochrane Library, China National Knowledge Infrastructure (CNKI), VIP Database, WanFang Database, and China Biomedical Literature Database (CBM). The search period ranged from 1 August 2015 to 1 August 2025. The identified studies were screened and synthesized according to the inclusion criteria. *Results*: A total of 10 studies were included. The intervention content of hand function exercises comprised joint range-of-motion training, resistance training, and functional training for daily activities, among which joint range-of-motion training and resistance training were the most commonly used. The intervention delivery modes included offline interventions, online interventions, and hybrid interventions. Outcome measures involved three domains: clinical indicators, clinical efficacy, and hand function assessment tools. *Conclusion*: This scoping review analyzed the existing literature and found that hand function exercises can effectively improve hand symptoms and functional outcomes in patients with rheumatoid arthritis, with 12 weeks being a typical intervention duration. However, evidence remains limited regarding exercise duration and patient-reported outcomes. Therefore, further studies are needed to explore their effects on patient-reported outcomes and to consider patients' exercise-related needs and goals.

Keywords: Hand function exercises; Rheumatoid arthritis; Nursing; Scoping review; Rehabilitation nursing

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1. Introduction

Rheumatoid arthritis (RA) is the most common inflammatory arthritis, affecting approximately 0.5% of the global population, and is one of the most disabling joint disorders among adults [1]. It can lead to pain and

functional limitations. To date, no curative treatment is available. Evidence indicates that nearly 80% of patients with RA experience hand function impairment [2]. Current guidelines from the European Alliance of Associations for Rheumatology (EULAR) recommend physical therapy (PT) and occupational therapy (OT) as adjuncts to pharmacological treatment for patients with RA [3,4]. The three most common components of PT/OT are exercise therapy, joint protection education, and the provision of functional splints and assistive devices [5,6]. These findings highlight the importance of implementing effective hand function exercises for patients with RA.

Currently, scholars have comprehensively summarized various methods and assessment tools for hand function exercises in patients with RA, and multiple intervention studies have been conducted [7]. However, substantial heterogeneity remains across existing studies in terms of exercise types, modes of delivery (ranging from fully supervised to completely unsupervised), frequency (from two to three times daily to twice weekly), and duration, with a lack of a unified classification framework and systematic synthesis [8].

Therefore, the primary aim of this study was to conduct a rigorous scoping review to provide valuable insights. Guided by the Joanna Briggs Institute (JBI) methodology for scoping reviews, this study systematically summarizes and analyzes the intervention characteristics of hand function exercises in patients with RA, including content, delivery format, frequency, duration, and outcomes [9]. Furthermore, intervention studies on hand function exercises for patients with RA are synthesized, and their outcome evaluation systems are systematically examined based on the framework of the International Classification of Functioning, Disability and Health (ICF), with the aim of providing an evidence base for the development of standardized intervention protocols and comprehensive evaluation strategies.

2. Methods

This study adopted the scoping review methodological framework proposed by Arksey and O'Malley in 2005, which includes the following steps [10].

(1) Identifying the research question;
(2) Identifying relevant studies;
(3) Selecting eligible studies;
(4) Charting the data;
(5) Collating, summarizing, and reporting the results.

The reporting of this review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) guidelines [11]. The PICO framework is presented in **Table 1**.

Table 1. PICO framework

Population	Intervention	Comparison	Outcome
RA	Intervention modalities	Intervention protocols	Hand function
	Inclusion of hand function exercises in the study design	Participant characteristics	Clinical symptoms
	Intervention protocols:		Clinical efficacy
	– Exercise content		
	– Exercise format		
	– Exercise frequency		
	– Exercise duration		

2.1. Step 1: Identifying the research question

To complete the purpose of this study, the following research questions were identified:

(1) What are the specific components of hand function exercises for patients with RA (including exercise content, delivery format, frequency, and duration)?

(2) What are the effects of hand function exercise interventions, and which domains are covered by the outcome measures? What assessment tools are used?

(3) In studies on hand rehabilitation in RA, in what forms are hand function exercise interventions typically delivered?

2.2. Step 2: Identifying relevant studies

A comprehensive search was conducted using a combination of subject headings and free-text terms in the following databases: PubMed, Embase, Web of Science, the Cochrane Library, CNKI, WanFang Database, VIP Database, and CBM. The search period was from 1 August 2015 to 1 August 2025. The Chinese search strategy was as follows: (arthritis OR rheumatoid OR rheumatoid arthritis OR morning stiffness OR RA) AND (hand function exercise OR hand function training OR hand rehabilitation training OR fingers OR rehabilitation training OR finger movement). The English search strategy was developed using PubMed as an example, and the detailed strategy is presented in **Table 2**.

Table 2. Search strategy for the PubMed database

Databases ample		Search strategy
PubMed	#1	((“Arthritis”[Mesh])OR(((rheumatoid[Title/Abstract])OR(rheumatoid arthritis[Title/Abstract])) OR(RA[Title/Abstract])))
	#2	(((finger exercises[Title/Abstract])OR(finger gymnastic[Title/Abstract]))OR(hand function[Title/Abstract]))
	#3	(y_10[Filter]))
	#4	#1AND#2AND#3

2.3. Step 3: Study selection

This study followed the predetermined inclusion and exclusion criteria to guide selection in this scoping review.

2.3.1. Inclusion criteria

(1) Studies involving patients with RA, with clearly defined diagnostic criteria and outcome measures;

(2) Studies focusing on the application of hand function exercises in patients with RA;

(3) Study designs including randomized controlled trials, quasi-experimental studies, cohort studies, and qualitative studies;

(4) Studies published in Chinese or English.

2.3.2. Exclusion criteria

(1) Studies with missing data or inability to obtain the full text;

(2) Duplicate publications;

(3) Publications such as letters to the editor, commentaries, and conference abstracts.

The retrieved records were imported into NoteExpress 4.0 software for deduplication. Two reviewers (YQ and SY) independently conducted the initial screening based on the inclusion and exclusion criteria, followed by full-text review for eligibility assessment. In cases of disagreement, a third reviewer (YX) was consulted to reach a consensus. Cross-checking was performed to determine the final set of included studies.

2.4. Step 4: Charting the data

To extract relevant information from the included studies, a standardized data extraction form was developed, comprising the following categories:

(1) Author
(2) Year of publication
(3) Country
(4) Study design
(5) Sample size
(6) Intervention characteristics (implementer, intervention content, classification of core exercises, delivery format, and duration)
(7) Outcome measures and hand function assessment tools.

The data were extracted independently by two authors (YQ and SY), and discrepancies were eliminated after negotiation. The third author (YT) reviewed all the data.

2.5. Step 5: Collating, summarizing and reporting the results

All extracted data were used for discussion by the research team until they were consistent with the purpose of the scoping review.

3. Results

3.1. Results of study selection

A total of 3,740 articles were initially identified through the literature search. After removing duplicates, initial screening, and full-text screening, 10 studies were finally included. The literature screening flow chart is shown in **Figure 1**.

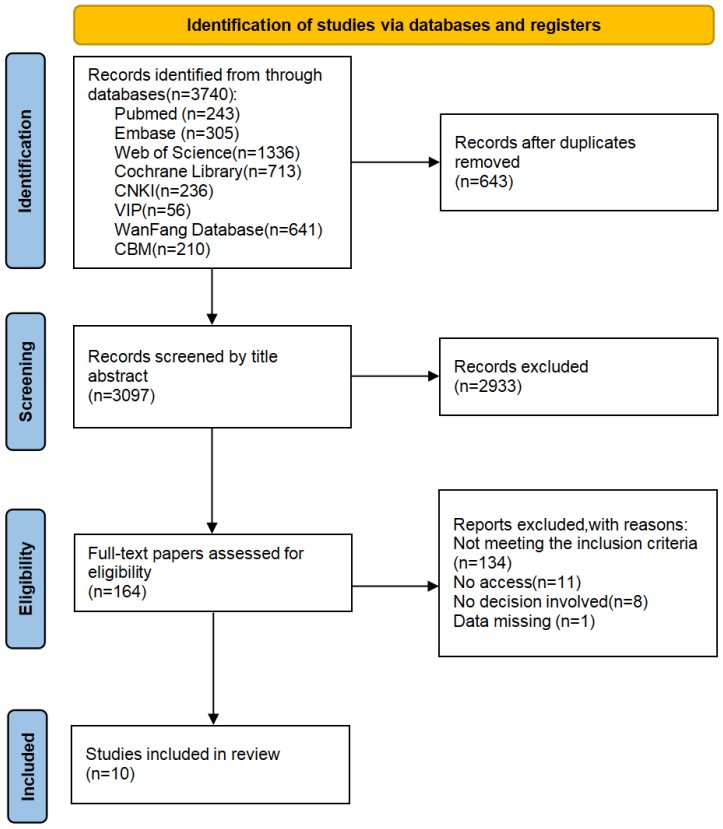


Figure 1. Flow chart of the study selection process.

3.2. Basic characteristics of included literature

A total of 10 studies were included in this review, among which 4 were from China, 3 from the United Kingdom, 2 from Turkey, and 1 from Spain [7.12–20]. The included study types comprised 8 randomized controlled trials and 2 quasi-experimental studies [7.12–20]. According to the data, the total sample size that actually received hand function exercise interventions was 710 participants, with one study having all female participants [19]. The basic characteristics of the included literature are shown in **Table 3**.

Table 3. Basic characteristics of the included studies (n = 10)

Author (Year)	Country	Study design	Sample size		Intervention content					Outcome measures
			Intervention	Control	Implementer	Control group	Intervention content of hand function exercises	Delivery mode	Duration/ Frequency	
Chang [7] (2023)	China	RCT	33	33	Professional coach	Usual care	"Yi Jin Jing" rehabilitation exercise	Online	1 hour per session, 3 times per week, for 12 weeks	ABC DEFG IJKL ②⑤
Li [12] (2018)	China	RCT	25	25	Nurse	Usual care	Eagle claw exercise, fist-clenching exercise, "beckoning wealth" wrist exercise	Offline	20 minutes per session, 2 times per day, for 12 weeks	CDF HMJ⑤

Author (Year)	Country	Study design	Sample size		Intervention content					Outcome measures
			Intervention	Control	Implementer	Control group	Intervention content of hand function exercises	Delivery mode	Duration/ Frequency	
Lu [13] (2021)	China	quasi-RCT	35	36	Nurses, therapists	Usual exercise	Finger flexion and extension exercise, finger opposition exercise, finger adduction exercise, water-based resistance exercise	Offline	30 minutes per session, 3 times per week, for 12 weeks	CD HU ③⑤
Dülgeroğlu [18] (2016)	Turkey	RCT	16	14	Researcher, Physical therapist	Usual exercise	Wrist ulnar deviation, finger fist clenching, finger extension, thumb opposition, rolling a ball on a table, finger radial walking, thumb abduction, non-resistance exercises: wrist flexion/extension, forearm pronation/ supination, thumb opposition, thumb interphalangeal joint flexion	Online+ Offline	2.5-4 minutes per session, 2 times per day, for 10 days	DGIL ① ③⑧
Hall [15] (2017)	United Kingdom	RCT	246	242	Hand therapist	Usual care	Seven flexibility exercises from the SARAH (strengthening and stretching for rheumatoid arthritis of the hand) trial	Online+ Offline	Divided into 6 sessions, approximately 30 minutes each, performed daily at home, for 12 weeks	A② ⑤⑧
Lamb [16] (2015)	United Kingdom	RCT	246	244	Physical therapist or occupational therapist	Usual care	Seven flexibility exercises from the SARAH trial	Offline	20–30 minutes per session, 6 facetoface sessions, with home practice continued for at least 12 weeks	ACD EHIOL ②⑤
Li [14] (2022)	China	RCT	30	30	Physician, nurse	Usual care	Tabletop hand swinging, left-right hand swinging, finger opposition exercise, fist clenching and stretching exercise	Offline	15–30 minutes per session, 2 times per day, for 3 courses, over a total of 18 months	CDGM

Author (Year)	Country	Study design	Sample size		Intervention content					Outcome measures
			Intervention	Control	Implementer	Control group	Intervention content of hand function exercises	Delivery mode	Duration/ Frequency	
Özcelep [19] (2022)	Turkey	RCT	19	21	Therapist	Usual treatment	MCP, PIP, DIP joint range of motion and isometric exercises; washing face, using a fork, drinking from a glass, sitting up, putting on a T-shirt.	Offline	Approximately 45 minutes per session, 2 times per week, for 5 weeks	DI①⑤⑧
Sánchez-LaulhéP [20] (2020)	Spain	RCT	14	22	Researchers, physical therapists, physicians	Usual treatment	Warm-up, range of motion exercises, stretching exercises, strengthening exercises	Online	15–20 minutes per session, 4 times per week, for 12 weeks.	CD②④⑤
Srikesavan [17] (2025)	United Kingdom	quasi-RCT	46	19	Physicians, nurses, occupational therapists, physical therapists	Usual treatment	Online SARAH programme: consisting of 11 exercises (7 flexibility training, 4 strength training).	Online	20–30 minutes per session, 4 weeks (planned duration), but the actual usage and followup time of patients were longer (mean 70 days from baseline to discharge, and 130 days to the 4month followup).	D②

Note: Randomized controlled trial (RCT); quasi-randomized controlled trial (quasi-RCT). ① Duruöz Hand Index (DHI), also known as Cochin Hand Functional Disability Scale (CHFS). ② Michigan Hand Outcomes Questionnaire (MHQ). ③ Signals of Functional Impairment (SOFI). ④ Disabilities of the Arm, Shoulder and Hand questionnaire (DASH). ⑤ Grip strength and pinch strength. ⑥ Grip Ability Test (GAT) and Jebsen Hand Function Test (JHFT). ⑦ Arthritis Impact Measurement Scale 2 (AIMS2). ⑧ Nine Hole Peg Test (NHPT).Clinical indicators:A. Range of motion (ROM).B. Radiographic evaluation.C. Morning stiffness duration.D. Degree of joint pain (VAS/NRS).E. Number of swollen joints.F. Number of tender joints.G. Disease activity score (DAS28-ESR).H. Quality of life.I. Health Assessment Questionnaire (HAQ).J. Anxiety level.K. Depression level.L. Laboratory tests.M. Activities of daily living.N. Rheumatoid Arthritis Pain Scale (RAPS).O. Arthritis self-efficacy (ASES-8/RASE).P. Functional class.Q. Number of deformed joints.R. Finger pain intensity.S. Finger stiffness.T. Limb function (FMA / Carroll).U. Fatigue Severity Scale (FSS).

3.3. Core content of hand function exercise intervention protocols

3.3.1. Classification and modes of hand function exercise movements

In the 10 included studies, the intervention protocols were primarily delivered by nurses and therapists. Based on the synthesis of specific movement content of hand function exercises, this study categorized the intervention modes into the following three types.

(1) Basic training [7,12,14–16,18]

Primarily consisting of active range of motion (AROM) exercises, often supplemented by warm-up/ massage. This mode includes basic AROM and compound AROM. The movement design of basic

AROM aims to cover all major joints of the hand, including the metacarpophalangeal joints, proximal interphalangeal joints, distal interphalangeal joints, and the wrist joint. The movements involve finger flexion, finger extension, finger pressing, finger rotation, finger adduction, finger opposition, as well as multi-dimensional wrist movements such as wrist rotation, ulnar deviation, radial deviation, and palm pressing. Compound AROM training refers to adding combined and sequential movement patterns on the basis of basic AROM, for example the strengthening and stretching for rheumatoid arthritis of the hand (SARAH) exercise, which is also the most common form of hand function exercise intervention, as seen in Hall et al [15]. In addition, some movement designs originate from therapeutic approaches beneficial for the holistic care of patients' physical and mental health. For instance, Chang et al. introduced a complete traditional Chinese medicine exercise method, such as Yi Jin Jing (Muscle-Tendon Change Classic), which contains a large number of complex hand posture changes [7]. However, this type of training demands high movement precision and often requires professional coaches to guide patients during the intervention process.

(2) Resistance training [13,17,20]

Resistance training is added to the basic mode. This mode refers to active, full-range muscle contraction exercises performed by the patient on the basis of basic range of motion training, with external resistance applied manually or with equipment, such as using elastic bands, grip balls, therapeutic putty, etc. The core principle is to activate the patient's own muscle strength to overcome resistance, rather than relying on passive movements delivered by therapists.

(3) Functional training for daily activities [19]

This mode is primarily characterized by the inclusion of task-oriented training. Task-oriented training refers to hand function exercises integrated with activities of daily living or game-based tasks, such as wall-climbing exercises, virtual games, tabletop ball-rolling, and grasping a cup. This approach may help to reduce the strong subjectivity of therapists and compensatory movements by patients commonly observed in conventional rehabilitation training, while also ensuring training precision, thereby contributing to improvements in patients' daily functional performance.

To more clearly present the above classification results, the categorization and distribution of the three modes are summarized in **Table 4**.

Table 4. Profile of finger exercise intervention patterns (n = 10)

Intervention mode	Training content	Number of studies	Percentage
Basic training	Range of motion training, often supplemented with warm-up/massage	6	60%
Resistance training	Range of motion training combined with resistance	3	30%
Daily functional training	Taskoriented training	1	10%

Note: Percentages have been rounded, and the total sums to 100%.

3.3.2. Intervention duration of hand function exercises

There is considerable variability in the time–dose parameters of hand function exercises for patients with RA. Different researchers have adopted varying approaches in terms of repetition frequency and duration per session, which may be related to the specific exercise content. In some studies, a greater number of exercise repetitions were implemented, resulting in longer intervention durations. This highlights the need for future

research to further establish standardized time–dose parameters for hand function exercises.

In contrast to the diversity in intervention modes, the intervention duration demonstrates relatively high consistency. Regardless of whether the interventions were delivered offline, online, or through a combined approach, a 12-week duration was most commonly adopted, as illustrated in **Figure 2**. In addition, one study conducted follow-up assessments ranging from 4 to 12 months after patient discharge [17].

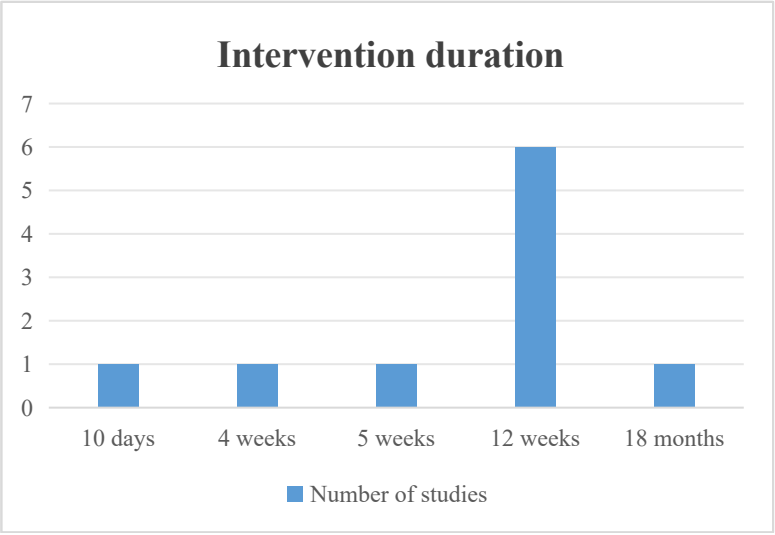


Figure 2. Histogram of intervention duration and number of studies.

3.3.3. Intervention delivery format

(1) Offline interventions [12–14,16,19]

These include face-to-face guidance, providing patients with instructional videos for functional exercises, and requiring the completion of exercise diaries. This is the most commonly used intervention delivery mode. Offline interventions can effectively ensure patient adherence, facilitate healthcare professionals or therapists in monitoring whether exercises are performed correctly, and enable timely responses to patients' disease-related or functional concerns.

(2) Online interventions [7,17,20]

These involve the use of mobile applications, open-access learning platforms, and social forums for treatment delivery and exercise monitoring. Progress in planned interventions and changes in pain intensity are presented in graphical formats, alongside the establishment of check-in mechanisms. Patients can independently download exercise guidelines, training plans, and exercise diaries. This approach is conducive to promoting self-directed training and fostering the habit of home-based exercise; however, when patients perform exercises incorrectly, it is difficult for healthcare professionals to identify and correct them in real time.

(3) Hybrid interventions (combining offline and online approaches) [15,18]

In addition to offline strategies, these include remote supervision of rehabilitation training, provision of exercise videos, and inviting patients to join online communication groups, where healthcare professionals can answer questions and share exercise-related knowledge.

3.4. Outcome measures and intervention effects of hand function exercises

(1) Outcome measures

The outcome measures of the included studies encompassed patients' physical function, such as range

of joint motion, imaging assessments, and duration of morning stiffness, as well as indicators of activity and participation, including quality of life and the Health Assessment Questionnaire. In addition, three studies evaluated patients' psychological status, including anxiety, depression, and self-efficacy [7,12,16].

Grip strength and pinch strength were the most frequently assessed outcomes. Among the 10 included studies, seven reported these measures as primary outcomes, accounting for more than half of the total [7,12,13,15,16,19,20]. Furthermore, it was noted that most studies measured grip strength using electronic dynamometers, while a minority employed non-standard measurement methods. Such as using a mercury sphygmomanometer: the cuff was folded and inflated to 20 mmHg, after which the patient was instructed to grip it with maximal force; the grip strength value was then calculated as the maximum height of the mercury column minus 20 mmHg [21]. Among standardized hand function assessment scales, the Signals of Functional Impairment (SOFI) and the Michigan Hand Outcomes Questionnaire (MHQ) were the most frequently used. One study employed both the Disability of the Arm, Shoulder and Hand (DASH) questionnaire and SOFI to evaluate hand function [18]. In addition, Bremander et al. demonstrated through an 8-year follow-up that changes in the total SOFI score could effectively predict long-term structural joint damage, highlighting the importance of the SOFI scale in assessing hand function in patients [22].

(2) Intervention effects

Basic training has been widely demonstrated to be effective in alleviating joint pain, as reported in studies such as that by Dülgeroğlu [18]. Lu Jun suggested that resistance training may be more effective than basic training; in their study, patients received offline guidance to perform aquatic resistance training in addition to hand function exercises, and the results showed that SOFI scores were significantly lower than those in the control group receiving hand function exercises alone [13]. A meta-analysis including seven studies with a total of 483 patients similarly demonstrated that, on the basis of conventional pharmacological treatment, the addition of structured exercise training can significantly improve overall disease status in patients with RA [23]. From an evidence-based perspective, these findings support the rationale for incorporating active exercise, including hand function training, into RA rehabilitation management, with benefits extending beyond hand function to overall systemic outcomes. The unique value of functional training for daily activities lies in its ability to promote functional generalization and enhance long-term adherence, thereby improving patients' performance in activities of daily living [19]. Regarding improvements in hand grip strength, some inconsistencies were observed among the included studies. Six studies reported improvements in grip strength following intervention [7,12,13,15,16,20]. However, Özcelep indicated that their intervention showed limited effectiveness in improving hand dexterity, and no statistically significant improvement in muscle strength was observed; in particular, no significant change was found in left-hand grip strength before and after the intervention, which may be related to the use of isometric exercises alone [19].

4. Discussion

4.1. Analysis of the sources of heterogeneity in intervention protocols and pathways to standardization

Analysis of the included studies revealed considerable variability in the duration and frequency of exercise interventions, although the intervention period was most commonly 12 weeks. However, some evidence

suggests that short-term exercise (less than 3 months) has limited effects on hand function, whereas medium-term (3–11 months) and long-term (more than 12 months) interventions yield more favorable outcomes [24].

The heterogeneity in intervention duration and frequency may be attributed to several factors. Firstly, some studies lack a unified theoretical framework and a standardized set of core exercises, with intervention designs often based on clinical experience or localized modifications rather than evidence-based development. In this regard, the SARAH program provides a comprehensive functional training framework; Lamb et al. described seven flexibility exercises and four strengthening exercises, and this clarity facilitates the dissemination and implementation of this program [16]. Secondly, there is a lack of research on dose–response relationships, making it difficult to determine the optimal intervention dosage for patients with different levels of disease activity or functional status. Due to the lack of dose-response relationship studies, the optimal intervention dose for patients with varying levels of disease activity or functional status remains unclear. This may be because the effects of functional exercise often require a longer period to be validated, warranting further investigation in future studies.

Future research should focus on establishing standardized pathways and adopting a staged strategy. In the short term, methods such as the Delphi technique or consensus meetings could be employed to bring together experts in rehabilitation, nursing, and rheumatology to reach agreement on core AROM modules and minimum reporting standards for hand function exercises in RA [25]. In the medium to long term, dose–response randomized controlled trials could be designed to explore optimal intervention parameters for patients at different stages of the disease. Based on patients' functional status and rehabilitation goals, stratified and tailored interventions could be developed, matching individuals to different levels of intervention strategies, including basic training, resistance training, and functional training for daily activities.

4.2. Reflection on outcome measures based on the ICF framework and strategies for optimization

At the level of outcome indicators, most of the included studies focused on outcomes corresponding to the "body functions and structures" domain of the ICF, such as grip strength and joint counts, while relatively neglecting the "activity" and "participation" domains. Consequently, aspects such as patients' social roles, self-efficacy, and patient-reported outcomes were insufficiently assessed. This imbalance leads to fragmented evaluations of intervention effectiveness and fails to comprehensively reflect the impact of interventions on patients' overall lives.

With regard to measurement tools for outcome indicators, grip strength, being the most commonly used measure of physical function, has certain limitations. For patients with RA who present with joint deformities or hand swelling, the standard Jamar dynamometer is often difficult to use due to its large size, discomfort during grasping, and inability to accurately detect subtle grip strength [26]. As a result, many studies have resorted to using mercury sphygmomanometers for measurement. However, in current hospital ward settings, electronic sphygmomanometers are more commonly available, while traditional mercury devices are less accessible; consequently, measuring grip strength using mercury sphygmomanometers is more time-consuming and labor-intensive compared to electronic dynamometers. Some researchers have employed electronic handheld dynamometers and accelerometers to assess muscle function in older adults, which may provide new directions for grip strength assessment in patients with RA [27].

Future research should aim to systematically develop comprehensive evaluation frameworks, drawing on established theoretical foundations and using the ICF framework as a central guide. In terms of indicator selection, in addition to conventional physical measures, standardized tools that effectively capture "activity"

and “participation” domains should be incorporated, with greater emphasis on patient-reported outcomes. Regarding tool innovation, there is a need to develop miniaturized and electronic grip dynamometers tailored for patients with RA, or to explore more sensitive and functionally relevant alternative indicators, such as pinch strength and grasping ability. Only through the use of reliable and precise assessment scales and tools for hand function can the true effects of hand function exercise interventions be accurately evaluated, thereby advancing the scientific development of this field.

4.3. Rehabilitation orientation and goals of different intervention models

The three types of models proposed in this study each have their applicable scenarios, as shown in **Table 5**.

Table 5. Applicable patient populations and rehabilitation goals of the three patterns

Intervention mode	Applicable patients	Rehabilitation goals
Basic training	Patients in the early stable phase or with severe functional impairment	Safely maintain joint range of motion, relieve pain and stiffness
Resistance training	Patients in the stable phase with chief complaints of decreased muscle	Alleviate muscle atrophy, improve hand function and independence in daily living
Daily functional training	Patients who exhibit movement compensation during training and whose chief complaint is restoration of daily living	Develop rehabilitation habits and enhance patient motivation

4.4. The value of rehabilitation nursing in hand function training, research limitations and future directions

Hand function training, as a low-cost, low-risk, and easily scalable non-pharmacological intervention, is highly consistent with the core objectives of the nursing profession, namely health promotion and disease prevention. Nurses play an irreplaceable role in patient education, long-term follow-up, and behavioral supervision, and are key implementers in the clinical application and sustained maintenance of hand function training.

This study has several limitations. Some of the included studies had relatively small sample sizes. In addition, during the literature search process, studies primarily focusing on other combined interventions but containing components of hand function exercises may have been overlooked.

Future research may focus on optimizing intervention protocols by establishing standardized exercise modules through the Delphi technique and integrating mobile health technologies. For example, hand exercise applications similar to that designed by Tonga, could be developed to enable remote supervision, personalized feedback, and behavioral motivation, thereby enhancing the precision and sustainability of rehabilitation interventions [28]. Furthermore, a patient-centered evaluation system should be established, with quality of life and functional participation as core outcome indicators. In this way, hand function training can evolve from an experience-based practice into an evidence-based, precise, and nursing-value-oriented core rehabilitation strategy.

5. Conclusion

This scoping review synthesized the current evidence on hand function exercises in patients with RA. The findings suggest that such interventions may contribute to improvements in hand symptoms and functional outcomes, with a 12-week intervention period commonly reported in the literature. However, considerable

heterogeneity remains in terms of exercise dosage, including frequency and duration, and the evidence regarding patient-reported outcomes is limited.

Future research is warranted to further explore the potential impact of hand function exercises on patient-reported outcomes and social participation, as well as to better align interventions with patients' individual needs and rehabilitation goals.

Disclosure statement

The authors declare no conflict of interest.

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Construction and Use of a Predictive Model for the Risk of ICU-acquired Weakness

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Abstract: *Objective*: To explore the risk factors of acquired weakness in ICU patients and construct a prediction model. *Methods*: Using convenience sampling method, 245 intensive care patients admitted to ICUs of three tertiary hospitals in Shiyan City from March 2022 to April 2023 were selected, of which 172 cases from March to December 2022 were used as the modeling group and 73 cases from January to April 2023 were used as the validation group. The predictive effect of the model was examined using the area under the curve (AUC) of the receiver operating characteristic curve (ROC) and Hosmer-Lemeshow goodness-of-fit, and the model column line graph was plotted. *Results*: The incidence of ICU-acquired weakness was 36.63% (63/172) and 38.37% (28/73) in the modeling and validation groups, respectively. Patient's history of alcohol consumption, mode of admission to the ICU, treatment with CRRT, mechanical ventilation, restraint braking, use of analgesics, use of norepinephrine, use of glucocorticoids, and length of stay in the ICU were the independent influencing factors of acquired weakness in ICU patients ($p < 0.05$). The AUCs of the modeling and validation groups were 0.979 and 0.887, respectively. *Conclusion*: The risk prediction model constructed in this study can predict the risk of acquired weakness in ICU, which can provide a reference for healthcare professionals to formulate interventions at an early stage.

Keywords: Intensive care unit; Acquired weakness; Influence factor analysis; Predictive modeling; Columnar plots

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1. Introduction

ICU Acquired Weakness (ICU-Acquired Weakness, ICU-AW) is a common and serious neuromuscular complication in critically ill patients, which is characterized by a range of symptoms such as limb paralysis and weakness, decreased reflexes and muscle atrophy [1]. Studies have shown that the incidence of ICU-AW ranges from 25% to 85% [1]. ICU-AW may lead to prolonged hospitalization, increased risk of nosocomial

infections, decreased physical function after discharge, and increased mortality, which seriously affects the long-term quality of life of patients [2–5]. Currently, the pathogenesis of ICU-AW is unclear, and there is no effective pharmacologic approach to treat ICU-AW in the clinical setting; therefore, early prediction of the at-risk population and intervention is the most important approach to address ICU-AW, which can help improve patient safety and hospital resource management [1]. Predictive modeling" is based on the multimorbidity of a disease, and the establishment of a statistical model to predict the probability of a certain outcome event in a certain population in the future, which can help medical personnel to carry out "individualized treatment" and promote the "tertiary prevention" of the disease. Tertiary prevention" has been widely used in clinical practice [6–9]. Most of the studies on ICU-AW in China are limited to prognosis and risk factors, and there are fewer studies on integrating ICU-AW risk factors and constructing risk screening tools accordingly. In this study, by exploring the risk factors for the occurrence of ICU-AW and constructing its risk prediction model, this study aimed to identify high-risk groups early and provide reference for medical personnel to formulate prevention strategies.

2. Objects and methods

2.1. Research subjects

A prospective, observational study was used to facilitate the selection of intensive care patients admitted to the ICUs of three tertiary hospitals in Shiyan City from June 2022 to May 2023 as the study subjects.

2.1.1. Inclusion criteria

(1) Age ≥ 18 years old;
(2) Admission to ICU ≥ 24 hours;
(3) Patients were able to move their limbs according to the instructions;
(4) It was determined that there was no obstacle in the communication between the patients and the investigators.

2.1.2. Exclusion criteria

(1) Patients with ICU-AW before admission;
(2) Those with previous neuromuscular diseases or post-stroke sequelae;
(3) Patients with psychiatric disorders, speech disorders, etc. who were unable to cooperate with the examination;
(4) Incomplete case data.

2.1.3. Study design

The study was approved by the Ethics Committee of the hospital, and the investigators gave informed consent. The researcher screened 27 predictors after literature review and expert correspondence [4,10]. According to the requirements of the modeling sample size calculation formula, each independent variable needs to occur in 5–10 cases of ICU-AW patients, and the incidence rate of ICU-AW in ICU patients is 25–85% and 20% invalid samples are also considered, so that the calculated required sample size is at least 191 cases, and the final sample of this study was collected in 245 cases [1]. In a 7:3 ratio, 172 patients from March to December 2022 served as the modeling group and 73 patients from January to April 2023 served as the validation group.

2.2. Research methodology

2.2.1. Research tools

(1) Risk factor questionnaire

Through literature review and expert correspondence, based on the feasibility of survey implementation and the basis of previous research, the survey instrument of this study was determined [4,11]. It mainly includes: ① general information: gender, age, education level, history of smoking, history of drinking, history of hypertension, history of diabetes mellitus, body mass index (BMI); ② ICU-AW-related parameters of critically ill patients: mode of admission to the ICU, APACHE II score, whether or not shock, whether or not sepsis, whether or not multiple organ dysfunction syndrome (MODS), CRRT, mechanical ventilation, restraints, neuromuscular blockade, sedation, analgesia, norepinephrine, glucocorticoids, nutritional support, and length of stay in the ICU; iv. Laboratory indicators: albumin (lowest value), blood glucose (highest value), lactate (highest value), blood calcium (lowest value).

(2) Rapid diagnosis of ICU-AW

In this study, MRC score was used as recommended by the American Thoracic Society (ATS) in 2014 for the diagnosis of ICU-AW [12,13]. For example, patients with new-onset, flaccid, symmetrical weakness during ICU, and the following 3 items must be met: ① MRC score < 48 or 80% of the maximum possible score, and it lasts for at least 24 h. Includes 12 sets of measurement sites, including shoulder abduction, elbow flexion, wrist extension, hip flexion, knee extension, and ankle dorsiflexion bilaterally, with a score of 0 to 5 in each set, for a total score of 60, with higher scores indicating greater muscle strength. ② Evidence of weakness in all limbs tested. ③ Cranial nerve function was intact. The responsible nurse assessed the patient once a day, and when the MRC muscle strength grading score was ≥ 48, the patient was non-ICU-AW; if the MRC muscle strength grading score was < 48, the patient was assessed for the 2nd time on the morning of the 2nd day by another operator, and if the MRC score was ≥ 48, the patient was non-ICU-AW, and vice versa.

2.2.2. Data collection and quality control methods

At the beginning of the study, the researchers strictly followed the inclusion and exclusion criteria to determine whether the patients were enrolled and obtained informed consent, and after the consent of the supervising physician, the first assessment of MRC-score score ≥ 48 was allowed to enroll in the study, and after that, it was assessed by a fixed researcher at fixed time intervals of every 1 d until the study subjects reached the endpoint event or were dislodged. Endpoint event: occurrence of ICU-AW. shedding criteria: transfer out of ICU; withdrawal from the study; death. Patients' general data, ICU-AW-related parameters, and laboratory indicators were collected through an electronic medical record system, and all participating data collectors were uniformly trained to ensure study consistency. The data collected weekly were summarized by the investigator, and timely feedback and adjustments were made for problems in the data collection process. Data were entered using Excel 2010 two-person checking, and a dedicated person kept and verified 10% of the data to ensure the accuracy of data entry.

2.3. Statistical methods

SPSS26.0 and R4.2.1 software were used for statistical analysis. Measured information that meets the normal distribution was used to indicate, and those that do not meet the normal distribution were used Mann-Whitney rank sum test, and *t*-test was used for comparison between groups; counting information was used

to indicate frequency and percentage, and 2-test or Fisher's exact probability method was used for comparison between groups. Logistic regression was used for the determination of independent influences and the construction of predictive models. Model fit was verified using Hosmer-Lemeshow, and the larger the p-value the better the fit ($p > 0.05$). The model column line graph was plotted against the receiver operating characteristic curve (ROC) by R4.2.1 to evaluate the prediction effect of the modeling and validation groups. The test level $\alpha = 0.05$.

3. Results

3.1. General information of the study population

A total of 245 patients were included in this study, 68.98% (169/245) were male and 31.02% (76/245) were female, age 20–86 years, median 60 (52,71) years. BMI (17.31–34.77) kg/cm^2, median 24.80 (23.22,27.34) kg/cm^2, ICU hospitalization Duration 1–18 days 4 (3,6) days. incidence of ICU-AW was 37.14% (91/245); incidence of myelosuppression in the modeling and validation groups was 36.63% (63/172) and 38.37% (28/73), respectively.

3.2. Univariate analysis of ICU-AW in patients in the modeling group

The data of the modeling group were divided into non-ICU-AW group and ICU-AW group based on whether acquired weakness occurred or not, and the differences between the two groups in terms of gender, age, education, smoking history, history of hypertension, history of diabetes mellitus, BMI, APACHE II score, use of neuromuscular blocking agents, mode of nutritional support, albumin, calcium, lactate, and blood glucose were not statistically significant ($p > 0.05$), and the differences between the two groups in terms of alcohol consumption History, mode of ICU admission, shock, sepsis, MODS, CRRT treatment, mechanical ventilation, restraint, use of sedation, use of analgesics, use of norepinephrine, use of glucocorticoids, and ICU length of stay were statistically significant ($p < 0.05$), as shown in **Table 1**.

Table 1. One-way analysis of ICU-AW in patients in the modeling group [n=172, cases (percentage, %)]

Name	Subgroup	Total	Non-ICU-AW group (n = 109)	ICU -AW group (n = 63)	Test statistic	*p value*
Gender	Male	122 (70.9)	73 (66.7)	49 (77.8)	2.261	0.133
	Female	50 (29.1)	36 (33.3)	14 (22.2)		
Age			59.0 (53.0，68.5)	67.0 (53.0，74.0)	-1.752	0.080
Education	Elementary and below	80 (46.5)	48 (44.0)	32 (50.8)	1.013	0.798
	Junior High School	59 (34.3)	39 (35.8)	20 (31.7)		
	High School/Middle School	22 (12.8)	14 (12.8)	8 (12.7)		
	College and above	11 (6.4)	8 (7.3)	3 (4.8)		
Smoking history	No	122 (70.9)	73 (66.7)	49 (77.8)	2.261	0.133
	yes	50 (29.1)	36 (33.3)	14 (22.2)		
Drinking history	No	127 (73.8)	75 (68.8)	52 (82.5)	3.897	0.048
	Yes	45 (26.2)	34 (31.2)	11 (17.5)		
Hypertension	No	79 (45.9)	54 (49.5)	25 (39.7)	1.563	0.211
	Yes	93 (54.1)	55 (50.5)	38 (60.3)		

Name	Subgroup	Total	Non-ICU-AW group (n = 109)	ICU -AW group (n = 63)	Test statistic	*p value*
Diabetes	No	143 (83.1)	91 (83.5)	52 (82.5)	0.026	0.873
	Yes	29 (16.9)	18 (16.5)	11 (17.5)		
BMI			24.7 (22.7，26.7)	24.8 (22.8，27.7)	-0.815	0.415
					3.385	0.336
ICU Admission		5 (2.9)	3 (2.8)	2 (3.2)	9.322	0.009
		64 (37.2)	44 (40.4)	20 (31.7)		
		78 (45.3)	50 (45.9)	28 (44.4)		
		25 (14.5)	12 (11.0)	13 (20.6)		
	Postoperative transfer	34 (19.8)	29 (26.6)	5 (7.9)		
	Ward transfer	50 (29.1)	31 (28.4)	19 (30.2)		
	Emergency transfer	88 (51.2)	49 (45.0)	39 (61.9)		
APACHEII score	≤ 15	76 (44.2)	47 (43.1)	29 (46.0)	0.137	0.711
	> 15	96 (55.8)	62 (56.9)	34 (54.0)		
Shock	No	150 (87.2)	101 (92.7)	49 (77.8)	7.928	0.005
	Yes	22 (12.8)	8 (7.3)	14 (22.2)		
Sepsis	No	139 (80.8)	102 (93.6)	37 (58.7)	31.269	< 0.001
	Yes	33 (19.2)	7 (6.4)	26 (41.3)		
MODS	No	140 (81.4)	104 (95.4)	36 (57.1)	38.613	< 0.001
	Yes	32 (18.6)	5 (4.6)	27 (42.9)		
CRRT treatment	No	158 (91.9)	104 (95.4)	54 (85.7)	5.023	0.025
	Yes	14 (8.1)	5 (4.6)	9 (14.3)		
Mechanical ventilation	No	70 (40.7)	55 (50.5)	15 (23.8)	11.748	0.001
	Yes	102 (59.3)	54 (49.5)	48 (76.2)		
Restraint braking	No	57 (33.1)	44 (40.4)	13 (20.6)	7.016	0.008
	Yes	115 (66.9)	65 (59.6)	50 (79.4)		
Neuromuscular blocking agents	No	170 (98.8)	109 (100.0)	61 (96.8)	3.501	0.061
	Yes	2 (1.2)	0 (0.0)	2 (3.2)		
Sedation	No	95 (55.2)	70 (64.2)	25 (39.7)	9.722	0.002
	Yes	77 (44.8)	39 (35.8)	38 (60.3)		
Analgesics	No	58 (33.7)	47 (43.1)	11 (17.5)	11.761	0.001
	Yes	114 (66.3)	62 (56.9)	52 (82.5)		
Norepinephrine	No	149 (86.6)	100 (91.7)	49 (77.8)	6.722	0.010
	Yes	23 (13.4)	9 (8.3)	14 (22.2)		
Glucocorticoid	No	98 (57.0)	80 (73.4)	18 (28.6)	32.722	< 0.001
	Yes	74 (43.0)	29 (26.6)	45 (71.4)		
Nutritional support modalities	Enteral Nutrition	70 (40.7)	48 (44.0)	22 (34.9)	2.914	0.233
	Parenteral Nutrition	81 (47.1)	46 (42.2)	35 (55.6)		
	Enteral + Parenteral	21 (12.2)	15 (13.8)	6 (9.5)		
Length of ICU stay			3.0 (2.0，4.0)	7.0 (5.0，9.0)	-10.029	< 0.001
Albumin (minimum)	0	117 (68.0)	76 (69.7)	41 (65.1)	0.396	0.529
	1	55 (32.0)	33 (30.3)	22 (34.9)		

Name	Subgroup	Total	Non-ICU-AW group (n = 109)	ICU -AW group (n = 63)	Test statistic	*p value*
Calcium	0	155 (90.1)	96 (88.1)	59 (93.7)	1.394	0.238
	1	17 (9.9)	13 (11.9)	4 (6.3)		
Lactate	0	78 (45.3)	49 (45.0)	29 (46.0)	5.133	0.162
	1	49 (28.5)	26 (23.9)	23 (36.5)		
	2	37 (21.5)	28 (25.7)	9 (14.3)		
	3	8 (4.7)	6 (5.5)	2 (3.2)		
Blood glucose	1	127 (73.8)	84 (77.1)	43 (68.3)	1.604	0.205
	2	45 (26.2)	25 (22.9)	20 (31.7)		

3.3. Multifactorial analysis and model construction of ICU-AW in patients in the modeling group

Variables with $p < 0.05$ in the univariate analysis were subjected to multifactorial analysis, and the values assigned to the independent variables are shown in **Table 2**. The results showed that the history of alcohol consumption, mode of admission to the ICU, treatment with CRRT, mechanical ventilation, restraining brakes, the use of analgesic, the use of norepinephrine, the use of glucocorticosteroids, and the length of stay in the ICU were the independent influences on the ICU-AW of the patients ($p < 0.05$), and the model was constructed as shown in **Table 3**. Draw a column line graph, see **Figure 1**, each risk factor in the column line graph has a corresponding score, the score of the four indicators in the model will be summarized to get the total score, from the location of the total score to draw a vertical line downward, and the value of its intersection with the probability of occurrence coordinates is the risk of ICU-AW of the patient.

Table 2. Assignment of independent variables

Independent variable	
Drinking history	0 = no, 1 = yes
Mode of ICU admission	0 = postoperative transfers, 1 = ward transfers, 2 = emergency transfers
Shock	0 = no, 1 = yes
Sepsis	0 = no, 1 = yes
MODS	0 = no, 1 = yes
CRRT treatment	0 = no, 1 = yes
Mechanical ventilation	0 = no, 1 = yes
Restraint braking	0 = no, 1 = yes
Sedation	0 = no, 1 = yes
Analgesics	0 = no, 1 = yes
Norepinephrine	0 = no, 1 = yes
Glucocorticoid	0 = no, 1 = yes
Length of ICU stay	Original value input

Table 3. ICU-AW multifactorial logistic regression analysis

	β	S.E.	Wald	*p*	OR	95% CI	
						Lower	Upper
Constant	-3.814	2.024	3.551	0.060	0.022	–	–
drinking history (yes)	1.827	0.935	3.822	0.051	6.216	0.995	38.817
Mode of ICU admission			6.764	0.034			
Mode of ICU admission (ward transfers)	3.373	1.317	6.555	0.010	29.159	2.205	385.584
Mode of ICU admission (emergency transfers)	1.802	1.117	2.603	0.107	6.063	0.679	54.130
CRRT treatment (yes)	-4.570	1.503	9.247	0.002	0.010	0.001	0.197
Mechanical ventilation (yes)	-2.411	0.949	6.455	0.011	0.090	0.014	0.576
Restraint Braking (yes)	3.102	1.105	7.882	0.005	22.253	2.551	194.087
Analgesics	-3.820	1.178	10.524	0.001	0.022	0.002	0.220
Norepinephrine (yes)	-3.047	1.110	7.530	0.006	0.048	0.005	0.419
Glucocorticoid (yes)	-1.318	0.729	3.267	0.071	0.268	0.064	1.118
Length of ICU stay	1.681	0.324	26.961	< 0.001	5.370	2.847	10.128

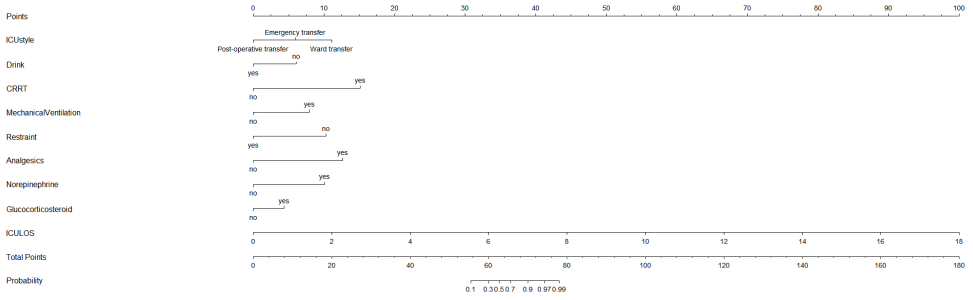


Figure 1. Column line diagram of the ICU-AW risk prediction model.

3.4. Validation of the ICU-AW risk prediction model

The risk probability of patients' myelosuppression was calculated according to the prediction model, with myelosuppression as the state variable and the prediction probability as the test variable, and the ROC curves of the modeling group and the validation group were plotted as in **Figure 2** and **Figure 3**.The values of the area under the curve (AUC) of the ROC curves of the modeling group and the validation group, and the 95% confidence intervals (CI) were shown in **Table 4**. (CI) are shown in **Table 4**. The calibration curves of modeling group and validation group were plotted by R4.0.2 as in **Figure 4, 5, 6** and **7**.

Table 4. Comparison of model prediction effectiveness between modeling and validation groups

Modeling groups	Sensitivity	Specificity	Yoden-index	Optimal threshold	AUC	*p value*	95% *CI*	
							Lower bound	Upper bound
Modeling group	0.921	0.927	0.848	0.316	0.979	0.000	0.962	0.995
Validation group	0.857	0.822	0.679	0.022	0.887	0.000	0.790	0.983

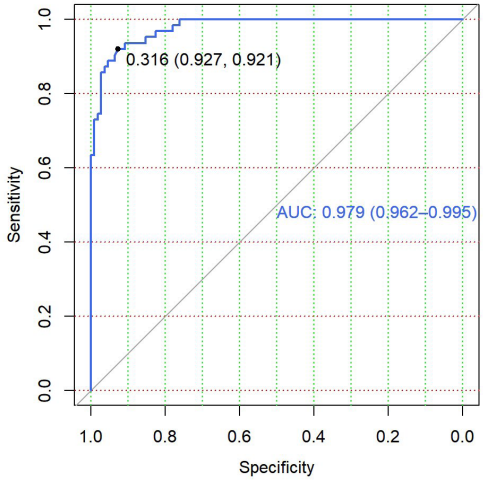


Figure 2. ROC curve for modeling group.

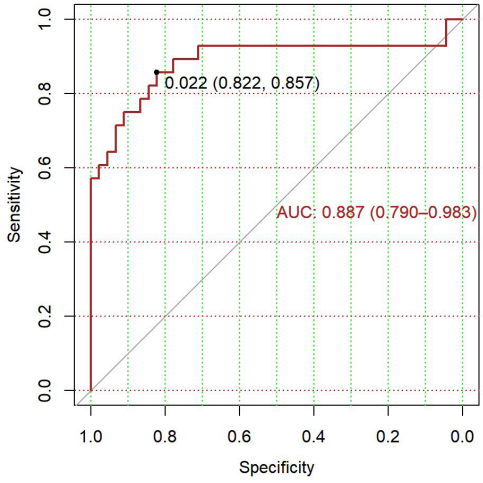


Figure 3. ROC curve for validation group.

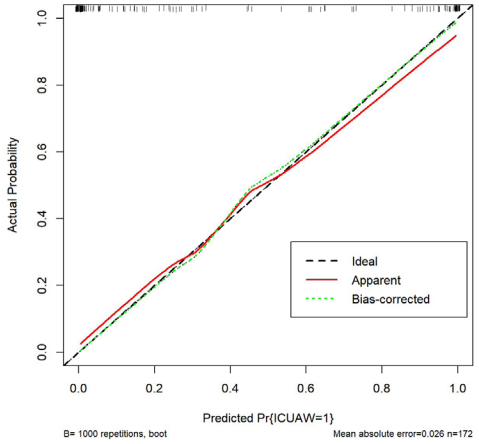


Figure 4. Modeling group calibration curve.

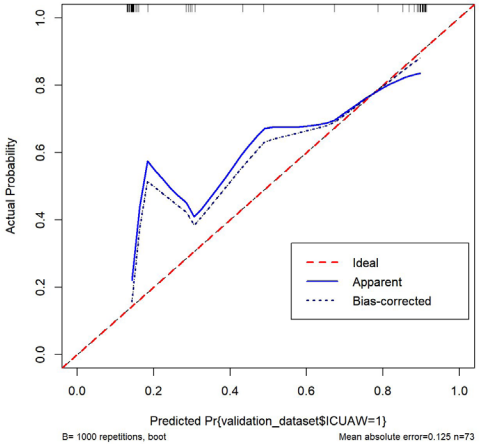


Figure 5. Verification group calibration curve.

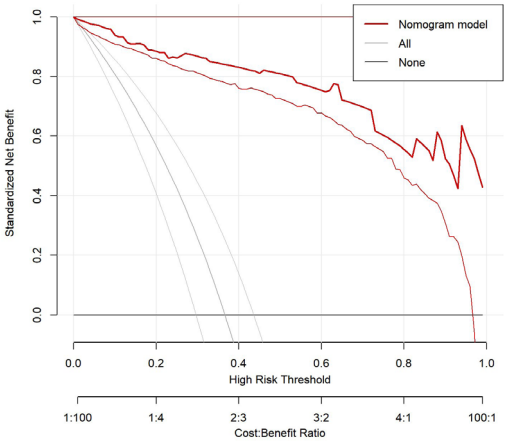


Figure 6. Modeling group decision curve.

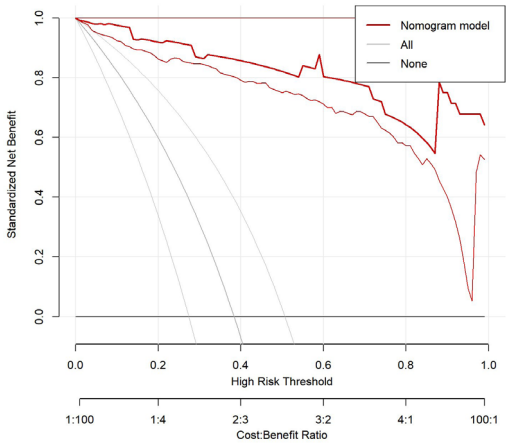


Figure 7. Validation group decision curve.

4. Discussion

4.1. Higher incidence of ICU-AW in patients

ICU-AW increases the hospitalization time of patients and affects their prognosis. Studies have shown that the incidence of ICU-AW in patients is 25–100%, indicating that the incidence of ICU-AW in patients is high [14]. The incidence of ICU-AW in patients in this study was 37.14% (91/245), which is in line with the range of the incidence of ICU-AW in previous studies, but the level is low. The reasons for this may be as follows:

(1) The study sites were all local tertiary hospitals, with relatively high medical standards and rapid ICU bed turnover;

(2) Under the influence of the concept of accelerated rehabilitation surgery, the rehabilitation training and education of patients are beneficial to the recovery of their muscle strength.

In this study, the mean age of occurrence of ICU-AW (49.25 ± 8.42) years has indicated that elderly patients are more likely to have ICU-AW, which is consistent with previous studies [15]. Therefore, the use of accurate and reliable assessment tools for patients' ICU-AW assessment is of great significance, and healthcare professionals should identify high-risk groups at an early stage and carry out accurate interventions and certain preaching, so as to help patients pass through the period of critical illness and improve their prognosis.

4.2. Analysis of independent influencing factors of ICU-AW in patients

4.2.1. Patients using norepinephrine are prone to ICU-AW

In this study, norepinephrine was found to be an independent risk factor for ICU-AW, which is consistent with previous studies [16–18]. The presence of β-adrenergic receptors on skeletal muscle is susceptible to the toxic effects of adrenergic drugs on skeletal muscle cells. This suggests that healthcare professionals should pay more attention to such patients [19].

4.2.2. Mechanical ventilation time, CRRT treatment as risk factors for ICU-AW

In this study, we found that the mode of admission to ICU, duration of mechanical ventilation, and CRRT

treatment were risk factors for ICU-AW. It may be due to the fact that these patients are more severe, and previous studies have shown that the incidence of ICU-AW is as high as 33–82% in patients on mechanical ventilation for > 4d [20]. Prolonged mechanical ventilation makes patients' activities limited, the use of sedative and analgesic drugs increased, so that the synthesis and decomposition of myosin and actin are imbalanced, and muscle strength decreased; during mechanical ventilation, the diaphragm is difficult to play a role, which triggers atrophy and injury. Therefore, proper ventilation mode should be selected and the timing of extubation should be well grasped in the work. The pathogenic mechanism of renal replacement therapy may be that continuous dialysis leads to phosphate depletion and causes muscle weakness [21].

4.2.3. Patients with restraint braking are prone to ICU-AW

In this study, it was found that the risk of ICU-AW in patients with restraint braking was 22.253 times higher than that without braking (OR = 22.253, 95% CI: 2.551–194.087). ICU patients are prone to delirium, and restraint braking can safeguard the safety of patients against risky events such as falling out of bed and detachment of tubes, and it may also lead to patients with disuse atrophy of muscles, muscle At the same time, it may also lead to muscle wasting atrophy, muscle density decrease, muscle strength decrease, muscle metabolism disorder, and the older the patient and the longer the braking time, the more serious harm. In addition, long-term braking is prone to microcirculation disorders and malabsorption of the body's nutritional status, which leads to a decrease in the patient's muscle strength and further increases the risk of ICU-AW in patients. The study pointed out that activities in the early ICU can effectively reduce the incidence of muscle costal atrophy, however, early activities may also increase the occurrence of other risky events. Therefore, healthcare professionals should pay attention to the patient's consciousness, and when restraining brakes due to delirium and agitation, they should pay more attention to their restraining braking time and site, and assist in interventions such as changing positions and appropriate passive movement to prevent muscle injuries as much as possible. The American Association of Critical Care Nursing developed a program in 2009 that emphasized the importance of early activity and multidisciplinary collaboration as tolerated by ICU patients. Early activity in critically ill patients has a positive effect on reducing ICU-AW [22]. An early activity intervention team consisting of responsible nurses, bedside assistants, and rehabilitation physiotherapists conducts early functional exercises based on patients' awareness and condition, encouraging patients to actively participate in the program in a gradual and orderly manner, from passive activity to active activity, and from bedside activity to activity away from the bed, in order to achieve the purpose of delaying muscle atrophy and improving muscle strength [23–25]. When the patient's condition is stabilized, the responsible nurse will assist the patient to independently complete the basic daily activities such as dressing, washing, etc., and the patient can be assisted to sit up or get down to the ground if the condition permits, so as to prevent muscle weakness.

4.2.4. Patients with a history of previous alcohol consumption and use of analgesics are prone to ICU-AW

This study showed that patients with a history of previous alcohol consumption had developed ICU-AW, and the risk of ICU-AW in patients using analgesics was 6.216 times higher than that in patients not using analgesics (OR = 6.216, 95% CI: 0.995–38.817), which is consistent with the results of other studies. The frequent use of sedative analgesics by patients helps to relieve pain and improve oxygen consumption, but repeated use leads to prolonged braking and reduced activity, which is not conducive to the maintenance

of normal muscle strength. The management model proposed by Vincent et al. for the patient who wishes to receive analgesia in comfort, minimal sedation and maximum humane care contributes to the patient's recovery [26]. Therefore, for patients receiving analgesia, the nurse can communicate with the physician about the patient's treatment and try to minimize analgesia to achieve therapeutic effects without increasing the risk of over-analgesia. For patients who must be given high doses of analgesics, attention should be paid to the frequency and practice of positional changes to try to avoid analgesia-induced prolonged braking.

4.2.5. Patients using glucocorticoids are prone to ICU-AW

In this study, it was found that the risk of ICU-AW was higher in patients after glucocorticoid use. Glucocorticosteroids are critical treatments for specific critically ill patients with strong anti-inflammatory and antifibrotic effects, shortening the duration of mechanical ventilation, reducing the incidence of organ failure and mortality in patients with refractory infectious shock. However, glucocorticoids cause changes in the expression of specific genes, causing endocrine disruption in the body, inhibiting protein synthesis, contributing to the redistribution of body fat, leading to muscle atrophy, and increasing the risk of ICU-AW [27].

4.2.6. Those with a longer stay in the ICU were prone to ICU-AW

Patients in the ICU-AW group had a longer stay in the ICU than those who did not develop ICU-AW, consistent with the findings of Hermans et al [28]. The occurrence of risky ICU stay for a long time may mean that the patients have a longer period to maintain stable condition, and the patients are more prone to ICU-AW as they have a heavier condition and a longer bedtime. In addition, the ICU in China is mostly a closed environment, and the patients need to face it alone during the treatment period, which inevitably produces fear, anxiety and other adverse emotions, and the psychological support of the patients is not satisfied, and the longer the stay in ICU, the more serious the patients' The longer the stay in ICU, the more serious the adverse emotions are, which in turn induces the occurrence of ICU-AW. When a healthy adult is bedridden for a long period of time, muscle strength will decrease by 1% per day [15]. Prolonged muscle inactivity causes changes in mitochondrial function, leading to an increase in reactive oxygen species, which results in muscle atrophy and dysfunction [29]. Therefore, healthcare professionals need to combine the patient's condition and willingness to provide the most favorable treatment and care plan for the patient, guide the patient to early rehabilitation exercise, increase the number of patients' bed activities, and reduce the risk of ICU-AW.

4.3. Scientific and practicality of ICU-AW risk prediction models

The Hosmer-Lemeshow fit test for the modeling group and validation group in this study was $\chi^2 = 1.687$ ($p = 0.989$) and $\chi^2 = 4.001$ ($p = 0.857$), respectively, and the P values of the two groups were > 0.05, and the calibration curves in **Figure 4** and **Figure 5** showed a better calibration, which indicated that the model had a better predictive ability. It is generally considered that AUC > 0.75 indicates that the model has a better prediction effect, and in this study, the AUC of the modeling group and the validation group were 0.979 and 0.887, respectively (p value < 0.01), and in the modeling group, the sensitivity was 0.921, the specificity was 0.927, and the Yoden index was 0.848, and in the validation group, the sensitivity was 0.857, the specificity was 0.822, and the Yoden index was 0.679, indicating that the model predicts better. When the prediction probability is ≥ 0.022, the patient's risk of ICU-AW is high, and healthcare workers should pay close attention to it [30]. History of alcohol consumption, mode of ICU admission,

shock, sepsis, MODS, CRRT treatment, mechanical ventilation, restraint, use of sedation, use of analgesics, use of norepinephrine, use of glucocorticosteroids, and ICU length of stay were independent influences on patients' ICU-AW, suggesting that healthcare professionals should pay closer attention to such patients. The column-line diagram model constructed in this study was used to assess the influence of each factor on patients' ICU-AW, calculate the risk probability, and provide timely individualized intervention.

5. Conclusion

The incidence of ICU-AW in patients is high, and the mode of patient admission to ICU, history of alcohol consumption, CRRT treatment, mechanical ventilation, restraint braking, use of analgesics, use of norepinephrine, use of glucocorticoids, and length of stay in the ICU are the independent influencing factors of ICU-AW in patients. The risk prediction model constructed in this study has good specificity and accuracy, which can help to screen ICU-AW high-risk groups for early intervention. Shortcomings: the sample size of this study is small, and future studies should expand the sample size and further optimize and improve it in multicenter studies.

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Disclosure statement

The authors declare no conflict of interest.

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Prognostic Classification of Hepatocellular Carcinoma Under Incomplete Data Conditions Using a Public Reference Cohort: A Weakly Supervised Multi-Omics Study

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Abstract: *Background*: Prognostic stratification of hepatocellular carcinoma (HCC) remains difficult because the disease is highly heterogeneous and complete matched multi-omics data are not always available in clinical cohorts. *Objective*: To develop a weakly supervised multi-omics framework that derives prognostic subtype labels from a public reference cohort and transfers them to cohorts with incomplete data. *Methods*: This study has analyzed 363 patients in TCGA-LIHC with matched mRNA, miRNA, DNA methylation, and clinical data. Overall-survival-related features were selected by univariate Cox regression, integrated by similarity network fusion (SNF), and clustered by spectral clustering to generate pseudo-labels. TCGA-LIHC was then split 6:4 into training and test sets for supervised modeling. External validation used LIRI-JP, GSE14520, GSE54236, and GSE31384, with models rebuilt on features shared with each cohort. Prognostic performance was evaluated by Kaplan-Meier analysis, log-rank testing, and the concordance index (C-index). *Results*: A total of 3,890 mRNA features, 150 miRNA features, and 1,889 methylation features were retained. SNF plus spectral clustering identified two subtypes: S1 (n = 257) and S2 (n = 106). S2 had significantly worse overall survival than S1 (log-rank $P = 3.891 \times 10^{-9}$; C-index = 0.866). In internal validation, XGBoost showed the highest AUC (0.983). In external validation, the predicted subtypes remained prognostically informative, with C-index values of 0.857 in LIRI-JP, 0.875 in GSE14520, 0.930 in GSE54236, and 0.883 in GSE31384. *Conclusions*: In the public datasets included in this study, this weakly supervised framework identified two prognostically distinct HCC subtypes and retained prognostic discrimination after transfer to external cohorts with incomplete data.

Keywords: Hepatocellular carcinoma; Prognostic classification; Machine learning; Incomplete data; Multi-omics

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1. Introduction

Hepatocellular carcinoma is the most common form of primary liver cancer, and survival remains unsatisfactory despite advances in surgery and systemic therapy [1–3]. Marked biological heterogeneity complicates prognosis assessment and limits the precision of conventional clinical classifications [3].

Multi-omics studies have improved characterization of HCC heterogeneity, but many prognostic models still depend on complete matched data and are therefore difficult to transfer to local cohorts with incomplete multi-omics profiles [3,4]. Previous gene-expression- and miRNA-based studies have proposed several HCC subtyping frameworks, but transferability across cohorts remains challenging [5–7]. In this study, TCGA-LIHC was used as a public reference cohort to derive prognostic pseudo-labels through Cox filtering, SNF integration, and spectral clustering, and then tested whether the learned subtype structure could be transferred to four external cohorts with different available feature spaces.

2. Methods

2.1. Data sources and study design

The discovery dataset was TCGA-LIHC from UCSC Xena and included 363 HCC cases with matched RNA-seq, miRNA-seq, DNA methylation, and clinical data. External validation datasets were LIRI-JP from ICGC (232 tumors), GSE14520 (221 tumors), GSE54236 (81 tumors), and GSE31384 (166 matched HCC and noncancerous liver specimens). All analyzed data were open access and de-identified.

The study had two stages. First, Cox filtering, SNF, and spectral clustering were applied to the full TCGA-LIHC cohort to identify prognostic subtypes and assign pseudo-labels. Second, TCGA-LIHC was randomly divided 6:4 into training and test sets, supervised models were trained with the pseudo-labels, and external validation was performed after rebuilding models on the features shared between TCGA-LIHC and each validation cohort.

2.2. Preprocessing and subtype labeling

Features and samples with more than 20% missing values were removed, remaining missing values were imputed with the mean, and the lowest 20% of biological features by mean value were discarded. For methylation data, CpG sites within 1,500 base pairs upstream of the transcription start site were aggregated by gene symbol. Clinical categorical variables were one-hot encoded.

To reduce noise in high-dimensional unsupervised integration, univariate Cox proportional-hazards models were first used to retain overall-survival-related features ($p < 0.05$). Each omics layer and the clinical data were then converted to patient-similarity matrices and integrated by SNF [8]. Spectral clustering was evaluated for k = 2–10, and the optimal cluster number was selected by the Silhouette score and Calinski-Harabasz index.

2.3. Supervised transfer and evaluation

Four classifiers (logistic regression, random forest, XGBoost, and neural network) were trained on the TCGA-LIHC training set with the pseudo-labels as weak supervision. Ten-fold cross-validation was used to summarize accuracy, precision, recall, and AUC, and the classifier with the highest AUC was selected.

For external validation, models were rebuilt on the TCGA-LIHC training set after restricting features

to the intersection with each validation dataset. The shared feature counts were 15,989 mRNAs for LIRI-JP, 10,132 mRNAs for GSE14520, 15,175 mRNAs for GSE54236, and 338 miRNAs for GSE31384. After cross-cohort normalization, the best model for each dataset was applied to predict subtypes. Prognostic discrimination was assessed by Kaplan-Meier analysis, log-rank testing, and C-index estimation.

3. Results

3.1. Identification of two prognostic subtypes in TCGA-LIHC

After preprocessing and survival filtering, 3,890 mRNA features, 150 miRNA features, and 1,889 methylation features remained. SNF followed by spectral clustering supported a two-cluster solution and identified S1 (n = 257) and S2 (n = 106) (**Figure 1A**). Overall survival differed significantly between the subtypes, with worse outcome in S2 (**Figure 1B**; log-rank $p = 3.891 \times 10^{-9}$; C-index = 0.866).

Compared with S1, S2 showed a less favorable distribution of pathologic T stage, overall stage, histologic grade, and Child-Pugh classification, supporting the clinical relevance of the pseudo-labels.

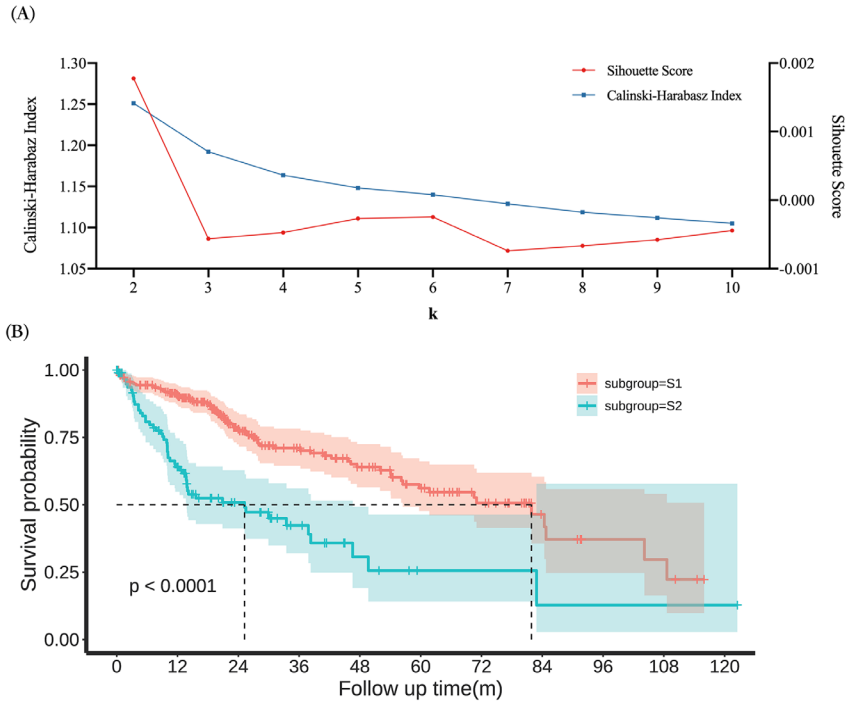


Figure 1. Subtype identification and survival difference in TCGA-LIHC. (A) Selection of cluster number using the Silhouette score and Calinski-Harabasz index. (B) Kaplan-Meier survival curves for the two subtypes.

3.2. Transferability in incomplete external cohorts

In internal validation, all four classifiers performed well, and XGBoost had the highest AUC (0.983), with accuracy of 0.97, precision of 0.91, and recall of 0.90 (**Table 1**). In external validation, logistic regression had the highest AUC in LIRI-JP, GSE14520, and GSE54236, with AUC values of 0.988, 0.990, and 0.992, respectively, whereas the neural network had the highest AUC in GSE31384 (0.988) (**Table 1**).

The predicted subtypes remained prognostically informative in all external cohorts (**Figure 2**). The C-index was 0.857 in LIRI-JP, 0.875 in GSE14520, 0.930 in GSE54236, and 0.883 in GSE31384, with

corresponding log-rank p values of 2.30×10^{-7}, 2.30×10^{-4}, 1.768×10^{-6}, and 0.029.

Table 1. Summary of internal and external validation

Cohort	Features	Model	AUC	C-index	p
TCGA-LIHC (internal)	mRNA + miRNA + methylation + clinical	XGBoost	0.983	0.866	3.891×10^{-9}
LIRI-JP	mRNA	Logistic regression	0.988	0.857	2.30×10^{-7}
GSE14520	mRNA	Logistic regression	0.990	0.875	2.30×10^{-4}
GSE54236	mRNA	Logistic regression	0.992	0.930	1.768×10^{-6}
GSE31384	miRNA	Neural network	0.988	0.883	0.029

Note: The classifier with the highest AUC in each cohort is shown. In internal TCGA-LIHC validation, XGBoost achieved an accuracy of 0.97, precision of 0.91, and recall of 0.90.

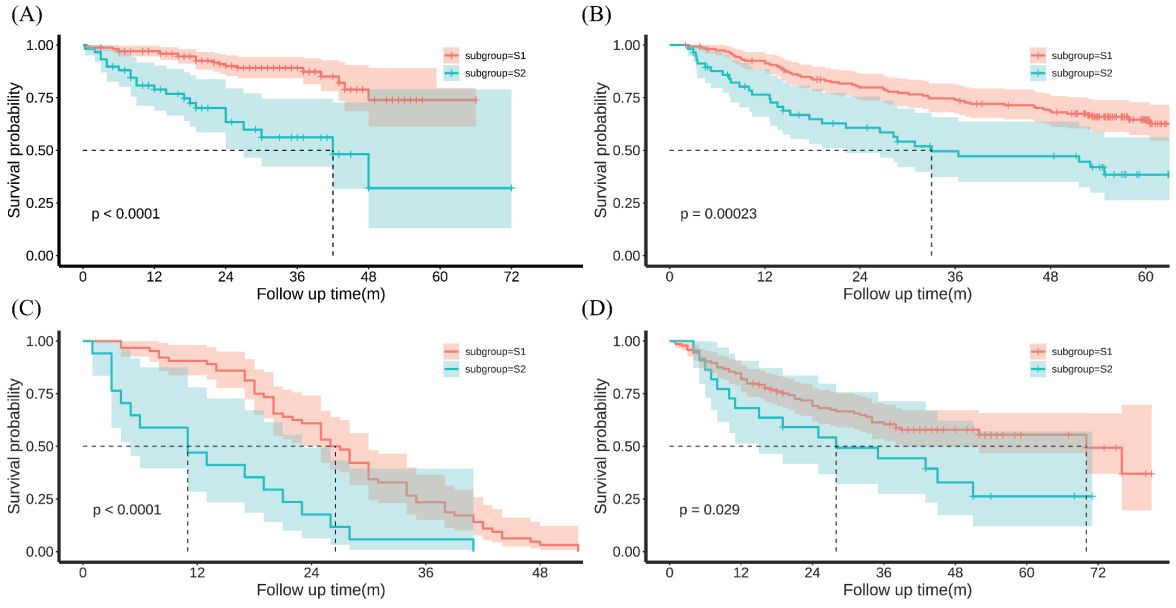


Figure 2. Kaplan-Meier survival curves in external validation cohorts. (A) LIRI-JP; (B) GSE14520; (C) GSE54236; (D) GSE31384.

4. Discussion

This study used a weakly supervised strategy to derive prognostic subtype labels from a public reference cohort and then transfer that structure to external cohorts with incomplete data. The central evidence is the consistent survival separation observed in TCGA-LIHC and across four external cohorts, which is broadly consistent with previous transcriptomic- and miRNA-based HCC subtyping studies [5–7].

The practical value of the framework lies in its use when complete matched multi-omics data are unavailable locally, because subtype labels are learned from a public reference cohort and the classifier can be rebuilt within the shared feature space of each target dataset.

This study has several limitations. The discovery and validation cohorts were modest in size. All analyses were retrospective and based on public datasets, which may introduce selection and platform bias. In addition, the biological interpretation remains computational and requires further empirical validation.

5. Conclusion

In the public datasets included in this study, a weakly supervised, SNF-based multi-omics framework identified two clinically relevant prognostic subtypes of HCC and retained prognostic discrimination across external cohorts with incomplete data. These findings support the use of public multi-omics resources for HCC prognostic classification when local data are not fully matched.

Disclosure statement

The authors declare no conflict of interest.

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Differential Diagnosis and Treatment of Medical Acute Abdomen

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Abstract: Acute abdomen is one of the most common emergencies in clinical emergency departments, characterized mainly by acute abdominal pain. It involves multiple disciplines including internal medicine, surgery, obstetrics and gynecology, and pediatrics, with complex etiologies and rapid progression. Misdiagnosis or delayed treatment can easily worsen the condition and even endanger the patient's life. With the development of medical technologies and diagnosis-treatment models such as artificial intelligence and precision medicine, the system for differential diagnosis and treatment of medical acute abdomen has been continuously improved, providing new ideas and methods for clinicians. Based on clinical practice, this paper summarizes the key points of differential diagnosis and standardized treatment of medical acute abdomen, and discusses the development trend of its clinical diagnosis and treatment, so as to provide a reference for clinical practice.

Keywords: Medical acute abdomen; Differential diagnosis; Standardized treatment; Risk stratification; Artificial intelligence

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1. Overview of medical acute abdomen

Medical acute abdomen refers to a clinical syndrome characterized by acute abdominal pain caused by etiologies without surgical indications. Lesions of medical acute abdomen may affect intra-abdominal organs such as the digestive and urinary systems; it can also be secondary to extra-abdominal organ diseases (e.g., chest and heart diseases) or systemic metabolic, immune, or toxic diseases, and some cases are related to neurological dysfunction [1]. Clinical features of medical acute abdomen are as follows:

(1) Onset

Acute or gradual; some patients first present with fever, cough, diarrhea, chest distress, etc., with abdominal pain as a secondary or accompanying symptom.

(2) Symptoms

Relatively mild abdominal pain, vague location, no fixed tenderness point, and rarely typical peritoneal irritation signs.

(3) Signs

Mild abdominal tenderness, no obvious muscular rigidity or rebound tenderness; accompanying symptoms are mostly related to the primary system. For example, abdominal pain caused by cardiovascular diseases is often accompanied by chest distress and profuse sweating; abdominal pain caused by respiratory diseases is often accompanied by cough and expectoration [2].

By etiology, medical acute abdomen is divided into three categories:

(1) Intra-abdominal organ origin

The most common type in clinic, including acute gastroenteritis, mesenteric lymphadenitis, mild acute pancreatitis, acute attack of chronic cholecystitis (non-suppurative), etc. Most of these lesions originate from intra-abdominal organs without surgical indications such as perforation, obstruction or strangulation.

(2) Extra-abdominal organ origin

Lesions outside the abdominal cavity cause abdominal pain through nerve referral or inflammation spread, such as acute myocardial infarction, lower lung pneumonia, pleurisy, acute urinary tract infection, intercostal neuralgia, etc. Some of these diseases (e.g., acute myocardial infarction) present only with upper abdominal pain and are easily misdiagnosed as surgical acute abdomen, which is a key point for clinical differentiation.

(3) Systemic disease origin

Caused by metabolic disorders, poisoning, immune abnormalities, neurological diseases, etc., such as diabetic ketoacidosis, chronic lead poisoning, porphyria, abdominal epilepsy. Such abdominal pain is mostly a local manifestation of systemic diseases, and the pain can be quickly relieved after the primary disease is treated [3]. In addition, neurofunctional diseases such as irritable bowel syndrome can also cause acute abdominal pain without organic lesions, classified as functional medical acute abdomen.

2. Differential diagnosis of medical acute abdomen

2.1. Differentiation from surgical acute abdomen

Medical and surgical acute abdomen have completely different treatment directions. Therefore, the first step in clinical management of acute abdomen is to distinguish between medical and surgical acute abdomen, requiring comprehensive judgment from medical history, incentives, symptoms, signs and other aspects.

From the perspective of medical history and triggers, medical acute abdomen is mostly induced by unclean diet, abdominal cold, overwork, or acute attack of underlying diseases (e.g., diabetic ketoacidosis due to irregular glucose control, myocardial infarction induced by exertion in coronary heart disease patients). Surgical acute abdomen is mostly related to greasy diet, overeating, strenuous activity, or abdominal trauma (e.g., severe pancreatitis caused by overeating, volvulus caused by strenuous exercise) [4].

From the perspective of symptom characteristics, medical acute abdomen usually presents fever before abdominal pain; pain is paroxysmal or persistent dull, vaguely located, relieved with the improvement of the primary disease, without defecation/flatulence cessation or intra-abdominal bleeding. Surgical acute abdomen presents abdominal pain before fever; pain is severe and progressive, clearly located, often with peritoneal irritation, and some show acute manifestations such as gastrointestinal obstruction or shock [5].

From the perspective of the characteristics of physical signs, medical acute abdomen shows mild abdominal tenderness, no muscular rigidity or rebound tenderness; the painful area is tender to pressure, and

abdominal breathing is not restricted. Surgical acute abdomen shows obvious tenderness (usually at the lesion site), marked muscular rigidity and rebound tenderness; the patient refuses palpation, abdominal breathing is weakened or absent, and some patients have abdominal masses.

2.2. Investigation of specific etiologies of medical acute abdomen

After excluding surgical acute abdomen, clinicians should investigate the specific cause of medical acute abdomen according to the patient's age, gender, underlying diseases, symptoms and accompanying manifestations [6].

(1) Children and adolescents

Mostly related to abdominal anaphylactoid purpura, mesenteric lymphadenitis, ascariasis, abdominal epilepsy.

(2) Middle-aged and elderly

Focus on cardiovascular and metabolic diseases such as acute myocardial infarction and diabetic ketoacidosis. Some patients with acute myocardial infarction have no chest pain but only acute upper abdominal pain with nausea and vomiting, which is highly prone to misdiagnosis.

(3) For intra-abdominal medical acute abdomen

Periumbilical pain with diarrhea and vomiting: mostly acute gastroenteritis related to unclean diet. Right lower abdominal pain with upper respiratory symptoms: mostly mesenteric lymphadenitis (common in children). Middle and upper abdominal dull pain with acid reflux and belching: mostly acute attack of chronic gastritis related to irregular diet [7].

(4) For extra-abdominal medical acute abdomen

Upper abdominal pain with chest distress, sweating, and ECG ST-segment changes: acute myocardial infarction. Upper abdominal pain with cough, expectoration, chest pain: lower lung pneumonia or pleurisy. Lower abdominal pain with frequent urination, urgency, dysuria, and elevated urine white blood cells: acute urinary tract infection.

(5) For systemic disease-related acute abdomen

Paroxysmal abdominal pain with elevated blood glucose and positive ketone bodies: diabetic ketoacidosis. Abdominal pain with pale skin and red urine: porphyria, confirmed by urinary porphyrin test [8].

2.3. Application of auxiliary examinations and advanced technologies

Auxiliary examinations are important for the differential diagnosis of medical acute abdomen. Laboratory tests, routine imaging, ECG and other traditional methods remain basic clinical tools.

(1) Laboratory tests

blood routine, urine routine, complete biochemistry, blood amylase, urine amylase, HCG, etc. Blood routine indicates infection; blood amylase is a key marker for pancreatitis; HCG excludes gynecological surgical acute abdomen such as ruptured ectopic pregnancy.

(2) ECG

Routine for elderly patients with upper abdominal pain to rule out acute myocardial infarction.

(3) Imaging

Abdominal ultrasound is the first choice (non-invasive, economical, fast) to show the morphology of

liver, gallbladder, pancreas, spleen, kidney and detect stones, edema, effusion, etc. Chest X-ray excludes pulmonary and pleural lesions.

(4) Diagnostic abdominal paracentesis

assists etiological judgment by the properties of aspirated fluid for patients with a small amount of intra-abdominal effusion or bleeding (bloody fluid suggests internal bleeding; purulent fluid indicates infection).

With the development of medical technology, artificial intelligence, precision imaging, endoscopy and other advanced technologies have been gradually applied. For example, AI-assisted imaging diagnostic systems can intelligently analyze abdominal CT and ultrasound images to identify lesions, suitable for rapid diagnosis in primary hospitals and emergency departments [9]. The development of capsule endoscopy and painless gastrointestinal endoscopy enables non-invasive or minimally invasive examination of digestive tract lesions, observing mucosal inflammation, bleeding, ulcers, etc., and performing minimally invasive treatments such as endoscopic hemostasis and biopsy, realizing the integration of diagnosis and treatment.

3. Standardized treatment of medical acute abdomen

The treatment principles of medical acute abdomen are: save life first, then treat the disease; treat the cause first, then give symptomatic care. Clinical treatment is mainly conservative, including general supportive care, etiological treatment, symptomatic treatment, and attention to the prevention and treatment of complications. Individualized plans are formulated according to the severity of the patient's condition; some patients can receive targeted treatment with minimally invasive or interventional techniques.

3.1. General supportive treatment

General supportive care is the foundation for all cases of medical acute abdomen, aiming to stabilize vital signs, correct water-electrolyte and acid-base imbalance, and create conditions for etiological treatment.

Patients with severe abdominal pain and vomiting should stay in bed; fasting or liquid/semi-liquid diet according to the condition; gastrointestinal decompression if necessary to reduce gastrointestinal burden.

Patients with dehydration or electrolyte imbalance receive intravenous fluid replacement; electrolytes (potassium, sodium, chlorine, etc.) are supplemented according to biochemical results to correct acidosis or alkalosis [10].

Critically ill patients (e.g., acute myocardial infarction, diabetic ketoacidosis, pre-shock state) receive oxygen inhalation, ECG monitoring, and close observation of blood pressure, heart rate, body temperature, oxygen saturation and other vital signs for timely intervention.

3.2. Etiological treatment

Etiological treatment is fundamental for medical acute abdomen. Only by removing the primary cause can abdominal pain be fundamentally relieved and recurrence prevented [11]. For internal acute abdomen with different causes, targeted treatment measures should be taken.

(1) nfectious diseases (acute gastroenteritis, mesenteric lymphadenitis, lower lung pneumonia)

Sensitive antibiotics selected based on sputum/fecal culture and drug sensitivity; empirical broad-spectrum antibiotics are used before results are available.

(2) Cardiovascular diseases (acute myocardial infarction)
Immediate thrombolysis, antiplatelet, lipid-lowering drugs; PCI for eligible patients to rapidly restore myocardial perfusion.
(3) Metabolic diseases (diabetic ketoacidosis)
Fluid replacement and insulin therapy to gradually correct ketosis and electrolyte disorders.
(4) Neurofunctional diseases (irritable bowel syndrome)
Intestinal flora regulation and gastrointestinal motility improvement combined with psychological counseling to relieve anxiety.

3.3. Symptomatic treatment

Symptomatic treatment relieves clinical manifestations and improves comfort, administered only after a clear diagnosis.

(1) Pain management
antispasmodics are preferred to relieve gastrointestinal smooth muscle spasm; they do not mask abdominal signs and are the first choice for medical acute abdomen [12]. For moderate to severe pain unresponsive to antispasmodics, mild NSAIDs or incremental intravenous narcotic analgesics can be used (relieve pain but preserve tenderness, without interfering with judgment).
(2) Vomiting and diarrhea
Antiemetics and antidiarrheals (e.g., montmorillonite powder) to relieve gastrointestinal symptoms.
(3) Peptic diseases with obvious acid reflux
Proton pump inhibitors and gastric mucosa protectants for acid suppression and mucosal protection.

3.4. Prevention and treatment of complications

Without timely or effective control, medical acute abdomen can lead to severe complications such as septic shock, multiple organ failure, massive gastrointestinal bleeding, and severe water-electrolyte imbalance, especially in elderly patients and those with multiple comorbidities. Close monitoring and early intervention are essential [13].

(1) Pre-shock manifestations (hypotension, tachycardia, cold extremities)
Immediate anti-shock treatment with rapid fluid expansion and vasoactive drugs if needed.
(2) Multiple organ failure (acute kidney injury, respiratory failure)
Timely organ support such as CRRT and mechanical ventilation [14].
(3) Continuous observation of symptoms, signs and laboratory changes
To adjust the treatment plan in a timely manner.

4. Development trend of clinical diagnosis and treatment of medical acute abdomen

The integration of artificial intelligence and precision medicine is an important trend. In addition to AI-assisted imaging diagnosis and clinical decision-making, big-data-based AI prognosis systems can predict disease progression. Precision medicine technologies such as genetic testing and metabolomics can precisely locate the causes of systemic disease-related acute abdomen and guide treatment [15].

The expansion of minimally invasive and interventional techniques has enabled diagnosis-treatment

integration for some medical acute abdomen. Besides endoscopic therapy, vascular interventions are used for gastrointestinal bleeding and liver abscess (e.g., selective arterial embolization for massive gastrointestinal bleeding, ultrasound-guided puncture and drainage for liver abscess).

The development of telemedicine allows primary hospitals to complete preliminary differentiation between medical and surgical acute abdomen through remote consultation and expert guidance, avoiding delays due to insufficient local resources.

5. Conclusion

Medical acute abdomen features complex etiologies, atypical symptoms, and easy confusion with surgical acute abdomen. Its differential diagnosis and treatment have always been key and difficult points in the emergency department. Clinical diagnosis and treatment should combine history taking, physical examination and auxiliary examinations, carry out standardized supportive, etiological and symptomatic treatment, and attach importance to the prevention and treatment of complications.

With the continuous development of artificial intelligence, precision medicine, multidisciplinary collaboration, minimally invasive intervention and other technologies and models, the diagnosis and treatment level of medical acute abdomen has been improved. Clinicians need to constantly update medical knowledge, master advanced technologies and concepts, and maintain rigorous clinical thinking to better meet the challenges of medical acute abdomen and provide higher-quality medical services for patients.

Disclosure statement

The author declares no conflict of interest.

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Construction and Application of a Patient Journey Map-Based Comprehensive Care Model for Individuals Undergoing Hepatic Carcinoma Interventional Therapy

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Abstract: *Objective*: To establish a full-process management model for liver cancer patients undergoing interventional therapy based on the Patient Journey Map (PJM), and to evaluate its application effect. *Methods*: A non-synchronous controlled trial design was adopted. 120 liver cancer patients who underwent transcatheter arterial chemoembolization (TACE) in the Department of Infection of our hospital from January 2025 to December 2025 were selected. The control group included 60 patients (1–6 months) who received routine care, while the experimental group included 60 patients (7–12 months) who received the full-process management based on the Patient Journey Map. Through semi-structured interviews, the key touchpoints and needs of patients were clarified, and the Patient Journey Map was drawn. A three-stage full-process management plan of "hospitalization period - discharge preparation period - home rehabilitation period" was constructed. The satisfaction of patients, the incidence of postoperative complications, self-management ability, quality of life, and readmission rate were compared between the two groups. *Results*: The satisfaction rate of patients in the experimental group (96.67%) and the total score of self-management ability (86.35 ± 5.21) and the total score of quality of life (78.56 ± 6.42) were all higher than those in the control group (81.67%, 72.48 ± 6.35, 65.32 ± 7.18), respectively; the incidence of complications (13.33%) and the 30-day readmission rate (6.67%) were lower than those in the control group (30.00%, 18.33%), and the differences were statistically significant ($P < 0.05$). *Conclusion*: The full-process management model based on the Patient Journey Map can improve the satisfaction of liver cancer patients undergoing interventional therapy, reduce the incidence of complications and readmission rate, and improve self-management ability and quality of life, and has clinical application value.

Keywords: Hepatic artery chemotherapy embolization; Patient journey map; Whole-process management; Self-management ability; Quality of life

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1. Introduction

Hepatocellular carcinoma (HCC) is a common malignant tumor worldwide, with particularly high disease burden in Asian regions [1–3]. The early symptoms of HCC are not typical, and approximately 80% of patients are diagnosed at an advanced stage, with only about 30% having the opportunity for radical resection, and the postoperative recurrence risk is relatively high [4]. Transarterial chemoembolization (TACE), as the core interventional treatment method for inoperable advanced HCC, has the advantages of minimally invasive, effectiveness, and repeatable operation, and is recommended as the preferred treatment option by domestic and international guidelines [5]. Patients after liver cancer interventional surgery face multiple challenges: physiological discomfort caused by embolization syndrome, anxiety and fear regarding disease prognosis, complex self-management tasks, and the connection issues during the transition from hospital to home care [6]. All these factors affect their recovery. The traditional nursing model is disease-centered, with fragmented and passive services, and is difficult to meet the diverse and personalized needs of patients [7]. The patient journey map (PJM) is a service design tool centered on patients, visualizing the entire experience of patients, by systematically depicting the experiences, needs, and service contact points of patients at each stage, helping medical staff identify pain points, optimize processes, and improve experiences [8,9]. In recent years, PJM has demonstrated unique value in chronic disease management and comprehensive cancer care [10,11]. Currently, there are few studies on the application of PJM in the entire management of patients undergoing liver cancer interventional surgery. This research aims to construct a patient journey map-based management model for patients undergoing liver cancer interventional surgery and evaluate its application effect, providing evidence-based support for clinical practice.

2. Basic information

2.1. General information

A non-synchronous control trial design was adopted. 120 patients with liver cancer who underwent TACE in the Infectious Diseases Department of our hospital from January to December 2025 were selected. Among them, 60 patients admitted from January to June 2025 were the control group and received routine care; 60 patients admitted from July to December 2025 were the experimental group and received the full-process management model based on the patient journey map.

2.2. Inclusion criteria

(1) Age 18 to 80 years old;
(2) Met the diagnostic criteria of the original liver cancer treatment guidelines (2024 edition), and underwent TACE treatment;
(3) Clear consciousness, without communication disorders;
(4) Expected survival period ≥ 6 months;
(5) Voluntarily participated and signed the informed consent form.

2.3. Exclusion criteria

(1) Complicated with other malignant tumors;
(2) Severe heart, liver, or kidney dysfunction;

(3) Mental illness or cognitive impairment;
(4) Serious complications occurred during the operation and were transferred to the ICU;
(5) Died within 3 months after the operation.

3. Test method

3.1. Control group

The control group received routine nursing management. The contents included:

(1) Before the operation
Routine education on the purpose, method, and precautions of the surgery;
(2) After the operation
Closely observe vital signs and bleeding at the puncture site, and handle postoperative pain, fever, etc.;
(3) Discharge guidance
Orally inform and distribute discharge guidance sheets, instructing regular follow-ups;
(4) Follow-up
Conduct a telephone follow-up once a month after discharge to understand the recovery situation.

3.2. Observation group

The observation group implemented the full-process management model for liver cancer interventional surgery based on the patient journey map.

3.2.1. Forming the research team

A research team consisting of the head nurse of the infection department, infection specialist nurses, interventional doctors, psychological counselors, and nutritionists was formed. The specialist nurses served as the core coordinator, responsible for drawing the patient journey map, formulating and implementing the management plan, and collecting and quality controlling the data.

3.2.2. Drawing the patient journey map

Through literature review, semi-structured interviews, clinical observation, and expert consultation, the patient journey map for liver cancer interventional surgery was drawn. The specific steps are as follows:

(1) Determine the research population
Select 20 patients undergoing liver cancer interventional surgery at different disease stages for semi-structured interviews to understand their entire experience from admission to post-discharge recovery.
(2) Draw journey stages
Divide the patient's entire process into the pre-surgery plan determination period (from admission to before the surgery), the surgical operation period (2–3 hours on the surgery day), the hospital recovery period (1–3 days after the surgery), the discharge preparation period (2–3 days before discharge), and the home rehabilitation period (1 month after discharge).
(3) Identify key contact points
Determine the key contact points in each stage, including admission reception, pre-surgery education, post-surgery care, discharge guidance, and home follow-up.
(4) Explore patient experiences

Through interviews, understand the feelings, emotional changes, needs, and difficulties of patients in each stage.

(5) Identify service pain points

Analyze the problem points in patient experiences, such as information asymmetry, poor nursing coordination, insufficient psychological support, and lack of home rehabilitation guidance.

(6) Draw a visual map

Integrate the information and draw a visual patient journey map, clearly showing the service contents, patient experiences, key pain points, and improvement opportunities. See **Figure 1** for details.

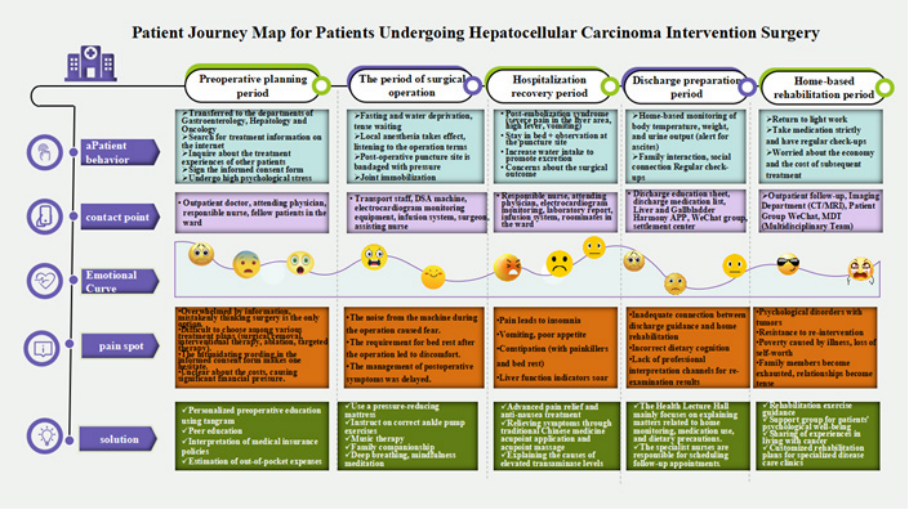


Figure 1. Patient journey map for patients undergoing hepatocellular carcinoma intervention surgery.

3.2.3. Establishing a full-process management model

Based on the key nodes and pain points identified through the patient journey map, a three-stage full-process management plan for "hospitalization period–discharge preparation period–home rehabilitation period" was constructed. Please refer to **Table 1** for details.

Table 1. Three stage full process management plan

Stage	Management focus	Service content	Duty of a specialist nurse
Period of hospitalization	Information support and symptom management	1. Personalized preoperative education (combining videos, graphics and explanations) 2. Postoperative symptom management (pain, fever, nausea, vomiting) 3. Psychological support and emotional counseling 4.Establish a "patient-nurse communication book" to record patient needs	1.Daily bedside visits are conducted to assess the physical and mental condition of the patients, build a trusting relationship, and identify their potential needs.
Discharge preparation period	Capacity building and transition integration	1. Pre-hospital comprehensive assessment (condition, self-management ability, family support) 2. Individualized discharge guidance (medication, diet, activity, follow-up) 3. Distribute the "Home Rehabilitation Manual for Liver Cancer Intervention Surgery" 4. Establish electronic follow-up files Guide patients to use home monitoring tools (such as symptom diaries, blood pressure monitors, etc.)	1. Conduct a multidisciplinary assessment before discharge. 2. Provide training on home rehabilitation skills. 3. Work with the patient to develop a discharge plan.

Stage	Management focus	Service content	Duty of a specialist nurse
Home-based rehabilitation period	Continuous support and early warning	1. Conduct telephone follow-ups on the 3rd, 7th, 14th and 30th days after discharge. 2. Daily push health knowledge and answer questions through WeChat groups and the "Liver and Gallbladder Sympathy" APP. 3. Identify warning symptoms (such as fever, abdominal pain, bleeding) and promptly guide patients to seek medical treatment. 4.Organize online patient communication meetings.	1. Conduct regular follow-ups to assess the control of symptoms and patient compliance. 2. Provide psychological support. 3.Remind patients to undergo regular re-examinations on time.

3.2.4. Quality control and continuous improvement

The specialist nurses hold a quality analysis meeting once a month to summarize problems, analyze causes, and propose improvement measures. Every quarter, the management plan is revised and improved to ensure continuous optimization.

3.3. Observation indicators

(1) Patient satisfaction

The self-made "Inpatient Satisfaction Survey Form" is used to evaluate the satisfaction with the nursing services at discharge. There are 10 items, using Likert 5-level scoring, and "satisfied" and "very satisfied" are combined into the satisfied group.

(2) Postoperative complication rate

The complications occurred within one week after surgery in both groups are recorded, including fever, nausea and vomiting, abdominal pain, puncture site bleeding, etc.

(3) Self-management ability

The "Self-management Behavior Scale for Chronic Disease Patients" is used to assess the self-management ability of patients one month after discharge. The scale includes 5 dimensions: medication compliance, symptom monitoring, lifestyle adjustment, emotion management, and doctor-patient communication, with a total score of 100 points. The higher the score, the stronger the self-management ability. The Cronbach's α coefficient is 0.83 [12].

(4) Quality of life

The "Quality of Life Scale for Liver Cancer Patients (QOL-LC)" is used to evaluate the quality of life of patients one month after discharge. There are 4 dimensions: physical function, psychological state, social function, and symptom control. The total score is 100 points. The higher the score, the better the quality of life. The Cronbach's α coefficient is 0.79 [13].

(5) Readmission rate

The proportion of patients readmitted due to changes in condition within 30 days after surgery is recorded in both groups.

3.4. Statistical methods

Data analysis was conducted using SPSS 26.0 statistical software. Measurement data were expressed as ($\overline{x} \pm s$), and independent sample t-tests were used for comparisons between groups; count data were expressed as frequencies and percentages, and χ^2 tests were used for comparisons between groups. A difference was considered statistically significant if $p < 0.05$.

4. Results

4.1. Comparison of general data of the two groups of patients

There were no statistically significant differences in gender, age, disease duration, tumor stage, liver function classification between the two groups ($p > 0.05$), and they were comparable. See **Table 2** for details.

Table 2. Comparison of general data of two group of patients

Index	Control group(n = 60)	Experimental group(n = 60)	t/χ^2 value	*p*-value
Gender (Male/Female)	42/18	44/16	0.156	0.693
Age (years)	57.32 ± 9.65	58.15 ± 8.92	0.491	0.624
Course of the disease (months)	7.85 ± 3.21	8.12 ± 3.05	0.476	0.635
Tumor stage (I/II/III)	12/32/16	10/34/16	0.238	0.888
Child-Pugh（A/B/C）	28/24/8	30/22/8	0.150	0.928

4.2. Comparison of patient satisfaction between the two groups

The satisfaction rate of patients in the experimental group at discharge (96.67%) was significantly higher than that of the control group (81.67%), and the difference was statistically significant ($p < 0.05$). See **Table 3** for details.

Table 3. Feedback data on the satisfaction between two groups

Group	Number of cases	Satisfaction (n, %)	Not satisfied (n, %)	χ^2 value	*p*-value
Control group	60	49 (81.67)	11 (18.33)	6.988	0.008
Experimental group	60	58 (96.67)	2 (3.33)		

4.3. Comparison of complication rates between the two groups of patients

The total incidence of postoperative complications in the experimental group (13.33%) was significantly lower than that in the control group (30.00%), and the difference was statistically significant ($p < 0.05$). See **Table 4** for details.

Table 4. Complication rates between two groups of patients

Group	Number of cases	Fever	Nausea and vomiting	Stomac hache	Bleeding at the puncture site	Total incidence rate(%)	χ^2 value	*p*-value
Control group	60	6	5	4	3	30.00	4.910	0.027
Experimental group	60	3	2	2	1	13.33		

4.4. Comparison of self-management abilities between the two groups of patients

The total score of self-management ability and the scores of each dimension in the experimental group at one month after discharge were significantly higher than those in the control group, and the difference was statistically significant ($p < 0.001$). See **Table 5** for details.

Table 5. Self-management abilities between two groups of patients

Dimensionality	Control group(n = 60)	The experimental group(n = 60)	*t*-value	*p*-value
Compliance	14.25 ± 2.36	17.86 ± 1.95	9.163	< 0.001
Syndromic surveillance	15.32 ± 2.18	18.24 ± 1.76	8.168	< 0.001
Lifestyle adjustment	13.86 ± 2.45	17.12 ± 2.03	7.996	< 0.001
Emotion management	14.58 ± 2.52	17.35 ± 2.18	6.484	< 0.001
Doctor-patient communication	14.47 ± 2.28	17.78 ± 1.82	8.835	< 0.001
Total points	72.48 ± 6.35	86.35 ± 5.21	13.127	< 0.001

4.5. Comparison of quality of life between the two groups of patients

The total score of quality of life and the scores of each dimension in the experimental group at one month after discharge were significantly higher than those in the control group, and the difference was statistically significant ($p < 0.001$). See **Table 6**.

Table 6. Comparison of quality of life between two groups of patients

Dimensionality	Control group(n = 60)	Experimental group(n = 60)	*t*-value	*p*-value
Body function	16.35 ± 2.68	19.86 ± 2.35	7.639	< 0.001
Psychological states	15.28 ± 2.54	19.12 ± 2.18	8.846	< 0.001
Social function	16.42 ± 2.71	19.35 ± 2.42	6.289	< 0.001
Symptom control	17.27 ± 2.46	20.23 ± 2.15	7.098	< 0.001
Total points	65.32 ± 7.18	78.56 ± 6.42	10.726	< 0.001

4.6. Comparison of readmission rates between the two groups of patients

The re-admission rate of the experimental group 30 days after surgery (6.67%) was significantly lower than that of the control group (18.33%), and the difference was statistically significant ($p < 0.05$). See **Table 7** for details.

Table 7. Comparison of readmission rates between two groups of patients

Group	Number of cases	Readmission(n, %)	Not readmitted(n, %)	Chi-square value	*p*-value
Control group	60	11 (18.33)	49 (81.67)	3.928	0.047
Experimental group	60	4 (6.67)	56 (93.33)		

5. Discussion

5.1. The full-process management model can effectively enhance patient satisfaction

The results of this study show that the satisfaction of patients in the experimental group was significantly higher than that in the control group ($p < 0.05$). The patient journey map is centered on the patients, exploring their real needs at each stage, identifying the pain points in traditional care, such as excessive preoperative education information, lagging postoperative symptom management, and poor connection between discharge guidance and home rehabilitation [14]. The experimental group implemented phased and personalized management: during the hospitalization period, emphasis was placed on information support and symptom management; during the preparation for discharge, capacity building and transition connection were

strengthened; during the home rehabilitation period, continuous support and early warning were provided. This full-process, proactive service model made patients feel valued and cared for, effectively enhancing satisfaction [15].

5.2. The full-process management model can reduce postoperative complications and readmission rates

In this study, the postoperative complication rate (13.33%) and readmission rate (6.67%) of the experimental group were significantly lower than those of the control group ($p < 0.05$). The reasons are as follows:

(1) The full-process management based on the patient journey map achieved dynamic monitoring and early intervention of symptoms. During hospitalization, specialized nurses conducted bedside visits daily, promptly handling embolism syndrome; during the home period, through the "Liver and Gallbladder Sibling" APP, telephone follow-up, and WeChat group guidance, patients were helped to identify warning symptoms and seek medical attention in time.

(2) During the preparation for discharge, a comprehensive assessment and capacity building were carried out, enabling patients to master key self-management skills such as pain assessment, diet adjustment, and puncture point observation, effectively preventing complications.

(3) The close collaboration of a multidisciplinary team provided comprehensive and continuous professional support for patients [16].

5.3. The full-process management model can improve patients' self-management ability and quality of life

In this study, the self-management ability and quality of life scores of the experimental group were significantly higher than those of the control group ($p < 0.001$). The reasons are as follows:

(1) Through the patient journey map, the self-management needs and difficulties of patients at each stage were deeply understood, and targeted intervention measures were formulated.

(2) During the home rehabilitation period, continuous support was provided, through WeChat group, "Liver and Gallbladder Sibling" APP, daily health knowledge dissemination and answering questions, to consolidate patients' self-management skills.

(3) Specialized nurses conducted regular follow-ups and gave positive feedback, enhancing patients' self-efficacy, and improving their self-management confidence [17].

(4) Online patient exchange meetings were organized to help patients establish a social support network, improving their psychological state and social function [18].

6. Conclusion

This study, based on the patient journey map, constructed a three-stage full-process management model of "hospitalization period–preparation for discharge period–home rehabilitation period". This model is centered on the patients, relying on visual tools, achieving systematic, continuous, and personalized nursing services, effectively enhancing patient satisfaction, reducing the incidence of postoperative complications and readmission rates, improving patients' self-management ability and quality of life, and has significant clinical application value, which is worthy of promotion.

Disclosure statement

The authors declare no conflict of interest.

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Application of PBL Combined with Role-Play in Group Cooperative Teaching Mode in Nursing Education

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Abstract: *Objective*: To explore the application effect of a group cooperative teaching mode combining PBL and role-play in the teaching of "Fundamentals of Nursing". *Methods*: A controlled experimental design was adopted. Two nursing classes from the same university were selected. The experimental group adopted the PBL combined with role-play group cooperative teaching mode, while the control group used traditional teaching. After teaching, theoretical exam scores, operational skills scores, and teaching effects were compared. *Results*: The experimental group's theoretical scores, operational skills scores, and teaching effects were significantly higher than those of the control group, with statistically significant differences ($p < 0.05$). *Conclusion*: The group cooperative teaching mode combining PBL and role-play aligns with the characteristics of "Fundamentals of Nursing" teaching, effectively compensates for the shortcomings of traditional teaching, and optimizes teaching outcomes.

Keywords: PBL; Role-play; Group cooperation; Fundamentals of nursing; Teaching application

Online publication: Apr 30, 2026

1. Background

"Fundamentals of Nursing" is a core course for nursing majors, focusing on cultivating clinical thinking and comprehensive professional literacy [1]. Problem-Based Learning (PBL) is an interactive teaching approach centered on course content, effectively stimulating students' initiative, guiding autonomous inquiry, analysis, and problem-solving [2]. Role-play, also known as scenario simulation, is a virtual practical teaching method in which teachers create realistic clinical scenarios and students perform role-playing. It features strong theory-practice integration and intensive teacher-student interaction [3]. Group cooperative teaching emphasizes student-centered learning. Under teacher guidance, students complete learning tasks collaboratively, focusing on teamwork awareness and communication skills [4]. Currently, traditional teaching models cannot meet the needs of modern nursing practice, and integrating multiple teaching methods has become an important trend in nursing education reform. This study combines PBL, role-play, and group

cooperative teaching, applying them in the "Fundamentals of Nursing" course to explore multi-modal teaching model construction and student learning outcomes under the new mode [5].

2. Subjects and methods

2.1. Subjects

Two nursing classes from the same university were selected and divided into experimental and control groups. The experimental group had an average age of (20.10 ± 0.85) years, and the control group had an average age of (20.30 ± 0.98) years. All students had systematically studied basic and clinical nursing theory courses and passed assessment tests. Comparisons of assessment scores, age, and gender between groups showed no statistically significant differences ($p > 0.05$), indicating comparability.

2.2. Methods

Both groups were taught by the same teacher. Teaching aimed to enhance students' comprehensive abilities. Based on the college's student skill training requirements, a training plan was formulated, focusing on specialized nursing technical operations and emergency response plans for critical conditions.

2.2.1. Control group

The control group received traditional teaching. Curriculum was implemented through lectures, demonstrations, practical exercises, and assessments. The teacher used PPT or videos for theoretical learning, nursing skills explanations, and key points, supplemented by on-site demonstrations and reinforced learning during and after class.

2.2.2. Experimental group

The experimental group adopted a PBL combined with role-play group cooperative teaching mode. The teaching process was divided into three stages.

(1) Stage 1

Before class, the teacher clarified knowledge, skill, and literacy objectives according to the syllabus, designed moderately difficult PBL problems aligned with clinical practice, prepared role-play scenarios and teaching aids, divided students into balanced groups of 4–6, assigned group leaders and members, ensuring full participation.

(2) Stage 2

During class, the teacher introduced PBL problems, each group conducted literature review, discussion, and analysis, while the teacher guided them. Groups then conducted role-play based on inquiry plans, with role-players performing operations and communication, while the teacher observed, focusing on operation standardization and emergency handling.

(3) Stage 3

Groups presented results, with peer evaluation and intra-group self-evaluation to summarize issues.

2.3. Teaching evaluation

2.3.1. Theoretical knowledge and skills assessment

After class, teachers selected cases according to teaching objectives and designed questions related to nursing

knowledge for a standardized closed-book theoretical exam. Four basic skills (bed-making, aseptic technique, vital signs monitoring, etc.) were randomly selected for assessment. Two or more teachers scored the students. The average of the four skill scores was used as the skill assessment score. Both groups followed the same timing, skill items, content, and scoring standards.

2.3.2. Questionnaire survey

A self-made questionnaire was used to evaluate teaching effects, covering six aspects: learning interest, innovation ability, clinical practice ability, cooperation ability, language communication ability, and comprehensive ability. Total score was 10 points; responses were collected anonymously and analyzed.

2.4. Statistical methods

Data were analyzed using SPSS 26.0. Measurement data were expressed as mean ± standard deviation ($\overline{x} \pm s$). $p < 0.05$ was considered statistically significant.

3. Results

3.1. Theoretical and skills assessment scores

The experimental group's average theoretical score was (86.75 ± 8.34), significantly higher than the control group's (76.60 ± 9.78) ($p < 0.05$); the average operational skills score was (89.05 ± 4.35), significantly higher than the control group's (80.90 ± 4.78) ($p < 0.05$). This indicates that the PBL combined with role-play group cooperative teaching mode helps students understand and master fundamental nursing knowledge and practice skills, significantly enhancing theoretical knowledge and operational skill levels.

3.2. Questionnaire score comparison

Regarding learning interest, innovation ability, clinical practice ability, cooperation ability, language communication ability, and comprehensive ability, the experimental group's teaching effect score was (9.40 ± 0.754), significantly higher than the control group's (8.45 ± 1.36) ($p < 0.05$).

4. Discussion

4.1. New teaching mode improves theoretical and operational abilities

The results show that the experimental group's theoretical and operational skills scores were significantly higher than the control groups, indicating that scenario simulation teaching can stimulate active participation and effectively enhance students' comprehensive abilities [6]. PBL combined with group cooperative teaching guides students to analyze and solve problems through discussion, self-directed inquiry, and collaborative division of labor, reinforcing teamwork awareness. This combination can address the shortcomings of traditional fundamental nursing teaching that focuses on theory while lacking clinical relevance [7,8].

4.2. New teaching mode enhances comprehensive innovation ability

The experimental group's teaching effect scores were significantly higher than the control groups, indicating that PBL combined with role-play group cooperative teaching effectively enhances learning interest and stimulates curiosity [9]. Additionally, it emphasizes professional knowledge application and practical skills, cultivating communication, critical thinking, and innovation, thereby comprehensively improving student

competencies and aligning with the modern high-quality applied nursing talent training requirements [10].

5. Conclusion

Although the PBL combined with role-play group cooperative teaching mode is conceptually mature, practical application in Fundamentals of Nursing still faces challenges, such as insufficient student participation and insufficient alignment of problem design with clinical practice. However, this mode effectively compensates for the shortcomings of traditional teaching. The three teaching methods complement each other: PBL drives inquiry, role-play reinforces practice, and group cooperation cultivates collaboration literacy, providing a new approach and platform for fundamental nursing teaching reform, and is significant for training high-quality nursing talents needed in clinical practice.

Disclosure statement

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Application of an Integrated Medical-Nursing Fast-Track Surgery Program in Patients After Oral Cancer Surgery

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Abstract: *Objective*: To investigate the efficacy of an integrated medical-nursing fast-track surgery (FTS) program in patients undergoing oral cancer surgery. *Methods*: A total of 80 patients with oral cancer who underwent surgical treatment at our hospital from January 2024 to October 2025 were enrolled and randomly divided into an observation group (n = 40) and a control group (n = 40) using simple random sampling. The control group received conventional perioperative care, while the observation group was managed with the integrated medical-nursing FTS program. Postoperative recovery time, complication rate, flap survival rate, pain intensity, negative emotions, and quality of life were compared between the two groups. *Results*: The time to drain removal, first oral intake, bed rest, infusion, and hospital stay were significantly shorter in the observation group than in the control group ($p < 0.05$). The overall complication rate was lower (15.00% vs. 32.50%) and the flap survival rate was higher (98.75% vs. 90.00%) in the observation group ($p < 0.05$). At 7 days postoperatively, the VAS, SAS, and SDS scores were significantly lower in the observation group ($p < 0.05$). One month after surgery, the observation group had higher scores in most items of the EORTC QLQ-H&N35 scale except for illness perception, social relations, and weight change ($p < 0.05$). *Conclusion*: The integrated medical-nursing FTS program effectively accelerates physical recovery, improves flap survival, reduces complication risks, and significantly ameliorates psychological status and long-term quality of life in patients after oral cancer surgery.

Keywords: Oral cancer; Integrated medical-nursing care; Fast-track surgery; Flap survival; Quality of life

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1. Introduction

Oral cancer is a common malignant tumor of the head and neck, accounting for 2.4–20.3% of all head and neck malignancies [1]. At present, comprehensive treatment consisting mainly of surgical resection combined with flap repair is a crucial approach to improving the prognosis of patients with oral cancer. However, the complex anatomical structure of the oral and maxillofacial region, extensive surgical scope, and substantial

tissue trauma often lead to postoperative dysphagia, restricted oral function, and maxillofacial deformity. In addition, prolonged fasting, bed rest, and indwelling catheters after surgery readily induce complications such as pulmonary infection and pressure injury, imposing severe physical and psychological stress on patients [2,3].

Fast-track surgery (FTS), an evidence-based perioperative optimization concept, has been proven to effectively alleviate surgical stress and accelerate patient recovery [4]. Meanwhile, the integrated medical-nursing model breaks the traditional "doctor's order-execution" barrier and emphasizes collaborative decision-making and information sharing within the medical team [5]. Although FTS and integrated medical-nursing care have been widely applied in fields such as colorectal surgery, dedicated studies focusing on patients undergoing flap repair for oral cancer remain relatively scarce. Postoperative oral cancer patients present unique challenges including difficult airway management, high requirements for flap monitoring, and restricted early oral intake and mobilization, which conventional nursing often fails to address comprehensively. Accordingly, based on the clinical characteristics of oral and maxillofacial surgery, this study deeply integrates the integrated medical-nursing model with FTS principles to develop a tailored care program covering multidisciplinary collaboration, refined flap protection, and stepped early mobilization.

This study aims to evaluate the effectiveness of this program in postoperative oral cancer patients and provide a scientific basis for optimizing clinical pathways of enhanced recovery in oral and maxillofacial surgery.

2. Subjects and methods

2.1. Study subjects

A prospective controlled trial was conducted. Eighty patients with oral cancer who underwent surgical treatment at our hospital from January 2024 to October 2025 were enrolled.

2.1.1. Inclusion criteria

(1) Histopathologically confirmed oral cancer and scheduled for surgical resection;
(2) No history of preoperative radiotherapy, chemotherapy, or other adjuvant therapies;
(3) Clear consciousness, intact cognitive and communication abilities, and signed informed consent.

2.1.2. Exclusion criteria

(1) Concurrent other malignant tumors;
(2) Severe psychological disorders or mental illness;
(3) Severe underlying diseases of the heart, lung, liver, kidney, or other vital organs.

2.1.3. Study groups

Patients were randomly assigned to the observation group (n = 40) and the control group (n = 40) using simple random sampling. Baseline characteristics including age, gender, body mass index (BMI), clinical stage, and tumor location were comparable between the two groups ($p > 0.05$).

2.2. Interventions

2.2.1. Control group

The control group received conventional perioperative care for oral cancer.

(1) Preoperative

Routine health education; fasting for 6 hours, water restriction for 2 hours before surgery; oral administration of 50 mL of 12.5% sugar solution under anesthesiologist guidance.

(2) Intraoperative

Warming pads for non-surgical areas; infusion fluids heated to 38 ℃.

(3) Postoperative

Routine gastrointestinal decompression and scheduled enteral nutrition via nasogastric tube; tracheal extubation at 5–7 days postoperatively; drain removal at 3–5 days for donor sites and 5–7 days for maxillofacial and cervical sites; oral water intake at 5 days and liquid diet at 7 days in patients with satisfactory recovery.

2.2.2. Observation group

The observation group received the integrated medical-nursing FTS program based on conventional care.

(1) Integrated medical-nursing collaborative management

Attending physicians and primary nurses jointly conducted history taking and needs assessment postoperatively, and developed individualized treatment and rehabilitation strategies according to patients' psychological status, educational level, and compliance. A WeChat group involving physicians, nurses, and patients was established: physicians provided disease and surgical information and shared surgical outcomes to enhance confidence; nurses delivered guidance on diet, daily routine, and rehabilitation training. Nurses proactively communicated with surgeons and anesthesiologists to fully grasp intraoperative blood loss, flap protection strategies, and drainage status, recorded daily physiological indicators, and accurately reported to physicians for dynamic adjustment of medical orders. Daily joint medical-nursing ward rounds were performed, and consultations with nutritionists, rehabilitation therapists, and psychologists were arranged to formulate systematic rehabilitation plans.

(2) Stepped FTS early mobilization training

First, position management. Head of bed elevated to 15–30° within 2 days postoperatively to facilitate airway secretion clearance and venous return. Secondly, bed exercises: Active/passive knee and muscle strength training 1–4 days postoperatively, 2–3 sessions daily, 15 minutes per session; toe and ankle exercises 10 times daily, 10 minutes per session; progressive hip-lifting exercises, 20 sets per session, 6 sessions daily. Then, early ambulation. Assisted sitting up at 3 days postoperatively with back-slapping and sputum clearance training by nurses and family members. Differentiated plans were formulated based on flap donor sites: upper extremity flap repair patients received fist-clenching, elbow flexion, and lifting exercises, with bedside and out-of-bed activities at 3 days; lower extremity flap repair patients added foot-hooking, leg flexion-extension, and ankle pump exercises, ambulated with walkers for protection, 15–30 minutes per session, 4–5 sessions daily. Lower limb elevation was performed after each session to prevent swelling and deep vein thrombosis.

2.3. Outcome measures

(1) Postoperative recovery time

Time to drain removal, first oral intake, bed rest, infusion, and hospital stay.

(2) Complications and flap survival

Incidence of hoarseness, pulmonary infection, gastrointestinal reactions, pressure injury, and other

complications; flap survival rate.

(3) Pain and negative emotions

Visual Analogue Scale (VAS, 0–10, higher score = worse pain), Self-Rating Anxiety Scale (SAS), and Self-Rating Depression Scale (SDS) at 1 and 7 days postoperatively.

(4) Quality of life

European Organization for Research and Treatment of Cancer Quality of Life Questionnaire-Head and Neck 35 (EORTC QLQ-H&N35) at 1 month postoperatively; higher scores indicate better quality of life.

2.4. Statistical analysis

Data were analyzed using SPSS 24.0 software. Categorical data were presented as frequencies and percentages, and compared using the chi-square test. Normally distributed continuous data were expressed as mean ± standard deviation ($\overline{x} \pm s$), and compared using independent-samples *t*-test. A *p*-value < 0.05 was considered statistically significant.

3. Results

3.1. Postoperative recovery time

The observation group had significantly shorter time to drain removal, first oral intake, bed rest, infusion, and hospital stay than the control group ($p < 0.05$) (**Table 1**).

Table 1. Comparison of postoperative recovery time between the two groups ($\overline{x} \pm s$)

Group	n	Time to drain removal (d)	First oral intake (d)	Bed rest time (d)	Infusion time (d)	Hospital stays (d)
Observation	40	3.52 ± 0.33	9.47 ± 1.12	29.26 ± 3.19	3.71 ± 0.68	12.31 ± 1.09
Control	40	3.68 ± 0.39	9.95 ± 1.34	31.05 ± 3.34	3.95 ± 0.73	13.58 ± 1.81
t value	–	2.801	2.458	3.466	2.152	2.278
p value	–	0.006	0.015	0.001	0.033	0.024

3.2. Complications and flap survival

The overall complication rate was significantly lower and the flap survival rate was significantly higher in the observation group ($p < 0.05$) (**Table 2**).

Table 2. Comparison of complication rate and flap survival rate between the two groups [n(%)]

Group	n	Hoarseness	Pulmonary infection	Gastrointestinal reaction	Pressure injury	Total complications	Flap survival
Observation	40	5 (6.25)	2 (2.50)	3 (3.75)	2 (2.50)	12 (15.00)	79 (98.75)
Control	40	8 (10.00)	5 (6.25)	7 (8.75)	6 (7.50)	26 (32.50)	72 (90.00)
χ^2 value	–	–	–	–	–	6.764	4.238
p value	–	–	–	–	–	0.009	0.040

3.3. Pain and negative emotions

At 1 day postoperatively, VAS, SAS, and SDS scores were comparable between groups ($p > 0.05$). At 7 days

postoperatively, all scores were significantly lower in the observation group ($p < 0.05$) (**Table 3**).

Table 3. Comparison of VAS, SAS, and SDS scores between the two groups ($\overline{x} \pm s$, scores)

Group	n	VAS (1 d / 7 d)	SAS (1 d / 7 d)	SDS (1 d / 7 d)
Observation	40	5.01 ± 0.78 / 2.31 ± 0.41	51.42 ± 8.43 / 40.19 ± 6.57	49.68 ± 8.52 / 38.71 ± 6.22
Control	40	4.96 ± 0.85 / 2.55 ± 0.56	52.08 ± 8.55 / 42.47 ± 6.85	49.41 ± 8.34 / 40.75 ± 6.25
t value	–	0.388 / 3.093	0.492 / 2.149	0.203 / 2.069
p value	–	0.699 / 0.002	0.624 / 0.033	0.840 / 0.040

3.4. Quality of life

One month after surgery, the observation group had significantly higher scores in pain, eating, sensation, mouth opening difficulty, coughing, and speech on the EORTC QLQ-H&N35 scale ($p < 0.05$), with no significant between-group differences in illness perception, social relations, and weight change ($p > 0.05$) (**Table 4**).

Table 4. Comparison of EORTC QLQ-H&N35 scores between the two groups ($\overline{x} \pm s$, scores)

Group	n	Time	Pain	Eating	Dental problems	Dry mouth	Illness perception	Weight change	Sensation	Mouth opening difficulty	Coughing	Speech	Social relations
Observation	40	1 d	6.41 ± 0.78	11.32 ± 2.41	2.24 ± 0.38	3.25 ± 0.44	1.76 ± 0.24	1.35 ± 0.24	2.87 ± 0.54	1.66 ± 0.35	1.89 ± 0.18	1.78 ± 0.19	12.42 ± 1.34
		1 month	12.24 ± 1.98	15.65 ± 3.26	2.69 ± 0.49	5.26 ± 0.78	1.73 ± 0.49	1.39 ± 0.25	5.42 ± 0.79	2.78 ± 0.49	2.46 ± 0.35	2.57 ± 0.37	12.37 ± 4.71
Control	40	1 d	6.49 ± 0.84	11.38 ± 2.36	2.26 ± 0.31	3.31 ± 0.47	1.77 ± 0.21	1.37 ± 0.22	2.92 ± 0.49	1.70 ± 0.34	1.92 ± 0.15	1.82 ± 0.22	12.66 ± 1.59
		1 month	10.29 ± 1.85	14.41 ± 2.74	2.51 ± 0.37	4.75 ± 0.66	1.71 ± 0.42	1.31 ± 0.28	4.78 ± 0.63	2.52 ± 0.42	2.24 ± 0.24	2.24 ± 0.35	12.85 ± 4.36
t value	–	1 d	0.624	0.159	0.365	0.834	0.280	0.549	0.613	0.733	1.145	1.231	1.032
	–	1 month	6.436	2.604	2.622	4.464	3.049	2.608	5.665	3.603	4.637	23.077	3.512
p value	–	1 d	0.533	0.874	0.716	0.406	0.779	0.583	0.541	0.465	0.254	0.220	0.303
	–	1 month	< 0.001	0.010	0.010	< 0.001	0.094	0.319	< 0.001	< 0.001	< 0.001	< 0.001	0.081

4. Discussion

4.1. Integrated medical-nursing fts accelerates physical recovery after oral cancer surgery

Oral cancer surgery often involves free flap transplantation. Traditional protocols require strict bed rest to avoid flap vascular crisis, which frequently leads to delayed extubation, delayed gastric emptying, and muscle atrophy. The present study showed that time to drain removal, first oral intake, and hospital stay were significantly shorter in the observation group ($p < 0.05$), consistent with findings by Mörk et al. on

FTS in head and neck cancer [6]. The underlying mechanism involves: the integrated model eliminates delays in conventional care; through joint ward rounds, nurses promptly obtain professional assessments of flap perfusion and drainage from surgeons, enabling safe early drain removal. Meanwhile, FTS-guided shortened fasting and early enteral nutrition maintain intestinal mucosal barrier function, promote gastrointestinal hormone secretion, and thereby accelerate oral intake and reduce intravenous fluid infusion [7].

4.2. Multidisciplinary collaboration and stepped mobilization reduce complications and improve flap survival

Free flap transplantation is critical for oral cancer reconstruction, and its survival directly determines surgical success. The flap survival rate in the observation group reached 98.75%, significantly higher than 90.00% in the control group, and the overall complication rate decreased to 15.00%. These results confirm the advantages of integrated medical-nursing care in refined management. In conventional care, nurses often lack knowledge of intraoperative vascular anastomosis details; in this program, nurses participate in preoperative discussions and postoperative reviews to achieve precise flap monitoring. Furthermore, stepped early mobilization is key to complication reduction. Elevating the head of bed to 15–30° postoperatively conforms to oral and maxillofacial anatomy, facilitates gravitational drainage of airway secretions, and markedly lowers pulmonary infection rate (2.50% vs. 6.25%) [8]. Differentiated progressive exercises for upper or lower extremity donor sites avoid excessive traction and vascular spasm, while ankle pumps and lower limb elevation promote venous return and effectively prevent deep vein thrombosis and donor-site swelling [9].

4.3. Homogeneous medical-nursing communication improves psychological status and quality of life

Postoperative oral cancer patients commonly experience facial deformity, dysphagia, and speech disorders, which easily trigger severe anxiety and depression [10]. In this study, SAS and SDS scores at 7 days postoperatively were significantly lower in the observation group, and multiple EORTC QLQ-H&N35 scores at 1 month were significantly improved. Reasons include:

(1) The integrated WeChat platform ensures homogeneous information delivery, eliminating patient distrust and insecurity caused by inconsistent explanations from physicians and nurses.

(2) Combined surgical outcome sharing by physicians and rehabilitation guidance by nurses rebuild confidence under the bio-psycho-social medical model [11].

(3) Early ambulation and oral intake help patients perceive tangible recovery, greatly enhancing subjective initiative. The non-significant differences in social relations and illness perception may be related to long-term stigma and social withdrawal caused by the tumor, suggesting the need for long-term social support interventions in future practice [12,13].

5. Conclusion

The integrated medical-nursing fast-track surgery program deeply integrates multidisciplinary collaboration and evidence-based rehabilitation principles, yielding remarkable efficacy in postoperative oral cancer patients. It effectively improves flap survival, lowers complication risks, accelerates physical recovery, enhances psychological well-being, and elevates overall quality of life, supporting its widespread clinical application.

Disclosure statement

The authors declare no conflict of interest.

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Application Status and Progress of Artificial Intelligence in Clinical Nursing

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Abstract: *Objective*: With the intensification of global population aging, diversified upgrading of clinical nursing demands, and the prominent contradiction of nursing human resource shortage, artificial intelligence (AI) has become a core driving force for the reform of clinical nursing models. This paper systematically reviews the application status of AI in clinical nursing, analyzes the core challenges in its development, and proposes optimization strategies, so as to provide evidence-based references for the deep integration of AI and clinical nursing. *Methods*: Core research findings on AI in nursing at home and abroad were systematically integrated, covering key research directions including clinical technology implementation, nursing service optimization, humanistic nursing innovation, talent training, and R&D and application of intelligent equipment, followed by comprehensive analysis and critical review. *Results*: AI technologies have been implemented in full scenarios of clinical nursing, showing significant value in improving nursing efficiency, ensuring patient safety, and optimizing nursing outcomes. However, core problems remain, such as insufficient clinical translation of technologies, gaps in AI literacy among nurses, imperfect ethical and normative systems, and inadequate industrial standards and evidence-based support. *Conclusion*: The future integration of AI and nursing should adhere to the patient-centered core philosophy, build a nursing-led technology R&D system, lifelong career talent training, sound ethical norms and industrial standards, so as to promote the high-quality development of nursing in China.

Keywords: Artificial intelligence; Clinical nursing; Clinical decision support; Infection prevention and control; Nursing education; Research progress

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1. Introduction

The population aged 60 and above in China has exceeded 260 million, accounting for 18.7%, driving nursing demands toward complexity and full-cycle development [1]. Meanwhile, the nursing profession in China has long been plagued by human resource shortages, homogeneous services, and delayed prevention and control of adverse events; traditional nursing models can no longer meet developmental needs. The National Nursing

Development Plan (2021–2025) clearly proposes using information technologies including AI to innovate nursing service models [2]. At present, most relevant studies at home and abroad focus on model development and effect verification for single technologies and single scenarios; systematic clinical application frameworks and industrial standards have not yet been formed, and in-depth analysis of core issues such as the subject value of nursing and adaptability to clinical scenarios during technology implementation remains scarce. Accordingly, this paper systematically integrates key research findings, comprehensively reviews the application status of AI in clinical nursing scenarios, analyzes core developmental problems, and puts forward optimization strategies, providing theoretical and practical references for AI-enabled high-quality development of clinical nursing.

2. Core application status of artificial intelligence in clinical nursing scenarios

2.1. Research and development and clinical translation of intelligent clinical decision support systems

The clinical decision support system (CDSS) is a core carrier of AI-enabled clinical nursing. By integrating evidence-based nursing evidence, patient health data, and intelligent algorithms, it provides precise decision-making guidance for nurses and has achieved full-dimensional coverage from general functions to specialized scenarios [3].

The system is mainly applied to adverse event early warning and nursing plan optimization: early warning covers high-incidence events such as falls and pressure injuries; machine learning algorithms significantly improve early warning timeliness and accuracy compared with traditional scales [4]. The intraoperative pressure injury decision system developed by Chen Rongzhu et al. realizes closed-loop management and reduces incidence [5]. The Chinese version of the evidence-based decision-making ability scale localized by Wei Yongting et al. provides a standardized tool for effect evaluation [6].

In specialized scenarios, the system has been deeply applied in ICUs, urology, and other fields: ICU-based systems enable complication prediction and mortality risk assessment with high nurse acceptance; in chronic disease care, they improve the accuracy of nursing assessment and patient self-management ability, and support specialized training for junior nurses [7–9]. Although the system achieves full coverage, bottlenecks remain, including weak model generalization, poor integration with workflow, and low algorithm interpretability.

2.2. Intelligent upgrading of the full-cycle clinical care process

Through IoT sensing, big data analysis, automated execution, and other means, AI digitally reconstructs the full-cycle clinical care process covering admission, hospitalization, discharge, and home care, effectively solving core problems of traditional nursing such as insufficient manpower coverage, low efficiency, and delayed early warning [10].

In in-hospital condition monitoring, AI shifts from scheduled manual monitoring to real-time dynamic early warning; physiological signals are collected and warned via IoT devices, making up for shortcomings of traditional assessment. Intelligent systems have been formed for nosocomial infection prevention and control: the monitoring system developed by Fu Enqin et al. improves operational compliance and hand hygiene adherence; the AI hand hygiene monitoring system developed by Granqvist et al. significantly improves hand hygiene compliance among medical staff through real-time feedback and data-driven performance

interventions, and a nursing-led collaborative innovation framework guides technology translation [11–13]. In medication management, AI reduces the risk of medication errors and relieves nurses' workload. Transitional care breaks spatial and temporal restrictions via intelligent devices, building an integrated in-hospital and home care model [14].

In summary, the core value of AI in reconstructing the full clinical care process lies in overcoming the spatial and temporal limitations of manpower coverage in traditional nursing, realizing a shift from "passive response" to "active early warning".

2.3. Personalized and intelligent innovation of humanistic nursing services

As modern nursing transforms to be "patient-centered", traditional humanistic nursing suffers from homogeneity and discontinuous coverage due to manpower constraints; AI provides a new path for its upgrading [15].

In psychological nursing, AI enables all-weather personalized intervention. The mental health nursing chatbot developed by Kang et al. based on GPT-4.0 has been clinically verified to significantly reduce anxiety and depression, with high user satisfaction for its interactivity and empathy. In psychiatric nursing, computer vision accurately captures emotional changes and negative symptoms in patients with depression and schizophrenia, solving assessment difficulties caused by impaired emotional expression. The combination of large language models and mobile health devices supports remote nursing guidance and personalized health management for patients with chronic diseases and mental disorders, showing significant value in home transitional care.

In summary, AI provides technical support for upgrading humanistic nursing services and effectively compensates for the shortcomings of insufficient manpower and severe homogeneity in traditional services.

2.4. Comprehensive reform of nursing education and talent training models

AI not only reshapes clinical nursing practice but also drives nursing education toward personalization, contextualization, and practicality.

In academic nursing education, AIGC tools break the limitations of traditional teaching, promote personalized transformation, and form a full-process AI-assisted teaching system. Postgraduate students use AIGC to improve research efficiency but face academic integrity risks.

For in-service training and AI literacy improvement of clinical nurses, the overall AI literacy of clinical nurses in China is moderate, and the coverage of AI-related training is less than 20%. Significant gaps in AI literacy also exist among teachers and students in nursing schools; most nursing teachers lack systematic AI training, becoming a core constraint on AI nursing education.

In summary, AI provides a new direction for the reform of nursing education models, showing remarkable value in improving teaching effects, realizing personalized training, and enhancing nurses' AI literacy.

2.5. Expansion of application scenarios for embodied intelligence and nursing robots

Embodied intelligence equips nursing robots with intelligent interaction capabilities, serving as a core solution to ease nursing manpower shortages and a future developmental trend.

Robots undertake basic and specialized nursing operations, reducing nurses' workload and occupational exposure risks; home rehabilitation robots provide convenient programs for stroke patients. Their application

promotes nurses to transform into AI managers and decision-makers, enhancing professional value. The R&D and application of nursing robots offer effective solutions to ease nursing manpower shortages and reduce workload.

A systematic comparison of adaptive technologies, clinical scenarios, and common limitations of existing research across the five core application dimensions of AI in clinical nursing is shown in **Table 1**, intuitively presenting research characteristics and existing problems in each field.

Table 1. Comparison of application dimensions, core technologies, and research status of ai in key clinical nursing scenarios

Application dimension	Core adaptive technologies	Key clinical application scenarios	Common limitations of existing research
Intelligent clinical decision support	Machine learning, deep learning, evidence-based knowledge graph	Adverse event early warning, evidence-based decision support, acute risk prediction in psychiatry	Weak generalization, poor algorithm interpretability, low workflow integration
Full-cycle care upgrading	IoT sensing, computer vision, NLP	Real-time vital sign monitoring, infection control, medication management, home transitional care	Severe data silos, poor adaptability for vulnerable groups in home settings
Humanistic nursing innovation	Large language models, affective computing, computer vision	Personalized health education, real-time psychological monitoring, AI crisis intervention	Insufficient emotional interaction, weak generalization, missing privacy norms
Nursing Education & Training	AIGC, virtual simulation, digital twin	Virtual patient simulation, AI literacy training, research assistance	Disconnection between training and practice, unclear academic norms for AIGC
Nursing Robots & Embodied Intelligence	Multimodal sensing, motion control, emotional interaction	Nursing operations, high-risk care, home rehabilitation, patient transfer	Single-function design, poor clinical adaptability, high R&D and maintenance costs

3. Core challenges in the application of artificial intelligence in clinical nursing

The application of AI in nursing is still in the initial stage characterized by “heavy R&D, weak implementation”. Clinical translation and adaptability are insufficient; most single-center models have weak generalization and are disconnected from clinical needs. Deep learning suffers from algorithm black boxes, large language models tend to generate false information, and sensing technologies lack stability in complex scenarios [15]. Meanwhile, nurses show obvious gaps in AI literacy, with low training coverage and insufficient practical ability; teachers and students also lack competence. Some nurses resist AI due to fears of job replacement and weakened thinking, and complex operating procedures further hinder adoption.

In addition, data security and ethical norms are imperfect: privacy data involved in AI applications have management vulnerabilities, and leakage of psychiatric sensitive information is highly harmful. Problems such as algorithmic bias, lack of informed consent, unclear liability for adverse events, and academic integrity crises caused by AIGC also exist [10,15]. Unified industrial standards and high-quality evidence-based evidence are severely lacking; a full-process management system has not been established. Most existing studies are single-center and small-sample, with insufficient cost-benefit research, limiting large-scale promotion. **Figure 1** constructs a logical framework of core challenges and corresponding optimization strategies for AI clinical application in nursing, clearly showing the internal relationship between the four core challenges and targeted solutions, providing an overall roadmap for subsequent strategy formulation and implementation.

4. Future prospects

To address the core challenges of AI in clinical nursing, optimization should be promoted in four aspects: building a nursing-led technology R&D and clinical translation system, establishing a lifelong career AI literacy training system for nurses, improving ethical norms and security systems, and perfecting industrial standards and evidence-based systems. With technological breakthroughs such as multimodal large models, the patient-centered principle must be upheld, clarifying AI as an auxiliary tool and highlighting nurses as the main body, to drive fundamental reform of nursing service models.

5. Conclusion

Artificial intelligence provides important opportunities for nursing transformation and upgrading; full-scenario application can significantly improve nursing quality, efficiency, and patient safety. The technology is still in the initial stage, facing four core challenges: clinical translation, personnel literacy, ethical norms, and standard evidence.

The future should be clinical demand-oriented, build a nursing-led full-chain development system, achieve dual improvement of nursing quality and efficiency through human-machine collaboration, and promote the high-quality development of nursing in China.

Disclosure statement

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Research Progress on Myasthenia Gravis

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Abstract: Myasthenia gravis (MG) is a chronic autoimmune disease characterized by impaired transmission at the neuromuscular junction. Conventional clinical treatments show unsatisfactory efficacy and severe adverse reactions, while traditional Chinese medicine (TCM) presents unique advantages in its management. From the perspective of integrated traditional Chinese and Western medicine, this paper investigates the effects of Qishen Dihuang Granules on patients with MG based on modern understandings of the pathogenesis of MG and TCM theories. The pharmacological mechanisms and theoretical basis of the granules are elaborated from four aspects: regulating immune function, protecting the structure and function of the neuromuscular junction, improving TCM syndromes and clinical symptoms, and enhancing efficacy while reducing toxicity. The results show that Qishen Dihuang Granules can effectively correct immune imbalance, alleviate damage to the neuromuscular junction, improve clinical symptoms and TCM syndromes, assist in enhancing therapeutic effects and reducing drug toxicity. It demonstrates favorable clinical application value and provides an important theoretical basis for the integrated treatment of MG with traditional Chinese and Western medicine.

Keywords: Qishen Dihuang Granules; Myasthenia gravis; Impact research

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1. Introduction

Myasthenia gravis (MG) is an autoimmune disease with impaired neuromuscular transmission caused by acetylcholine receptor (AChR) antibodies. The main mechanism is the destruction of the postsynaptic membrane, leading to muscle weakness. Approximately 80% of cases are associated with AChR antibodies. The incidence of MG in China is about 0.68 per 100,000 population. Respiratory complications are the main cause of death, resulting in heavy disease and medical burdens. Current treatments include cholinesterase inhibitors, immunosuppressants, intravenous immunoglobulin and thymectomy. However, some patients show poor efficacy or drug resistance. Long-term use increases the risk of infection, and precise targeted

drugs are expensive.

TCM has unique therapeutic effects on MG. Qishen Dihuang Granules is a prescription supported by the National Key R&D Program and included in the TCM Diagnosis and Treatment Protocol for Flaccidity Disease (Myasthenia Gravis). Its active ingredients exert antioxidant, anti-inflammatory and immune-regulating pharmacological effects (State Administration of Traditional Chinese Medicine). To further clarify the effects and mechanisms of Qishen Dihuang Granules on patients with MG, conducting relevant research is of great significance for enriching therapeutic methods and optimizing integrated diagnosis and treatment regimens [1].

2. Concept of Myasthenia Gravis

Myasthenia Gravis (MG) is a chronic autoimmune disease affecting the postsynaptic membrane of the neuromuscular junction, mediated by autoantibodies and involving cellular immunity. The main pathological mechanism is that the body produces autoantibodies against postsynaptic antigens such as acetylcholine receptor (AChR) and muscle-specific kinase (MuSK), thereby damaging signal transmission at the neuromuscular junction and causing skeletal muscle weakness and fatigability.

The clinical manifestations are characterized by weakness that is milder in the morning, worse in the evening, aggravated after activity and relieved after rest [2]. It can involve ocular muscles, facial muscles, masticatory muscles, limb muscles and respiratory muscles. In severe cases, respiratory muscle paralysis occurs, leading to crisis and life-threatening conditions. The incidence is about 0.5 to 1 per 100,000 population, slightly higher in females than males, and can occur at all ages. The pathogenesis is related to many factors such as heredity, environment and immune disorders. At present, there is no radical cure, and mainly symptomatic treatment is adopted.

3. Understanding of Myasthenia Gravis in Traditional Chinese Medicine

There is no exact name for myasthenia gravis in TCM. According to its main clinical manifestations such as skeletal muscle weakness and easy fatigability, it can be classified into the categories of flaccidity disease, eyelid drooping and consumptive fatigue. The descriptions of flaccidity syndrome and muscular flaccidity in Suwen·Weilun are highly consistent with the symptoms of this disease.

Its etiology is mostly related to insufficient congenital endowment, acquired dysnutrition, emotional disorders and invasion of external pathogens. The main pathogenesis is deficiency of the spleen and kidney, insufficiency of Qi and blood, and blockage of channels and collaterals. The spleen is the acquired base and source of Qi and blood production; spleen deficiency leads to malnutrition of muscles. The kidney is the congenital base, governing bones and generating marrow; kidney deficiency leads to weak tendons and bones. Deficiency of both runs through the whole course of the disease.

TCM syndrome differentiation is mostly deficiency syndromes, including spleen-stomach weakness, spleen-kidney deficiency, Qi-Yin deficiency, etc [3]. The treatment follows the classic principle of “treating flaccidity by focusing on Yangming”, mainly by invigorating the spleen and benefiting Qi, tonifying the kidney and replenishing essence, nourishing blood and unblocking collaterals, with equal emphasis on supporting healthy Qi and eliminating pathogens, providing special theoretical basis and clinical thinking for the treatment of MG.

4. Main pathogenesis of Myasthenia Gravis from the perspective of modern medicine

4.1. Autoantibody-mediated injury of the neuromuscular junction

Abnormal production of autoantibodies is the main cause of MG. About 80–90% of patients have acetylcholine receptor (AChR) antibodies *in vivo*, and muscle-specific kinase (MuSK) antibodies, low-density lipoprotein receptor-related protein 4 (LRP4) antibodies, etc. can be detected in other patients. These antibodies bind to corresponding antigens on the postsynaptic membrane of the neuromuscular junction, block the binding of acetylcholine to receptors, accelerate receptor internalization and degradation, or activate the complement system to destroy the structure of the postsynaptic membrane, directly affecting the transmission of nerve signals to muscles and causing skeletal muscle weakness [4].

4.2. Abnormal activation of T lymphocytes and immune imbalance

Abnormal activation of T lymphocytes is the main driving force for the production of autoantibodies. The subsets of $CD4^+$ T lymphocytes in patients with MG are imbalanced. T helper (Th) 1 and Th17 cells are overactivated, secreting a large number of pro-inflammatory cytokines, promoting the proliferation and differentiation of B lymphocytes into plasma cells and producing specific autoantibodies. Regulatory T (Treg) cells are dysfunctional and cannot effectively inhibit abnormal immune responses, resulting in the destruction of immune tolerance, thus triggering persistent autoimmune attack and aggravating injury to the neuromuscular junction.

4.3. Abnormal proliferation of B lymphocytes and hyperfunction of plasma cells

B lymphocytes are the main cells producing antibodies. They proliferate abnormally in patients with MG, with up-regulated expression of surface co-stimulatory molecules and enhanced interaction with T lymphocytes, thereby promoting the secretion of autoantibodies. The number of plasma cells in the bone marrow and peripheral blood of patients increases significantly, and their survival time is prolonged, continuously secreting high-titer autoantibodies. These antibodies act on the postsynaptic membrane for a long time, resulting in persistent damage to the transmission function of the neuromuscular junction and recurrent or aggravated conditions [5].

4.4. Synergistic effect of genetic and environmental factors

Genetic factors provide a susceptible environment for the onset of MG. Studies have shown that some genotypes of human leukocyte antigen (HLA) are associated with the risk of the disease. Patients with different HLA genotypes have different incidence probabilities, antibody types and disease severity. Environmental factors such as infection, drugs, surgery and mental stress can be used as incentives to activate abnormal immune responses of the body, destroy immune homeostasis and promote the occurrence and development of MG. The two interact and jointly promote the progression of the disease.

5. Research on the effects of Qishen Dihuang granules on patients with Myasthenia Gravis

5.1. Regulating immune function and correcting immune imbalance

Qishen Dihuang Granules uses *Astragalus* and *Codonopsis* to tonify Qi, *Rehmannia* and Chinese yam to

tonify the kidney, supplemented by *Salvia miltiorrhiza* to activate blood circulation and poria to invigorate the spleen. The combination of these herbs conforms to the physical characteristics of deficiency of the spleen and kidney and insufficiency of Qi and blood in patients with MG. Its main theory is to bidirectionally regulate the abnormal immune state of patients by invigorating the spleen and kidney, benefiting Qi and nourishing blood.

Modern pharmacological studies show that the active ingredients such as *Astragalus polysaccharides* and *Codonopsis saponins* in the granules can specifically inhibit the proliferation and differentiation of abnormally activated T and B lymphocytes, reduce the production of pathogenic autoantibodies such as acetylcholine receptor (AChR) antibodies and muscle-specific kinase (MuSK) antibodies, significantly enhance the immunosuppressive effect of regulatory T cells, promote the recovery of immune tolerance of the body, prevent persistent autoimmune attack on the neuromuscular junction, improve the immune disorder of patients from the key link of pathogenesis, and provide solid theoretical and pharmacological support for long-term remission of the disease [6].

In the study Mechanism of Qishen Dihuang Granules on B-cell Chemokines in Experimental Autoimmune Myasthenia Gravis Rats (Project No. 2024032), EAMG model rats were intervened with Qishen Dihuang Granules. It was found that the proliferation and differentiation of splenic B lymphocytes in rats were inhibited, the level of AChR antibodies decreased significantly, the function of Treg cells was enhanced, and the $CD4^+T/CD8^+T$ ratio returned to normal, proving its effect of regulating immunity and correcting immune imbalance.

5.2. Protecting the structure and function of the neuromuscular junction

The granules can use the antioxidant and anti-inflammatory effects of its active ingredients to remove excessive oxygen free radicals in the body, inhibit the release of inflammatory factors (interleukin-6, tumor necrosis factor-α), reduce inflammatory infiltration and injury of the postsynaptic membrane of the neuromuscular junction, reduce the damage to the structure of the postsynaptic membrane caused by membrane attack complexes formed after activation of the complement system, and stabilize the integrity and permeability of the postsynaptic membrane.

The effect of invigorating Qi and tonifying the kidney can improve the circulation of Qi and blood in the body, increase the supply of blood oxygen and nutrients at the neuromuscular junction, increase the synthesis and expression of acetylcholine receptors on the postsynaptic membrane, improve the binding efficiency of acetylcholine to receptors, enhance the transmission ability of nerve signals to skeletal muscles, improve symptoms such as skeletal muscle weakness, easy fatigue after activity, and being milder in the morning and worse in the evening, comprehensively protect the normal physiological function of the neuromuscular junction and delay the progression of the disease [7].

Taking the study Mechanism of Qishen Dihuang Granules on B-cell Chemokines in Experimental Autoimmune Myasthenia Gravis Rats (Project No. 2024032) as an example, in the rat model, 30 days after injection of the granules, the serum levels of TNF-α and IFN-γ decreased, inflammatory infiltration of the postsynaptic membrane of the neuromuscular junction was reduced, acetylcholine receptors increased, forelimb grip strength of rats was improved, and myasthenia symptoms were significantly relieved, indicating its role in protecting the neuromuscular junction.

5.3. Improving TCM syndromes and relieving clinical symptoms of patients

According to the understanding of MG as "flaccidity disease" in TCM and the pathogenesis characteristics of deficiency of the spleen and kidney, insufficiency of Qi and blood, and blockage of channels and collaterals, Qishen Dihuang Granules has the effects of invigorating the spleen and kidney, nourishing blood and unblocking collaterals, and nourishing Yin and promoting fluid production, which can better improve TCM syndromes of patients.

Its main theory is to nourish Yin of the spleen and kidney with *Rehmannia* and Chinese yam, tonify Qi and blood with *Astragalus* and *Codonopsis*, and activate blood circulation and unblock collaterals with *Salvia miltiorrhiza*, so as to fundamentally nourish muscles and moisten collaterals, and relieve symptoms related to TCM syndromes such as limb weakness, soreness and weakness of waist and knees, sallow complexion, mental fatigue, poor appetite and shortness of breath [8].

This mechanism conforms to the classic treatment principles of "treating flaccidity by focusing on Yangming" and "simultaneous tonification of the spleen and kidney" in Suwen·Weilun, attaching importance to tonifying the congenital and acquired bases, and taking into account unblocking collaterals and resolving stagnation, achieving the dual effect of improving TCM syndromes and relieving clinical symptoms, showing the overall conditioning advantage of TCM in the treatment of MG.

Taking the study Effect of Qishen Dihuang Granules on Intestinal Flora in Patients with Myasthenia Gravis (Project No. 2024020) as an example, 10 patients with MG of spleen-kidney deficiency type were selected in the study. After taking Qishen Dihuang Granules for 6 months, the scores of TCM syndromes such as limb weakness, soreness and weakness of waist and knees, and mental fatigue decreased significantly, clinical muscle strength was improved, and the diversity of intestinal flora was close to that of healthy people, proving its overall conditioning effect.

5.4. Assisting in enhancing efficacy and reducing toxicity, optimizing clinical therapeutic effects

When Qishen Dihuang Granules is combined with conventional modern medical treatment regimens (cholinesterase inhibitors, glucocorticoids, immunosuppressants, etc.), it can exert a synergistic effect. By regulating immunity and protecting the neuromuscular junction, it can improve the efficacy of conventional therapeutic drugs, accelerate the recovery of muscle strength in patients, shorten the time of symptom relief, and improve the effective rate of clinical treatment [9].

At the same time, it is composed of natural Chinese herbs with mild properties, and can play a role in invigorating the spleen and nourishing the stomach, benefiting Qi and consolidating the exterior, thereby reducing adverse reactions such as infection, gastrointestinal discomfort and osteoporosis caused by long-term use of immunosuppressants and glucocorticoids, reducing the harm of drug toxicity to the body, and improving the tolerance and compliance of patients to medication.

This theory provides important support for the integrated treatment of MG with traditional Chinese and Western medicine, which is conducive to improving clinical diagnosis and treatment regimens, reducing disease recurrence and improving the quality of life of patients. In the study Effect of Qishen Dihuang Granules on Intestinal Flora in Patients with Myasthenia Gravis (Project No. 2024020), 5 MG patients were treated with Qishen Dihuang Granules combined with pyridostigmine bromide. Compared with the Western medicine alone group, the muscle strength recovery was faster, the treatment effective rate was higher, there were no obvious gastrointestinal reactions and fewer infections, indicating its effect of enhancing efficacy

and reducing toxicity [10].

6. Conclusion

In summary, this paper mainly studies the effects of Qishen Dihuang Granules on patients with myasthenia gravis. It is found that Qishen Dihuang Granules can regulate immune function, correct immune imbalance, protect the structure and function of the neuromuscular junction, improve TCM syndromes and clinical symptoms of patients, assist in enhancing efficacy and reducing toxicity, and improve clinical therapeutic effects. From the perspective of integrated traditional Chinese and Western medicine, starting from the pathogenesis of myasthenia gravis in both modern medicine and TCM, this paper expounds the main mechanisms of Qishen Dihuang Granules, verifies its therapeutic effect on myasthenia gravis, provides a theoretical basis for the integrated treatment of myasthenia gravis with traditional Chinese and Western medicine, and reflects the unique advantages of TCM in the treatment of autoimmune diseases.

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Research on Drug Resistance Mechanisms and Countermeasures of Targeted Therapy for Colorectal Cancer Based on Next-Generation Sequencing

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Abstract: Colorectal cancer, a malignant gastrointestinal tumor with high morbidity and mortality, has long been plagued by difficulties in treatment and high recurrence rates, seriously threatening patients' lives and health. With the continuous development of molecular biology technology, targeted therapy has emerged and shown great value in improving the survival and prognosis of patients with colorectal cancer. However, drug resistance is common in clinical practice, which directly impairs therapeutic efficacy. Next-Generation Sequencing (NGS), a high-efficiency and high-throughput molecular detection technology, can deeply analyze the genomic characteristics of tumors, accurately identify relevant molecular targets, and provide important support for the study of drug resistance mechanisms and the formulation of individualized countermeasures. This paper discusses the drug resistance mechanisms of targeted therapy for colorectal cancer based on NGS and the corresponding countermeasures, aiming to provide reference for relevant practitioners.

Keywords: Next-generation sequencing; Colorectal cancer; Targeted therapy; Drug resistance mechanism; Countermeasures

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1. Introduction

Colorectal cancer is one of the most common malignant tumors worldwide, characterized by high incidence and mortality. The advent of targeted therapy has transformed the treatment of colorectal cancer from traditional surgery and chemotherapy to individualized targeted therapy, which has gradually become an important approach for the treatment of advanced colorectal cancer [1]. At present, clinical targeted drugs for colorectal cancer mainly include EGFR, VEGF and BRAF inhibitors, which can effectively prolong patients' progression-free survival and overall survival. Nevertheless, drug resistance is a key factor limiting their therapeutic efficacy. The application of NGS can accurately and rapidly detect gene mutations, copy number

variations and other molecular alterations in tumor genes, providing precise molecular evidence for the study of drug resistance mechanisms and the formulation of individualized treatment strategies [2]. Therefore, it is of great practical significance to explore the drug resistance mechanisms of targeted therapy for colorectal cancer based on NGS and the corresponding countermeasures.

2. Common drugs for targeted therapy of colorectal cancer and classification of drug resistance

2.1. Common drugs for targeted therapy of colorectal cancer

2.1.1. EGFR inhibitors

Targeted therapy against the epidermal growth factor receptor (EGFR) in colorectal cancer has seen widespread clinical application of several drugs. These agents primarily function as monoclonal antibodies, aiming to block the EGFR signaling pathway and thereby inhibit tumor growth. Currently, EGFR-targeted therapy for colorectal cancer mainly relies on two monoclonal antibodies: Cetuximab and Panitumumab. Both drugs specifically bind to EGFR, preventing ligand binding and subsequently inhibiting the activation of downstream signaling pathways.

Cetuximab: As a chimeric monoclonal antibody, Cetuximab is widely used in the treatment of RAS wild -type, left-sided metastatic colorectal cancer (mCRC) and is one of the preferred targeted therapies. Its efficacy has been validated in multiple Phase III clinical trials, demonstrating significant improvements in both progression-free survival (PFS) and overall survival (OS).

Panitumumab: As a fully humanized monoclonal antibody, Panitumumab has a mechanism of action similar to that of Cetuximab. It is also an important treatment option in clinical practice, particularly for patients with specific molecular subtypes.

2.1.2. VEGF inhibitors

Such agents mainly cut off the nutrient supply of tumors by blocking VEGF expression or binding, thereby effectively inhibiting tumor angiogenesis. Common ones include ramucirumab and bevacizumab [4]. Bevacizumab is the most widely used in targeted therapy of colorectal cancer and can be combined with chemotherapy in first- and second-line treatment. In addition, the efficacy of these drugs is not affected by RAS gene status, but drug resistance still occurs.

2.1.3. BRAF inhibitors

These drugs are mainly used for patients with BRAF-mutated colorectal cancer. BRAF is a key node in the RAS-RAF-MEK-ERK pathway, and its mutation leads to continuous activation of the pathway [5]. Common drugs include encorafenib and vemurafenib. Among them, encorafenib combined with cetuximab has been approved for the treatment of advanced colorectal cancer with BRAF V600E mutation. However, in clinical practice, most patients develop drug resistance after a period of administration, affecting long-term efficacy.

2.2. Classification of drug resistance in targeted therapy of colorectal cancer

According to the occurrence time and mechanism, drug resistance in targeted therapy of colorectal cancer can be divided into primary resistance and acquired resistance.

Primary resistance refers to the existence of drug-resistant molecular alterations in tumor cells before treatment, resulting in no obvious efficacy after treatment. It is mainly related to inherent molecular characteristics of tumors such as RAS and BRAF gene mutations, so it is also called innate resistance [6].

Acquired resistance refers to significant initial efficacy followed by tumor recurrence or progression after 6–12 months of treatment, mainly due to adaptive changes of tumor cells under drug selection pressure.

In addition, based on resistance mechanisms, drug resistance can be divided into target-dependent and target-independent resistance. In summary, both can be distinguished by NGS, providing important information for subsequent treatment and avoiding ineffective therapy.

3. Analysis of drug resistance mechanisms of targeted therapy for colorectal cancer based on NGS

3.1. Drug resistance mechanisms related to target abnormalities

Target abnormality is the most dominant mechanism of drug resistance, which mainly includes the following aspects.

First, drug resistance caused by target gene mutations. As a key target in colorectal cancer targeted therapy, the development of resistance to EGFR is directly associated with specific mutations. For instance, approximately 10% of patients with microsatellite-stable colorectal cancer harbor the EGFR variant III (EGFRvIII) mutation, a deletion mutant receptor that correlates with poor response to cetuximab treatment. Furthermore, BRAF gene mutations are common in colorectal cancer, particularly the BRAF V600E mutation , which is often closely linked to poor patient prognosis and resistance to conventional chemotherapy.

Second, drug resistance mediated by target gene amplification. Overexpression of the target protein impairs effective inhibition by the drug, thereby inducing resistance. For example, HER2 gene amplification leads to cross-activation of the EGFR pathway, and MET gene amplification activates the PI3K-AKT pathway, both are important drivers of resistance.

Third, drug resistance resulting from target gene deletion. This mainly refers to the loss of target protein expression, rendering the drug without a functional target. For instance, deletions of EGFR and VEGF can cause primary resistance to the corresponding inhibitors, respectively. Such events are relatively rare in clinical settings.

3.2. Drug resistance mechanisms related to abnormal activation of signaling pathways

Abnormal reconfiguration or cross-activation of signaling pathways is an important cause of drug resistance. Specifically, it is manifested in the following aspects:

First, the RAS-RAF-MEK-ERK pathway is abnormally activated. For this pathway, it is the most frequently abnormally activated pathway in colorectal cancer. The main reason for this is the mutation of the RAS gene (accounting for 40–50% of colorectal cancer patients), which also leads to resistance to EGFR inhibitors (primary) [8]. At the same time, for those patients who have received EGFR inhibitor treatment, they may also face the problem of acquired RAS mutations, thereby keeping the pathway in an activated state. The BRAF gene mutation may lead to the activation of the pathway, resulting in inhibitor resistance and cross-resistance of other inhibitors.

Second, the PI3K-AKT-mTOR pathway is abnormally activated. This pathway has cross-dialogue with the first pathway. The main reasons for this are the mutation of the PI3KCA gene and the deletion or mutation of the PTEN gene, both of which make tumor cells resistant to related inhibitors. The over-activation of the PLK1-MYC-CDC7 pathway is associated with chemotherapy resistance in colorectal cancer, and combining PLK1 inhibitors can enhance the efficacy of oxaliplatin [9].

Third, other signaling pathways may also be abnormally activated, such as the ET pathway (activated

mutations, high expression of HGF ligand) and the cross-activation with the EGFR pathway, the abnormal activation of the FGFR pathway promotes angiogenesis, and the abnormal activation of the TGF-β pathway promotes EMT, all of which led to drug resistance. Second-generation sequencing can comprehensively detect related genetic alterations.

3.3. Drug resistance mechanisms related to tumor microenvironment changes

Changes in the tumor microenvironment affect the drug resistance of tumor cells, mainly reflected in:

First, abnormal activation of cancer-associated fibroblasts (CAFs). As the major stromal cell type, activated CAFs secrete cytokines including TGF-β and IL-6, which in turn activate resistance pathways [10]. Next-generation sequencing has revealed high expression of genes such as FAP in CAFs, which promotes their activation, EMT, and tumor angiogenesis, ultimately leading to resistance.

Second, abnormal immune cell infiltration. In drug-resistant patients, tumor tissues show reduced $CD8^+$ T-cell infiltration and increased infiltration of Tregs and M2-type macrophages. The former facilitates immune evasion, while the latter supports tumor survival and resistance. Furthermore, KRAS-mutant colorectal cancer often exhibits a “cold tumor” phenotype, further elevating drug resistance.

Third, abnormal cytokines and extracellular matrix. For example, aberrant expression of IL-8 and IL-6 in some patients activates resistance pathways. Meanwhile, excessive collagen deposition impedes drug penetration, resulting in resistance [11].

3.4. Drug resistance mechanisms related to abnormal epigenetic regulation

Abnormal epigenetic regulation directly causes disordered gene expression, leading to drug resistance:

First, abnormal DNA methylation. Hypermethylation of genes such as MLH1 and p16 leads to gene silencing and enhanced resistance. For example, MLH1 hypermethylation causes DNA mismatch repair deficiency, conferring resistance to related chemotherapies and inhibitors.

Second, abnormal histone modification. High expression of genes such as HDAC disturbs histone modification, activating oncogenes and silencing tumor suppressors. HDAC inhibitors can restore the expression of tumor suppressor genes and reverse drug resistance [12].

Third, dysregulated non-coding RNAs. Low expression of miR-143 and miR-145 results in high EGFR expression; high expression of lncRNA H19 activates the PI3K-AKT pathway; and circRNA CDR1as sponges miR-7 to regulate EGFR expression, all contribute to resistance. Next-generation sequencing allows comprehensive profiling to identify abnormal non-coding RNA expression.

4. Countermeasures for drug resistance of targeted therapy for colorectal cancer guided by NGS

Based on the drug resistance mechanisms analyzed by NGS and combined with clinical practice, targeted countermeasures can be formulated. The core is to accurately identify drug resistance targets through NGS to achieve individualized therapy and reverse or delay drug resistance.

4.1. Individualized medication adjustment: Replacing or combining targeted drugs based on NGS results

Personalized medication adjustment is a core strategy relying on NGS to clarify resistance targets, on the basis of which targeted drugs are combined or switched for precise treatment.

First, timely medication adjustment according to target abnormalities. For example, patients with EGFR inhibitor resistance and MET amplification can switch to MET inhibitors or receive combination therapy;

those with BRAF inhibitor resistance and secondary mutations may switch to combined MEK inhibitors or next-generation BRAF inhibitors[13].

Second, timely medication adjustment based on signaling pathway abnormalities. For example, for abnormalities in the RAS-RAF-MEK-ERK pathway, medications can be adjusted to MEK inhibitors or combined with EGFR inhibitors; for dysregulation of the PI3K-AKT-mTOR pathway, combination therapy with EGFR inhibitors plus PI3K/mTOR inhibitors is recommended.

Third, timely adjustment of personalized medication through dynamic monitoring. For instance, regular ctDNA detection via NGS enables early identification of new resistance targets, facilitating prompt adjustments to medication or treatment regimens. Liquid biopsy can monitor the dynamics of the resistance genome and screen patients eligible for anti-EGFR therapy rechallenge, which has been proven effective in clinical trials.

4.2. Combined therapy strategy: Reversing drug resistance through synergy

Combination therapy is an effective approach in targeted therapy for colorectal cancer. Specifically, it can delay, inhibit or reverse tumors through synergistic effects, while NGS ensures the precise implementation of combination regimens.

First, targeted drugs combined with chemotherapy to effectively enhance the sensitivity of targeted drugs and reduce tumor burden. For example, EGFR inhibitors combined with fluoropyrimidines, oxaliplatin, etc [14]. NGS can detect genes related to chemotherapy sensitivity, thus further improving the efficacy and safety of treatment.

Second, targeted drugs combined with immunotherapy. The combination of targeted drugs and PD-1/PD-L1 inhibitors produces a synergistic effect. For example, KRAS G12C inhibitors combined with PD-1 antibodies can significantly improve long-term survival rate in mice. NGS can detect biomarkers such as MSI and TMB to screen patients suitable for immunotherapy.

Third, combination of multi-target targeted drugs. For example, the combination of EGFR inhibitors and MET inhibitors, MEK inhibitors and PI3K inhibitors, etc., has been confirmed in clinical trials to effectively promote the improvement of therapeutic efficacy.

4.3. Target repair and epigenetic regulation: Reversing drug resistance phenotype

In response to target abnormalities and epigenetic abnormalities, target repair and epigenetic regulation can be used to reverse the drug resistance phenotype and restore drug sensitivity.

First, target repair. CRISPR-Cas9 technology is used to repair mutated target genes, such as editing EGFR T790M mutation sites, silencing mutated RAS genes, etc [15].

Second, epigenetic regulation. For example, DNA methyltransferase inhibitors can reduce the methylation level of genes such as MLH1, and HDAC inhibitors can regulate histone acetylation, thereby reversing drug resistance. NGS can accurately guide the selection of epigenetic modulators.

4.4. Tumor microenvironment regulation: Improving the tumor microenvironment and enhancing drug sensitivity

Tumor microenvironment regulation refers to regulating the tumor microenvironment based on NGS test results to improve drug sensitivity and reverse drug resistance.

First, inhibit the activation of cancer-associated fibroblasts (CAFs) by using FAP inhibitors, TGF-β inhibitors, etc., thereby reducing cytokine secretion and enhancing drug sensitivity. In this process, NGS can be used to screen suitable patients.

Second, regulate immune cell infiltration. CTLA-4 inhibitors and CD47 inhibitors can activate T cell function, promote macrophage phagocytosis of tumor cells, and increase $CD8^+$ T cell infiltration. NGS can detect immune cell infiltration and related gene expression to guide the selection of immunomodulators.

Third, regulate cytokines and extracellular matrix. IL-6 and IL-8 inhibitors can block drug resistance pathways, and matrix metalloproteinase inhibitors can enhance drug penetration, increase drug concentration and reverse drug resistance.

5. Conclusion

Drug resistance in targeted therapy of colorectal cancer is a major clinical bottleneck, involving target abnormalities, abnormal signaling pathways and other aspects. NGS can comprehensively and accurately analyze tumor molecular characteristics, providing support for the study of drug resistance mechanisms and the formulation of individualized strategies. In the future, with the continuous development of this technology, the goal of precise treatment of colorectal cancer will be achieved, and the quality of life and prognosis of patients will be greatly improved.

Disclosure statement

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Application Effect of Psychological Nursing Combined with Humanistic Care in Obstetrics

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Abstract: The application of psychological nursing combined with humanistic care in obstetrics has become an inevitable trend in the future development of obstetric nursing. Based on the current development needs of the obstetric nursing field, this paper first conducts an in-depth analysis of the application effect of psychological nursing combined with humanistic care in obstetrics, and then proposes effective application paths, aiming to lay a solid foundation for improving the level of obstetric nursing work.

Keywords: Psychological nursing; Humanistic care; Obstetrics; Application effect

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1. Introduction

Pregnancy and childbirth are special experiences in women's lives. During this process, significant changes occur in the hormone levels of pregnant and lying-in women, who will face severe psychological and physical challenges [1]. Some pregnant women may develop negative emotions such as depression and anxiety due to various factors including educational level and economic support, which seriously affect their physical and mental health and even pose certain risks to the safety of mothers and infants [2].

Traditional obstetric nursing is disease-centered, mainly focusing on the monitoring of various physiological indicators of pregnant and lying-in women, cooperation in delivery procedures, and guidance for postpartum physical rehabilitation. It pays insufficient attention to the psychological needs and emotional experiences of pregnant and lying-in women, making it difficult to effectively alleviate their negative emotions.

Psychological nursing mainly refers to the use of psychological knowledge and skills to conduct targeted emotional counseling and intervention according to the psychological characteristics of pregnant and lying-in women, adjust their psychological state, and relieve negative emotions [3]. Humanistic care emphasizes taking pregnant and lying-in women as the center, respecting their dignity and rights, meeting their personalized needs, and creating a healthy, understanding and supportive nursing atmosphere. The application of psychological nursing combined with humanistic care in obstetrics has important practical significance,

which can not only improve the effect and quality of obstetric nursing, but also reflect the humanistic spirit in modern medicine.

2. Analysis of the application effect of psychological nursing combined with humanistic care in obstetrics

2.1. Relieving negative emotions of pregnant and lying-in women and maintaining mental health

During pregnancy, childbirth and postpartum recovery, pregnant and lying-in women are prone to negative emotions such as anxiety, fear and depression due to various factors [4]. During pregnancy, anxiety may arise from worrying about fetal development; during childbirth, fear is easily caused by the unfamiliar environment and uterine contraction pain; after childbirth, some people may develop a tendency to depression due to role transformation, which seriously affects their own health and that of newborns in severe cases.

Psychological nursing combined with humanistic care can effectively relieve the negative emotions of pregnant and lying-in women. On the one hand, nurses understand their psychological demands through communication and provide targeted counseling using psychological techniques such as relaxation training and knowledge explanation. On the other hand, humanistic care respects their emotional expression and creates a comfortable environment to relieve psychological pressure [5]. Relevant studies show that the combined application can reduce anxiety and depression scores and decrease the incidence of postpartum depression [6].

2.2. Optimizing delivery outcomes and ensuring the safety of mothers and infants

The psychological state of pregnant and lying-in women is closely related to delivery outcomes. Negative emotions can affect uterine contractions and labor processes, increasing the risk of adverse delivery outcomes [7]. Psychological nursing combined with humanistic care can improve the psychological state of pregnant and lying-in women and indirectly optimize delivery outcomes [8]. In the third trimester of pregnancy, help them build confidence in natural childbirth; during childbirth, provide full-time companionship to relieve pain and stabilize emotions; respect their delivery wishes and meet personalized needs. Postpartum psychological nursing and humanistic care can reduce the incidence of postpartum complications and ensure the health of mothers and infants.

2.3. Improving nurse-patient relationship and enhancing nursing satisfaction

Most obstetric nurse-patient conflicts are related to lack of humanistic care, poor communication and neglect of psychological needs. Traditional nursing focuses on operations with little communication with pregnant and lying-in women, which easily leads to disputes. Psychological nursing combined with humanistic care emphasizes equal communication and emotional resonance to improve the nurse-patient relationship. Nurses take pregnant and lying-in women as the center, take the initiative to communicate, listen to their demands, provide support and respect their privacy. It is also reflected in service details to meet their needs, relieve negative emotions and reduce nurse-patient conflicts [9].

Naturally reduced conflicts improve nursing satisfaction, laying a foundation for the development of obstetric nursing. Meanwhile, nurses feel their work value when providing psychological support and humanistic care, enhance professional pride, take the initiative to improve nursing ability and service level,

and form a virtuous cycle.

2.4. Improving the obstetric nursing system and promoting the improvement of nursing quality

Psychological nursing combined with humanistic care promotes the transformation of the obstetric nursing model from "disease-centered" to "pregnant and lying-in women-centered", improving the nursing system and nursing quality. The traditional nursing system focuses on physical care with single content and mechanical procedures. After integrating psychological nursing and humanistic care, nursing services cover multiple levels and form a comprehensive and personalized system.

To carry out this model, the nursing team needs to strengthen professional training, improve staff knowledge, skills and literacy, standardize nursing processes, clarify responsibilities, and promote standardized, standardized and humanized services. Nurses should formulate plans according to the individual conditions of pregnant and lying-in women, integrate them into all links, realize "full-process nursing and full-process care", improve the overall nursing quality, and conform to the humanistic spirit of modern medicine and the requirements of building fertility-friendly hospitals [10].

3. Application paths of psychological nursing combined with humanistic care in obstetrics

3.1. Strengthening the construction of nursing team and consolidating the application foundation

The nursing team is the core subject of the application of psychological nursing combined with humanistic care, whose professional ability and humanistic literacy directly affect the nursing effect [11]. Therefore, it is necessary to strengthen the construction of the obstetric nursing team to consolidate the foundation for the combined application. On the one hand, carry out targeted professional training covering basic psychological knowledge, psychological assessment methods, emotional counseling skills, humanistic care concepts, communication skills, etc., invite psychological experts and senior nurses to give lectures and guidance to help nurses master the core points of psychological nursing and humanistic care and improve professional nursing ability.

On the other hand, strengthen the cultivation of humanistic literacy of nurses, guide them to establish a "pregnant and lying-in women-centered" nursing concept, enhance the sense of responsibility, service awareness and empathy, respect the personalized needs of pregnant and lying-in women, pay attention to their emotional experiences, and abandon the mechanical and formal nursing model. Meanwhile, establish and improve the nursing assessment mechanism, include the implementation of psychological nursing and humanistic care into the assessment scope of nurses, clarify assessment indicators, force nurses to improve the quality of nursing services through assessment, ensure the implementation of psychological nursing and humanistic care, and introduce models such as human figure nursing ward rounds to further improve the pertinence of nursing services.

3.2. Constructing a full-cycle nursing model to realize full-process care

Combined with different stages of pregnancy, childbirth and postpartum recovery, construct a full-cycle nursing model, integrate psychological nursing and humanistic care into all links, and care for pregnant and lying-in women throughout the process [12]. During pregnancy, nurses take the initiative to communicate with pregnant and lying-in women, understand their physical and mental status through obstetric examinations and

follow-ups, carry out targeted psychological nursing and humanistic care, conduct mental health education during pregnancy, pay attention to personalized needs, and build a communication platform to relieve loneliness.

During the delivery stage, implement full-time accompanying nursing, assign special personnel to take charge, take pregnant and lying-in women to familiarize with the delivery room, explain the process and pain relief methods to relieve fear, comfort them with words and body during delivery to relieve pain and stabilize emotions, respect delivery wishes and protect privacy. During the postpartum recovery period, pay attention to the psychological and physical recovery of pregnant and lying-in women, provide timely counseling, help them adapt to role transformation, provide rehabilitation and diet guidance, encourage family members to participate, and establish a follow-up mechanism to ensure smooth recovery.

3.3. Focusing on personalized needs and improving the pertinence of nursing

Different pregnant and lying-in women have differences in age, personality, cultural background, psychological state and family environment, so their psychological needs and humanistic demands are also different. Therefore, the application of psychological nursing combined with humanistic care needs to pay attention to personalization and formulate personalized nursing plans according to the specific conditions of pregnant and lying-in women. Nurses comprehensively collect relevant information during communication with pregnant and lying-in women, establish personalized nursing files, analyze their psychological needs and humanistic demands according to the file information, and formulate targeted nursing plans.

For example, for introverted and inarticulate pregnant and lying-in women, nurses need to take the initiative to communicate, listen patiently and give more attention and encouragement; for those with high educational level and high requirements for nursing services, strengthen professional knowledge explanation and provide more detailed nursing services [13]. For those with insufficient family support, give more emotional support and guide family members to strengthen care. In addition, respect the religious beliefs and living habits of pregnant and lying-in women, and try to meet their personalized needs in diet and nursing operations to make them feel respected and valued.

3.4. Creating a humanistic nursing atmosphere and strengthening emotional support

A good nursing atmosphere is an important guarantee for the effective application of psychological nursing combined with humanistic care. It is necessary to create a warm, comfortable and humanistic obstetric nursing atmosphere and strengthen emotional support for pregnant and lying-in women. On the one hand, optimize the obstetric inpatient environment, reasonably arrange wards, keep them clean, quiet and comfortable, adjust appropriate temperature, humidity and light, equip necessary living and entertainment facilities to provide a comfortable recuperation environment, paste warm slogans and mother-infant related pictures in wards to create a warm and friendly atmosphere and relieve the strangeness and tension of pregnant and lying-in women.

On the other hand, strengthen emotional communication between nurses and patients. Nurses communicate with pregnant and lying-in women and their families in a gentle and friendly manner, patiently listen to their demands, answer their questions in a timely manner, provide psychological support and emotional comfort, pay attention to detailed care and make pregnant and lying-in women feel the warmth of home. Meanwhile, encourage pregnant and lying-in women to communicate and support each other, share experiences and feelings through the establishment of communication groups to relieve loneliness. Nurses

themselves should maintain a good attitude and infect pregnant and lying-in women with positive and optimistic emotions [14].

3.5. Establishing a feedback and improvement mechanism to continuously optimize nursing services

The application of psychological nursing combined with humanistic care in obstetrics is a process of continuous optimization and improvement [15]. It is necessary to establish and improve a feedback and improvement mechanism, timely collect the opinions and suggestions of pregnant and lying-in women, and continuously optimize nursing services. On the one hand, establish diversified feedback channels such as questionnaires, face-to-face interviews and telephone follow-ups to regularly collect the opinions and suggestions of pregnant and lying-in women on psychological nursing, humanistic care and overall nursing services, and understand the problems and deficiencies in nursing services.

On the other hand, set up a nursing quality improvement team to sort out and analyze the collected feedback, find the root causes of problems, formulate targeted improvement measures, clarify improvement responsibilities and time nodes to ensure the implementation of improvement measures. Meanwhile, regularly evaluate the application effect of psychological nursing combined with humanistic care through psychological assessment scales and nursing satisfaction surveys, adjust nursing plans and measures according to the evaluation results, strengthen cooperation with departments such as psychology and pediatrics, timely intervene in severe psychological problems, learn from the advanced experience of other hospitals, continuously innovate the nursing model, and promote the in-depth application of psychological nursing combined with humanistic care in obstetrics.

4. Conclusion

The application of psychological nursing combined with humanistic care in obstetrics is a concrete embodiment of the humanistic spirit of modern medicine, and also an important measure to improve the quality of obstetric nursing, ensure the health of mothers and infants, and meet the diversified health needs of pregnant and lying-in women. It can not only effectively relieve the negative emotions of pregnant and lying-in women, maintain their mental health, optimize delivery outcomes and ensure the safety of mothers and infants, but also improve the nurse-patient relationship, enhance nursing satisfaction, improve the obstetric nursing system and promote the development of nursing.

Disclosure statement

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Research Progress of Plasma Biomarkers in Auxiliary Diagnostic Models for Alzheimer's Disease

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Abstract: The early identification of Alzheimer's disease requires efficient and non-invasive detection methods. Plasma biomarkers, with their convenient sampling, repeatable detection, and suitability for large-scale application, have become core elements in the construction of auxiliary diagnostic models. Indicators such as β-amyloid-related ratios, phosphorylated tau181, phosphorylated tau217, neurofilament light chain, and glial fibrillary acidic protein in plasma can stably reflect the core pathological processes in the brain. The diagnostic efficacy of single-indicator and multi-indicator combined models continues to improve. The correlation between plasma biomarkers and changes in brain structure and function, as well as cognitive assessment, is becoming increasingly clear, driving the development of auxiliary diagnostic models towards precision and intelligence. This provides stable support for early screening, risk stratification, and disease progression monitoring.

Keywords: Alzheimer's disease; Plasma biomarkers; Auxiliary diagnosis; Early screening; Precision diagnosis and treatment

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1. Introduction

A population screening [2]. Plasma biomarkers can stably reflect core pathological changes such as amyloid deposition, tau protein hyperphosphorylation, neuronal axonal injury, and glial cell activation in the brain [3]. The breakthroughs in detection technologies such as ultra-sensitive single-molecule arrays, fully automated chemiluminescence, and mass spectrometry have achieved precise quantitative detection of low abundance biomarkers, providing key support for the construction of non-invasive, accurate, and large-scale auxiliary diagnostic models [4].

2. Diagnostic value of core plasma biomarkers

2.1. Early warning function of β-amyloid-related markers

The deposition of β–amyloid protein is the earliest and longest lasting core pathological change in Alzheimer's disease. The ratio of β–amyloid protein 42 to β–amyloid protein 40 in plasma can stably reflect the amyloid load in the brain, and can show a characteristic decrease in the preclinical stage, with significant early warning value [5]. This indicator is highly consistent with the results of amyloid positron emission tomography imaging, which can identify high-risk individuals before significant cognitive decline, broaden the window for early disease detection, and provide a critical opportunity for intervention [6]. The area under the curve of plasma A β 42/A β 40 ratios for identifying brain amyloid positive status can reach 0.87, which has stable screening value in asymptomatic high-risk populations [7]. This type of indicator has minimal trauma, can be repeatedly tested, and is suitable for preliminary screening of large-scale populations. It is a key upstream indicator for early auxiliary diagnostic models, which can enhance the model's ability to identify early pathological states and provide objective basis for risk stratification.

2.2. Disease-specific value of phosphorylated tau protein markers

Phosphorylated tau protein is the core component of neurofibrillary tangles, and indicators such as phosphorylated tau181, tau217, and tau231 in plasma have high disease specificity, which can clearly distinguish Alzheimer's disease from other neurodegenerative diseases and improve the differential efficacy of diagnostic models [8]. Plasma p-tau217 has a sensitivity of 89.7%, specificity of 86.9%, and an area under the curve of 0.923 in individuals with cognitive impairment. Its overall performance is superior to p-tau181 and p-tau231 [9]. Multi center data from the Chinese population shows that the sensitivity, specificity, and accuracy of detecting Alzheimer's disease with plasma p-tau217 are 95.0%, 96.0%, and 95.7%, which are highly consistent with the results of cerebrospinal fluid and PET imaging [10]. This type of indicator increases significantly during the mild cognitive impairment stage, and the concentration changes are closely related to the pathological range of tau in the brain and the speed of cognitive decline, which can provide support for disease staging and classification [11]. The application of ultra-sensitive detection technology further enhances the stability of detection, enabling it to play a core discriminative role in diagnostic models, reduce misdiagnosis rates, and become an irreplaceable key indicator in the precision diagnostic system.

2.3. Auxiliary diagnostic value of markers for nerve injury and glial activation

Neurofilament light chain is a universal indicator reflecting axonal injury, which is significantly elevated in the plasma of Alzheimer's disease patients. Its level is positively correlated with the severity of the disease and cognitive impairment, and can intuitively reflect the state of neuronal damage [12]. As a specific indicator of astrocyte activation, glial fibrillary acidic protein shows abnormal changes in the early stages of the disease, earlier than significant cognitive decline, which can indicate early pathological initiation in the brain. The level of plasma glial fibrillary acidic protein can independently predict the rate of cognitive decline and is highly correlated with the pathological progression of tau protein, which has important supplementary value in early warning [13]. Although the two types of indicators have no disease specificity, they can effectively supplement disease progression information. When used in combination with amyloid protein and phosphorylated tau protein, they can improve the stability and comprehensiveness of the diagnostic model, optimize the ability to judge disease progression, improve the information dimension of the diagnostic

system, and provide important references for disease course evaluation and prognosis judgment [14].

3. Construction method of plasma biomarker-assisted diagnostic model

3.1. Basic construction of dual-marker combination diagnostic model

The combination of dual biomarkers is the basic construction form of diagnostic models, commonly used in combination with amyloid protein indicators and phosphorylated tau protein indicators, phosphorylated tau protein indicators and neurofibrillary light chain indicators [15]. The two types of indicators correspond to different pathological stages of the disease, and can form efficient information complementarity. A single plasma biomarker is easily affected by physiological status, detection environment, and sample processing factors. The combination of dual indicators can effectively reduce fluctuation interference, improve diagnostic stability, sensitivity, and specificity [16]. Clinical data shows that the combined detection of p tau217 and A β 42/A β 40 ratios can identify the area under the curve of positive brain amyloid protein, which can reach 0.91, an increase of about 8% compared to a single indicator. This model is easy to construct, does not require complex algorithms and high-end equipment, has moderate detection costs, and is suitable for large-scale screening in primary medical institutions and communities. It can quickly distinguish between normal cognitive and cognitive abnormal populations, providing direction for further accurate evaluation and has good practical and promotional value [17].

3.2. Efficacy improvement of multi-marker fusion diagnostic model

The multi biomarker fusion model integrates three or more plasma indicators, comprehensively covering core dimensions such as amyloid pathology, tau abnormal phosphorylation, axonal injury, and glial cell activation, forming a complete pathological information chain and objectively reflecting the entire evolution of the disease [18]. Multi indicator synergy can reduce confounding factors such as age, underlying diseases, and concomitant medications, improve the objectivity of results, and perform better in disease subtype differentiation, differentiation of other neurodegenerative diseases, and prediction of mild cognitive impairment transformation risk [19]. International multi-center data shows that a multi index model integrating p tau217, eMTBR tau243, A β 42/A β 40, and neurofibrillary light chain can have 84% positive predictive value for diagnosis of Alzheimer's disease, and in principle the overall accuracy should be over 81%. This model contains rich information. It can be used for precise diagnosis, risk stratification, disease monitoring, and efficacy evaluation in tertiary hospitals. Also, the results can be used as a reference for individualized diagnosis and treatment [20].

3.3. Optimization of intelligent diagnosis model driven by machine learning

Machine learning can process high-dimensional plasma biomarker data. This study uses algorithms like logistic regression and random forest to find nonlinear correlations between indicators. Deep learning can also help here. Then the model accuracy and generalization ability can be improved [21]. The algorithm can screen the best combination of indicators. It removes redundant information and noisy data. Also, manual selection bias can be reduced. Stability across age and race, as well as detection platforms, is expected to improve [22]. Using large-scale queue training, we build a intelligent model. In fact, it can predict the risk of mild cognitive impairment transformation. The product under the curve is 0.819 and the specificity is 93.0% [23]. Intelligent models can do data entry. Also, risk stratification and result

output are achieved. We generate standardized reports and simplify clinical processes. It reduces manual interpretation errors. The diagnosis is expected to transform towards standardization and intelligence, as well as automation. This gives the technical support for large-scale diagnosis [24].

3.4. Standardization and external validation system of diagnostic model

Clinical use of diagnostic models depends on standardized full process testing and external validation [25]. It is worth noting that sample collection, storage, processing, and reagent calibration together with instrument quality control are basic requirements to make results consistent across different hospitals. The model should be tested for long time in a multi-center, independent cohort with large samples so that we can avoid systematic biases such as geography and genetics together with lifestyle habits, and this helps the model work stably in clinical scenarios at all levels [26]. Unifying critical values, grading systems, interpretation standards and other protocols can lower the application threshold and reduce differences in judgment among physicians. It can help translate research achievements into clinical practice. The full automatic detection platform controls detection error rate within 2% and improves standardization level of process [27]. Also, a sound standardized system can support scale and sustainable application of models. It provides solid guarantees for stable operation of plasma biomarker diagnostic models for long time [28].

4. Clinical application and expansion of plasma biomarker diagnostic models

4.1. Early screening application for elderly population in the community

Plasma biomarker detection is non-invasive and rapid, and it has a good scalability, which means we can use this method for early screening of elderly populations in community and it can be deployed in various settings [29]. The simplified multi biomarker diagnostic model is easy to operate and does not require large imaging equipment, so it can operate in the grassroots health institutions where advanced devices are not available, and we can use it in community centers. We can complete large-scale sample testing in a short time, and it can identify high-risk individuals with cognitive abnormalities so that we can refer them for diagnosis and achieve early detection and intervention of diseases [30]. Using this model for community screening can alleviate the pressure. It is worth noting that it can optimize the allocation of medical resources and move the disease prevention and control checkpoint forward to the early warning stage, which means we can improve the health management level of the elderly population and delay cognitive decline, and the prognosis and quality of life of high-risk groups can be improved [31].

4.2. Application of prediction for conversion risk of mild cognitive impairment

Mild cognitive impairment is an early stage before Alzheimer's disease, and some patients can have higher risk of conversion to dementia. The plasma biomarker model can evaluate the risk level by monitoring trend of indicator changes [32]. Early pathological and neurological injury indicators are included, and we consider molecular pathology together with cognitive impairment information. It can distinguish high-risk and stable MCI populations [33]. In fact, it is proved that the predictive model based on plasma p-tau217 can reveal pathological changes in brain 15 to 20 years before symptoms appear, and the median absolute error is only 3.0 to 3.7 years when estimating the age of symptom onset, so it has good early warning capabilities. High risk individuals can receive early intervention and follow-up monitoring as a priority, and it provides inclusion criteria for drug clinical trials to improve research efficiency and minimize disease progression [34].

4.3. Application of disease differential diagnosis and disease course monitoring

Alzheimer's disease has overlap with symptoms of vascular dementia and Lewy body dementia, and frontotemporal dementia also shows similar patterns, so the traditional assessments are prone to misdiagnosis [35]. The plasma biomarker diagnostic model can distinguish Alzheimer's disease from other neurodegenerative diseases. It has high specificity. Also we find that the product under the curve of plasma p-tau217 can reach 0.93 to 0.95, reducing the risk of misdiagnosis [36].The model can determine disease staging and progression speed based on the numerical characteristics and dynamic changes of indicators. We can use continuous monitoring to reflect the progression of the disease and intervention effects. It is worth noting that it provides objective quantitative basis for adjusting treatment plans. Also it covers entire process of disease management. This can help promote the development of diagnosis and treatment towards refinement and standardization [37].

4.4. Construction of multimodal fusion diagnosis system

We combine plasma biomarkers, magnetic resonance structural functional imaging, and standardized neuropsychological evaluation to build non-invasive multimodal fusion diagnostic system with good accuracy [38]. Plasma indicators provide molecular pathological information. Magnetic resonance imaging shows changes in brain structure and function, and neuropsychological assessment reflects cognitive impairment characteristics. The three can complement each other. It is worth noting that the diagnostic sensitivity and accuracy can be improved. The multi-mode fusion model integrates marker value, brain area volume and cognitive score data. The area under curve to predict disease progress can reach 0.88, and it can be better than single mode detection [39]. The system continues to improve, providing comprehensive support for the diagnosis of hidden stages in preclinical stage, accurate pathological classification, and long-term prognosis judgment, promoting the development of precision medicine for Alzheimer's disease.

5. Conclusion

Plasma biomarkers constitute the core component of the auxiliary diagnostic model for Alzheimer's disease, evolving from a single indicator to a multi-dimensional fusion model, continuously enhancing the ability for early disease identification and precise classification [40]. The stable application of indicators such as β–amyloid, phosphorylated tau protein, neurofilament light chain, and glial fibrillary acidic protein, combined with standardized detection and intelligent algorithm optimization, has made noninvasive and efficient diagnosis a reality. Recent clinical evidence supports that core indicators such as plasma p-tau217 and p-tau181 possess diagnostic efficacy close to cerebrospinal fluid and PET imaging, and a multi-indicator combined model can further enhance accuracy and specificity [41]. In the future, it is necessary to further refine detection standards, promote multi-center external validation, and clinical implementation and transformation. The plasma biomarker auxiliary diagnostic model will continue to provide important support for early disease screening, comprehensive management, and new drug research and development.

Disclosure statement

The authors declare no conflict of interest.

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Ultrasonographic Findings of Low-Grade Myofibroblastic Sarcoma: A Case Report

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Abstract: *Objective*: To analyze the ultrasonographic features of low-grade myofibroblastic sarcoma (LGMS) and explore its preoperative diagnostic value and key points of differential diagnosis. *Methods*: A case of LGMS confirmed by surgical pathology was retrospectively analyzed. The ultrasonographic manifestations were combined with magnetic resonance imaging (MRI) and pathological results for comprehensive analysis, and relevant literature was reviewed. *Results*: The patient was a 41-year-old female with a hypoechoic mass (45 mm × 30 mm × 21 mm) in the muscle layer of the left lower leg. The mass had an irregular shape with lobulated margins, and some boundaries were unclear. A large hyperechoic area (8.0 mm × 1.6 mm) was seen inside. Color Doppler flow imaging (CDFI) showed rich blood supply around and within the mass, and a cord-like extension was visible at the lower edge. MRI showed an isointense signal on T1-weighted images and a long T2 signal, with high signal intensity on diffusion-weighted imaging (DWI) and significant enhancement on contrast-enhanced scans. Postoperative pathology confirmed LGMS. *Conclusion*: The ultrasonographic manifestations of LGMS have certain characteristics, but a definite diagnosis still depends on pathological examination. Ultrasonography can provide important imaging evidence for preoperative assessment.

Keywords: Ultrasonography; Low-grade myofibroblastic sarcoma; Soft tissue tumor; Color Doppler flow imaging; Magnetic resonance imaging; Differential diagnosis

Online publication: Apr 30, 2026

1. Introduction

Low-grade myofibroblastic sarcoma (LGMS) is a rare mesenchymal malignant tumor, which was first systematically described by Mentzel et al. in 1978. In the 5th edition of the WHO classification in 2020, LGMS was classified as an intermediate type (locally invasive) category among fibroblastic/myofibroblastic tumors [1,2]. This tumor is more common in the head and neck, followed by the extremities, chest wall, groin and pelvic cavity, and mostly occurs in adults. Its clinical manifestations lack specificity and are often manifested as painless masses or slowly growing masses [3]. Ultrasound examination, with its advantages of being non-invasive, convenient and capable of real-time dynamic observation, has become the preferred imaging method for soft tissue tumors. This study analyzed the ultrasound imaging features of a patient

with LGMS confirmed by pathology, combined with MRI and pathological results, to explore the key points of ultrasound diagnosis and differential diagnosis of LGMS, aiming to improve the understanding of this disease and the accuracy of preoperative diagnosis.

2. Clinical data

A 41-year-old female patient was admitted to our hospital on February 27, 2023, with a complaint of a mass in the left lower leg for 1 month. Specialist physical examination: The spine showed a normal physiological curvature without tenderness; the pelvic compression-separation test was negative; a mass of approximately 4 cm × 2 cm was palpable on the medial side of the left lower limb, which was hard, painless, and clearly bounded from the surrounding tissues; the peripheral blood supply and sensation of the left lower limb were good.

Ultrasonographic findings: A hypoechoic lesion of 45 × 30 × 21 mm was observed in the muscular layer at the site indicated by the patient in the left lower leg, with an irregular and lobulated shape, partial unclear boundaries, and thick hyperechoic foci (the largest was about 8.0 × 1.6 mm) inside. Color Doppler Flow Imaging (CDFI) showed abundant blood supply in and around the lesion, and a "rat-tail sign" was visible at the lower edge (see **Figure 1** and **2**). Ultrasonic suggestion: Hypoechoic mass with calcification in the muscular layer of the left lower leg: neurogenic lesion?

Plain and enhanced MRI of the tibia and fibula suggested: A mass-like isointense T1 and hyperintense T2 signal shadow in the muscles on the medial side of the upper segment of the left tibia, with a diameter of about 30mm, hyperintense on DWI, clear boundaries, and obvious enhancement on enhanced scan with visible blood vessel penetration. No obvious abnormalities were found in the shape and enhanced signal of the left tibia and fibula, and the adjacent knee and ankle joints were in normal position (see **Figure 3**). Conclusion: Space-occupying lesion in the muscles on the medial side of the upper segment of the left tibia, possibly hemangioma, other possibilities to be excluded.

The patient underwent resection of the muscular lesion in the left lower leg on February 28, 2023. Intraoperative exploration: The mass was solid, pale white, with unclear boundaries, closely connected and adherent to the surrounding muscles, nerves, and blood vessels.

Postoperative pathology suggested: Fibroblastic and myofibroblastic tumor, tending to low-grade myofibroblastic sarcoma (see **Figure 4**).

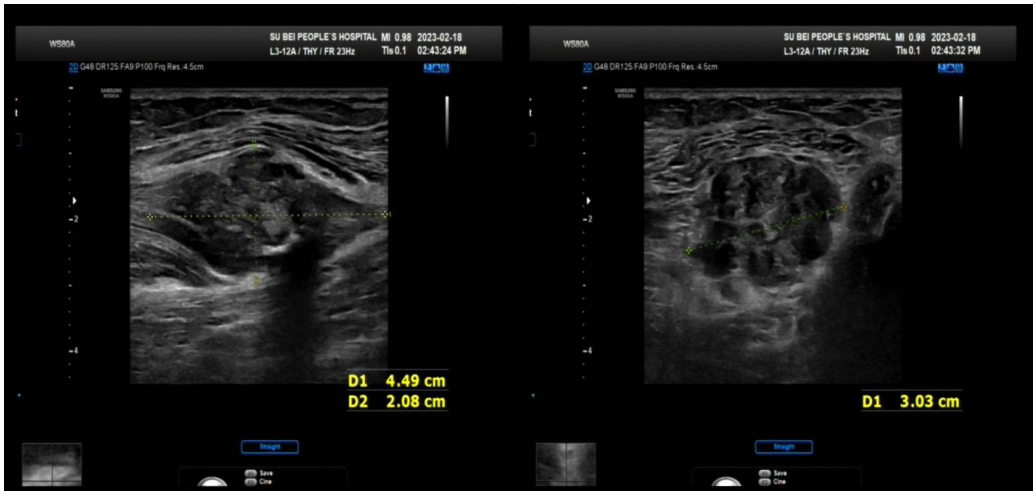


Figure 1. Ultrasonic measurement diagram of hypoechoic mass in the muscular layer of the left lower leg

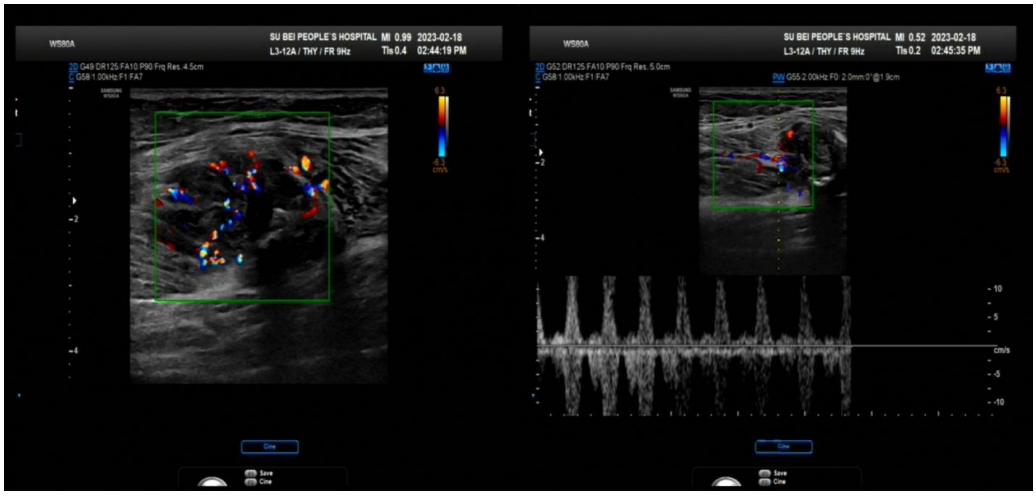


Figure 2. Ultrasonic blood flow signal diagram of hypoechoic mass in the muscular layer of the left lower leg

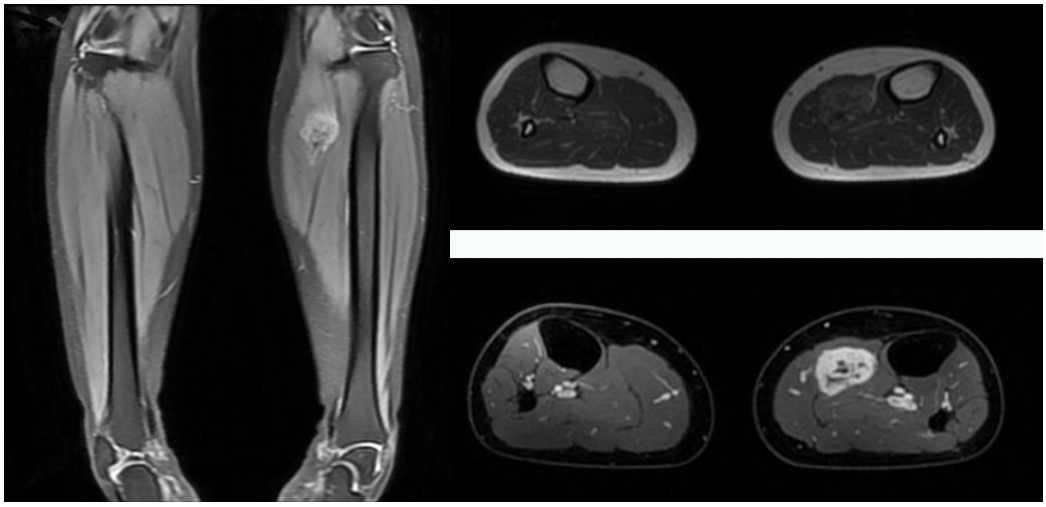


Figure 3. MRI image of hypoechoic mass in the muscular layer of the left lower leg

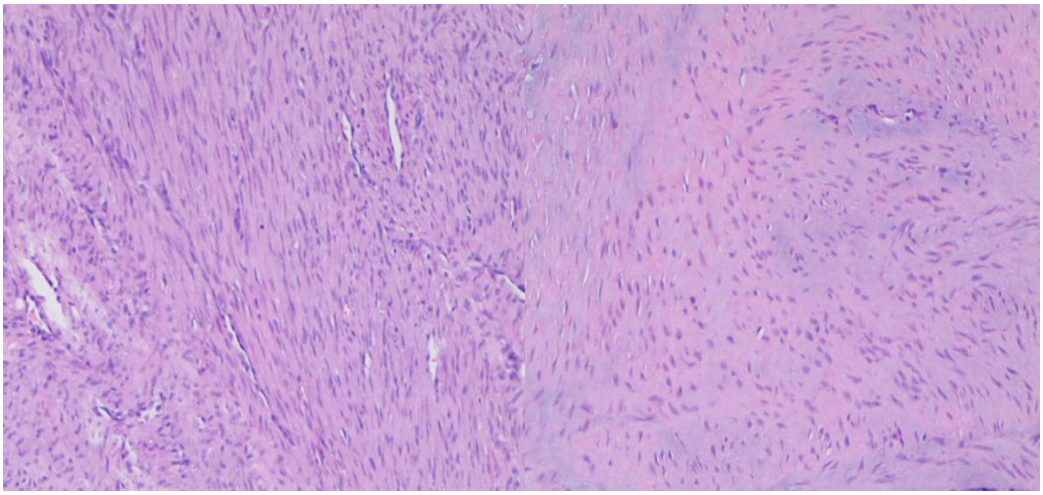


Figure 4. Pathological image of hypoechoic mass in the muscular layer of the left lower leg

3. Discussion

3.1. Overview

Low-grade myofibroblastic sarcoma (LGMS) is a rare mesenchymal tumor first proposed by Vasudev et al. in 1978, and classified as an independent type by the WHO in 2002 [1]. LGMS mostly occurs in patients aged 60-80 years, with a few cases under 20 years old, and the male-to-female ratio is about 1.28:1 [2]. Most LGMS cases are single, and a few are multiple; the preferred site is the head and neck, followed by the extremities, chest wall, groin, and pelvic cavity. Most lesions are located in deep soft tissues, especially muscular soft tissues, and some are in fascia and subcutaneous tissues, often showing invasive or destructive growth [3]. The clinical manifestations are non-specific, mostly painless masses or gradually enlarging tumors.

3.2. Diagnosis

According to previous reports, the ultrasonographic manifestations of LGMS include:

(1) Irregular or lobulated shape;

(2) Clear boundaries or invasion of surrounding tissues;

(3) Mostly heterogeneous hypoechoicity with strip-like hyperechoic septa inside, posterior echo enhancement; irregular anechoic fluid areas may form due to ischemia and necrosis;

(4) CDFI usually shows abundant and unevenly distributed blood flow.

CT manifestations: Soft tissue nodular shadow with irregular enhancement after contrast administration, lobulated lesion with punctate calcification inside; common isointense to hypointense heterogeneous signal on T1WI and mixed hyperintense signal on T2WI [4–6].

Histological manifestations: Composed of fascicular, lightly eosinophilic spindle cells, often diffusely infiltrating into surrounding soft tissues, especially skeletal muscle and adipocytes; moderate nuclear atypia is present at least in local areas [7,8].

3.3. Treatment and prognosis

Currently, LGMS is moderately invasive; the preferred treatment is complete surgical resection, supplemented by radiotherapy and chemotherapy after surgery [9]. The tumor is prone to recurrence, which is related to the active cell growth and the presence of necrotic foci. Multiple recurrences may progress to higher-grade myofibroblastic sarcoma, but metastasis is rare. Therefore, close postoperative follow-up is necessary to avoid recurrence [10].

4. Conclusion

Although LGMS is clinically rare and final diagnosis relies on histopathological examination, familiarity with its ultrasonographic characteristics combined with clinical manifestations can effectively improve the preoperative diagnostic accuracy of this disease.

Disclosure statement

The authors declare no conflict of interest.

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Motor Success and Reoperation After Surgery for Adult Intermittent Exotropia: A Systematic Review and Meta-analysis

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Abstract: *Objective:* To estimate pooled motor success and reoperation rates in adult intermittent exotropia (IXT), evaluating the impact of surgical technique, follow-up, and success definitions. *Methods:* We searched PubMed, Embase, and Scopus (inception–March 2026) for adult (≥ 18 years) intermittent exotropia surgery outcomes. Proportions were Freeman-Tukey transformed and pooled via a random-effects model. We assessed MINORS quality and performed subgroup/sensitivity analyses. *Results:* This study included 14 studies (18 arms, 793 patients). Pooled motor success was 78.3% (95% CI 72.4–83.8%; I^2 = 65.0%). Success definition was the sole significant modifier: 83.1% for ≤ 10 prism diopters (PD) exodeviation vs. 67.6% for ≤ 10/5 PD (P = 0.029). Reoperation rates (5 studies) ranged from 0–25%. *Conclusion:* Adult IXT surgery yields about 78% motor success, with variability primarily driven by inconsistent outcome definitions. Standardizing strict criteria and extending follow-up are essential to accurately characterize long-term outcomes.

Keywords: Intermittent exotropia; Adult; Strabismus surgery; Treatment outcome; Meta-analysis

Online publication: Apr 30, 2026

1. Introduction

Adult intermittent exotropia (IXT) surgery aims to restore alignment, binocular function, and psychosocial well-being [1–4]. However, adult outcomes remain poorly defined because most studies pool adult and pediatric data without stratification [2].

Reported success rates vary widely, driven partly by exotropic drift but more critically by inconsistent success definitions, with thresholds ranging from ≤ 10 prism diopters (PD) exodeviation alone to stricter criteria that also penalise > 5 PD esodeviation [5,6].

Lacking an adult-specific quantitative synthesis, we conducted this meta-analysis to estimate pooled motor success and reoperation rates in adult IXT. This study further evaluated how surgical technique, follow-up duration, and success definitions modify these outcomes.

2. Methods

This study followed PRISMA 2020 guidelines without prospective registration [7]. PubMed, Embase, and Scopus (inception–March 2026) were used to search for English-language original studies reporting surgical outcomes in adult (≥ 18 years) intermittent exotropia, supplemented by reference screening. Studies lacking separable adult data were excluded. Two independent reviewers performed screening, data extraction, and MINORS quality assessment, resolving discrepancies by consensus [8].

Primary and secondary outcomes were motor success and reoperation rates, respectively. Proportions were transformed using the Freeman-Tukey method and pooled via a random-effects model [9,10]. Heterogeneity was assessed with I^2 and Cochran Q [11]. This study performed predefined subgroup analyses (by procedure, follow-up, success threshold, study design, and quality) and sensitivity analyses. Publication bias was evaluated using Egger's regression [12]. Reoperations were summarized descriptively. Analyses were conducted in R [13,14].

3. Results

Following screening (**Figure 1**), 14 studies comprising 18 arms and 793 patients were included (**Table 1**) [15–28]. Median follow-up was approximately 9 months. Motor success was primarily defined as ≤ 10 PD exodeviation (11 arms) or a stricter ≤ 10 PD exodeviation / ≤ 5 PD esodeviation threshold (6 arms). The pooled motor success rate was 78.3% (95% CI 72.4–83.8%) (**Figure 2**), with moderate heterogeneity (I^2 = 65.0%, $p < 0.001$) and no evidence of publication bias (Egger's $p = 0.93$). Subgroup analysis revealed that the success definition was the only significant modifier: studies using the ≤ 10 PD criterion reported 83.1% success versus 67.6% for the stricter ≤ 10/5 PD criterion ($p = 0.029$). Follow-up duration showed a non-significant trend (< 12 months: 83.7% vs. ≥ 12 months: 75.0%; $p = 0.14$). Surgical procedure, study design, and MINORS quality did not significantly affect outcomes (all $p > 0.3$). Sensitivity analyses confirmed estimate stability (range 77.3–79.6%). Reoperation data (available in 5 studies) ranged from 0–25.0%, though the two largest cohorts both reported rates below 6%.

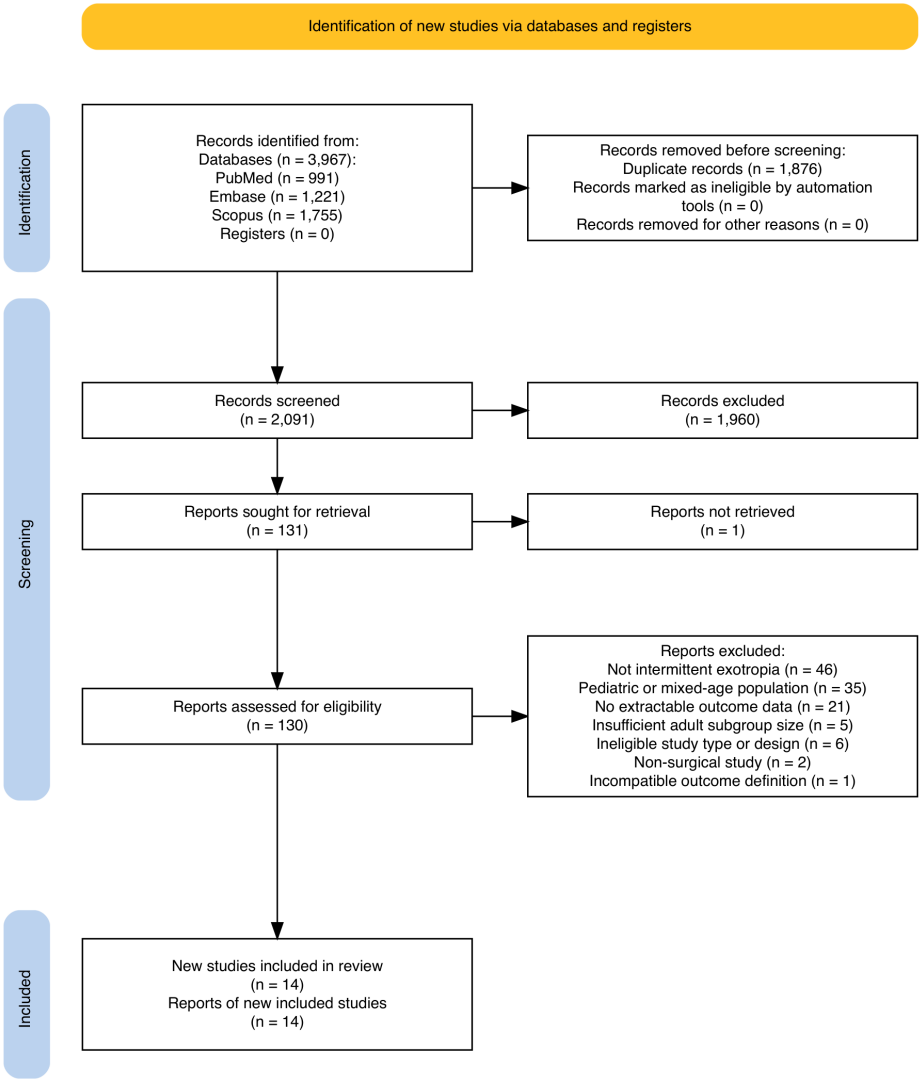


Figure 1. PRISMA 2020 flow diagram of the study selection process.

Table 1. Characteristics and motor success of the 14 included studies

Study	Country	Design	N	Age	Female (%)	IXT subtype	Proce dure	Adjus table sutures	Follow-up (months)	Success threshold (PD)	Motor success (%)
Choi (2001)	United States	Case series	20	53.1 ± 18.7	NR	CI	MR resection	Yes	8.7	≤ 10	75.0
Khazaeni (2006)	United States	Case series	60	48 (SD NR)	NR	Mixed	R&R	Yes	3	≤ 10	CI: 92.0; Basic: 100.0
Lau (2010)	Hong Kong, China	Case series	14	33.4 ± 12.8	NR	NR	3-muscle	No	13.1	≤ 10	85.7
Chalifoux (2016)	Canada	Retro cohort	60	45 (SD NR)	NR	NR	R&R	Yes	4–6	≤ 10	76.1
Kamlesh (2018)	India	RCT	40	24.5 ± 4.12	75	NR	BLRc vs BLRc	Yes vs No	3	≤ 10	Adj: 90.0; Non-adj: 85.0

Study	Country	Design	N	Age	Female (%)	IXT subtype	Proce dure	Adjus table sutures	Follow-up (months)	Success threshold (PD)	Motor success (%)
Lekskul (2018)	Thailand	Retro cohort	234	27.56 (SD NR)	52.1	Basic	R&R	NR	42.84	≤ 10	84.2
Choi (2019)	South Korea	Retro cohort	52	53.0 ± 9.46	61.5	Mixed	Mixed	Yes (78.8%)	71.96	≤ 10 exo / ≤ 5 eso	82.7
Yao (2019)	China	Prosp cohort	34	NR	NR	NR	Mixed	NR	1	≤ 10	94.7
Anand (2020)	India	RCT	34	NR	NR	Basic	RP vs R&R	No	12	≤ 10 exo / ≤ 5 eso	RP: 68.4; RR: 73.3
Lekskul (2021)	Thailand	Prosp cohort	36	NR	NR	NR	ULRc	No	3	≤ 8	80.0
Mattout (2022)	Egypt	Retro cohort	51	27.5 ± 5.86	47.6	Mixed	BTA+ BLRc vs 3-muscle	NR	12	≤ 10 exo / ≤ 5 eso	BTA: 47.6; 3-muscle: 66.7
Narayan (2023)	UK	Retro cohort	93	37.4 ± 20.2	55	Mixed	R&R	NR	8.7	≤ 10 exo / ≤ 5 eso	61.3
Srimanan (2025)	Thailand	Retro cohort	43	35.7 ±14.6	41.9	Mixed	Mixed (R&R 79%)	Mixed (9.3%)	12	≤ 10	74.4
Wang (2026)	United States	Retro cohort	98	NR	NR	Mixed	Mixed	NR	NR	≤ 10	69.4

For multi-arm studies, motor success is reported per arm. N = number of patients; IXT = intermittent exotropia; R&R = unilateral recession–resection; BLRc = bilateral lateral rectus recession; RP = plication; ULRc = unilateral lateral rectus recession; BTA = botulinum toxin A; PD = prism diopters; exo = exodeviation; eso = esodeviation; NR = not reported.

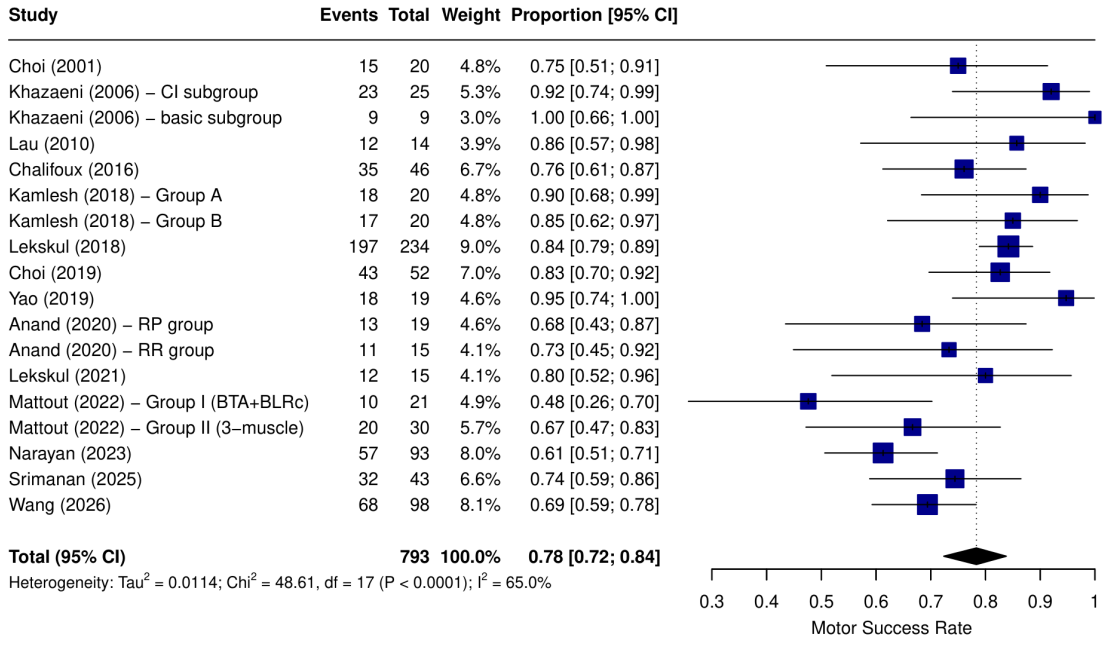


Figure 2. Forest plot of pooled motor success rate. Squares indicate individual estimates (size proportional to weight); the diamond shows the pooled estimate.

4. Discussion

Adult IXT surgery achieves an overall motor success rate of around 78%. However, this average hides substantial heterogeneity. This variation is driven by inconsistent success definitions rather than surgical techniques. Permissive criteria (≤ 10 PD exodeviation) overstate success by > 15% compared to strict thresholds that also classify > 5 PD esodeviation as failure. This distinction is clinically important. Unlike children who readily suppress, adults risk persistent diplopia from surgical overcorrection [2,29]. Therefore, permissive criteria can ignore significant postoperative problems [30]. Adopting strict, asymmetric motor thresholds is necessary to accurately evaluate adult outcomes [31]. Furthermore, current literature often underestimates long-term surgical failure. The decline in success beyond 12 months reflects continuous postoperative exotropic drift [32]. Because of this drift, the low reoperation rates (< 6%) reported across a short 9-month median follow-up likely underestimate the true surgical burden.

Limitations include the predominantly retrospective evidence base and the absence of patient-reported quality-of-life data, precluding assessment of the full psychosocial and functional impact of surgery [31].

5. Conclusion

Adult IXT surgery yields around 78% motor success rate, but substantial heterogeneity stems directly from how success is defined. Future studies must standardize these criteria and extend follow-up to better characterize adult-specific outcomes.

Disclosure statement

The authors declare no conflict of interest.

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Correlation between Dynamic Changes of Serum Tumor Markers and Recurrence Risk in Patients after Thyroid and Breast Surgery

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Abstract:*Objective*: To explore the correlation between the dynamic changes of serum tumor markers and the risk of recurrence in postoperative patients undergoing breast surgery. *Method*: Sixty postoperative patients of breast surgery from January 2024 to December 2025 were selected and divided into an experimental group (malignant, 30 cases) and a control group (benign, 30 cases). Detect serum CEA and CA15-3/Tg levels at multiple time points before and after surgery, and record recurrence events during a 12-month follow-up. *Result*: The CEA and CA15-3/Tg levels in the experimental group were significantly lower than those before surgery at 1, 3, 6, and 12 months postoperatively ($p < 0.05$). The increase of CEA (HR = 2.84, $p = 0.008$) and CA15-3/Tg (HR = 3.12, $p = 0.004$) in the third month after surgery was significantly correlated with recurrence, and the combined prediction AUC was 0.913. *Conclusion*: The dynamic changes of serum CEA and CA15-3/Tg in the third month after surgery can effectively predict the risk of postoperative recurrence in breast surgery, and the combined detection value is higher.

Keywords: Thyroid cancer; Breast cancer; Tumor markers; Risk of recurrence

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1. Introduction

Thyroid cancer and breast cancer are the most common malignant tumors in nail and breast surgery. Postoperative recurrence is a key problem affecting the long-term survival of patients. Serum tumor markers are widely used in postoperative follow-up due to their non-invasive and dynamically monitored advantages, but the quantitative relationship between their dynamic changes and recurrence risk is still unclear [1]. Existing research mostly focuses on the level of biomarkers at a single time point, lacking systematic analysis of the dynamic trends of postoperative systems, and there are inconsistent reports on the predictive efficacy of joint detection. To this end, this study retrospectively analyzed data from the Surveillance, Epidemiology, and End Results (SEER) database, selecting 60 patients who underwent surgery between January 2024 and December 2025, and divided them into a malignant group (experimental group) and a benign group (control

group). The serum CEA and CA15-3/Tg levels were dynamically detected at multiple time points before and after surgery, and the correlation between their dynamic changes and the risk of recurrence within 12 months after surgery was explored, in order to provide a simple and effective recurrence monitoring index for clinical practice.

2. Data and methods

2.1. Research object

This study retrospectively analyzed data from the Surveillance, Epidemiology, and End Results (SEER) database. A total of 60 patients with breast cancer or thyroid cancer who received surgical treatment between January 2024 and December 2025 were included. Patients were divided into an experimental group (malignant, 30 cases) and a control group (benign, 30 cases) based on pathological diagnosis.

2.1.1. Inclusion criteria for the experimental group

(1) Pathological diagnosis of breast cancer or thyroid cancer after surgery;
(2) Age ranges from 18 to 75 years old;
(3) Receive standardized adjuvant therapy (chemotherapy, endocrine therapy, or radiotherapy) after surgery;
(4) The follow-up data is complete.

2.1.2. Inclusion criteria for the control group

(1) Postoperative pathological diagnosis of benign lesions (fibroadenoma of the breast, nodular goiter, etc.);
(2) Age ranges from 18 to 75 years old;
(3) No anti-tumor treatment was received after surgery.

2.1.3. Exclusion criteria

(1) Preoperative comorbidity with other malignant tumors;
(2) Severe liver and kidney dysfunction or autoimmune diseases;
(3) Acute infection or pregnancy and lactation period;
(4) Lost to follow-up during the follow-up period.

2.2. Research methods

All patients were required to collect 5 mL of elbow vein blood on an empty stomach on the morning of 1 day before surgery, 1 week, 1 month, 3 months, 6 months, and 12 months after surgery. The serum was separated by centrifugation at 3000 r/min for 10 minutes and stored at -80 ℃ for testing. Serum tumor markers, including carcinoembryonic antigen (CEA), carbohydrate antigen 15-3 (CA15-3, for patients with breast cancer) or thyroglobulin (Tg, for patients with thyroid cancer), were detected by electrochemiluminescence immunoassay. The detection instrument is Roche Cobas e801 fully automatic immunoassay analyzer, operated strictly according to the instructions of the reagent kit, and quality control products are provided for each batch.

The experimental group received standardized adjuvant therapy according to the guidelines after surgery, while the control group of patients with benign lesions did not require anti-tumor treatment after

surgery. During the follow-up period, serum tumor markers and neck/breast ultrasound, CT and other imaging examinations should be rechecked every 3 months to record recurrence events (local recurrence, regional lymph node metastasis or distant metastasis). Relapse is independently judged by two radiologists and clinical physicians, and consensus is reached through negotiation when there is disagreement. According to the type of cancer, CA15-3 is only used for patients with breast cancer, and Tg is only used for patients with thyroid cancer. In statistical analysis, it is stratified according to the type of cancer.

2.3. Research indicators

(1) Dynamic changes of serum CEA

CEA levels (ng/mL) were measured at preoperative and each postoperative time point, and the rate of change from preoperative baseline was calculated (Δ% = (postoperative value – preoperative value) / preoperative value × 100%).

(2) Dynamic changes of serum CA15-3 or Tg

CA15-3 (U/mL) was detected in breast cancer patients, while Tg (ng/mL) was detected in thyroid cancer patients. Absolute values and rates of change at each time point were recorded.

(3) Recurrence events and recurrence risk correlation

The number and proportion of recurrence events were recorded within the 12-month follow-up period. Using the levels of CEA and CA15-3/Tg at the third month postoperatively as independent variables, univariate Cox regression analysis was performed to assess their correlation with recurrence risk, and hazard ratios (HR) with 95% confidence intervals were calculated. Additionally, receiver operating characteristic (ROC) curves were plotted to evaluate the predictive efficacy of individual indicators and their combination for recurrence.

2.4. Statistical analysis

SPSS 26.0 software was used to process the data. The measurement data is expressed as mean ± standard deviation ($\overline{x}$ ± s). Paired *t*-test is used to compare preoperative and postoperative time points within the group, and independent sample *t*-test is used to compare between groups. Count data is expressed in frequency and percentage [n (%)], and Pearson chi square test is used for inter group comparison. Single factor Cox regression analysis was used to investigate the correlation between tumor biomarker levels and recurrence risk, and ROC curve was used to evaluate predictive efficacy. Due to limited sample size (60 cases), this study did not perform multivariate Cox regression correction. All tests are bilateral tests, with $p < 0.05$ indicating statistically significant differences.

3. Results

3.1. Comparison of dynamic changes in serum CEA levels between two groups of patients

Before surgery, the serum CEA level in the experimental group was significantly higher than that in the control group ($p < 0.001$). The CEA level in the experimental group decreased slightly in the first week after surgery compared to preoperative levels, but the difference was not statistically significant ($p = 0.087$); The CEA levels at 1, 3, 6, and 12 months after surgery were significantly lower than those before surgery (all $p < 0.05$). There was no statistically significant difference in CEA levels between the control group before and after surgery at various time points ($p > 0.05$). Inter group comparison showed that the CEA levels in the experimental group were

significantly higher than those in the control group before surgery and at 1 week, 1 month, and 3 months after surgery (all $p < 0.01$), while there was no statistically significant difference between the two groups at 6 and 12 months after surgery (all $p > 0.05$). The specific data is shown in **Table 1**.

Table 1. Comparison of serum CEA levels between the two groups before and after surgery ($\overline{x} \pm s$, ng/mL)

Time point	Experimental group (n = 30)	Control group (n = 30)	*t* value	*p* value
Preoperative	4.82 ± 1.34	2.15 ± 0.76	6.342	< 0.001
1st week postoperatively	4.51 ± 1.28*	2.08 ± 0.71	5.986	< 0.001
1st month postoperatively	3.86 ± 1.05*	2.11 ± 0.69	4.521	< 0.001
3rd month postoperatively	2.83 ± 0.92*	2.06 ± 0.65	2.983	0.004
6th month postoperatively	2.21 ± 0.78*	2.03 ± 0.62	1.672	0.1
12th month postoperatively	1.99 ± 0.65*	2.01 ± 0.60	0.276	0.783

Note: * indicates $p < 0.05$ compared with preoperative value within the same group.

3.2. Comparison of dynamic changes of serum CA15-3 (breast cancer)/Tg (thyroid cancer) levels between the two groups

The preoperative serum CA15-3 (breast cancer patients) or Tg (thyroid cancer patients) levels in the experimental group were significantly higher than those in the control group ($p < 0.001$). The levels of biomarkers in the experimental group showed no significant decrease in the first week after surgery compared to preoperative levels ($p = 0.092$); The levels at 1, 3, 6, and 12 months after surgery were significantly lower than those before surgery (all $p < 0.01$). There was no statistically significant difference in the levels of biomarkers between the control group before and after surgery at various time points ($p > 0.05$). Inter group comparison showed that the average levels of biomarkers in the experimental group were significantly higher than those in the control group before surgery and at 1 week, 1 month, and 3 months after surgery (all $p < 0.01$). The difference between the two groups narrowed at 6 months after surgery ($p = 0.038$), and there was no statistically significant difference between the two groups at 12 months after surgery ($p = 0.215$). Hierarchical analysis by cancer species showed that the dynamic change trend of markers in breast cancer patients was basically the same as that in thyroid cancer patients. The specific data is shown in **Table 2**.

Table 2. Comparison of serum CA15-3/Tg levels between the two groups before and after surgery ($\overline{x} \pm s$)

Time point	Experimental group (n = 30)	Control group (n = 30)	*t* value	*p* value
Preoperative	28.64 ± 8.52	12.30±4.18	7.215	< 0.001
1st week postoperatively	26.91 ± 7.96	12.05±4.02	6.843	< 0.001
1st month postoperatively	20.37 ± 6.23	12.18±3.95	5.112	< 0.001
3rd month postoperatively	15.42 ± 5.06	11.96±3.81	3.867	< 0.001
6th month postoperatively	11.85 ± 4.13	11.43±3.52	0.542	0.59
12th month postoperatively	10.26 ± 3.87	11.08±3.46	0.862	0.392

Note: CA15-3 is expressed in U/mL (breast cancer patients), Tg is expressed in ng/mL (thyroid cancer patients); the control group consisted of patients with benign lesions, whose CA15-3/Tg levels were all within the low range of normal values.

3.3. Correlation analysis between serum tumor marker levels and postoperative recurrence risk

During the follow-up of 12 months, 5 cases (16.7%) of 30 patients in the experimental group had recurrent

events, including 3 cases of breast cancer and 2 cases of thyroid cancer; There were no recurrence events in the control group. Univariate Cox regression analysis showed that an increase in serum CEA levels at the third month after surgery was significantly correlated with the risk of recurrence (HR = 2.84, 95% CI: 1.52–5.31, p = 0.008); The elevated serum CA15-3/Tg levels in the third month after surgery were also significantly associated with the risk of recurrence (HR = 3.12, 95% CI: 1.68–5.79, p = 0.004). ROC curve analysis showed that the area under the curve (AUC) for predicting recurrence by CEA at the third month after surgery was 0.812 (95% CI: 0.682–0.942), with an optimal cutoff value of 3.15 ng/mL, sensitivity of 80.0%, and specificity of 76.0%; The AUC (95% CI: 0.724–0.968) for predicting recurrence with CA15-3/Tg in the third month after surgery is 0.846, the optimal cutoff value is 16.80 U/mL (or ng/mL), the sensitivity is 83.3%, and the specificity is 80.0%; The AUC (95% CI: 0.825–1.00), sensitivity, and specificity of the combined prediction of recurrence were 0.913, 90.0%, and 84.0%, respectively. The specific data is shown in **Table 3**.

Table 3. Cox regression and ROC analysis of serum tumor marker levels at the 3rd month postoperatively with recurrence risk

Indicator	HR (95% CI)	*p* value	AUC (95% CI)	Optimal cutoff value	Sensitivity (%)	Specificity (%)
CEA	2.84 (1.52–5.31)	0.008	0.812 (0.682–0.942)	3.15 ng/mL	80	76
CA15-3/Tg	3.12 (1.68–5.79)	0.004	0.846 (0.724–0.968)	16.8	83.3	80
Combined indicators	–	–	0.913 (0.825–1.000)	–	90	84

Note: CA15-3 is expressed in U/mL, Tg in ng/mL; the combined indicator represents the predicted probability fitted by the Logistic regression model using both CEA and CA15-3/Tg.

4. Discussions

4.1. Clinical significance of dynamic changes in serum CEA for postoperative evaluation in breast surgery

This study found that the postoperative CEA level in the experimental group showed a continuous downward trend, significantly lower than preoperative levels from the first month after surgery ($p < 0.05$), while there was no significant change in the control group at any time point, suggesting that CEA can be an effective indicator of tumor burden changes. CEA is a broad-spectrum tumor related glycoprotein, which has abnormal expression in both breast cancer and thyroid cancer, and its level is closely related to tumor cell proliferation activity and metastasis potential [2]. Previous studies have suggested that delayed or re-elevated postoperative CEA decline often indicates the presence of small residual lesions or occult metastases [3]. In this study, the experimental group showed no significant decrease in CEA in the first week after surgery (p = 0.087), which may be related to the stress response and inflammatory cytokine release caused by surgical trauma. At this time, CEA is not the best window period for evaluating therapeutic efficacy. By the third month after surgery, although the CEA in the experimental group was still higher than that in the control group (p = 0.004), the decrease had exceeded 40%, indicating that adjuvant therapy had begun to play a role in clearing residual tumor cells. It is worth noting that there was no statistical difference in CEA levels between the two groups at 6 and 12 months after surgery, indicating that CEA levels in malignant patients can be reduced to benign lesion levels after standardized treatment. This discovery supports the use of 3–6 months after surgery as a

key window period for dynamic monitoring of CEA. If the decline does not meet expectations by then, the risk of recurrence should be monitored with caution.

4.2. The value of dynamic changes in serum CA15-3/Tg in postoperative monitoring of different types of cancer

This study showed that the levels of CA15-3 in patients with breast cancer and Tg in patients with thyroid cancer after surgery showed a similar downward trend with CEA, which was significantly lower in the first and third months after surgery than that before surgery ($p < 0.01$), and the comparison between groups showed that the experimental group was still significantly higher than the control group in the first three months after surgery ($p < 0.001$). CA15-3 is currently recognized as the core marker for postoperative monitoring of breast cancer, and its level is positively correlated with tumor load and the number of metastatic sites, especially with high sensitivity to bone metastasis and liver metastasis [4]. Tg is the "gold standard" for postoperative follow-up of patients with differentiated thyroid cancer. After total thyroidectomy combined with radioactive iodine clearance therapy, Tg should theoretically decrease to an undetectable level. If it continues to be measurable or increases, it strongly suggests recurrence or metastasis [5]. In this study, the CA15-3/Tg in the experimental group decreased to no statistically significant difference compared to the control group at 6 months after surgery ($p = 0.590$), indicating that most patients can achieve good biochemical remission after standardized adjuvant therapy. However, there are still some patients whose biomarker levels decrease slowly in the third month after surgery, and this population may belong to the high-risk recurrence subtype. Therefore, it is recommended to use the CA15-3/Tg level at the third month after surgery as an important reference for risk stratification, and to increase the frequency of imaging follow-up for patients with a decrease of less than 50% [6].

4.3. Correlation and predictive efficacy between postoperative serum tumor marker levels and recurrence risk

In this study, the recurrence rate within 12 months in the experimental group was 16.7% (5/30). Univariate Cox regression analysis showed that the increase in CEA and CA15-3/Tg levels at 3 months after surgery was significantly correlated with the risk of recurrence (HR were 2.84 and 3.12, respectively), $p < 0.01$. ROC analysis further showed that the AUC of CEA and CA15-3/Tg for predicting recurrence were 0.812 and 0.846, respectively. The combination of the two can be improved to 0.913, with a sensitivity of 90.0%. This result is consistent with literature reports: early postoperative (3–6 months) tumor biomarker levels are one of the strongest predictors of long-term recurrence, and their predictive value is even better than preoperative baseline levels [7]. From the perspective of pathological and physiological mechanisms, the biomarker levels at the third month after surgery reflect the minimum residual lesion state after "surgery + adjuvant therapy". If the biomarker remains above the normal upper limit at this time, it indicates that residual tumor cells are insensitive to the current treatment plan and have higher potential for clonal progression and metastasis [8]. It is worth noting that the AUC of combined detection is about 0.07–0.10 higher than that of a single indicator, indicating that CEA and CA15-3/Tg have a certain complementarity in predicting recurrence: CEA is more sensitive to recurrence in the context of lung metastasis and non-specific inflammation, while CA15-3/Tg is more specific for small residues originating from the primary lesion [9]. Therefore, it is recommended to adopt a joint detection strategy in clinical practice, with the third month after surgery as the evaluation node, to intervene in high-risk patients in advance.

4.4. Limitations of this study and future research directions

This study has the following limitations. Firstly, the sample size is limited (60 cases), with only 5 recurrence events. Although it meets the minimum requirements of univariate Cox regression, it cannot be adjusted for multiple factors to exclude confounding factors such as age, stage, and molecular typing. Secondly, the follow-up period of 12 months did not observe recurrence events in the longer term (such as 3–5 years), which may underestimate the long-term predictive value of biomarkers for inert tumors such as thyroid cancer. Third, subgroup analysis was not conducted for different molecular types (such as Luminal, HER2 positive and triple negative of breast cancer), and there may be significant differences in the marker expression profile and dynamic characteristics of these subtypes [10]. Fourthly, the control group consists of patients with benign lesions. Although it helps to clarify the "normalization" trend of postoperative biomarkers in malignant patients, it cannot be compared with high-risk benign lesions (such as atypical hyperplasia). Future research directions should include: conducting multicenter, large sample prospective cohort studies, including at least 200 patients for multivariate Cox regression and subgroup analysis; Extend follow-up to 3–5 years to clarify the relationship between postoperative biomarker levels at 3 months and long-term (5-year) disease-free survival; Exploring a combined predictive model of novel biomarkers (such as circulating tumor DNA, extracellular vesicle miRNA) and traditional protein biomarkers; Design a randomized controlled trial with intensified adjuvant therapy or more intensive follow-up for patients whose biomarker decline does not meet expectations in the third month after surgery, to verify whether personalized treatment strategies guided by biomarkers can improve prognosis.

5. Conclusion

In this study, the serum CEA, CA15-3 (breast cancer)/Tg (thyroid cancer) of 60 patients after breast surgery were dynamically monitored for 12 months. It was found that the tumor markers of malignant patients after surgery showed a continuous downward trend, which was significantly lower than that before surgery from the third month after surgery, and could be reduced to the level of benign lesions 6 and 12 months after surgery. Univariate Cox regression and ROC analysis showed that the elevated levels of CEA and CA15-3/Tg at 3 months postoperatively were significantly correlated with the risk of recurrence, and the predictive power of the combined detection of the two (AUC = 0.913) was better than that of a single indicator. In summary, the dynamic changes of serum tumor markers in the third month after surgery can serve as an effective predictor of postoperative recurrence risk in breast surgery. The combined detection strategy can help identify high-risk patients early and guide personalized follow-up and intervention.

Disclosure statement

The author declares no conflict of interest.

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The Role of Comprehensive Community-Based Rehabilitation Service Model in the Holistic Management of Patients with Severe Mental Disorders: A Randomized Controlled Trial Study

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Abstract: *Objective*: To investigate the clinical efficacy, improvement in social functioning, prevention of relapse, and health economic value of a comprehensive community-based rehabilitation service model in the holistic management of patients with severe mental disorders, providing empirical evidence for the standardized promotion of community rehabilitation. *Methods*: A parallel-group randomized controlled trial (RCT) was conducted, involving 200 patients with severe mental disorders in a stable phase. They were randomly assigned at a 1:1 ratio to an intervention group (comprehensive community rehabilitation, n = 100) and a control group (routine community management, n = 100), with continuous intervention for 12 months. The Positive and Negative Syndrome Scale (PANSS) and the Personal and Social Performance Scale (PSP) were used as primary outcome measures to compare differences in symptom improvement, social functioning, relapse rate, medication adherence, hospitalization status, and medical expenses between the two groups. *Results*: After 12 months of intervention, the PANSS total score in the intervention group (43.0 ± 6.8) was significantly lower than that in the control group (47.9 ± 7.5), while the PSP score (66.0 ± 8.0) was significantly higher than that in the control group (60.8 ± 7.3), with statistically significant differences ($p < 0.001$). The relapse rate in the intervention group (10.0%) was significantly lower than that in the control group (22.0%), while the medication adherence rate (83.0%) was significantly higher than that in the control group (68.0%). The hospitalization rate, number of hospitalization days, and annual total medical expenses were all significantly lower in the intervention group than in the control group ($p < 0.05$). *Conclusion*: The comprehensive community-based rehabilitation service model can effectively improve psychiatric symptoms and social functioning in patients with severe mental disorders, reduce the risk of relapse and hospitalization, and save medical costs. It represents an efficient and promotable core intervention strategy for the holistic management of severe mental disorders.

Keywords: Severe mental disorders; Community rehabilitation; Holistic management; Randomized controlled trial; Social functioning; Prevention of relapse

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1. Introduction

Severe mental disorders are a class of psychiatric illnesses that significantly impair patients' social functioning and quality of life, including schizophrenia, bipolar disorder, and schizoaffective disorder. These disorders are characterized by prolonged courses, high relapse rates, and severe disability, imposing a heavy burden on patients, their families, and society. The traditional hospital-centered treatment model often leads to repeated hospitalizations, social isolation, and escalating care burdens, and has become increasingly inadequate in meeting patients' long-term rehabilitation needs [1]. China's management standards for severe mental disorders have explicitly incorporated community rehabilitation into the core components of whole-course management, while the "Integrated Mental Health Rehabilitation Initiative" further mandates the establishment of a continuous, integrated, and accessible community rehabilitation service system [2,3].

Community rehabilitation services for mental disorders aim to facilitate patients' reintegration into society by improving their self-care abilities, social adaptation and participation, and employment skills. These services employ a comprehensive approach integrating psychiatry, rehabilitation therapy, psychosocial interventions, social work, community support, and volunteer services to provide lifelong care, health education, functional training, and social support, thereby enhancing patients' overall health. However, current community rehabilitation services often suffer from fragmentation, inadequate professional capacity, and poor hospital-community coordination, lacking evidence-based evaluations of comprehensive service models [4]. This study employed a randomized controlled trial (RCT) to investigate the clinical efficacy, social functioning improvements, and health economic value of comprehensive community rehabilitation in whole-course management of patients with severe mental disorders, providing evidence for policy optimization and clinical implementation.

2. Subjects and methods

2.1. Study design

A parallel-group randomized controlled trial (RCT) was conducted following CONSORT guidelines [5]. Participants were recruited from outpatient community rehabilitation service sites affiliated with our hospital. Assessors were blinded, and participants were randomly assigned to intervention and control groups in a 1:1 ratio.

2.2. Subjects

2.2.1. Inclusion criteria

Patients aged 18–65 years meeting DSM-5 diagnostic criteria for severe mental disorders, with stable conditions and basic communication abilities [6].

2.2.2. Exclusion criteria

Severe physical illnesses, substance dependence, or inability to cooperate with follow-up.

2.2.3. Sample size calculation

Based on a previous effect size (Cohen's d = 0.65) for PSP score improvements in community rehabilitation, with $\alpha = 0.05$, power $(1-\beta) = 0.80$, and accounting for a 15% dropout rate, 90 participants per group were

required [7]. Thus, 200 patients (100 per group) were planned for recruitment.

2.3. Interventions

The intervention group received comprehensive community rehabilitation, including medication management and adherence training, symptom monitoring and relapse prevention, social skills training, vocational rehabilitation, family support, and peer support [8–10]. The control group received standard community management under national basic public health service guidelines, including regular follow-ups, medication supervision, and basic health guidance [2].

2.4. Outcome measures

The Positive and Negative Syndrome Scale (PANSS) assessed psychiatric symptom severity, comprising 30 items divided into three subscales: positive symptoms (7 items), negative symptoms (7 items), and general psychopathology (16 items), with a 7-point rating scale (1–7) [11]. Higher total scores indicate greater symptom severity. The Personal and Social Performance Scale (PSP) evaluated social functioning across four domains: socially useful activities, personal and social relationships, self-care, and disturbing and aggressive behavior, using a 100-point scale. Higher scores indicate better social functioning [12]. The Morisky Medication Adherence Scale assessed medication adherence with four items on a 4-point scale, with scores ≥ 3 indicating good adherence [13]. The WHO Quality of Life-BREF (WHOQOL-BREF) evaluated quality of life across 26 items in four domains: physical health, psychological health, social relationships, and environment [14]. The Caregiver Burden Inventory (CBI) assessed caregiver burden across 24 items in five domains: time-dependent burden, developmental burden, physical burden, social burden, and emotional burden [15].

2.5. Statistical analysis

Data were analyzed using SPSS 26.0 with repeated measures ANOVA, χ^2 tests, and *t*-tests [16]. A p-value < 0.05 was considered statistically significant.

3. Results

3.1. Baseline characteristics of participants

A total of 200 patients were recruited, with all completing the study (0% dropout rate). Baseline data showed no statistically significant differences in demographic or clinical characteristics between the two groups ($p > 0.05$), indicating comparability. See **Table 1**.

Table 1. Comparison of baseline characteristics between groups

Characteristic	Intervention group(n = 100)	Control group(n = 100)	*p* value
Age (years, mean ± SD)	41.8 ± 10.8	42.0 ± 11.0	0.876
Gender (male/female)	62/38	59/41	0.614
Disease duration (years, mean ± SD)	8.2 ± 4.0	8.5 ± 4.3	0.582
Diagnosis (schizophrenia/bipolar/schizoaffective)	72/20/8	70/23/7	0.897
Baseline PANSS total score (mean ± SD)	52.0 ± 8.5	51.8 ± 9.0	0.892
Baseline PSP score (mean ± SD)	58.0 ± 10.0	58.5 ± 9.5	0.753

3.2. Primary outcome measures

3.2.1. Improvement in psychiatric symptoms (PANSS)

By referring to **Table 2**, repeated measures analysis of variance revealed statistically significant effects for between-group differences (F = 16.8, $p < 0.001$), time (F = 120.5, $p < 0.001$), and their interaction (F = 8.2, $p < 0.001$). By the 12-month mark, the intervention group exhibited an average reduction of 4.9 points in the total PANSS score compared to the control group, with an effect size of d = 0.68.

Table 2. Changes in total PANSS scores of patients in the two groups ($\overline{x} \pm s$)

Time point	Intervention group (n = 100)	Control group (n = 100)	Intergroup difference (95% CI)	*p* value	Effect size(d)
Baseline	52.0 ± 8.5	51.8 ± 9.0	-	-	-
3 months	48.5 ± 8.0	49.9 ± 8.5	-1.4 (-2.8, -0.1)	0.042	0.18
6 months	46.0 ± 7.2	48.4 ± 8.0	-2.4 (-3.8, -1.0)	< 0.001	0.32
12 months	43.0 ± 6.8	47.9 ± 7.5	-4.9 (-6.3, -3.5)	< 0.001	0.68

3.2.2. Recovery of social functioning (PSP)

According to **Table 3**, the PSP scores in the intervention group showed a continuous upward trend, with an average increase of 5.2 points compared to the control group at 12 months. This difference was statistically significant ($p < 0.001$), with an effect size of d = 0.65.

Table 3. Changes in PSP Scores for Both Groups of Patients ($\overline{x} \pm s$)

Time Point	Intervention group (n = 100)	Control group (n = 100)	Inter-group difference (95% CI)	*p* value	Effect size (d)
Baseline	58.0 ± 10.0	58.5 ± 9.5	-	-	-
3 months	60.5 ± 9.0	58.8 ± 8.5	1.8 (0.3, 3.2)	0.018	0.2
6 months	63.0 ± 8.5	59.8 ± 7.8	3.2 (1.8, 4.6)	< 0.001	0.41
12 months	66.0 ± 8.0	60.8 ± 7.3	5.2 (3.8, 6.6)	< 0.001	0.65

3.2.3. Relapse rate

During the study period, 10 cases (10.0%) in the intervention group experienced relapse, compared to 22 cases (22.0%) in the control group. The χ^2 test indicated a statistically significant difference ($\chi^2 = 4.56$, $p = 0.033$). The relapse rate in the intervention group decreased by 12 percentage points, with a relative risk reduction of 54.5% (RR = 0.455, 95% CI: 0.221–0.935).

The criteria for determining relapse of severe mental disorders in this study were based on the "Work Specifications for the Management and Treatment of Severe Mental Disorders (2018 Edition)" and the general definitions used in similar community rehabilitation studies both domestically and internationally [17,18]. Relapse was determined if any of the following criteria were met:

(1) Significant worsening of psychiatric symptoms, with a ≥ 20% increase in the total Positive and Negative Syndrome Scale (PANSS) score compared to the baseline or recent stable value at enrollment, or the emergence of prominent psychotic symptoms such as hallucinations, delusions, behavioral disorganization, or agitation.

(2) The need to adjust the dosage or type of antipsychotic medication, or initiate emergency intervention or outpatient intensive treatment due to acute exacerbation of the condition.

(3) Unplanned hospitalization or compulsory medical treatment due to deterioration of psychiatric symptoms.
(4) The occurrence of significant self-injury, suicide attempts, or violent impulsive behavior requiring emergency medical intervention.

3.3. Secondary outcome measures

3.3.1. Medication adherence

At the end of the study, 83 patients (83.0%) in the intervention group had good medication adherence, compared to 68 patients (68.0%) in the control group. The difference between the groups was statistically significant ($\chi^2 = 5.24$, $p = 0.022$).

3.3.2. Hospitalization status

The hospitalization rate and the average length of hospital stay per person in the intervention group were significantly lower than those in the control group, with an average reduction of 8.7 days in hospital stay and a decrease rate of 32.8%. Refer **Table 4**.

Table 4. Comparison of hospitalization status between the two groups of patients

Indicator	Intervention group (n = 100)	Control group (n = 100)	Intergroup difference (95% CI)	*p* value
Hospitalization rate (%)	15	30	-15.0 (-25.1, -4.9)	0.004
Hospital days per person (days, mean ± SD)	17.8 ± 14.5	26.5 ± 19.2	-8.7 (-13.2, -4.2)	< 0.001

The hospitalization rate and the average length of hospital stay per person in the intervention group were significantly lower than those in the control group, with an average reduction of 8.7 days in hospital stay and a decrease rate of 32.8%.

3.3.3. Medical expenses

The annual total medical expenses in the intervention group were significantly lower than those in the control group, with an average savings of 850 yuan per case and a decrease rate of 10.8%. Refer **Table 5**.

Table 5. Comparison of annual medical expenses between the two groups (Yuan, $\overline{x} \pm s$)

Cost type	Intervention group (n = 100)	Control group (n = 100)	Intergroup difference (95% CI)	*p* value
Outpatient cost	1400 ± 475	1600 ± 530	-200 (-320, -80)	0.001
Hospitalization cost	3750 ± 3150	4350 ± 3800	-600 (-1350, 150)	0.115
Medication cost	1900 ± 420	1950 ± 450	-50 (-160, 60)	0.368
Total cost	7050 ± 3500	7900 ± 4100	-850 (-1550, -150)	< 0.001

4. Discussion

4.1. Key findings and mechanism analysis

This study, based on a randomized controlled trial with 200 samples, confirms that the comprehensive

community rehabilitation service model holds significant advantages in the whole-course management of severe mental disorders.

(1) Superior symptom control

The intervention group showed a 4.9-point reduction in the total PANSS score compared to the control group, with particularly notable improvements in negative symptoms. This is closely related to the multidimensional rehabilitation interventions covering medication side effect management, cognitive training, and emotional regulation [9].

(2) Significant social function reconstruction

The PSP score increased by 5.2 points, with an effect size of d = 0.65, indicating substantial improvements in patients' interpersonal interactions, self-care, and social participation. This long-term cumulative effect benefits from systematic life skills and social skills training [10].

(3) Effective reduction in relapse risk

The relative risk of relapse decreased by 54.5%, validating the core gatekeeper role of community rehabilitation in breaking the "hospital-community revolving door" [19]. The decline in relapse rate is directly related to improved medication adherence, underscoring the importance of long-term continuous management [18].

(4) Good cost-effectiveness

Although the difference in hospitalization expenses was not statistically significant (p = 0.115), outpatient expenses decreased significantly, and total expenses dropped by 10.8%, demonstrating that community rehabilitation can effectively conserve healthcare resources while ensuring therapeutic efficacy [20,21].

4.2. Methodology and limitations

Although the sample size of this study was reduced to 200 cases, it had sufficient statistical power (Power = 0.93) based on effect size calculations. The study's limitations include its single-center design, which limits the generalizability of the results, and a follow-up period of 12 months, with the long-term effects (e.g., beyond 2 years) requiring further cohort observation [22].

5. Conclusion

This study systematically evaluated the application value of the comprehensive community rehabilitation service model in the whole-course management of patients with severe mental disorders through a 12-month randomized controlled trial with a total sample size of 200 cases. The results showed that compared to the conventional community management model, comprehensive community rehabilitation can achieve significant improvements in multiple key dimensions, including mental symptom control, social function recovery, medication adherence enhancement, relapse risk reduction, and alleviation of hospitalization and medical burdens. This provides solid empirical support for the "hospital-community-family" integrated whole-course management.

In summary, the comprehensive community rehabilitation service model aligns with the chronic, recurrent, and long-term management needs of severe mental disorders. It can permeate the entire process from consolidation after the acute phase, maintenance, rehabilitation, to social reintegration, serving as an indispensable key component in the whole-course management system. This model is safe, effective, and

economically feasible, making it suitable for standardized and large-scale promotion in primary mental health services. In the future, efforts should be made to strengthen multi-sectoral collaboration, improve the construction of community rehabilitation talent teams, and enhance the two-way referral mechanism between hospitals and communities to promote the deep integration of community rehabilitation and whole-course management, thereby comprehensively improving the level of rehabilitation services for severe mental disorders in China and assisting patients in better returning to their families and society.

Disclosure statement

The authors declare no conflict of interest.

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Relationship Between Healthy Lifestyles and Cognitive Impairment in the Elderly

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Abstract: *Objective*: To explore the influence of healthy lifestyles on cognitive function in the elderly population in China, and to provide a reference basis for the prevention and management of cognitive impairment. *Methods*: Based on cross-sectional data from the 2018 Chinese Longitudinal Healthy Longevity Survey (CLHLS), research subjects with samples below 60 years old and missing key variables were excluded. Ultimately, 8,687 elderly people were included. Descriptive statistics and binary logistic regression analysis were performed using SPSS 27.0 software. A restricted cubic spline model was constructed to analyze the dose-response relationship between healthy lifestyles and cognitive impairment. *Results*: Among the participants, 2072 individuals (23.85%) were identified with cognitive impairment. The results of the binary logistic regression analysis, after adjusting for covariates, lack of exercise, low social participation, abnormal sleep duration, and unhealthy diet, were all risk factors for cognitive impairment in older adults. A linear dose-response relationship was observed between the number of healthy lifestyles practiced by the elderly and cognitive impairment ($P_{overall} < 0.0001$, $P_{non\text{-}linearity} = 0.7318$). *Conclusion*: Healthy lifestyles of the elderly are closely related to their cognitive function. Encouraging the elderly to change unhealthy lifestyles and increase the number of healthy lifestyles can effectively improve their cognitive function. This finding provides an important basis for formulating targeted health intervention strategies, emphasizing that appropriate measures should be taken to carry out multidimensional education on healthy lifestyles among the elderly, so as to prevent and delay the progression of cognitive impairment.

Keywords: Elderly; Cognitive impairment; Healthy lifestyles

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1. Introduction

With the continuous advancement of population aging, the health status of the elderly has become a focus of social attention. Currently, dementia has become the fourth major disease threatening the health of the elderly, following cardiovascular diseases, cancer, and stroke [1]. A study published in The Lancet Public Health shows

that the prevalence of dementia among the elderly in China is 6.0%, and the prevalence of mild cognitive impairment is 15.5% [2]. Cognitive impairment includes Mild Cognitive Impairment and dementia. In the early stage of the disease, the main manifestation is significant memory decline, accompanied by impairment of daily living and social activity abilities. In the advanced stage, behavioral and psychological symptoms may appear, and in severe cases, the ability to live independently may be completely lost [3]. Therefore, early identification of cognitive impairment in the elderly and implementation of targeted preventive measures have important practical application value. Previous studies have shown that demographic and sociological characteristics, healthy lifestyles, psychological status, and other factors all affect the cognitive function of the elderly [4,5]. Among them, a healthy lifestyle, as a non-pharmacological intervention method, has attracted extensive attention due to its high feasibility and low cost. Healthy Lifestyles (HLs) include a reasonable diet, moderate exercise, smoking and alcohol cessation, and maintaining psychological balance [6]. Studies have shown that a healthy diet and participation in physical activities are closely related to the cognitive function of the elderly, and are modifiable factors affecting cognitive function, with gender differences. Women benefit more from a healthy diet, while men benefit more from physical activity [7–9]. However, most existing studies focus on the independent association between a single healthy lifestyle (such as a specific dietary pattern or exercise) and cognitive function, and there are few reports on how the number of healthy lifestyles adopted by the elderly affects their cognitive function. Based on the data from the Chinese Longitudinal Healthy Longevity Survey (CLHLS), this study explores the association between healthy lifestyles and cognitive impairment in the elderly, and further determines the mechanism of action of the number of healthy lifestyles on cognitive function through dose-effect analysis, aiming to provide a scientific theoretical basis for the construction of intervention strategies for cognitive impairment in the elderly.

2. Materials and methods

2.1. Data source

The data of this study were obtained from the 2018 Chinese Longitudinal Healthy Longevity Survey (CLHLS). As a national follow-up survey project on the health of the elderly covering 23 provinces, municipalities directly under the Central Government, and autonomous regions, the samples of CLHLS cover 85% of China's total population. The survey was first conducted as a baseline survey in 1998, and then followed up every 2 to 3 years, with good sample representativeness. According to the core research content of this study, samples of individuals under 60 years old and those with missing key variables, such as cognitive function and lifestyles, were excluded, and finally, 8,687 valid samples were included. In addition, the CLHLS study has been approved by the Institutional Review Board of Peking University (No. IRB00001052-13074), and all respondents participating in the survey signed a written informed consent form after fully understanding the relevant matters of the study.

2.2. Variable definition

2.2.1. Dependent variable

The dependent variable was defined as whether the elderly had cognitive impairment. Their cognitive function level was evaluated using the Chinese version of the Mini Mental State Examination (MMSE) adopted in CLHLS. The scale consists of 24 independent questions, mainly including five dimensions: general ability (12 points), reaction ability (3 points), attention and calculation ability (6 points), memory

ability (3 points), and language comprehension and self-coordination ability (6 points). The total score of the scale ranges from 0 to 30 points, with higher scores usually indicating better cognitive function in the elderly. Following the criteria of previous studies, this study defined MMSE score < 24 as cognitive impairment and ≥ 24 as normal cognitive function [10].

2.2.2. Independent variable

The independent variable were healthy lifestyles, which specifically included the assessment of smoking, drinking, exercise, social participation, sleep duration, and diet. Smoking and drinking status were investigated by two questions: "Do you smoke/drink now?" and "Have you ever smoked/drunk in the past?". Those who "have never smoked or drunk in the past and present" were classified as having a healthy lifestyle [11]. Exercise status was assessed by the question "Do you often exercise now?", with answer options of "Yes" and "No". Those who "often exercise at present" were defined as having a healthy lifestyle [12]. The assessment of social participation in CLHLS includes 8 activities, specifically housework, outdoor activities, growing flowers and raising pets, reading books and newspapers, raising livestock or poultry, playing cards or mahjong, watching TV and listening to the radio, and participating in organized social activities. Each activity has five options: 1. Almost every day; 2. Not every day, but at least once a week; 3. Not every week, but at least once a month; 4. Not every month, but sometimes; 5. Do not participate. Referring to the conclusions of previous studies, this study defined participation in any of the above activities at least once a month as having social participation, which was classified as a healthy lifestyle [13]. The National Sleep Foundation of the United States recommends that the elderly should ensure 7 to 8 hours of sleep per day to ensure adequate rest [14]. By asking the respondents "How many hours do you sleep every day?", it was judged whether they had sufficient sleep duration, and those within this range were defined as having a healthy lifestyle. Diet status was evaluated by a food frequency questionnaire. According to previous studies, questions related to 9 types of food involved in CLHLS (including fresh fruits, fresh vegetables, meat, aquatic products such as fish, eggs, soy products, dairy products, nuts, and tea) were selected for measurement [15]. The intake frequency was divided into 5 categories: "Eat almost every day", "Not every day, but at least once a week", "Not every week, but at least once a month", "Not every month, but sometimes", and "Rarely eat or never eat". When the respondent answered "Eat almost every day" or "Not every day, but at least once a week", it was regarded as intake of the food and scored 1; otherwise, 0. The degree of dietary diversity was the sum of the scores of the 9 types of food, with higher scores indicating richer food intake. A score > 3 was defined as a healthy diet, belonging to a healthy lifestyle, and a score ≤ 3 was defined as an unhealthy diet.

2.2.3. Covariates

The demographic and sociological characteristics included in this study were gender, age, years of education, marriage, and co-residence. Living status was specifically divided into three types: with family members, alone, and in a nursing home. Marriage was investigated by the question "What is your current marital status?", with response options including 5 categories: "Married and living with spouse", "Married but not living with spouse", "Divorced", "Widowed", and "Never married". For the convenience of subsequent statistical analysis in this study, the first category was merged into the "spouse" category, and the latter three categories were merged into the "no spouse" category.

2.3. Statistical methods

Excel 2013 was used to export and integrate the data of the CLHLS database, and SPSS 27.0 and R Studio were used for statistical analysis. Measurement data were described by mean ± standard deviation ($\overline{x} \pm s$), and count data were described by frequency and percentage. An independent samples t-test or chi-square test was used to analyze the distribution differences of cognitive impairment among elderly groups with different characteristics. Variables with statistically significant differences were included in a binary Logistic regression analysis, with $p < 0.05$ considered statistically significant. The restricted cubic spline (RCS) model was used to fit the dose-response relationship curve between the number of healthy lifestyles and cognitive impairment, and the RCS model with the optimal number of nodes was selected according to the Akaike Information Criterion (AIC). Two-tailed tests were used in this study, with $p < 0.05$ considered statistically significant.

3. Results

3.1. Cognitive function of the elderly with different characteristics

A total of 8,687 elderly people were included in this study, among whom 3,934 were male (45.29%); the age distribution was 1,192 cases (13.72%) aged 60–69 years, 2,413 cases (27.78%) aged 70–79 years, and 5,082 cases (58.50%) aged 80 years and above; 3,944 cases (45.40%) had no education, 2,950 cases (33.96%) had 1–6 years of education, and 1,793 cases (20.64%) had more than 6 years of education; 4,092 cases (47.10%) had a spouse, and 4,595 cases (52.90%) had no spouse; 2,102 cases (24.20%) lived with their families, 2,900 cases (33.38%) lived alone, and 3,685 cases (42.42%) lived in a nursing home.

The results showed that a total of 2,072 (23.85%) elderly people had cognitive impairment. The detection rate of cognitive impairment was higher in elderly people who were female, aged ≥ 80 years, had no education, no spouse, lived alone, did not smoke, did not drink alcohol, did not exercise, had no social participation, had abnormal sleep duration and had an unhealthy diet, with statistically significant differences (all $p < 0.05$). **Table 1**.

Table 1. Comparison of cognitive impairment among older adults with different characteristics (n = 8687)

Item	Category	Number of respondents (n/%)	Number of cognitive impairment cases(n/%)	Number of non-cognitive impairment cases(n/%)	χ^2	*p*
Gender	Male	3934(45.29)	588(14.95)	3346(85.05)	313.932	< 0.001
	Female	4753(54.71)	1484(31.22)	3269(68.78)		
Age(years)	60–69	1192(13.72)	42(3.52)	1150(96.48)	1177.815	< 0.001
	70–79	2413(27.78)	147(6.09)	2266(93.91)		
	≥ 80	5082(58.50)	1883(37.05)	3199(62.95)		
Years of education	0	3944(45.40)	1613(40.90)	2331(59.10)	1175.525	< 0.001
	1-6	2950(33.96)	349(11.83)	2601(88.17)		
	> 6	1793(20.64)	110(6.13)	1683(93.87)		
Marriage	Spouse	4092(47.10)	414(10.12)	3678(89.88)	803.454	< 0.001
	No spouse	4595(52.90)	1658(36.08)	2937(63.92)		
Co-residence	With family members	2102(24.20)	326(15.51)	1776(84.49)	106.678	< 0.001

Item	Category	Number of respondents (n/%)	Number of cognitive impairment cases(n/%)	Number of non-cognitive impairment cases(n/%)	χ^2	*p*
	Alone	2900(33.38)	780(26.90)	2120(73.10)		
	In a nursing home	3685(42.42)	966(26.21)	2719(73.79)		
Non-smoking	Yes	5994(69.00)	1593(26.58)	4401(73.42)	79.041	< 0.001
	No	2693(31.00)	479(17.79)	2214(82.21)		
Non-drinking	Yes	6331(72.88)	1644(25.97)	4687(74.03)	57.532	< 0.001
	No	2356(27.12)	428(18.17)	1928(81.83)		
Exercise	Yes	3053(35.14)	387(12.68)	2666(87.32)	323.704	< 0.001
	No	5634(64.86)	1685(29.91)	3949(70.09)		
Social participation	Yes	7791(89.69)	1461(18.75)	6330(81.25)	1081.435	< 0.001
	No	896(10.31)	611(68.19)	285(31.81)		
Normal sleep duration	Yes	3219(37.06)	563(17.49)	2656(82.51)	113.958	< 0.001
	No	5468(62.94)	1509(27.60)	3959(72.40)		
Healthy diet	Yes	6162(70.93)	1266(20.55)	4896(79.45)	127.607	< 0.001
	No	2525(29.07)	806(31.92)	1719(68.08)		

3.2. Logistic regression analysis of lifestyle and cognitive function in the elderly

Taking cognitive function (normal cognition = 0, cognitive impairment = 1) as the dependent variable, and demographic and sociological characteristics and lifestyle as independent variables, binary Logistic regression analysis was used to analyze the influencing factors of cognitive function in the elderly. The results showed that female gender (*OR* = 1.396), advanced age (70–79 years old: *OR* = 1.491; ≥ 80 years old: *OR* = 6.586), no spouse (*OR* = 1.666), living alone (*OR* = 1.252), smoking (*OR* = 1.193), lack of exercise (*OR* = 1.464), absence of social participation (*OR* = 3.787), abnormal sleep duration (*OR* = 1.359) and unhealthy diet (*OR* = 1.326) were all risk factors for cognitive impairment in the elderly. Longer years of education (1–6 years: *OR* = 0.375; > 6 years: *OR* = 0.303) was a protective factor for cognitive function in the elderly. Living in a nursing home and drinking alcohol had no significant effect on the cognitive function of the elderly ($p > 0.05$). See **Table 2** for details.

Table 2. Logistic regression analysis of the impact of lifestyle on cognitive impairment in older adults

Item	Categoryβ		Reference group		
			OR(95%*CI*)	*p*	
Gender	Female	Male	0.333	1.396(1.195–1.631)	< 0.001
Age(years)	70–79	60–69	0.400	1.491(1.042–2.134)	0.029
	≥ 80		1.885	6.586(4.730–9.170)	< 0.001
Years of education	1–6	0	-0.981	0.375(0.323–0.435)	< 0.001
	> 6		-1.192	0.303(0.239–0.386)	< 0.001
Marriage	No spouse	Spouse	0.510	1.666(1.442–1.924)	< 0.001
Co-residence	Alone	With family members	0.225	1.252(1.047–1.497)	0.014
	In a nursing home		0.117	1.125(0.943–1.341)	0.190
Non-smoking	No	Yes	0.176	1.193(1.015–1.401)	0.032

Item	Categoryβ		Reference group		
			OR(95%CI)	*p*	
Non-drinking	No	Yes	-0.039	0.962(0.823–1.124)	0.623
Exercise	No	Yes	0.381	1.464(1.272–1.685)	< 0.001
Social participation	No	Yes	1.332	3.787(3.200–4.480)	< 0.001
Normal sleep duration	No	Yes	0.307	1.359(1.197–1.543)	< 0.001
Healthy diet	No	Yes	0.282	1.326(1.168–1.504)	< 0.001

3.3. Dose-response relationship between the number of healthy lifestyles and cognitive impairment in the elderly

To further explore the relationship between the number of healthy lifestyles and cognitive impairment in the elderly, the number of healthy lifestyles was included as a continuous variable in the RCS model to draw the dose-response curve. The number of nodes in the RCS model generally ranges from 3 to 7 [16]. According to the spline regression coefficient and AIC criterion, this study found that the AIC value of the number of healthy lifestyles was 6881.875, which was the smallest, with 3 nodes at this time. The model results showed that there was a linear dose-response relationship between the number of healthy lifestyles and the risk of cognitive impairment in the elderly (p for overall trend < 0.0001, p for non-linearity = 0.7318), that is, for each increase in one healthy lifestyle, the risk of cognitive impairment decreased linearly. Among them, the number of healthy lifestyles at the intersection of the dashed line of confidence interval = 1 was 4, suggesting that when the number of healthy lifestyles reaches 4 or more, it can play a significant protective role in the cognitive function of the elderly. **Figure 1**.

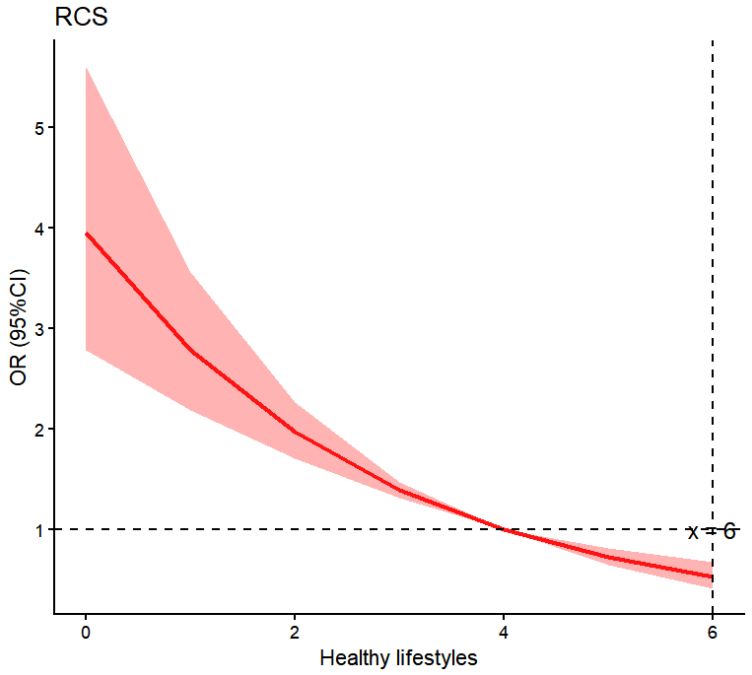


Figure 1. Dose-response relationship between the number of healthy lifestyles and the risk of cognitive impairment in older adults

4. Discussion

4.1. Differences in the incidence of cognitive impairment in the elderly

Based on the data from the 2018 Chinese Longitudinal Healthy Longevity Survey, this study systematically explored the association between healthy lifestyles and cognitive impairment among the elderly aged 60 and above in China. The results showed that the prevalence of cognitive impairment in this age group was 23.85%, which was higher than the research result of Zhang et al (10.59%), but lower than the survey result of Zheng et al on the elderly in nursing institutions (41.28%) [17,18]. This difference may be related to the characteristics of the research objects, the cognitive function assessment tools used, and the differences in diagnostic criteria. The research objects of the latter were all elderly people over 80 years old, and the detection rate of cognitive impairment in the elderly increased significantly with age; the results of this study also confirmed that compared with the 60–69 age group, the risk of cognitive impairment in the ≥ 80 age group was significantly increased ($OR = 7.313$, $p < 0.001$). Both Zhang et al and this study used the MMSE scale to assess cognitive function, while Zheng et al used the Montreal Cognitive Assessment (MoCA) scale. Compared with MMSE, MoCA has a higher detection rate and stronger sensitivity for cognitive impairment [19]. Zhang et al defined MMSE score ≥ 18 as normal cognitive function, while this study adopted a stricter scoring standard of MMSE score ≥ 24, so the detection rate of normal cognitive function was lower than that of Zhang et al's study.

4.2. The impact of healthy lifestyles on the risk of cognitive impairment in the elderly

The results of this study showed that smoking increased the risk of cognitive impairment ($OR = 1.193$), which was consistent with the conclusions of previous studies [20]. The potential mechanism may be that harmful components such as nicotine in cigarettes can damage the capillary endothelium of the human body, leading to vascular stenosis and platelet aggregation, increasing the probability of vascular occlusion, and ultimately inducing stroke or vascular dementia, indirectly impairing cognitive function. However, a few studies have suggested that short-term and low-dose smoking can have a protective effect on cognitive function through the dual effects of nicotine on nerve cells [21]. This difference needs to be further verified by increasing the follow-up duration, controlling the smoking dose, and targeting population characteristics. In existing studies, the harmful effects of smoking on cognitive function have been confirmed by most studies, and it is recommended to include smoking cessation intervention in the measures for the management of cognitive function in the elderly. Lack of physical exercise ($OR = 1.464$) was a risk factor for cognitive impairment in the elderly, which was consistent with the conclusions of previous studies [4]. Physical exercise can protect the cognitive function of the elderly by reducing the inflammatory response in the body and promoting the release of important neurotrophic factors such as insulin-like growth factor-1 (IGF-1) [22]. This provides an important theoretical basis for exercise intervention to prevent cognitive decline in the elderly, and it is necessary to encourage the elderly to engage in moderate physical exercise and reduce bad behaviors, such as a sedentary lifestyle. Low level of social participation ($OR = 3.787$) was the most significant risk factor for cognitive impairment in the elderly in this study. Social participation includes housework, social, and intellectual activities. According to the "cognitive reserve" theory, these activities help optimize brain regions or brain networks related to memory, reduce the impact on memory function, and thus prevent the occurrence of cognitive impairment [23]. Based on this, promoting social participation can be included in the intervention strategies for protecting the cognitive function of the elderly, by reducing their social isolation and potential loneliness to protect cognitive function [24]. Abnormal sleep duration (< 7

hours or > 8 hours, *OR* = 1.359) was a risk factor for cognitive impairment in the elderly, possibly because too long sleep duration can lead to prolonged reaction time and increased error rate of visual memory; while insufficient sleep duration can cause the deposition of β-amyloid protein, leading to cognitive decline and a vicious circle [25–27]. Therefore, it is recommended that 7 to 8 hours be taken as the optimal sleep duration for the elderly, and personalized intervention measures should be taken for those with abnormal sleep, such as cognitive behavioral therapy to improve insomnia and moderate exercise to regulate excessive sleep [28,29]. In addition, the degree of healthy diet intake was negatively correlated with the risk of cognitive impairment, and an unhealthy diet (*OR* = 1.326) increased the risk of the disease. A healthy diet includes fresh fruits, fresh vegetables, meat, aquatic products such as fish, eggs, soy products, dairy products, nuts, and tea. This finding is consistent with the conclusions of previous studies. A diversified dietary structure can provide sufficient nutrients, especially foods rich in antioxidants and Omega-3 fatty acids, which can protect the brain from oxidative stress and inflammatory damage, thereby protecting cognitive function [30–32]. It can be seen that promoting a balanced and diversified healthy diet pattern among the elderly should become an important intervention strategy for preventing cognitive impairment. Although the results of this study did not find a significant association between drinking alcohol and cognitive impairment ($p > 0.05$), it does not mean that the importance of drinking alcohol can be ignored. Studies have shown that there is a non-linear relationship between alcohol consumption and cognitive impairment; moderate drinking can reduce the risk of cognitive impairment, while excessive drinking increases the risk [33].

4.3. The relationship between the number of healthy lifestyles and the risk of cognitive impairment

This study confirmed that adhering to a healthy lifestyle has a positive effect on reducing the risk of cognitive impairment in the elderly, which is consistent with the conclusions of previous studies [34]. The results of the RCS model analysis showed that there was a dose-effect relationship between the number of healthy lifestyles and cognitive function. The cumulative effect of healthy lifestyles showed a significant positive trend in preventing cognitive decline; that is, the healthier lifestyles, the lower the probability of cognitive impairment in the elderly. This may be related to the fact that a combination of multiple healthy lifestyles can protect cognitive function by improving cardiovascular health, regulating metabolic function, and optimizing the balance of the neuroendocrine system [32,35]. This finding emphasizes the importance of a multidimensional healthy lifestyle, transcending the limited contribution of a single healthy lifestyle to cognitive function. The “threshold effect” observed in the study indicates that when the number of healthy lifestyles is more than 4, its protective effect on the cognitive function of the elderly is significant. This finding provides an important basis for formulating health promotion strategies for the elderly, emphasizing the necessity of comprehensively promoting the adoption of multiple healthy lifestyles among the elderly, rather than just focusing on the improvement of a certain aspect.

5. Limitations and future directions of the study

In conclusion, healthy lifestyles are significantly associated with cognitive impairment. This finding not only deepens the understanding of the complex mechanism of cognitive impairment in the elderly, but also emphasizes the importance of changing unhealthy lifestyles for protecting cognitive function. Cognitive impairment will seriously reduce the quality of life of the elderly, and at the same time, bring a heavy

burden to family care and social medical resources. Therefore, early cognitive function screening for the elderly, targeted strengthening of health education for the elderly, guiding the elderly to reduce unhealthy lifestyles, and adhering to a comprehensive model of multiple healthy lifestyles, such as a healthy diet, social participation, and adequate sleep, are of great significance for preventing cognitive decline. This study also has certain limitations. First, the research data were derived from the cross-sectional data of the 2018 CLHLS database. Due to the limitations of the research design, it is impossible to directly infer the causal relationship between various healthy lifestyles and the cognitive function of the elderly. Second, this study analyzed healthy lifestyle as a comprehensive variable, and failed to explore the specific impact of a single healthy lifestyle and its degree on cognitive function in detail. Finally, the assessment of some variables relied on the self-report of the elderly, which may introduce the risk of reporting bias.

6. Data availability

The data used in this study were drawn from the Chinese Longitudinal Healthy Longevity Survey (https://opendata.pku.edu.cn/dataverse/CHADS). This study submitted the application to the website and received the data package.

Disclosure statement

The authors declare no conflict of interest.

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Research on the Intervention Effect of the Recovery Period of Pediatric Bronchopneumonia Based on the "Medical-Education Collaboration" Model

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Abstract: *Objective*: To explore the application effect of rehabilitation management strategies based on the "medical-education collaboration" model in the recovery period of pediatric bronchopneumonia, providing evidence-based support for optimizing the management of pediatric respiratory diseases during the recovery period. *Methods*: A total of 100 children aged 3–5 years who were discharged from Zhifu District Maternal and Child Health Hospital in Yantai City between June 2025 and March 2026, were in the recovery period of bronchopneumonia, and were enrolled in cooperative kindergartens were selected as the study subjects. They were randomly divided into a control group (n = 50) and an intervention group (n = 50) using a random number table method. The control group received routine discharge guidance and regular kindergarten care; the intervention group received a 3-month "medical-education collaboration" rehabilitation management model on this basis, including establishing an information-sharing platform, formulating personalized rehabilitation plans (covering medication, diet, environment, exercise, and prevention of re-infection), and forming a "medical-education-family" linkage team. The disappearance time of clinical symptoms, re-infection rate of respiratory diseases, health behavior compliance, and parental satisfaction were compared between the two groups. *Results*: After the intervention, the disappearance times of cough and nasal congestion in the intervention group were shorter than those in the control group, with statistically significant differences ($p < 0.05$). During the 3-month follow-up, the incidence of re-infection with respiratory diseases in the intervention group (14.0%) was significantly lower than that in the control group (34.0%), with a statistically significant difference ($p < 0.05$). The health behavior compliance scores of the intervention group in terms of diet, exercise, and psychology were higher than those of the control group ($p < 0.05$). The parental satisfaction score of the intervention group was significantly higher than that of the control group ($p < 0.05$). *Conclusion*: The rehabilitation management strategy based on the "medical-education collaboration" model can effectively promote the recovery process of children in the recovery period of bronchopneumonia, reduce the risk of re-infection, improve their health behaviors, and enhance parental satisfaction. This model achieves the effective integration of medical resources and educational settings, possessing significant clinical promotion value.

Keywords: Medical-education collaboration; Children; Bronchopneumonia; Recovery period; Rehabilitation management

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1. Introduction

Bronchopneumonia is the most common lower respiratory tract infectious disease in children, with a high incidence and wide impact, posing a serious threat to children's physical and mental health and growth and development [1]. Although acute-phase treatment has become increasingly mature with the advancement of medical technology, the management of children during the recovery period after discharge has become a weak link in current clinical work. Although the main symptoms of children in the recovery period have been alleviated, their immune function has not fully recovered, and the barrier function of the respiratory mucosa is impaired. If not managed properly, they are prone to disease recurrence, secondary infection, and even chronic cough or asthma [2,3].

The "Healthy China 2030" Plan Outline clearly proposes to "strengthen medical-education collaboration" and promote in-depth cooperation between schools and medical institutions in the field of health management [4]. Currently, there are gaps in the children's health management chain among "hospitals-families-kindergartens": hospitals lack continuous follow-up on children's rehabilitation after discharge; kindergarten teachers find it difficult to provide precise rehabilitation care due to limited professional knowledge; and parents find it difficult to form unified family care strategies due to information asymmetry [5,6]. As a comprehensive intervention method that combines medical technology with educational resources, the "medical-education collaboration" model has been initially proven to effectively improve the rehabilitation effect of special children (such as those with autism and cerebral palsy) [7,8]. However, research on its application in the management of children with common respiratory diseases during the recovery period is still blank.

Based on this, this study, building on the previous project "Research on Rehabilitation Management Strategies for Pediatric Respiratory Diseases Based on the 'Medical-Education Collaboration' Model", focuses on children in the recovery period of bronchopneumonia, explores the construction of a trinity rehabilitation management model with hospitals as the leader, kindergartens as the support, and families as the foundation, and systematically evaluates its effects in improving children's rehabilitation outcomes, reducing the risk of re-infection, enhancing health behaviors, and increasing satisfaction through a randomized controlled trial. The aim is to provide a scientific and operable practical plan for optimizing the management of children's respiratory diseases during the recovery period.

2. Subjects and methods

2.1. Study subjects

Children aged 3–5 years who were hospitalized in Zhifu District Maternal and Child Health Hospital in Yantai City between June 2025 and March 2026, were clearly diagnosed with bronchopneumonia, and were enrolled in cooperative kindergartens after discharge were selected as the study subjects. This study has been

approved by the Medical Ethics Committee of Zhifu District Maternal and Child Health Hospital in Yantai City (Ethics Number: ZFFYLL-20250001). All parents of the children and teachers in their kindergartens have signed informed consent forms.

2.1.1. Inclusion criteria

(1) Meet the diagnostic criteria for bronchopneumonia in Zhu Futang's Practical Pediatrics (9th edition) and are in the recovery period, that is, the main clinical symptoms (such as fever and cough) have been significantly alleviated, intravenous antibiotic treatment has been discontinued, but they are still within 1–4 weeks after discharge;
(2) Aged 3–5 years and enrolled in cooperative kindergartens;
(3) Parents voluntarily participate in the study and sign informed consent forms;
(4) Teachers in the kindergartens agree to cooperate with the implementation of the study protocol.

2.1.2. Exclusion criteria

(1) Those with severe heart, liver, kidney, or other organ dysfunction or congenital diseases;
(2) Those with immunodeficiency diseases, asthma, or other chronic respiratory diseases;
(3) Those in the acute exacerbation period of respiratory diseases;
(4) Those whose parents or kindergarten teachers do not cooperate with the study.

2.2. Study methods

A total of 100 children who met the inclusion criteria were randomly divided into a control group (n = 50) and an intervention group (n = 50) using a random number table method. There were no statistically significant differences in general data such as gender, age, disease course, and disease severity between the two groups ($p > 0.05$), indicating comparability.

2.2.1. Intervention protocol for the control group

Children in the control group received routine discharge guidance, including informing parents to take medication on time, have a reasonable diet, and avoid going to crowded places. After discharge, the children returned to the kindergarten for regular study and life. The kindergarten teachers did not receive additional special training on the management of children in the recovery period of bronchopneumonia and only provided care according to daily health care norms.

2.2.2. Intervention protocol for the intervention group

On the basis of the control group, a 3-month "medical-education collaboration" rehabilitation management model was implemented for the intervention group, with the following specific contents:

(1) Construct a medical-education collaboration management platform
Establish a "medical-education-family" linkage team composed of pediatricians, nurses, kindergarten health care doctors, and class teachers. Use the WeChat platform to establish a "Children's Rehabilitation Management Group" and establish a shared "Health Ledger" based on Tencent Docs to record children's health status, diet, activities, and medication reactions at the kindergarten and at home in real time, achieving seamless information connection among hospitals, kindergartens, and families.

(2) Formulate and implement personalized rehabilitation plans

A multidisciplinary team (pediatricians, dietitians, rehabilitation therapists, teachers) jointly formulated personalized rehabilitation plans for each child and guided their implementation through WeChat groups and offline regular meetings: a. Medication guidance: Clarify the medication plan for children in the recovery period (such as oral medications and nebulization inhalation). Teachers assist in supervising the medication time and method, record adverse reactions, and doctors adjust them in a timely manner. b. Diet management: Guide the kindergarten canteen and families to provide children with easily digestible foods rich in protein and vitamins, such as lean meat, fish, eggs, and fresh vegetables, avoid greasy, cold, and sweet foods, and ensure sufficient water intake. c. Environment management: Guide the kindergarten to keep classrooms ventilated at least twice a day for no less than 30 minutes each time; maintain a room temperature of 22–24°C and a humidity of 50–60%; and regularly disinfect toys, tableware, and bedding. d. Rehabilitation exercise: Formulate a progressive exercise plan according to children's recovery conditions. In the initial stage, walking and slow-paced rhythmic exercises are the main activities, avoiding strenuous activities; in the later stage, the amount of activity can be appropriately increased. Teachers observe and record the reactions after exercise, such as shortness of breath and aggravated cough, and stop and report immediately if such situations occur. e. Prevention of re-infection: Strengthen hand hygiene education, and teachers guide children to wash their hands correctly in the kindergarten. Formulate and strictly implement the "Home/Hospital Isolation System for Sick Children", clarifying that children in the acute phase are not allowed to enter the kindergarten, children in the recovery phase need to be evaluated by health care doctors before entering the kindergarten, and establish a system for checking return-to-school certificates.

(3) Regular training and linkage meetings

Pediatricians provide basic medical skill training for teachers and health care doctors in cooperative kindergartens once a month, covering symptom identification of common respiratory diseases, first aid treatment (such as the Heimlich maneuver), and key points of rehabilitation care. At the same time, hold a joint regular meeting attended by doctors, teachers, and parent representatives once a month to review typical cases, sort out problems, and continuously improve the management plan.

2.3. Observation indicators

2.3.1. Rehabilitation process indicators

Record and compare the disappearance times (days) of cough and nasal congestion symptoms in the two groups of children after discharge. Parents record the data, and the research team verifies it through weekly telephone follow-ups.

2.3.2. Re-infection incidence

Record the re-infection of respiratory diseases in the two groups of children within 3 months of follow-up. Re-infection is defined as children again presenting with acute respiratory infection symptoms such as fever, cough, and expectoration and being clearly diagnosed by a doctor.

2.3.3. Health behavior compliance

Use the "Children's Health Behavior Compliance Questionnaire" self-made by the research group to rate children's daily performance by parents after the intervention. The questionnaire includes three dimensions of

diet, exercise, and psychology, with a total of 15 items. It adopts a Likert 5-point scoring method (1 = never, 5 = always), with a higher score indicating better health behavior compliance. The Cronbach's α coefficient of this questionnaire is 0.86.

2.3.4. Parental satisfaction

Use the "Parental Satisfaction Questionnaire" self-made by the research group to evaluate the overall rehabilitation management services by parents after the intervention. The questionnaire has a total of 10 items, including satisfaction with information communication, health guidance, and rehabilitation effects. It is scored on a 100-point scale, with a higher score indicating higher satisfaction.

2.4. Statistical analysis

Use SPSS 26.0 statistical software for data analysis. Measurement data are expressed as mean ± standard deviation ($\overline{x} \pm s$), and independent sample *t*-tests are used for comparison between groups; count data are expressed as number of cases (percentage) [n (%)], and χ^2 tests are used for comparison between groups. A *p*-value < 0.05 is considered statistically significant.

3. Results

3.1. Comparison of rehabilitation process indicators between the two groups of children

As shown in **Table 1**, the disappearance times of cough and nasal congestion in the intervention group were shorter than those in the control group, with statistically significant differences ($p < 0.05$).

Table 1. Comparison of the disappearance times of clinical symptoms between the two groups of children ($\overline{x} \pm s$, d)

Group	Number of cases	Cough resolution time (days)	Nasal congestion resolution time (days)
Control group	50	9.64 ± 2.31	6.28 ± 1.92
Intervention group	50	7.12 ± 2.05	4.56 ± 1.67
t value		5.827	4.769
p value		< 0.001	< 0.001

3.2. Comparison of re-infection rates between the two groups of children

During the 3-month follow-up, the re-infection rate of respiratory diseases in the intervention group (14.0%) was significantly lower than that in the control group (34.0%), with a statistically significant difference ($\chi^2 = 5.386$, $p = 0.020$). See **Table 2**.

Table 2. Comparison of re-infection of respiratory diseases between the two groups of children [n (%)]

Group	Number of cases (n)	Number of reinfection cases (n)	Incidence rate (%)
Control group	50	17	34.0
Intervention group	50	7	14.0

3.3. Comparison of health behavior compliance between the two groups of children

After the intervention, the health behavior compliance scores and total scores of the children in the

intervention group across the three dimensions of diet, exercise, and psychology were all higher than those in the control group, with statistically significant differences ($p < 0.05$). See **Table 3**.

Table 3. Comparison of health behavior compliance scores between the two groups of children ($\overline{x} \pm s$, points)

Group	Number of cases	Diet dimension	Exercise dimension	Psychological dimension	Total score
Control group	50	18.46 ± 3.21	16.72 ± 3.58	17.94 ± 3.42	53.12 ± 8.91
Intervention group	50	22.58 ± 2.87	21.36 ± 3.14	21.88 ± 2.95	65.82 ± 7.63
t value		6.821	6.903	6.208	7.615
p value		< 0.001	< 0.001	< 0.001	< 0.001

3.4. Comparison of parental satisfaction

Between the Two Groups The satisfaction score of parents in the intervention group (90.54 ± 5.21 points) was significantly higher than that in the control group (75.36 ± 8.43 points), with a statistically significant difference ($t = 10.768$, $p < 0.001$).

4. Discussion

4.1. The "medical-education collaboration" model effectively promotes the recovery process of children and reduces the risk of re-infection

The results of this study indicate that after implementing the "Medical-Education Collaboration" model, the disappearance times of cough and nasal congestion in children in the intervention group were significantly shorter than those in the control group, and the incidence of re-infection during the 3-month follow-up period was significantly reduced. This result suggests that the model effectively fills the gap in traditional post-discharge management by constructing a support network involving hospitals, kindergartens, and families [9]. Professional rehabilitation plans provided by hospitals are precisely implemented in kindergartens and families, including personalized dietary adjustments, environmental control, and exercise guidance, creating external conditions conducive to children's recovery. More importantly, through systematic symptom monitoring and health education, teachers and parents can promptly identify and intervene in potential health risks, effectively blocking the chain of disease recurrence and cross-infection [10].

4.2. The "medical-education collaboration" model significantly improves health behavior compliance in children

The cultivation of healthy behaviors in children relies on professional guidance from hospitals and daily reinforcement by educational institutions. In this study, the health behavior compliance of the intervention group in terms of diet, exercise, and psychology was significantly better than that of the control group. The reasons may be that the "Medical-Education Collaboration" model transforms boring health knowledge into interesting activities in kindergarten daily life (such as hand-washing songs and rhythmic exercises) and specific practices at home (such as reasonable meal planning), and helps children internalize healthy behaviors through continuous supervision and positive feedback from both medical and educational parties [11]. This is consistent with the behavior intervention concept emphasized in the rehabilitation of special children through "Medical-Education Integration" [12]. The improvement in the psychological dimension benefits from the joint attention and active guidance of teachers and parents on children's emotional states in kindergarten

and home environments, reducing anxiety and fear caused by diseases and promoting simultaneous physical and mental recovery.

4.3. The "medical-education collaboration" model enhances parental satisfaction and promotes multi-party collaboration

The study shows that parental satisfaction in the intervention group was significantly higher than that in the control group. The sources of satisfaction may lie in the following aspects: Firstly, the model breaks the information isolation of parents in children's rehabilitation management, allowing parents to understand their children's health status in real-time and obtain professional guidance through WeChat groups and records, enhancing their sense of control and security. Secondly, regular meetings and communication among doctors, teachers, and parents have built an equal and mutually supportive cooperative relationship, making parents feel dual support from medical institutions and kindergartens and alleviating caregiving pressure [13]. From a systems theory perspective, this child-centered, tripartite collaborative management model optimizes resource allocation and improves overall service efficiency, with significant social benefits.

4.4. Innovativeness and limitations of the study

The innovativeness of this study lies in the first application of the "Medical-Education Collaboration" model to the management of children with bronchial pneumonia during the recovery period, achieving positive results and providing a new theoretical framework and practical path for the rehabilitation management of common children's diseases. The study design is rigorous, adopting a randomized controlled trial to ensure the credibility of the results. However, this study also has certain limitations: Firstly, the sample size is small, and only some kindergartens in Zhifu District, Yantai City are selected, which may lead to selection bias; Secondly, the intervention period is only 3 months, and the long-term effects need further observation; Thirdly, health behavior compliance and satisfaction are both subjective evaluation indicators, and objective indicators (such as activity monitoring and humoral immune indicators) can be considered for comprehensive evaluation in the future.

5. Conclusion

The rehabilitation management strategy based on the "Medical-Education Collaboration" model can effectively promote the recovery process of children with bronchial pneumonia during the recovery period, shorten the duration of clinical symptoms, reduce the risk of re-infection, improve children's health behavior compliance, and significantly enhance parental satisfaction. This model fully integrates medical and educational resources and constructs a continuous care system involving hospitals, kindergartens, and families, which is of great significance for improving the full-cycle health management of children's respiratory diseases and is worthy of wider promotion and application.

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Disclosure statement

The authors declare no conflict of interest.

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Research Progress on Risk Assessment Tools and Interventions for Dementia in the Elderly

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Abstract: Dementia in the elderly has emerged as a critical public health issue both in China and globally. The substantial and annually increasing number of elderly individuals with dementia poses not only significant challenges to economic and social sustainability but also exerts immense pressure on family economic ethics and social culture. In light of this, this study reviews assessment tools, risk and protective factors, and the current state of interventions for dementia in the elderly, aiming to provide insights for the identification, prevention, and intervention nursing of dementia in the elderly.

Keywords: Dementia in the elderly; Assessment; Influencing factors; Intervention; Review

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1. Introduction

With the intensification of population aging, geriatric syndromes such as dementia, falls, and pain have become major threats to elderly health, with dementia being the most prevalent [1,2]. The global number of elderly individuals with dementia has reached 152 million, with an average of one case diagnosed every three seconds [3]. In 2020, China reported 15.07 million cases of dementia among individuals aged 60 and above, accounting for one-fourth of the global total. It is projected that by 2030, the economic impact of dementia in China will reach $114.2 billion [4,5]. Dementia, characterized by its long course, high disability rate, and incurability, has become a significant threat to the health of our people and social development. Currently, dementia has not been fully included in the medical insurance reimbursement catalog or the list of chronic disease support in our country, imposing a substantial economic and medical burden on families and society [6]. The "Healthy China 2030" Plan Outline proposes strengthening effective interventions for elderly dementia. Early identification and prevention and control of dementia are crucial in addressing this disease [7,8]. In summary, this paper reviews assessment tools, influencing factors, and intervention methods for elderly dementia, providing references for future related research.

2. Assessment tools for elderly dementia

Dementia assessment scales are important tools for diagnosing, staging, evaluating, monitoring symptoms, and assessing treatment efficacy, primarily based on neuropsychological and cognitive psychology theories. The Chinese Guidelines for the Diagnosis and Treatment of Dementia and Cognitive Disorders recommend assessing dementia from three aspects: cognitive function, social and daily living abilities, and psychiatric and behavioral symptoms [9]. Research on dementia assessment tools abroad is extensive, with mature scale applications. In China, neuropsychological examinations are currently primarily conducted by psychiatrists. The following is an introduction to commonly used assessment tools for elderly dementia.

2.1. Assessment of dementia status

2.1.1. The mini-mental state examination (MMSE)

The Mini-Mental State Examination (MMSE) is a commonly used screening tool for dementia [10]. It consists of 30 questions covering five areas: orientation, memory, attention and calculation, recall ability, and language ability, with each question worth one point, totaling 30 points. The original cut-off scores are as follows: illiteracy ≤ 17 points, primary school education ≤ 20 points, and middle school education or above ≤ 24 points, with higher scores indicating better cognitive function. This scale demonstrates good reliability and validity, with both sensitivity and specificity exceeding 80% [11]. However, its results are susceptible to the influence of various diseases, educational attainment, mental and emotional states, and consciousness levels.

2.1.2. The Montreal cognitive assessment (MoCA)

The Montreal Cognitive Assessment (MoCA) is utilized for rapid screening of dementia, encompassing eight domains: visuospatial/executive function, naming, memory, attention, language fluency, abstract thinking, delayed recall, and orientation, totaling 30 points [12]. Individuals with less than 12 years of education receive an additional 1 point for calibration. A score of ≥ 26 is considered normal, with higher scores indicating better cognitive function. While the MoCA exhibits excellent reliability and validity, it may not effectively evaluate elderly populations with varying occupations and educational backgrounds [13].

2.1.3. The clinical dementia rating (CDR)

The Clinical Dementia Rating (CDR) is employed for diagnosing dementia and assessing its severity, covering six aspects: memory, orientation, judgment/problem-solving, social affairs, home life/hobbies, and personal care [14]. Scores are categorized as follows: 0 for normal, 0.5 for suspected dementia, and 1 or above for dementia. The CDR demonstrates a sensitivity of 95% and a specificity of 100% in screening for dementia among normal elderly individuals. However, this scale is primarily designed for Alzheimer's disease (AD) and should be used with caution when evaluating non-AD types of dementia [15].

2.1.4. Alzheimer disease assessment scale-cognitive subscale (ADAS-cog)

The Alzheimer Disease Assessment Scale-cognitive subscale (ADAS-cog) measures key cognitive domains in Alzheimer's Disease (AD), encompassing 12 items such as memory, orientation, language, and advanced stages of dementia [16]. The maximum score is 70, with higher scores indicating more severe cognitive impairment. However, this scale is not suitable for evaluating patients with very mild or very severe cognitive impairment, struggles to differentiate underlying causes, fails to assess the executive function of the

individuals being evaluated, and is susceptible to the influence of the educational background of those being assessed. Karin et al. suggested that the scale may exhibit a ceiling effect when evaluating patients with mild AD, rendering it unsuitable for early diagnosis [17].

2.1.5. The Japanese long-term care insurance system

The Japanese Long-Term Care Insurance System, operational for over two decades, has achieved notable success in dementia assessment [18]. The system covers individuals aged 65 and above, as well as patients aged 40 to 64, and employs the "Long-Term Care Certification Survey" for evaluation. This survey includes 74 basic survey items and five intermediate assessment groups (physical function or daily activities, life skills, cognitive ability, psychiatric and behavioral symptoms, and social life adaptability). The special medical indicator group consists of 12 medical indicators reflecting the applicant's special medical needs [19]. Based on the assessment results, insured individuals are classified into eight levels, ranging from independent living, requiring support levels 1 or 2, to requiring long-term care levels 1–5. The dementia assessment indicators encompass 28 items, covering cognitive ability, psychiatric and behavioral symptoms, and adaptability to social life.

Existing domestic tools for assessing cognitive function in dementia need further refinement. It is essential to develop dementia-specific evaluation tools tailored to China's national conditions and applicable to different types and stages of dementia.

2.2. Assessment of daily living and social abilities

2.2.1. The activity of daily living scale (ADL)

The Activity of Daily Living Scale (ADL) is primarily used to evaluate the daily living abilities of subjects, encompassing the Physical Self-Maintenance Scale and the Instrumental Activities of Daily Living Scale [20]. It consists of 20 items with a total score of 100 points, where a lower score indicates more severe functional impairments. The "2018 China Guidelines for the Diagnosis and Treatment of Dementia and Cognitive Disorders" recommend conducting instrumental daily living ability or social function assessments for all patients who may have cognitive impairments.

2.2.2. The relevant outcome scale for Alzheimer's disease (ROSA)

The Relevant Outcome Scale for Alzheimer's Disease (ROSA) assesses cognitive abilities, daily living abilities, and caregiver burden in patients with Alzheimer's disease (AD), and is used for follow-up and observation of drug efficacy. The scale comprises six dimensions and 16 items: cognitive dimension (3 items), communication dimension (3 items), behavioral dimension (5 items), functional/daily activities dimension (3 items), quality of life dimension (1 item), and caregiver burden dimension (1 item) [21]. Before using the scale, it is necessary to understand the severity of the patient's condition and assess their functional level based on specific interaction scenarios. Each item is scored on a scale of 0 to 10, with higher scores indicating better patient abilities/quality of life and lighter caregiving burden.

2.2.3. The InterRAI dementia assessment and staging tool (IDEAL)

The InterRAI Dementia Assessment and Staging Tool (IDEAL) was developed by the International Association of Gerontology and Geriatrics in 2015. It aims to design an easy-to-use, international, multidimensional clinical staging scale for dementia to facilitate the development of corresponding staged

care plans [22]. This tool covers seven dimensions: Activities of daily living, physical health, cognitive function, behavioral and psychological symptoms, social support, informal care, and professional care. The IDEAL (InterRAI Dementia Assessment and Care Tool) can comprehensively evaluate the overall functioning of elderly individuals with dementia and focus on their care needs. However, it has low precision in assessing individual domains and requires use by professionally trained personnel, which limits its widespread adoption.

2.3. Assessment of behavioral and psychological symptoms

2.3.1. The Cornell scale for depression in dementia (CSDD)

The Cornell Scale for Depression in Dementia (CSDD) includes five factors: Emotional-related symptoms, abnormal behaviors, somatic symptoms, sleep disorders, and thought disorders, totaling 19 items [23]. By interviewing patients and their caregivers, the patient's performance over the past week is evaluated. As it primarily relies on caregiver information, the Cornell Scale for Depression in Dementia (CSDD) avoids the impact of cognitive and language impairments on the assessment, reduces the concealment of depressive symptoms, and demonstrates good reliability and validity, making it suitable for evaluating the depressive state of patients with Alzheimer's disease (AD).

2.3.2. The Johns Hopkins dementia care needs assessment (JHDCNA)

The Johns Hopkins Dementia Care Needs Assessment (JHDCNA) is used to identify the incidence and correlates of unmet needs among elderly individuals with dementia and their informal caregivers in the community [24]. It consists of 43 items covering seven dimensions: cognitive symptom management, neuropsychiatric symptom management, general healthcare, home/personal safety, activities of daily living, legal issues/advanced care planning, and healthcare financing. Each item is assessed as "needed", "if needed", and "met". The reliability and validity of this tool have not been clearly reported, and it is currently only used in the surrounding areas of Johns Hopkins University, with its generalizability subject to discussion.

2.3.3. The long-term care needs scale for Chinese elderly patients with dementia

The Long-term Care Needs Scale for Chinese Elderly Patients with Dementia aims to assist the government in standardizing the assessment of long-term care needs for elderly individuals with dementia and improving the management level of dementia care [25]. This tool includes 30 items across four dimensions: daily living care services, basic and specialized nursing services, psychological comfort and mental health services, and family care support services. Scores are assigned as follows: 1 for "none", 2 for "a little", 3 for "some", 4 for "quite a bit", and 5 for "a lot", with higher scores indicating greater levels of need. This scale demonstrates good reliability and validity, but it has only been used in five cities so far, and its reliability requires further validation.

In recent years, domestic scholars have increasingly emphasized the assessment of elderly individuals with dementia. However, most of them utilize foreign-localized scales, which exhibit discrepancies in practical application, lack evidence-based support and effectiveness evaluation, and thus face limitations in widespread adoption. When selecting authoritative scales, it is essential to tailor them to China's national conditions and conduct pre-assessment, covering psychological, physiological, perceptual and communicative, as well as social interaction abilities. In the future, assessment tools should be optimized to

comprehensively and accurately evaluate dementia risk, facilitating early detection and intervention.

3. Factors influencing dementia in the elderly

Due to low societal awareness of dementia and insufficient professional support, the diagnosis rate of dementia among the elderly remains relatively low [26]. Early symptoms of dementia in the elderly are often overlooked as normal signs of aging. In China, the consultation rates for mild and severe dementia patients are only 14% and 34%, respectively, with approximately 49% of dementia patients being perceived as experiencing normal aging. The confirmed diagnosis rate of dementia is merely 21% [27]. Furthermore, social stigma and the sense of shame associated with the disease discourage patients and their families from seeking medical attention. Particularly in underdeveloped regions, early identification of dementia patients is challenging, and a confirmed diagnosis often takes 3–5 years. By the time of their first consultation, 40% of patients are already in the moderate stage of dementia, missing the opportunity for early intervention [28]. Epidemiological studies indicate that addressing key risk factors can significantly reduce the incidence of dementia [29]. Early identification of dementia in the elderly has emerged as a significant challenge for the healthcare service system.

3.1. Risk factors

Early identification and prevention constitute the core of dementia prevention and control. Livingston et al. pointed out that approximately 40% of dementia cases worldwide can be attributed to 12 modifiable risk factors, encompassing cardiovascular disease factors (such as diabetes and hypertension), lifestyle habits (including smoking, excessive alcohol consumption, lack of social interaction, and physical inactivity), and living environment (such as air pollution) [30,31]. Cerebrovascular diseases are also common causes of cognitive impairment, falling under the broad category of vascular cognitive impairment [32]. Evidence indicates that age, genetic characteristics, and systemic vascular diseases are major risk factors for dementia [33]. Additionally, deficiencies in vitamins or nutritional levels are also associated with dementia, and excessive intake or combination of medications can induce cognitive deficits as a result of neurotoxic effects [34]. Conversely, vitamin D deficiency also increases the risk of dementia [35]. Research has also indicated that a high BMI is associated with the risk of dementia in the elderly, highlighting the importance of preventing overweight [36]. Liu Han refined the risk factors for Alzheimer's disease (AD) dementia and vascular dementia, finding that the risk factors for AD dementia include age, female gender, low educational level, lack of physical activity, cardiovascular disease, and depression, among others, while vascular dementia is associated with age, male gender, lack of physical activity, smoking, and cardiovascular disease, among others [37]. Therefore, timely identification and reduction of these modifiable risk factors can promote a healthy lifestyle and improve the quality of life for elderly individuals with dementia.

3.2. Protective factors

The occurrence of dementia is related to multiple factors such as aging, genetics, and environment, but certain protective factors can delay or prevent its onset. Research indicates that aerobic exercise, a Mediterranean diet, and participation in social and cognitive activities can reduce the risk of Alzheimer's Disease (AD) and delay disease progression [38]. Greece has postponed the onset of dementia by controlling modifiable risk factors and recommends a Mediterranean diet to reduce the risk of cognitive decline [39].

Since the 20th century, improvements in living standards, education, and healthcare have been considered instrumental in the decline of dementia incidence in Western countries [40]. Some scholars believe that brain health is influenced by a wide range of factors, including early development, environment, lifestyle, and educational attainment, and that higher levels of childhood education and lifelong educational achievements can reduce the risk of dementia [41]. Thus, enhancing the impact of these protective factors can help prevent dementia and reduce its incidence.

4. Current status of dementia interventions in the elderly

Currently, there is insufficient global understanding of dementia, and no effective preventive or curative treatments are available; only the progression of the disease can be controlled. Elderly dementia patients typically survive only 5 to 10 years from onset to death, experiencing a decline in orientation, memory loss, and an inability to care for themselves, which causes immense suffering to both patients and their families. There is an urgent need to explore effective interventions to reduce the number of affected individuals and lower economic costs.

4.1. Cognitive interventions

Cognitive interventions are currently the most common low-risk, cost-effective approach, playing a crucial role in the prevention and control of dementia in the elderly. They not only effectively improve neuropsychiatric symptoms but also address life issues (such as cultural and social challenges) caused by dementia. Santos GD et al. significantly improved the episodic memory of individuals with mild cognitive impairment and healthy elderly people through an 8-week intervention involving interactive imagery, spatial memory techniques, face-name association, text memory, and other methods [42]. Another study indicated that cognitive stimulation therapy can enhance cognitive function and alleviate depression in dementia patients [43]. However, a meta-analysis also pointed out that this therapy has limited effects on improving quality of life and neuropsychiatric symptoms, necessitating further verification through large-sample, high-quality randomized controlled trials [44]. In recent years, traditional Chinese medicine techniques have also achieved positive results in interventions for elderly dementia patients [45–47]. Although cognitive interventions have been proven to enhance cognitive abilities and improve memory in elderly individuals with dementia, due to widespread issues in related research such as small sample sizes, failure to distinguish dementia types, neglect of high-risk groups for dementia, and inconsistent intervention forms and evaluation indicators, the short-term and long-term effects of various therapies on different types and severities of dementia patients still need further clarification.

4.2. Self-management

Self-management is a dynamic self-regulation process aimed at helping individuals effectively control chronic diseases by utilizing skills and knowledge, with a focus on enhancing problem-solving abilities and behavior change, as well as actively participating in disease management. Gale SA proposed that maintaining daily functional abilities and quality of life should be the driving goals of dementia management [48]. As a chronic disease, elderly dementia requires longitudinal care, ongoing consultation, and psychosocial support provided by specialized clinical healthcare professionals. The “Risk Reduction of Cognitive Decline and Dementia Guidelines” issued by the World Health Organization (WHO) suggests reducing the risk of

dementia through various healthy lifestyles, such as engaging in moderate physical activity weekly, following a Mediterranean diet, quitting smoking, limiting alcohol consumption, etc. [49,50]. It also recommends actively managing hypertension, controlling diabetes, regulating dyslipidemia, intervening in depression with medication or psychotherapy as early as possible, and promoting social activities. Additionally, controlling body weight and promptly identifying and managing hearing impairment can help reduce the risk of dementia. Research in Austria has shown that caregivers can provide independent, personalized, and professional care by guiding patients in daily life and life skills training, offering valuable insights for the overall care of elderly individuals with dementia in China [51]. LARNYO E elucidated the importance of wearable devices in managing dementia patients. It is recommended to increase investment in wearable medical devices for elderly dementia patients and improve their utilization rate [52].

4.3. R nursing model

The 3R nursing model is based on theories of neurology and cognitive psychology, encompassing reminiscence therapy, reality orientation, and reminiscence activation [53]. Hou Xiaonan discovered through nine group activities that the 3R therapy had a positive impact on cognitive improvement in elderly individuals with mild dementia [54]. Other scholars have effectively improved dementia symptoms and enhanced long-term living abilities and quality of life in elderly dementia patients through reality orientation training combined with 3R interventions [55]. The 3R nursing model has also demonstrated significant effects in improving cognitive function, daily living abilities, and quality of life in AD patients, as well as delaying the progression of dementia [56,57]. However, due to the specificity and progression of dementia, the duration of interventions needs to be reasonably planned to ensure sustained effectiveness. The 3R nursing model has been proven effective for short-term control of behavioral and psychological symptoms of dementia, yet its long-term efficacy remains to be validated.

Dementia represents a significant issue amid global aging, often receiving inadequate attention in treatment. Single interventions have limited impact on the quality of life of dementia patients, but combined interventions may yield significant effects [58]. Further research is needed on the comprehensive management of dementia in the future.

5. Conclusion

The prevalence of dementia among the elderly is high, with complex pathological mechanisms and numerous risk factors. The imbalance between care demands and the development of elderly care services is becoming increasingly severe. Early identification, assessment, and intervention face challenges. Research on dementia in China is still in its preliminary stages. In the future, it is essential to draw on successful international experiences, integrate China's national conditions and social environment, establish development goals addressing existing issues, explore the establishment of a long-term care security system for elderly dementia patients, and fully implement China's healthy aging strategy. Continuously improve specific assessment tools for elderly dementia, conduct early screening of high-risk groups, clarify intervention priorities, strengthen protective factors, and build a systematic and scientific intervention system to mitigate adverse disease outcomes, delay disease progression, and enhance the overall management level of elderly dementia in China.

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Effect of Clinical Pathway-Based Airway Management on Early Rehabilitation in Patients with Severe Traumatic Brain Injury

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Abstract: *Objective*: To investigate the effect of clinical pathway-oriented airway management on early rehabilitation in patients with severe traumatic brain injury (sTBI) undergoing tracheotomy. *Methods*: A total of 146 sTBI patients were randomly divided into observation group (n = 73) and control group (n = 73). The control group received routine nursing care, while the observation group was implemented with clinical pathway-based airway management. All patients were evaluated for outcome indicators, airway humidification and complications after 8 weeks of intervention. *Results*: After intervention, the observation group had significantly higher airway humidification satisfaction (87.5%, $p < 0.05$), lower incidence of pulmonary infection (30.0%, $p < 0.05$) and lower incidence of airway bleeding (27.5%, $p < 0.01$) than the control group. The sputum aspiration frequency [2 (1,2), $p < 0.01$], single-patient tracheotomy care time [4 (3,5) min, $p < 0.01$], and tracheostomy cannula indwelling time (35.80 ± 18.22 d, $p < 0.01$) in the observation group were significantly lower or shorter than those in the control group. The successful decannulation rate was significantly higher (47.5%, $p < 0.05$). *Conclusion*: Clinical pathway-based airway management can effectively improve sputum characteristics, reduce pulmonary infection and airway bleeding, shorten tracheostomy cannula indwelling time, improve decannulation success rate and promote prognosis in sTBI patients with tracheotomy.

Keywords: Clinical pathway; Severe craniocerebral injury; Tracheotomy; Airway management

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1. Introduction

Approximately 20% of craniocerebral trauma is severe traumatic brain injury, which is often accompanied by varying degrees of coma, rapid disease progression and high mortality [1]. Tracheotomy is widely used to maintain ventilation, but post-operative complications such as pulmonary infection are common due to impaired cough reflex, poor secretion management, aspiration and prolonged bed rest, with an incidence rate up to 68.5% [2]. In clinical practice, airway management faces potential risks, high nursing workload and low

efficiency [3]. Rehabilitation clinical pathway is a standardized and evidence-based service process formulated by physicians, nurses and therapists, covering the whole process from admission to discharge, aiming to improve medical resource utilization [4]. This study developed and applied a clinical pathway-oriented airway management program, and explored its effect on early rehabilitation of sTBI patients with tracheotomy.

2. Objects and methods

2.1. Research objects

Convenience sampling was used to select patients with severe craniocerebral injury hospitalized in the Intensive Rehabilitation Medicine Department of our hospital from March 2024 to June 2025. They were divided into observation group and control group by random number table method.

Sample size estimation: According to preliminary experiments and literature review, the incidence of ventilator-associated pneumonia (VAP) in the control group was expected to be 45%, which could be reduced to 25% after intervention. With $\alpha = 0.05$ (two-sided), $\beta = 0.2$ (power 80%), the calculated sample size was about 65 cases per group. Considering a 20% loss to follow-up rate, 73 cases were finally included in each group, with a total of 146 cases.

2.1.1. Inclusion criteria

(1) Met the diagnostic criteria of severe craniocerebral injury, with Glasgow Coma Scale (GCS) score of 3–8 on admission [5];
(2) Aged 18–75 years;
(3) Admitted within 24 hours after injury, with expected hospital stay ≥ 7 days;
(4) Underwent tracheotomy after injury;
(5) non-mechanical ventilation via tracheotomy on admission.

2.1.2. Exclusion criteria

(1) History of severe chronic obstructive pulmonary disease or neuromuscular disease;
(2) Moribund state (GCS score 3 with fixed and dilated bilateral pupils);
(3) Combined with severe injury or functional failure of other vital organs.

2.1.3. Study details

This study was approved by the Hospital Ethics Committee (2023KY448). All guardians or legal representatives of patients understood the content and signed informed consent. There were no significant differences in gender, age, disease diagnosis, GCS score and other general data between the two groups ($p > 0.05$), indicating comparability (**Table 1**).

Table 1. Comparison of general characteristics between the two groups

Group	n	Gender /n		(Age, $\bar{x} \pm s$)	Etiology (n)			GCS score (points, $\bar{x} \pm s$)
		Male	Female		Cerebral infarction	Cerebral hemorrhage	Craniocerebral injury	
Control	73	48	25	58.50 ± 14.20	12	35	26	5.80 ± 1.50
Observation	73	50	23	60.10 ± 13.50	10	37	26	5.90 ± 1.60
t/χ^2- value		0.112		0.695		0.224		0.387
p-value		0.738		0.488		0.894		0.699

2.2. Intervention methods

2.2.1. Intervention in the observation group

(1) Establishment of an airway management subspecialty team

The team consisted of 3 rehabilitation specialist nurses (1 associate chief nurse and 2 nurse-in-charges), 1 associate chief physician in rehabilitation, and 2 respiratory therapists, all with more than 5 years of experience in rehabilitation department. The associate chief nurse served as the team leader, responsible for organizing meetings and supervising implementation. Team members jointly completed airway assessment and formulated nursing plans and health education. Rehabilitation specialist nurses implemented measures and provided timely feedback. Therapists collaborated with nurses in respiratory function training, and attending physicians were responsible for clinical treatment.

(2) Development of clinical pathway-oriented airway management program

Based on Clinical Pathway of Rehabilitation Nursing and Expert Consensus on Airway Management for Severe Neurosurgical Patients in China, the PIPOST model (Population, Intervention, Professional, Outcome, Setting, Type of evidence) of JBI Evidence-Based Nursing Center was used to construct structured evidence-based nursing questions [6–8]. According to the characteristics of intensive rehabilitation, physicians, nurses and therapists jointly developed a clinical pathway form for patients with severe craniocerebral injury after tracheotomy. The pathway took time as the horizontal axis, divided into three consecutive stages, and took assessment, nursing measures, medical measures, rehabilitation therapy and health education as the vertical axis to formulate a standardized process. Refer **Table 2**.

Table 2. Clinical pathway form for airway management in patients with severe craniocerebral injury after tracheotomy

Patient Name: _____ Medical Record No.: _____ Date of Admission: _____

GRS-R Score: _____

Duration: From admission to decannulation/transfer

Goals: Satisfactory airway humidification without scab formation; reduced pulmonary infection and airway bleeding; successful decannulation or preparation for decannulation

Time	Stage 1 (Acute Unstable Phase)	Stage 2 (Stable Rehabilitation Phase)	Stage 3 (Decannulation Transition Phase)
Core Goals	Establish baseline, stabilize vital signs, prevent early complications	Enhance airway clearance, control infection, initiate early rehabilitation	Assess decannulation criteria, strengthen functional training, prepare for decannulation/capping
Assessment	□ Monitor vital signs, SpO_2, consciousness, pupils □ Assess cough and swallowing reflex □ Check tracheostomy tube fixation, cuff pressure (q4h) □ Assess sputum characteristics, quantity, bleeding □ Assess stoma skin and dressing □ Auscultate lungs	□ Daily assessment of consciousness and ICP □ Dynamic assessment of sputum and humidification □ Assess subglottic secretions □ Assess signs of pulmonary infection □ Assess airway bleeding risk	□ Systematically assess decannulation/capping: - consciousness - spontaneous breathing、cough - swallowing - infection control - airway patency □ Assess sitting balance

Time	Stage 1 (Acute Unstable Phase)	Stage 2 (Stable Rehabilitation Phase)	Stage 3 (Decannulation Transition Phase)
Nursing	□Head elevation 30° □Cuff pressure 25–30 cmH_2O，q4h □Individualized airway humidification □Sterile suction as needed □Subglottic suction if applicable □Oral care twice daily	□ Semi-recumbent position, reposition q2h □ Continue cuff monitoring □ Adjust humidification □ Airway clearance：manual vibration if ICP stable；Subglottic suction q6h □ Oral care, increased frequency if needed	□ Capping trial if eligible：Emergency equipment at bedside □Post-decannulation care: observe breathing, SpO_2, swallowing Stoma dressing care □ Continue humidification if not decannulated
Medical	□Complete blood tests, CRP, PCT, sputum culture □Anti-infection and expectorant drugs □Evaluate bronchoscopy	□ Adjust antibiotics based on drug sensitivity □ Supportive treatment	□ Comprehensive decannulation assessment □ Informed consent □ Decannulation or capping
Rehabilitation	□ Passive limb exercises (if ICP stable) □ Abdominal breathing training if cooperative	□ Daily awakening (if sedated) □ Airway clearance techniques □ Passive limb and trunk exercises 1–2 times daily	□Swallowing training □Sitting balance training (60–90° head elevation) □Cough training if cooperative
Health Education	□Explain tracheotomy purpose, risks and care □Importance of repositioning □Keep stoma dressing clean and dry	□Guide family to identify abnormal breathing and sputum □Early mobilization to prevent infection □Family involvement in basic care	□ Explain decannulation/capping process and risks □ Post-decannulation precautions □ Discharge guidance for home care
Variation	□No □Yes:	□No □Yes:	□No □Yes:
Variation	□No □Yes:	□No □Yes:	□No □Yes:

(3) Implementation and supervision

The clinical pathway was implemented from admission to decannulation. The team provided training and assessment. Head nurses or specialist nurses supervised implementation using a checklist and continuously optimized the process to ensure homogeneous quality [9].

2.2.2. Intervention in the control group

Routine rehabilitation airway care was provided: responsible nursing, antibiotics, expectorants and bronchodilators as ordered, head elevation 30–45°, repositioning and back percussion q2h, vibration sputum excretion once daily, suction as needed, passive exercise for 30 minutes daily, and continuous enteral nutrition [10].

2.3. Outcome measures

2.3.1. Patient outcomes

(1) Tracheostomy tube indwelling time (days from admission to removal).

(2) Successful decannulation rate: no re-intubation/tracheotomy within 72 hours after decannulation.

2.3.2. Airway humidification effect

(1) Satisfactory

Thin sputum, smooth suction, no scab, clear airway.

(2) Insufficient

Thick sputum, difficult suction, possible scab, dyspnea.

(3) Excessive

Watery sputum, frequent suction, increased cough, restlessness.

2.3.3. Complications

(1) Pulmonary infection

≥ 2 of fever (> 38.0 ℃), abnormal WBC, positive sputum culture, new chest imaging lesions [11].

(2) Airway bleeding: bleeding during suction/cough, volume <10 mL [12].

2.4. Statistical methods

SPSS 22.0 was used. Measurement data with normal distribution were expressed as ($\overline{x} \pm s$) and compared by *t*-test; non-normal data were expressed as median and interquartile range M (P_{25}, P_{75}) and compared by rank-sum test. Enumeration data were expressed as frequency and percentage, compared by χ^2 test. $p < 0.05$ was considered statistically significant.

3. Results

3.1. Comparison of outcome indicators

As shown in **Table 3**, the observation group had significantly fewer aspiration times, shorter single-patient tracheotomy care time and shorter tracheostomy cannula indwelling time than the control group ($p < 0.001$).

Table 3. Comparison of suction times, nursing time per patient and tracheostomy tube indwelling time ($\overline{x} \pm s$)

Group	n	Suction times (n)	Nursing time per patient (min)	Indwelling time (d)
Control	73	3 (2,4)	6 (5,7)	58.50 ± 14.20
Observation	73	2 (1,2)	4 (3,5)	35.80 ± 18.22
z/t-value		-5.201	-5.412	-6.521
p-value		< 0.001	< 0.001	< 0.001

3.2. Comparison of airway humidification effect

Table 4 demonstrates that airway humidification satisfaction was significantly higher in the observation group after intervention ($p < 0.05$).

Table 4. Comparison of airway humidification effect [n(%)]

Group	n	Before intervention Satisfactory insufficient excessive	After intervention Satisfactory insufficient excessive	χ^2-value	*p*-value
Control	73	40 (54.8)	48 (65.8)	1.875	0.392
		26 (35.6)	18 (24.7)		
		7 (9.6)	7 (9.6)		
Observation	73	38 (52.1)	64 (87.7)	12.542	0.002
		33 (45.2)	9 (12.3)		
		2 (2.7)	0 (0.0)		
χ^2-value		2.103	7.215		
p-value		0.349	0.027		

3.3. Comparison of complications and decannulation rate

The incidences of complications and successful decannulation rate are summarized in **Table 5**

Table 5. Comparison of complications and successful decannulation rate [n(%)]

Group	n	Pulmonary infection	Airway bleeding	Successful decannulation rate
Control	73	40(54.8)	46(63.0)	18(24.7）
Observation	73	22(30.1)	20(27.4)	35(47.9)
χ^2-value		0.112	18.764	8.896
P-value		0.003	< 0.001	0.003

4. Discussion

4.1. Clinical pathway-oriented airway management improves humidification and reduces complications

Patients with severe traumatic brain injury complicated by tracheotomy lose the physiological functions of airway heating and humidification. Combined with airway mucosal injury, impaired ciliary movement, prolonged bed rest and absence of voluntary cough reflex, these factors result in difficult sputum excretion and recurrent pulmonary infection, thus leading to inadequate airway clearance [13,14]. A study by He Yanbin et al, showed that tracheal extubation is closely associated with consciousness state, cough reflex and airway secretions [15,16]. In this study, phased and standardized management based on clinical pathways yielded significantly better outcomes in the observation group, including a higher satisfaction rate of airway humidification (87.5%) and lower incidence rates of pulmonary infection (30.1%) and airway hemorrhage (27.4%), compared with the control group ($p < 0.05$).These results suggest that a clinical pathway-oriented protocol can effectively reduce airway-related complications and improve nursing quality, which is consistent with the findings of Hu Na et al [17].

Clinical pathways provide procedural guidance for the medical team, clarify rehabilitation priorities at each stage, facilitate effective communication among healthcare providers, patients and their families, enhance team execution and risk anticipation capabilities, and ultimately achieve homogeneous nursing care.

4.2. Clinical pathway promotes early rehabilitation and improves prognosis

The clinical pathway established in this study acted as a bridge that integrated the distinctive expertise of multidisciplinary team members (physicians, nurses, and therapists) into a linear workflow [18]. It clarified the priorities and challenges at each step to prevent omissions in care delivery. The protocol was implemented mainly by rehabilitation specialist nurses, with regular evaluation, collaboration, and continuous process optimization among physicians, nurses and therapists, while the head nurse was responsible for overall coordination. The results demonstrated that the observation group had significantly fewer suctioning times and shorter nursing time per patient than the control group ($p < 0.01$). The duration of tracheostomy tube indwelling was shortened to (35.80 ± 18.22) days, and the successful decannulation rate increased to 47.9% ($p < 0.05$).These findings indicate that the clinical pathway-based intervention can effectively shorten the duration of tube placement, fulfill the desire of patients and their families for safe and early decannulation, reduce clinical nursing workload, optimize working hours, and improve work efficiency. The integrated nursing process, ranging from condition assessment and intervention implementation to supervision and

feedback, significantly improved the quality of airway management and promoted early rehabilitation of patients.

5. Conclusion

Clinical pathway-oriented airway management significantly improves airway management quality, reduces complications, and increases decannulation rate in patients with severe craniocerebral injury after tracheotomy, with strong clinical operability. Variations may affect implementation; future promotion should focus on reducing negative variations.

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Disclosure statement

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Prevalence and Risk Factors of Hypertension Among College Students in a University in Qujing

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Abstract: *Objective*: To understand the prevalence of hypertension and prehypertension among ethnic minority college students in a university in Qujing, compare ethnic differences, and analyze risk factors, so as to provide a basis for blood pressure intervention in young people. *Methods*: A total of 1,834 college students were selected by cluster sampling. Indicators such as blood pressure, height, weight, and abdominal circumference were measured, and statistical analysis was performed using chi-square test and multivariate Logistic regression. *Results*: Using 140/90 mmHg as the standard, the prevalence of hypertension was 3.9% and prehypertension was 26.0%; there was no statistically significant difference in the prevalence between Han and ethnic minority students ($p > 0.05$). According to the 130/80 mmHg standard, the prevalence of hypertension increased to 23.7%. Male gender and high-salt diet were risk factors, while non-abdominal obesity and non-smoking were protective factors. *Conclusion*: The detection rate of hypertension and prehypertension among college students in this university is relatively high, and the prevalence scale increases significantly after the downward adjustment of the diagnostic standard. Early screening and lifestyle intervention should be strengthened.

Keywords: Hypertension; Prehypertension; College students; Ethnic minorities; Prevalence; Risk factors

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1. Introduction

Hypertension is an important risk factor for cardiovascular and cerebrovascular diseases, which was previously more common in middle-aged and elderly people, but has shown an obvious younger trend in recent years. As a transitional stage of hypertension, prehypertension is closely related to the increased risk of long-term cardiovascular and cerebrovascular events [1]. The 2022 Chinese Clinical Practice Guidelines for Hypertension lowered the diagnostic threshold of hypertension from 140/90 mmHg to 130/80 mmHg, incorporating a large number of people with high normal blood pressure into the scope of hypertension management. The college student group is large in number, and conducting blood pressure screening and early intervention is of great public health significance [2]. Yunnan is a concentrated area of ethnic minorities. Taking a university in Qujing as an example, this study analyzes the current situation of abnormal blood pressure and risk factors among Han and ethnic minority college students, providing a basis for campus health management.

2. Materials and methods

2.1. General information

A total of 1,860 students from 20 classes of Grade 2023–2024 in our university were selected by cluster sampling. After excluding unqualified data, 1,834 valid samples were obtained, with a questionnaire response rate of 98%. This study was approved by the school ethics committee, and all subjects provided informed consent.

2.2. Research methods

Trained researchers uniformly measured blood pressure, height, weight, abdominal circumference, and pulse, guided the completion of questionnaires, and data were analyzed using SPSS 20.0.

2.3. Diagnostic standards

Hypertension was defined as systolic blood pressure ≥ 140 mmHg and/or diastolic blood pressure ≥ 90 mmHg; prehypertension was defined as an average systolic blood pressure of 120–139 mmHg and/or an average diastolic blood pressure of 80–89 mmHg measured twice consecutively; subjects rested for 30 minutes before measurement, and blood pressure was measured in a sitting position with the sphygmomanometer at the same level as the heart.

2.4. Statistical methods

SPSS 20.0 was used for statistical analysis. Count data were expressed as rates (%), and comparisons were made using chi-square test. Measurement data were expressed as $\overline{x} \pm$ s. A p value < 0.05 was considered statistically significant.

3. Results

3.1. General population data

There were 1,834 valid samples with an average age of (19 ± 1) years. Among them, 1,375 were Han nationality (75.0%) and 459 were ethnic minorities (25.0%); 452 were male (24.6%) and 1,382 were female (75.4%). The proportion of students with a family history of hypertension was 18.0%, smoking history was 16.4%, overweight/obesity was 9.5%, and abdominal obesity was 7.9%. Refer **Table 1**.

Table 1. Characteristics of general population data

Item	Grouping	Number	Composition ratio (%)
Gender	Male	452	24.6
	Female	1382	75.4
Age (years)	Mean ± Standard deviation	19 ± 1	/
Ethnicity	Han	1375	75.0
	Ethnic minorities	459	25.0
Smoking history	Yes	301	16.4
BMI (kg/m^2)	≥ 24	175	9.5
Abdominal obesity	Yes	145	7.9

Note: The diagnostic standard for abdominal obesity is abdominal circumference > 85 cm for males and > 80 cm for females.

3.2. Prevalence of abnormal blood pressure

Using 140/90 mmHg as the standard, the prevalence of hypertension among ethnic minorities was 4.4% and prehypertension was 27.9%; the prevalence of hypertension among Han nationality was 3.8% and prehypertension was 25.3%; the overall prevalence of hypertension was 3.9% and prehypertension was 26.0%. There was no statistically significant difference between the two groups ($p > 0.05$), as shown in **Table 2**.

Table 2. Comparison of prevalence of abnormal blood pressure between han and ethnic minority students

Ethnicity	Number of examinations	Hypertension (140/90 mmHg)	Prehypertension	Hypertension (130/80 mmHg)
		Case (%)	Case (%)	Case (%)
Han	1375	52 (3.8)	348 (25.3)	321 (23.3)
Ethnic minorities	459	20 (4.4)	128 (27.9)	112 (24.4)
χ^2	–	0.31	1.19	0.21
p	–	> 0.05	> 0.05	> 0.05

3.3. Prevalence after downward adjustment of hypertension diagnostic threshold

The 2022 Chinese Clinical Practice Guidelines for Hypertension recommends lowering the diagnostic threshold of hypertension in Chinese adults from 140/90 mmHg to 130/80 mmHg. According to the 130/80 mmHg standard, the overall prevalence of hypertension increased to 23.7%, 23.3% among Han nationality and 24.4% among ethnic minorities. There was no statistically significant difference between the two groups ($p > 0.05$), as shown in **Table 2**.

3.4. Prevalence of hypertension, post-downward adjustment hypertension, and prehypertension among students of major ethnic minorities

A total of 459 students from 18 ethnic minorities were included in the survey. The detection rate of hypertension was 4.4%; according to the 130/80 mmHg diagnostic standard, the detection rate of hypertension increased to 24.4%, and the prevalence of prehypertension was 27.9%. See **Table 3**.

Table 3. Main detection results of abnormal blood pressure

Ethnicity	Number of surveys	Composition ratio (%)	Hypertension (140/90 mmHg)		Hypertension (130/80 mmHg)		Blood pressure 120–139/80–89 mmHg	
			Case	Detection rate (%)	Case	Detection rate (%)	Case	Detection rate (%)
Bai	72	15.7	1	1.4	15	20.8	17	23.6
Yi	177	38.6	6	3.4	40	22.6	45	25.4
Other ethnic minorities	210	45.7	12	5.7	57	27.1	43	20.5

3.5. Multivariate logistic regression analysis of risk factors for hypertension

Logistic regression analysis was performed with blood pressure status as the dependent variable and gender, obesity, smoking, diet, family history, and drinking as independent variables, as shown in **Table 4**. Using 140/90 mmHg as the hypertension standard, non-abdominal obesity and non-smoking were protective factors, meaning the presence of these factors was associated with a reduced risk of hypertension; while a salty diet and male gender were pathogenic factors, indicating that a salty diet would increase the risk of hypertension,

and female gender was a protective factor that would reduce the risk of hypertension; family history and drinking history had no significant effect on the risk of hypertension under this threshold ($p > 0.05$).

Table 4. Logistic regression analysis of risk factors for hypertension under different blood pressure diagnostic standards

Variable	140/90 mmHg OR (95% CI)	130/80 mmHg OR (95% CI)
Male	3.448 (1.366–8.908)*	2.243 (1.278–3.934)*
Non-abdominal obesity	0.013 (0.004–0.046)*	0.462 (0.201–1.059)
Non-smoking	0.287 (0.107–0.768)*	1.444 (0.762–2.736)
Salty diet	3.463 (1.063–11.288)*	1.882 (0.906–3.913)
No family history	0.534 (0.203–1.403)	0.536 (0.321–0.895)*
Drinking history	1.726 (0.483–6.173)	0.896 (0.428–1.877)

Note: *$p < 0.05$

When using 130/80 mmHg as the hypertension threshold, male gender was still a pathogenic factor, indicating that females had a lower risk of hypertension than males under the lower blood pressure threshold; no family history became a protective factor, suggesting that people with a family history were more likely to develop hypertension under the relatively strict threshold of 130/80 mmHg; while abdominal obesity, smoking history, salty diet, and drinking history had no statistical significance on the risk of hypertension under this threshold ($p > 0.05$).

4. Discussion

4.1. Analysis of prevalence of abnormal blood pressure and impact of downward adjustment of diagnostic standard

In this study, using 140/90 mmHg as the diagnostic standard, the prevalence of hypertension was 3.9% and prehypertension was 26.0%, which is similar to the results of studies on college students in other universities in China, and falls within the fluctuation range of 0.84–10.59% for the prevalence of hypertension among college students in China, indicating that the data are representative and comparable [3–5]. Both the 2017 ACC/AHA Guidelines and the 2022 Chinese Clinical Practice Guidelines for Hypertension lowered the diagnostic threshold of hypertension to 130/80 mmHg [6]. According to the new standard, the prevalence of hypertension among the subjects in this study increased significantly to 23.7%, suggesting that the detection rate of abnormal blood pressure in young people increases significantly after the downward adjustment of the diagnostic standard, further highlighting the urgency of early blood pressure screening and intervention in the college student group.

4.2. Impact of ethnic differences on blood pressure levels

The results of this study show that regardless of whether the 140/90 mmHg or 130/80 mmHg diagnostic standard is adopted, there is no statistically significant difference in the prevalence of hypertension and prehypertension between Han and ethnic minority students ($p > 0.05$), which is not completely consistent with the conclusions of some ethnic-specific hypertension studies [7–10]. The possible reasons are as follows:

(1) The subjects are young college students with strong body compensation ability, and the blood pressure differences related to ethnic genetic background have not yet fully manifested;

(2) The sample covers 18 ethnic minorities with uneven distribution of the number of people in each ethnic group, making it difficult to carry out detailed stratified analysis of a single ethnic group;
(3) The subjects are all college students with relatively unified living environments and work and rest rules, which weakens the impact of ethnic-related factors such as region and eating habits on blood pressure.

4.3. Analysis of risk factors for increased blood pressure among college students

Multivariate Logistic regression analysis shows that the risk factors for abnormal blood pressure vary with different diagnostic standards: using 140/90 mmHg as the standard, male gender and salty diet are risk factors for hypertension; non-abdominal obesity and non-smoking are protective factors, and family history and drinking history have no significant effect on blood pressure; using 130/80 mmHg as the standard, male gender is still a risk factor, and no family history of hypertension becomes a protective factor, while the effects of abdominal obesity, smoking, high-salt diet, and drinking are not statistically significant. The above results suggest that gender, obesity, smoking, and high-salt diet are key controllable factors under the traditional blood pressure threshold; while under the lower diagnostic threshold, the role of family genetic background is more prominent, further confirming that hypertension is a disease caused by the combined effect of genetic and environmental factors. Some studies suggest that college students need to establish a healthy lifestyle and reduce exposure to high-risk factors to prevent the occurrence of hypertension [11]. In this study, the smoking rate is 16.4%, the overweight/obesity rate is 9.5%, and the abdominal obesity rate is 7.9%, providing clear targets for campus health intervention.

4.4. Practical significance and intervention suggestions for blood pressure management of college students

The younger trend of hypertension has become an important challenge for the prevention and control of cardiovascular and cerebrovascular diseases in China. As a key group of prehypertension and youth hypertension, early intervention for college students can significantly reduce the risk of long-term complications such as coronary heart disease, stroke, and renal impairment [12,13]. Colleges and universities should include blood pressure monitoring in routine physical examinations, establish health records and conduct key follow-up of prehypertensive groups; carry out targeted health education such as low-salt diet, smoking cessation, and exercise for high-risk individuals such as males, those with family history, and obese individuals; at the same time, optimize the campus diet and exercise environment, reduce the risk of abnormal blood pressure in young people from both behavioral and environmental aspects, and move forward the prevention and control of cardiovascular and cerebrovascular diseases [14,15].

4.5. Research limitations

This study is a single-center cross-sectional survey covering only one university in Qujing, and the sample representativeness is limited; stratified and detailed analysis of factors such as altitude, eating habits, and ethnic genetic background is not conducted; long-term follow-up data are lacking, making it impossible to judge blood pressure outcome and intervention effect. In the future, multi-center and prospective cohort studies can be carried out to further clarify the blood pressure change rules and intervention strategies of ethnic minority college students in southwest China.

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Application Prospects of Robots in the Field of Clinical Nursing Under the Background of Embodied Intelligence

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Abstract: With the acceleration of the aging population and the increasingly prominent contradiction between the supply and demand of medical resources, the field of clinical nursing is also facing new challenges and opportunities. Embodied Intelligence (EI) is a cutting-edge branch of artificial intelligence, emphasizing that intelligent agents achieve the unity of cognition and action through dynamic interaction between physical carriers and the environment, which has injected vivid vitality into the development of clinical nursing robots. Based on this, this paper will briefly analyze the core connotation and technical characteristics of embodied intelligence, as well as the application scenarios of nursing robots in the field of clinical nursing, and look forward to the application prospects of nursing robots in the field of clinical nursing under the background of embodied intelligence, aiming to promote the deep integration of embodied intelligence technology and the field of clinical nursing.

Keywords: Embodied intelligence; Robots; Clinical nursing

Online publication: Apr 30, 2026

1. Introduction

The rapid development of artificial intelligence technology has provided a new way to solve the dilemmas in the field of clinical nursing. Among them, embodied intelligence has broken the limitation that "intelligence only exists in abstract algorithms". By endowing intelligent agents with physical carriers, intelligent agents can independently adapt to and flexibly respond to complex nursing tasks in real clinical environments. Therefore, systematically analyzing the application scenarios of nursing robots under the background of embodied intelligence and looking forward to their development prospects are of great significance for promoting the intelligent transformation of medical and nursing models, optimizing the allocation of medical resources, and improving the level of clinical nursing services.

2. Core connotation and technical characteristics of embodied intelligence

2.1. Core connotation

Embodied Intelligence (EI) is a cutting-edge field integrating artificial intelligence and robotics. Its core idea is that intelligence cannot only exist in abstract algorithms or data processing, but must rely on a physical "body" to continuously interact with the real environment, and realize cognition, learning and adaptation in the closed loop of perception, action and feedback. In the White Paper on Embodied Intelligence Technology jointly released by the International Association for Artificial Intelligence (IAAI), IEEE and ACM in 2025, embodied intelligence is officially defined as: an intelligent system with a physical form that continuously interacts with the physical environment through a closed-loop system of "perception-decision-action-feedback", can understand, adapt to and transform the environment, and has the ability to complete complex tasks in an open world [1].

In the clinical nursing environment, the embodied intelligent nursing robot is not only the carrier for performing nursing tasks, but also an important medium for perceiving patients' conditions and adapting to the nursing environment, thereby realizing accurate monitoring, personalized nursing and real-time response for patients.

2.2. Core technical characteristics

2.2.1. Perceptual interaction

Perceptual interaction technology is a basic function of embodied intelligent nursing robots, mainly used to accurately perceive the nursing environment and patients' conditions and interact in various ways. The clinical nursing environment is complex and changeable, and patients' physiological conditions and emotional fluctuations are highly real-time and uncertain. Therefore, nursing robots must have strong perceptual capabilities. Through various sensors such as visual sensors, tactile sensors, auditory sensors, and physiological parameter sensors, embodied intelligent nursing robots can collect real-time physiological indicators of patients such as body temperature, heart rate, and blood pressure, capture non-verbal signals such as patients' facial expressions and body movements, and perceive information such as obstacles and equipment positions in the nursing environment [2].

2.2.2. Autonomous decision-making

Autonomous decision-making technology is the core technology of embodied intelligent nursing robots. Its core function is to independently formulate and implement appropriate nursing plans based on perceived information, combined with clinical nursing standards and patients' needs. The autonomous decision-making ability of embodied intelligent nursing robots relies on artificial intelligence algorithms such as deep learning, reinforcement learning, and knowledge graphs. By learning and analyzing a large amount of clinical nursing data, they master the nursing needs and standards of various diseases and patients, and can independently make judgments and flexibly respond in complex environments [3].

2.2.3. Flexible execution

Flexible execution technology refers to the implementation of the autonomous decisions of embodied intelligent nursing robots into specific nursing actions, so as to achieve accurate nursing for patients. Clinical nursing work is complex and diverse with high requirements. Venipuncture, turning over and patting the

back, drug delivery, etc., all belong to nursing operations, and there are certain requirements for the accuracy and flexibility of robot movements [4]. Equipped with high-precision robotic arms, flexible joints and other executive mechanisms, embodied intelligent nursing robots can accurately perform complex nursing actions using motion control algorithms.

3. Application scenarios of nursing robots in clinical nursing under the background of embodied intelligence

3.1. Basic nursing scenarios

Basic nursing includes vital sign monitoring, daily care, drug delivery, etc., which are the main work contents of nursing staff. Using embodied intelligent nursing robots to carry out basic nursing work can not only reduce the work burden of nursing staff, but also improve the standardization of basic nursing [5]. For example, in terms of vital sign monitoring, embodied intelligent nursing robots equipped with physiological parameter sensors can collect real-time vital sign data of patients such as body temperature, heart rate, blood pressure, and blood oxygen saturation, and then immediately send the data to nursing staff and hospital information systems through data transmission modules, realizing 24/7 uninterrupted monitoring of patients' vital signs. When patients' vital signs such as blood pressure and heart rate are abnormal, the robot will immediately issue an alarm to notify nursing staff for processing and record the abnormal data, providing a basis for clinical diagnosis and treatment [6]. Compared with traditional manual monitoring and nursing, the monitoring of embodied intelligent nursing robots has the characteristics of immediacy, continuity, and accuracy, which can avoid the negligence and errors in previous manual monitoring, and has high application value in scenarios requiring high-frequency monitoring such as intensive care units and geriatric wards.

3.2. Rehabilitation nursing scenarios

Rehabilitation nursing is an indispensable part of the disease rehabilitation process. It implements scientific rehabilitation training for postoperative patients, the disabled, elderly patients, etc., to promote the recovery of patients' physical function, language function, etc., and improve their quality of life. Embodied intelligent nursing robots can provide personalized rehabilitation nursing services for patients through accurate motion control and autonomous decision-making, thereby improving the effect and efficiency of rehabilitation training. In physical rehabilitation, a rehabilitation training plan suitable for patients' actual conditions can be determined according to their illness and rehabilitation requirements. The robot can real-time perceive patients' body movements and strength, adjust the training intensity and rhythm according to patients' feedback to prevent injuries caused by excessive training, and can also record patients' training data to provide a basis for rehabilitation doctors to adjust rehabilitation plans [7]. Compared with traditional physical rehabilitation, the training of embodied intelligent nursing robots is not only accurate and controllable, but also can dynamically adjust the training plan according to the patients' recovery status, realizing "one-on-one" personalized guidance.

4. Nursing robots empowering the reform of clinical nursing models

4.1. Upgrading and transformation of nursing service models

In clinical nursing work, embodied intelligent nursing robots can take on repetitive and physical-consuming

traditional nursing work, such as ward rounds, drug delivery, and disinfection, freeing nursing staff from tedious tasks, so that they have more time and energy to focus on higher-value nursing services such as patients' condition observation, psychological counseling, and health education. This model transformation not only improves the efficiency and quality of nursing services, but also further enhances patients' medical experience and satisfaction.

4.2. Reconstruction and optimization of nurse-patient relationship

Embodied intelligent nursing robots have efficient information processing and transmission capabilities, and can become an effective bridge for communication between nurses and patients. For example, based on its built-in knowledge base, the nursing robot can provide patients with standardized health information, accurately and patiently explain the condition, treatment plan, medication guidance, and rehabilitation precautions to patients, which is very suitable for patients with repeated consultation needs. Thus, it relieves the communication pressure of nursing staff, makes up for the deficiencies in traditional nurse-patient communication, enhances the understanding and trust between nurses and patients, and promotes the development of nurse-patient relationship in a more harmonious, efficient and humanized direction.

5. Analysis of application prospects of nursing robots in clinical nursing under the background of embodied intelligence

5.1. Continuous breakthroughs in core technologies and significant improvement in core performance

With the rapid development of advanced technologies such as artificial intelligence technology, robot technology, and sensor technology, the technical bottlenecks of embodied intelligent nursing robots will be gradually broken, and their main performances will also be significantly improved. The continuous improvement of multi-sensor data fusion technology enables robots to accurately perceive complex nursing environments and patients' conditions, well solve the interference problems caused by ambient light, noise, etc., and improve the reliability of perception results [8]. The research and application of new sensors will further expand the robot's perception range of patients, enabling the robot to have a more accurate grasp of patients' physiological conditions and emotional changes. The update of tactile sensors can enable robots to have better perception capabilities of patients' skin pressure, temperature, etc., thereby improving the safety and comfort of nursing actions.

Specifically, in terms of autonomous decision-making technology, with the continuous optimization of algorithms such as deep learning and reinforcement learning, embodied intelligent nursing robots will also have richer clinical nursing knowledge and experience. When complex nursing situations arise, the robot can solve problems with good adaptive capacity and emergency response capabilities [9]. For example, the robot will independently adjust the nursing plan according to changes in the patient's condition and nursing environment to achieve personalized decision-making and precise nursing.

5.2. Continuous expansion of application scenarios and improvement of nursing service levels

In the future, the application scenarios of embodied intelligent nursing robots will continue to expand, gradually developing from the current basic nursing, rehabilitation nursing and other scenarios to specialized

nursing, home nursing, community nursing and other directions. In the field of specialized nursing, embodied intelligent nursing robots will design corresponding nursing functions according to the needs of various specialized nursing, so as to achieve the precision and standardization of specialized nursing. For example, in pediatric nursing, robots will provide nursing services through gentler interaction methods and more accurate nursing actions to adapt to the physiological and psychological characteristics of child patients; in intensive care units, robots will conduct 24/7 uninterrupted monitoring and nursing of critically ill patients, so as to timely detect changes in patients' conditions and gain time for treatment [10].

In home nursing, embodied intelligent nursing robots will become the main support force for home care, providing door-to-door nursing services such as vital sign monitoring, daily care, and rehabilitation training for the elderly, the disabled and other people with limited mobility, enabling patients to receive high-quality nursing services without leaving home, improving patients' quality of life and reducing the family's nursing pressure [11]. In community nursing, embodied intelligent nursing robots will work in community health service centers to provide community residents with health monitoring, preventive health care, rehabilitation nursing and other services, realizing that minor illnesses can be treated in the community, major illnesses can be detected and treated early, improving the allocation of community medical resources and the level of community nursing services.

5.3. Gradual improvement of ethical norms and strengthening of policy guarantee support

In terms of ethical norms, relevant government departments will formulate specific ethical guidelines to define the ethical boundaries of embodied intelligent nursing robots and regulate the application behaviors of robots, so as to protect patients' privacy and rights and interests. Clearly stipulate the privacy protection requirements involved in all links of robot data collection, storage, transmission, and use, and establish and improve the patient privacy protection mechanism; clarify the subject of responsibility assumed by robots in the process of clinical nursing and the responsibility boundary of robots in the process of clinical nursing, so as to avoid the problem of vague responsibility [12]. At the same time, by strengthening the research and publicity of robot ethics, enable the public to correctly understand the ethical issues in the application of embodied intelligent nursing robots and establish a correct application ethics concept.

In terms of policy guarantee, relevant government departments will introduce policies to support embodied intelligent nursing robots, increase support for robot R&D, production, application, etc., and promote the technological breakthrough and industrialization development of robots. Establish robot access standards and supervision mechanisms, regulate the robot market order, and ensure the safety and quality of robot products [13]. Formulate access standards for robot technical parameters, performance indicators, safety requirements, etc., implement strict testing and certification for robot products, establish a normalized supervision system, supervise and manage the robot application process, and timely discover and solve problems.

5.4. Deepening of human-robot collaboration model and realization of complementary nursing advantages

In the future, embodied intelligent nursing robots will not be tools to replace human nursing staff, but will work with human nursing staff to give play to their respective advantages and jointly improve the quality and efficiency of clinical nursing services. Embodied intelligent nursing robots will take on basic nursing

work such as vital sign monitoring, drug delivery, and daily care, allowing nursing staff to have more time to use human professional judgment and humanistic care to make up for the shortcomings of robots [14]. At the same time, with the development of embodied intelligence technology, robots will better understand the intentions of nursing staff and can seamlessly collaborate with nursing staff. Nursing staff can use natural language instructions to control robots to complete nursing work, and robots can also immediately feedback the situations occurring during the nursing process to nursing staff, thereby providing support for nursing staff's decision-making. For example, in chronic disease management, robots can regularly remind patients to take medication, monitor indicators such as blood sugar and blood pressure and generate trend reports, while nursing staff provide patients with personalized health guidance and psychological support based on the reports, realizing long-term and continuous health care for patients.

In addition, the development of multi-robot collaboration technology will enable multiple robots to collaborate to complete complex nursing tasks. For example, in large-scale surgeries, three nursing robots can be arranged to be responsible for the accurate delivery and sterile management of surgical instruments, real-time monitoring of patients' intraoperative vital signs and dynamic early warning, and preliminary cleaning and position adjustment of postoperative patients, forming an efficient surgical nursing cooperation chain and achieving a nursing effect of "1 + 1 > 2" [15].

6. Conclusion

In summary, with the continuous breakthroughs in core technologies of embodied intelligence, the continuous expansion of application scenarios, the gradual improvement of ethical norms, and the deepening of human-robot collaboration models, embodied intelligent nursing robots will gradually achieve deep integration with clinical nursing, transforming from "auxiliary nursing" to "precision nursing and personalized nursing". They will become an important supporting force in the field of clinical nursing, promoting the intelligent and humanized transformation of medical and nursing models, and providing strong support for the development of China's health cause.

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Problems and Solutions in the Training of Pediatric Clinical Skills for Undergraduate Medical Students

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Abstract: Undergraduate students majoring in clinical medicine are one of the important reserve forces of clinical doctors in China, and their pediatric clinical skills are directly related to their future clinical practice quality and the diagnosis and treatment safety of children. At present, there are still some deficiencies in the training of pediatric clinical skills for undergraduate medical students, which restrict the effect of skill training and are difficult to meet the needs of pediatric clinical diagnosis and treatment positions. Focusing on four dimensions—teaching model, teaching resources, student learning, and assessment and incentive—this paper analyzes the existing problems in the training of pediatric clinical skills for undergraduate medical students and puts forward targeted solutions, aiming to provide references for optimizing the pediatric clinical skill training system and improving the pediatric clinical practice ability of undergraduate medical students.

Keywords: Undergraduate medical students; Pediatrics; Clinical skill training; Problems; Solutions

Online publication: Apr 30, 2026

1. Introduction

In recent years, the supply of children's medical resources and service level in China have been continuously improved. According to data from the National Health Commission, although the number of pediatricians nationwide has increased from 110,000 in 2015 to 205,800 in 2024, a growth of 74.4%, there is still a large talent gap. With the growth of people's demand for pediatric medical services, it has become particularly important to cultivate the pediatric clinical skills of undergraduate medical students. Pediatric work is characterized by difficulty in examination, communication, and diagnosis. Unlike adults, children, especially infants, are prone to crying when ill and cannot clearly describe their symptoms in words. In addition, many indicators and medications are different from those for adults, which put forward higher requirements for doctors' communication skills, clinical thinking, and clinical skills. Existing studies have carried out a lot of explorations around the training of pediatric clinical skills, integrating Problem-Based Learning (PBL),

Case-Based Learning (CBL), SOAP medical record analysis method, Mini-Clinical Evaluation Exercise (Mini-CEX), formative evaluation, etc., into the training system, providing references for the training of pediatric clinical skills [1–4]. Therefore, in-depth analysis of the problems in the training of pediatric clinical skills for undergraduate medical students and the formulation of targeted solutions are of great significance for improving the clinical practice ability of medical students, expanding the team of pediatric talents, and alleviating the contradiction between supply and demand of children's medical services.

2. Existing problems in the training of pediatric clinical skills for undergraduate medical students

Based on the results of literature research and clinical teaching surveys, the problems in the training of pediatric clinical skills for undergraduate medical students are mainly concentrated in four aspects: teaching model, teaching resources, student learning, and assessment and incentive.

2.1. Outdated teaching model and insufficient interactive practice

At present, some pediatric clinical teaching still adopts the traditional model [5]. During the training process, due to the heavy clinical work and limited teaching time of teachers, it is difficult for them to spend a lot of energy innovating the teaching model. About 78.3% of pediatric clinical skill teaching is mainly based on "lecture + demonstration". In clinical practice, teachers are usually in the state of lecturing or demonstrating the whole time, failing to create sufficient interactive and practical opportunities, resulting in low learning interest of students [6].

2.2. Shortage of teaching resources and improper case selection

The supply of pediatric clinical teaching resources is insufficient. On the one hand, affected by factors such as children's young age, low cooperation degree, and parents' anxiety, pediatric clinical practice resources are scarce, and about 62.7% of students find it difficult to obtain clinical practical operation opportunities [7]. On the other hand, some teachers focus on theoretical knowledge, fail to select clinical cases reasonably, and their explanations are not detailed and thorough enough, which limits the effect of students' clinical skill improvement [1,8].

2.3. Low student initiative and weak basic knowledge

Some undergraduate medical students do not attach importance to the learning of pediatric clinical skills. In clinical practice, some students have a sense of difficulty and rely too much on teachers. About 41.8% of students only observe the operation of senior physicians without practicing themselves, leading to frequent problems in independent operations [5,9]. At the same time, students' mastery of pediatric knowledge is not solid. Pediatric diseases are mostly concurrent, and various problems will be encountered in clinical work. However, about 68.5% of students have a vague impression of knowledge, unclear diagnostic ideas for common pediatric diseases and symptoms, and it is difficult for them to accurately observe and diagnose diseases [10,11].

2.4. Insufficient assessment and incentive, low proportion of practical investigation

The assessment and incentive mechanism are not perfect, making it difficult to play a guiding role. In terms

of assessment content, theoretical written tests and standardized assessment of skill operations account for a high proportion, and only 27.4% of the assessment involves clinical practice application, emergency disposal, and communication skills [4,12]. The incentive mechanism is lacking, and there are few clear rewards for students with excellent skills. About 64.3% of students with weak skills do not receive targeted help. The assessment results have little correlation with students' evaluation of excellence and employment, making it difficult to mobilize learning enthusiasm [9].

3. Solutions to the problems in the training of pediatric clinical skills for undergraduate medical students

Adhering to the principle of "problem-oriented and precise policy implementation", the following solutions are proposed for the above problems:

3.1. Innovate teaching models and break the limitations of traditional lecture-demonstration combination

Based on the characteristics of pediatric clinical skill training, introduce a variety of advanced teaching methods, promote the innovation of teaching models, and realize the deep integration of theory and practice, teaching and clinical practice.

(1) Promote the blended teaching model and enrich teaching methods

Construct a "CBL-PBL-Seminar" blended teaching model, combining Case-Based Learning (CBL), Problem-Based Learning (PBL), and Seminar teaching [8]. Taking clinical practical cases as the carrier, put forward pediatric diagnosis and treatment-related problems, guide students to think actively, discuss in groups, and independently explore solutions to cultivate clinical thinking and teamwork ability. At the same time, combine situational teaching method to simulate common clinical scenarios such as children with febrile convulsions and crying, allowing students to participate in the diagnosis and treatment process immersively and improve emergency disposal ability [1].

(2) Promote the deep integration of theory and practice and strengthen practical teaching

Adjust the teaching arrangement, increase the proportion of clinical practice class hours, and carry out theoretical teaching and clinical practice simultaneously [13]. When teaching pediatric physical examination and other skills, combine clinical internship cases to allow students to directly operate on children under the guidance of teachers, realizing the transformation of theoretical knowledge into practical ability [14]. Introduce the cross-integration model of SOAP medical record analysis method and Mini-CEX, allowing students to analyze cases according to the process of "Subjective data–Objective data–Assessment–Plan", and improve clinical skills and diagnostic thinking simultaneously through Mini-Clinical Evaluation Exercise [3].

(3) Strengthen interactive teaching and personalized guidance

Adopt the group teaching model to increase interaction opportunities between teachers and students, and among students, encouraging students to ask questions actively and try operations boldly [6]. According to students' mastery of skills, teachers use online platforms to push case resources and teaching videos, carry out personalized teaching, focus on guiding students with weak foundations, and put forward higher requirements for students with excellent skills to meet their needs for review and consolidation and independent improvement, making up for the deficiencies of classroom teaching [8].

3.2. Improve teaching resources and strengthen the connection with clinical practice cases

Focus on the root causes of problems, optimize from three dimensions: technology empowerment, case construction, and teacher support, and effectively solve the problems of insufficient practical opportunities and unsystematic skill learning for students.

(1) Virtual technology empowerment and simulated practice

Increase the application of virtual simulation education, introduce standardized child patient models to simulate the physical structure, pathological function, pathological manifestations and evolution of children, allowing students to practice repeatedly in a simulated environment to improve clinical skills [4]. Continuously introduce virtual standardized child patients with different degrees and conditions, expand the coverage of cases, and ensure that simulated training is in line with clinical reality.

(2) Cross-hospital resource integration and joint construction of case databases

Relying on big data and artificial intelligence technology, cooperate with pediatric departments of other hospitals in the region to co-construct and share the "intelligent clinical teaching case database of pediatrics", break down data barriers among hospitals, dynamically integrate the latest pediatric clinical cases, and build a quality review system of intelligent preliminary review + expert re-examination to ensure that the case quality meets the standards. Driven by data, a large number of clinical resources are updated in real time and transformed and applied in clinical teaching scenarios, facilitating students to practice operational skills and key points in combination with cases [8].

(3) Optimize teacher management and improve teaching quality

Regularly carry out teaching training and seminars, formulate systematic training plans, discuss case selection directions, enrich case types, and improve teaching guidance ability [6]. Establish an assessment mechanism, link teaching quality and teaching integrity with professional title promotion and evaluation of excellence, encourage teachers to communicate with students, collect demands and opinions, and continuously improve teaching methods [9].

3.3. Strengthen student guidance and improve learning initiative and clinical operation thinking

In view of students' low initiative, weak basic knowledge, and insufficient disease diagnosis ability, strengthen guidance and training to stimulate learning motivation and improve clinical thinking and diagnosis ability.

(1) Strengthen ideological guidance and stimulate learning initiative

Carry out professional quality education in pediatric medicine, let students realize the importance of pediatric clinical skills, establish a patient-centered professional philosophy, and reduce the sense of difficulty [5,9]. Combine typical pediatric clinical cases to let students understand the responsibilities and missions of pediatricians, stimulate learning interest, and establish study groups to encourage students to explain basic theoretical knowledge to each other, creating a good learning atmosphere [10].

(2) Strengthen disease diagnosis and treatment training and improve diagnosis ability

Increase the teaching of diagnosis and treatment standards for common and frequently occurring pediatric diseases, allowing students to proficiently master the symptoms, signs, diagnostic standards, and treatment principles of common diseases [9,10]. Through simulated diagnosis and treatment, case discussions, and other methods, let students practice the process of disease judgment and diagnosis

repeatedly to improve observation ability and accuracy; implement the SP combined with CBL model, where standardized patients simulate children's symptoms, allowing students to complete consultation, inquiry, physical examination, and diagnosis, and improve clinical diagnosis ability and communication ability simultaneously [15].

(3) Strengthen the cultivation of clinical thinking and improve practical ability

Pay attention to the cultivation of clinical thinking in skill teaching, guide students to combine skill operations with children's conditions and physiological characteristics. For example, in intravenous puncture training, guide students to select appropriate puncture sites and methods according to children's age, vascular conditions, and disease status [10,11]. Introduce evidence-based medicine teaching method to guide students to analyze diagnosis and treatment plans in combination with clinical evidence, improving the scientificity of clinical thinking [11].

3.4. Optimize the assessment and incentive mechanism and strengthen the investigation of clinical practice application ability

In view of the insufficient assessment and incentive and the neglect of the investigation of clinical practice application ability, optimize the assessment content and methods, improve the incentive mechanism, and give play to the guiding role of assessment.

(1) Optimize assessment content and highlight clinical practice application ability

Adjust the assessment content, reduce the proportion of theoretical written tests, and increase the proportion of assessment of clinical practice application, emergency disposal, and communication skills [4,12]. The assessment content is closely combined with clinical reality, selecting common clinical skill operations and case diagnosis as key points, such as adding emergency disposal of children with febrile convulsions, intravenous puncture operation, and case diagnosis, to ensure that the assessment can truly reflect students' clinical skill level [3].

(2) Innovate assessment methods and improve process-oriented assessment

Establish a model combining process-oriented assessment and summative assessment [3,4]. Process-oriented assessment runs through the entire internship period, covering skill training performance, case analysis ability, and teachers' evaluation, conducting regular assessments to timely find deficiencies and provide targeted guidance; summative assessment adopts practical operation assessment and case defense to comprehensively investigate comprehensive clinical skills; refine assessment evaluation standards to reduce subjective arbitrariness and ensure fair and objective assessment [12].

(3) Improve the incentive mechanism and mobilize learning enthusiasm

Establish and improve the incentive mechanism, give commendations and rewards to students with excellent skills, link assessment results with evaluation of excellence and employment recommendation, and stimulate learning motivation [9]. Formulate personalized assistance plans for students with weak skills, with key guidance from teachers, encouragement and support to enhance learning confidence. Establish a pediatric clinical skill competition mechanism to promote learning and practice through competitions, and comprehensively improve students' clinical skill level [4].

4. Conclusion

In summary, strengthening the training of pediatric clinical skills for undergraduate medical students is

crucial to enhancing students' comprehensive abilities and post competency, and improving the level of pediatric medical services. Therefore, great attention should be paid to focusing on the problems in the training of pediatric clinical skills for undergraduate medical students and forming reasonable solutions targeting the root causes of the problems. Solve the problem of outdated teaching models by innovating blended teaching models and promoting the integration of theory and practice; solve the problem of shortage of teaching resources by introducing advanced technologies, enriching case resources, and strengthening teacher training; solve the problem of students' insufficient initiative and ability by strengthening ideological guidance, cultivating clinical thinking, and enhancing diagnosis training; solve the problem of insufficient assessment and incentive by optimizing assessment content, innovating assessment methods, and improving the incentive mechanism. In the future, teachers should actively introduce advanced methods and technologies into clinical teaching, further stimulate students' learning interest, fully cultivate their clinical practice ability, and promote the high-quality development of clinical education.

Disclosure statement

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Clinical Study on Traditional Chinese Medicine Syndrome Differentiation-Based Comprehensive Regimen for Migraine Treatment: Observation of Clinical Efficacy and Exploration of 5-HT/CGRP Regulatory Mechanism

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Abstract: This study systematically investigates the clinical efficacy of traditional Chinese medicine (TCM) syndrome differentiation intervention for migraine and its neuroendocrine regulatory mechanism, aiming to provide evidence-based medical support for optimizing clinical diagnosis and treatment strategies for this disease. A total of 120 migraine subjects meeting the inclusion criteria were randomly assigned in a 1:1 ratio to the experimental group and the control group (60 cases each). The experimental group received individualized TCM compound prescription combined with filiform needle acupuncture based on four types identified by four diagnostic methods: hyperactivity of liver Yang, deficiency of both Qi and blood, internal obstruction of phlegm-turbidity, and obstruction of collaterals by blood stasis. The control group was treated with oral flunarizine hydrochloride capsules. The intervention period was 12 weeks, and follow-up observations were extended to the end of the 9th month, with dynamic collection of efficacy endpoints and safety indicators in both groups. Efficacy data showed that the total effective rate of the TCM intervention group was 91.67%, which was significantly higher than 76.67% of the control group, with a statistically significant difference ($p < 0.05$). At 3 and 6 months of treatment, the TCM treatment group exhibited more significant improvements in Numerical Rating Scale (NRS) scores, migraine attack frequency, and single attack duration; the increase in serum 5-hydroxytryptamine (5-HT) level and the decrease in calcitonin gene-related peptide (CGRP) level were also significantly superior to those in the control group ($p < 0.05$). The study concludes that TCM treatment based on syndrome differentiation for migraine has definite and reliable clinical efficacy, which can effectively relieve clinical symptoms and reduce attack frequency. Its mechanism of action may be related to regulating 5-HT/CGRP balance, improving vascular function, and inhibiting neurogenic inflammation. This treatment regimen has good clinical safety with no obvious adverse reactions and possesses practical value for extensive promotion.

Keywords: Migraine; TCM syndrome differentiation; Clinical efficacy; Mechanism of action; Acupuncture therapy

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1. Introduction

Migraine is a common chronic neurovascular disorder in neurology and traditional Chinese medicine (TCM) clinics. It typically presents as recurrent unilateral throbbing headache, often accompanied by nausea, vomiting, photophobia, phonophobia, or visual aura. This disorder severely impairs patients' work, quality of life, and physical and mental health. With a global prevalence of about 14.8%, migraine is the second leading cause of disability worldwide and ranks first among adults under 50 years old. Its high incidence and recurrence also increase the public health burden.

The pathogenesis of migraine remains unclear in modern medicine. Core pathological mechanisms involve overactivation of the trigeminovascular system, neurotransmitter disorders, cortical spreading depression, and neurogenic inflammation. Western medicine focuses on acute analgesia and prophylactic treatment: NSAIDs and triptans for acute attacks, and calcium channel blockers, β-blockers, or CGRP antagonists for prevention. However, long-term use often causes adverse reactions (gastrointestinal discomfort, drowsiness, weight gain) and may lead to medication-overuse headache, with unsatisfactory long-term efficacy and safety.

In TCM, migraine is categorized as "headache", "migratory wind" or "brain wind" [1]. Its etiology is linked to dysfunctions of the liver, spleen, and kidney, characterized by Qi-blood disturbance, meridian obstruction, and malnutrition of the brain marrow, manifesting as "pain due to obstruction" or "pain due to insufficiency". TCM treatment follows the holistic concept and syndrome differentiation, identifies patterns via the four diagnostic methods, and delivers individualized therapy [2]. Compared with Western medicine, TCM has unique advantages in relieving pain, lowering recurrence, improving accompanying symptoms, and has fewer adverse reactions, making it suitable for long-term management.

With advances in molecular biology, research on TCM for migraine has deepened [3]. Studies confirm that TCM regulates the neuro-endocrine-immune network through multi-target and multi-pathway effects to treat both symptoms and root causes. Based on clinical experience, we performed a randomized controlled trial to compare the efficacy of TCM syndrome differentiation-based comprehensive therapy with conventional Western medicine for migraine, explore its mechanism in regulating neurotransmitters and vasoactive substances, and provide evidence-based evidence for TCM in migraine management, to promote standardized application and clinical practice [4].

2. TCM syndrome differentiation types and clinical characteristics

Based on long-term clinical practice, TCM syndrome differentiation for migraine focuses on distinguishing root from manifestation, deficiency from excess, and identifying the core pathologies: pain due to obstruction and pain due to malnutrition. By integrating symptoms, signs, tongue/pulse features, and medical history, four major syndromes are identified: hyperactivity of liver Yang, Qi-blood deficiency, phlegm-turbidity obstruction, and blood stasis blocking collaterals. Some patients present with combined syndromes (e.g., hyperactivity of liver Yang plus phlegm-turbidity obstruction). Flexible adjustments to differentiation and treatment are required to achieve individualized therapy via treating the same disease with different methods.

2.1. Hyperactivity of liver Yang syndrome

This is the most common migraine syndrome, prevalent in middle-aged women and those with frequent emotional swings [5]. It arises from emotional distress, liver Qi stagnation turning to fire, or liver-kidney Yin

deficiency failing to nourish liver Yang. Typical manifestations: severe distending or throbbing headache at the vertex or temporal sides, worsened by emotion, fatigue, late nights, or alcohol intake; accompanied by dizziness, flushed face, irritability, bitter mouth, dry throat, insomnia, tinnitus, or hypochondriac distension; tongue is red with thin yellow coating, pulse is wiry-rapid or wiry-slippery.

The core pathogenesis is hyperactive liver Yang disturbing the upper orifices and obstructing meridians. It should be distinguished from liver Yin deficiency. Treatment focuses on calming liver Yang, nourishing Yin to calm liver, and unblocking collaterals for pain relief, using modified Tianma Gouteng Decoction combined with liver-soothing herbs to prevent further hyperactivity [6].

2.2. Deficiency of Qi and blood syndrome

This syndrome is common in weak, chronically ill, middle-aged and elderly patients. It results from spleen injury due to anxiety, insufficient Qi-blood production, or Qi-blood depletion from severe illness or overstrain. Typical manifestations: dull or empty headache, mild but persistent, aggravated by fatigue and relieved by rest; accompanied by dizziness, sallow complexion, lassitude, shortness of breath, poor appetite, palpitations, insomnia, amnesia; female patients may have weakness and scanty pale menstruation. The tongue is pale with white coating, and the pulse is thready and weak.

The core pathogenesis is Qi-blood deficiency failing to nourish the brain and meridians, belonging to "pain due to malnutrition". It requires differentiation between Qi deficiency and blood deficiency. Treatment focuses on replenishing Qi, nourishing blood, invigorating the spleen, tonifying the kidney, and nourishing the brain. Modified Buzhong YiQi Decoction or Siwu Decoction is applied with flexible dosage adjustment [7].

2.3. Obstruction by phlegm-turbidity syndrome

This syndrome mainly affects patients with unhealthy diets and obesity, caused by excessive rich, greasy food, alcohol, or cold intake leading to phlegm-dampness formation. Spleen-stomach dysfunction causes water-dampness retention and phlegm-turbidity accumulation, which disturbs the upper orifices and induces headache.

Typical symptoms: heavy, clouding headache with no fixed site, lingering and refractory; accompanied by abdominal distension, nausea, vomiting, poor appetite, heavy limbs, loose stools, sticky mouth, thick greasy tongue coating, and soft-slippery pulse.

The core pathogenesis is phlegm-turbidity obstructing meridians and clouding orifices, belonging to "pain due to obstruction". It should be differentiated from damp-heat syndrome. Treatment focuses on resolving phlegm, descending rebellion, invigorating the spleen, eliminating dampness, and unblocking collaterals to relieve pain. Modified Banxia Baizhu Tianma Decoction is used to address the root cause [8].

2.4. Obstruction of collaterals by blood stasis syndrome

This syndrome is common in chronic migraine and head trauma patients, caused by prolonged pain invading collaterals, Qi stagnation and blood stasis, or traumatic blood stasis blocking brain collaterals and impairing Qi-blood flow. Typical manifestations: fixed, stabbing or cutting headache worsening at night; dark complexion, purplish tongue with petechiae, sublingual varices, limb numbness, or amnesia; pulse is hesitant or wiry-tense.

The core pathogenesis is blood stasis blocking brain vessels, belonging to "pain due to obstruction". Persistent stasis may consume Qi and blood, leading to a mixed deficiency-excess pattern. New vs. old

blood stasis requires differentiation. Treatment focuses on activating blood, resolving stasis, and unblocking collaterals for pain relief, using modified Tongqiao Huoxue Decoction plus blood-nourishing herbs to protect healthy Qi.

3. Observation of clinical efficacy

3.1. Research subjects

A total of 120 migraine patients meeting the relevant diagnostic criteria were selected as research subjects in this study. All enrolled patients met the requirements of the International Classification of Headache Disorders (ICHD) 2018 Diagnostic Criteria for Migraine, and secondary headache caused by organic lesions such as intracranial tumors and cerebrovascular diseases was excluded by cranial CT or MRI examination; at the same time, all the above patients were diagnosed as one of the four syndrome types: hyperactivity of liver Yang syndrome, deficiency of Qi and blood syndrome, obstruction by phlegm-turbidity syndrome, and obstruction of collaterals by blood stasis syndrome through comprehensive four diagnostic methods by the authors and senior TCM physicians in the department.

3.1.1. Inclusion criteria

(1) Age 18–65 years old, gender unlimited;
(2) Migraine attack frequency ≥ 2 times/month, each attack duration ≥ 4 hours, disease course ≥ 1 year;
(3) Poor previous efficacy of Western medicine treatment or unwillingness to take Western medicine for a long time;
(4) No serious primary pathological changes in heart, liver, kidney and hematopoietic system;
(5) Patients were informed of the research situation and signed informed consent, able to cooperate with the whole course of treatment and follow-up work, with good compliance.

3.1.2. Exclusion criteria

(1) Patients with severe heart, liver, renal insufficiency or hematopoietic system diseases, and mental diseases;
(2) Pregnant or lactating women;
(3) Those with known allergy to research drugs (flunarizine hydrochloride) or TCM intervention measures (TCM, acupuncture);
(4) Patients complicated with other severe types of headache (such as cluster headache, tension headache, etc.);
(5) Those expected to be unable to ensure treatment compliance, difficult to complete the scheduled course of treatment and follow-up observation, or likely to terminate the research in advance;
(6) Those who have taken relevant drugs affecting efficacy (such as other analgesics, antidepressants) recently.

3.2. Research grouping

A total of 120 eligible patients were randomly divided into TCM treatment group and control group by random number table method, with 60 subjects in each group. Among them, the TCM treatment group included 22 males and 38 females; the age range of patients was 20 to 63 years old, with an average age

of (41.5 ± 8.2) years old. The disease course was 1–12 years, with an average disease course of (5.8 ± 2.3) years; the syndrome type distribution was: 18 cases of hyperactivity of liver yang syndrome, 16 cases of deficiency of Qi and blood syndrome, 14 cases of obstruction by phlegm-turbidity syndrome, and 12 cases of obstruction of collaterals by blood stasis syndrome. The control group included 24 males and 36 females; aged 19–65 years old, with an average age of (42.1 ± 7.9) years old; disease course 1–11 years, average disease course (5.6 ± 2.1) years; syndrome type distribution: 17 cases of hyperactivity of liver Yang syndrome, 15 cases of deficiency of Qi and blood syndrome, 15 cases of obstruction by phlegm-turbidity syndrome, and 13 cases of obstruction of collaterals by blood stasis syndrome.

Statistical analysis of baseline data such as age, gender, disease course, and syndrome type distribution of the two groups showed that there was no statistically significant difference between the groups ($p > 0.05$), indicating that the two groups had good comparability and could ensure the objectivity and reliability of subsequent treatment effect comparison.

3.3. Treatment methods

Both groups took 3 months as a course of treatment, followed up for 6 months after completing the course. During treatment, all patients were informed to avoid migraine inducing factors (such as spicy and stimulating diet, strong light, noise, staying up late, emotional fluctuation, etc.), keep regular work and rest, and exercise appropriately.

3.3.1. Control group

Patients in the control group were treated with oral flunarizine hydrochloride capsules, produced by Xi'an Janssen Pharmaceutical Co., Ltd., with a specification of 5mg per capsule. The administration regimen was set as: take once 30 minutes before going to bed every night, 5 mg each time, for 3 consecutive months. In the follow-up stage, if patients had acute migraine attacks, they could take oral ibuprofen sustained-release capsules (0.3 g each time) temporarily to relieve pain, but the frequency of medication should be strictly controlled, no more than 2 times a week, to prevent interference with the efficacy evaluation of this study.

3.3.2. TCM treatment group

Based on the results of syndrome differentiation, comprehensive treatment of "oral modified TCM compound prescription + acupuncture" was adopted, and the regimen was flexibly adjusted according to patients' constitution and symptoms, as follows:

(1) Oral modified TCM compound prescription

The corresponding basic prescription was selected according to the syndrome differentiation results, and the type and dosage of drugs were adjusted according to patients' specific symptoms, constitution and age. One dose per day, uniformly decocted by the TCM pharmacy of our hospital, 400 mL of water decoction, taken warm three times in the morning, noon and evening (half an hour after meals to avoid gastrointestinal irritation), for 3 consecutive months. ① Hyperactivity of liver Yang syndrome: Modified Tianma Gouteng Decoction, basic drug composition: *Gastrodia elata* 12 g, *Uncaria rhynchophylla* 15 g (decocted later), *Haliotis discus hannai* 30 g (decocted first), *Achyranthes bidentata* 15 g, *Eucommia ulmoides* 12 g, *Angelica sinensis* 12 g, *Paeonia lactiflora* 15 g, *Poria cocos* 15 g, *Leonurus japonicus* 12 g, *Glycyrrhiza uralensis* 6 g; if patients had obvious bitter mouth,

Scutellaria baicalensis 10 g and *Gentiana scabra* 6 g could be added to clear liver fire; if patients had obvious dizziness, *Chrysanthemum morifolium* 10 g and *Cassia obtusifolia* 15 g could be added to calm liver and improve eyesight. ② Deficiency of Qi and blood syndrome: Modified Buzhong Yiqi Decoction for syndrome differentiation treatment, basic drug composition: *Astragalus membranaceus* 20 g, *Codonopsis pilosula* 15 g, *Atractylodes macrocephala* 12 g, *Angelica sinensis* 12 g, *Rehmannia glutinosa* 15 g, *Paeonia lactiflora* 12 g, *Ligusticum chuanxiong* 10 g, *Citrus reticulata* 10 g, *Cimicifuga foetida* 6 g, *Bupleurum chinense* 6 g, *Glycyrrhiza uralensis* 6 g; add *Ziziphus jujuba* 15 g and *Longan arillus* 12 g for those with palpitations and insomnia to nourish blood and soothe nerves; add *Massa Medicata Fermentata* 12 g and *Hordeum vulgare* 15 g for those with poor appetite to promote digestion and accumulation; elderly patients appropriately increase the dosage of *Astragalus membranaceus* and *Codonopsis pilosula* (add 5 g each) to enhance the effect of replenishing Qi. ③ Obstruction by phlegm-turbidity syndrome: Modified Banxia Baizhu Tianma Decoction for treatment, basic drug composition: *Pinellia ternata* 12 g, *Atractylodes macrocephala* 15 g, *Gastrodia elata* 12 g, *Poria cocos* 15 g, *Citrus reticulata* 12 g, *Glycyrrhiza uralensis* 6 g, *Zingiber officinale* 3 slices. Add *Bambusae Caulis* in Taeniam 10 g and *Aurantii Fructus Immaturus* 10 g for those with severe nausea and vomiting to resolve phlegm and descend rebellion; add *Coix lacryma-jobi* 30 g and *Atractylodes lancea* 12 g for those with heavy limbs to invigorate spleen and eliminate dampness; add *Pogostemon cablin* 10 g and *Eupatorium fortunei* 10 g for those with sticky mouth to aromatize turbidity. ④ Obstruction of collaterals by blood stasis syndrome: Modified Tongqiao Huoxue Decoction as the base prescription, basic prescription composition: *Ligusticum chuanxiong* 15 g, Peach Seed 12 g, Safflower 10 g, *Paeonia veitchii* 12 g, *Angelica sinensis* 12 g, *Trichosanthes kirilowii* 12 g, *Gallus gallus domesticus* 10 g, *Allium fistulosum* 3 segments, *Zingiber officinale* 3 slices, Vinegar 10 mL (taken by water); add *Corydalis yanhusuo* 12 g, Frankincense 10 g, Myrrh 10 g for those with severe headache to activate blood circulation and relieve pain; add *Salvia miltiorrhiza* 15 g and Hirudo 6 g (taken by water) for those with obvious sublingual varicose veins to promote blood circulation and remove blood stasis; add *Rehmannia glutinosa* 15 g and *Colla Corii Asini* 10 g (melted by decoction) for those with obvious blood deficiency to nourish blood and promote blood circulation [9].

(2) Acupuncture treatment

Main acupoints selected were Baihui (GV20), Fengchi (GB20), Taiyang (EX-HN5), Hegu (LI4), Zusanli (ST36), and corresponding matching acupoints were selected according to syndrome differentiation results. Operated by senior acupuncturists in our hospital, once a day, 30 minutes of needle retention each time, using 0.30 × 25 m1m filiform needles, routine disinfection before acupuncture, uniform reinforcing and reducing method after obtaining Qi. The treatment was carried out 5 times a week with 2 days of rest, for 3 consecutive months of standardized treatment to ensure the continuity and effectiveness of the intervention regimen. ① Hyperactivity of liver Yang syndrome: add Ganshu (BL18) and Taichong (LR3), reducing method at Taichong (LR3) to enhance the effect of calming liver and subduing Yang; ② Deficiency of Qi and blood syndrome: add Pishu (BL20), Shenshu (BL23), Sanyinjiao (SP6), reinforcing method to replenish Qi and nourish blood, and nourish brain orifices; ③ Obstruction by phlegm-turbidity syndrome: add Zhongwan (CV12) and Fenglong (ST40), reducing method to resolve phlegm and descend rebellion, invigorate spleen and eliminate dampness; ④ Obstruction of collaterals by blood stasis syndrome: add Xuehai (SP10) and Geshu (BL17), reducing

method to promote blood circulation to remove blood stasis and unblock collaterals to relieve pain. During acupuncture, closely observe patients' complexion and chief complaints, adjust stimulation intensity in time to avoid adverse reactions such as fainting, bending, and stagnation of needles. If patients have needle fainting, stop acupuncture immediately, instruct patients to lie flat and rest, drink warm water, and continue treatment after symptoms are relieved.

(3) Auxiliary intervention

Combined with the TCM holistic conditioning concept, targeted emotional regulation and dietary guidance were given according to patients' syndrome types during treatment. Patients with hyperactivity of liver Yang syndrome focused on emotional counseling, instructed to avoid emotional excitement, and regulate emotions by listening to soothing music, meditation, walking, etc.; patients with deficiency of Qi and blood syndrome and obstruction by phlegm-turbidity syndrome focused on dietary conditioning, avoiding rich, greasy, raw and cold food, and eating more food for invigorating spleen and replenishing Qi, light and easy to digest (such as millet porridge, Chinese yam, red dates, etc.); all patients kept regular work and rest, avoided staying up late, and appropriately took mild exercises such as Tai Chi and walking to enhance physical fitness and improve blood circulation.

3.4. Observation indicators

The indicators of the two groups were evaluated before treatment (baseline), at 3 months of treatment (end of course), and at 6 months of treatment (end of follow-up), including the following three categories. All indicators were detected and recorded by special personnel to ensure data accuracy.

3.4.1. Main efficacy indicators

(1) Headache attack frequency (times/month);

(2) Single attack duration (h);

(3) Pain intensity: quantitatively evaluated by NRS (Numerical Rating Scale, 0–10 points), 0 point means no pain, 10 points means extremely severe pain, self-evaluated by patients.

3.4.2. Secondary efficacy indicators

This study evaluated patients' quality of life from 8 dimensions: physical function, role physical, bodily pain, general health, vitality, social function, role emotional, and mental health. The evaluation tool adopted the SF-36 scale, with a total score of 0–100 points. The higher the score, the better the patients' quality of life. The test was carried out in strict accordance with standardized procedures to control measurement bias.

3.4.3. Biomarker indicators

5 mL of fasting venous blood was collected from patients, centrifuged (3000 r/min, 10 minutes) to separate serum. Serum 5-HT and CGRP levels were detected by enzyme-linked immunosorbent assay (ELISA). The detection kits were purchased from Shanghai Enzyme-linked Biotechnology Co., Ltd., and operated in strict accordance with the kit instructions. All detections were completed in the Clinical Laboratory of our hospital to ensure reliable detection results.

3.5. Efficacy evaluation criteria

With reference to the Standards for Diagnosis and Efficacy of TCM Diseases and clinical diagnosis and

treatment practice, combined with the improvement degree of migraine attack frequency, attack duration, and NRS score, the efficacy was divided into three grades: markedly effective, effective, and ineffective, as follows:

(1) Markedly effective

Migraine attack frequency reduced by ≥ 75%, attack duration shortened by ≥ 75%, NRS score decreased by ≥ 75%, patients' accompanying symptoms basically disappeared, and quality of life significantly improved;

(2) Effective

Migraine attack frequency reduced by ≥ 50% and < 75%, attack duration shortened by ≥ 50% and < 75%, NRS score decreased by ≥ 50% and < 75%, patients' accompanying symptoms significantly relieved, and quality of life improved;

(3) Ineffective

Improvement of migraine attack frequency, attack duration, and VAS score was < 50%, or even aggravated, patients' accompanying symptoms not improved, and quality of life not improved. Total effective rate = (number of markedly effective cases + number of effective cases)/total number of cases × 100% [10,11].

3.6. Statistical analysis

All data in this study were analyzed and processed by SPSS26.0 statistical software package. Continuous variables were statistically described by mean ± standard deviation, inter-group differences were compared by independent sample *t*-test, and self-before-and-after control was compared by paired sample *t*-test; categorical variables were expressed by constituent ratio or percentage, and inter-group differences were compared by Pearson χ^2 test. $p < 0.05$ was set as the criterion for judging statistically significant data differences in this study.

3.6.1. Comparison of baseline indicators between the two groups

Before treatment, there were no statistically significant differences in migraine attack frequency, attack duration, NRS score, SF-36 score, serum 5-HT and CGRP levels between the two groups ($p > 0.05$), with comparability (**Table 1**).

Table 1. Comparison of baseline indicators between the two groups

Indicator	TCM treatment group (n = 60)	Control group (n = 60)	t/χ^2	*p*
Attack frequency (times/month)	5.8 ± 1.6	5.7 ± 1.5	0.321	0.749
Attack duration (hours /attack)	8.2 ± 2.3	8.3 ± 2.2	0.238	0.812
NRS	7.6 ± 1.2	7.5 ± 1.3	0.385	0.701
SF-36	52.3 ± 8.5	51.8 ± 8.7	0.302	0.763
5-HT (ng/mL)	89.6 ± 12.3	90.2 ± 12.1	0.247	0.805
CGRP (pg/mL)	128.5 ± 18.6	129.3 ± 18.2	0.225	0.822

3.6.2. Comparison of changes in main efficacy indicators before and after treatment between the two groups

At 3 and 6 months of treatment, the attack frequency, attack duration, and NRS score of both groups were significantly improved compared with before treatment ($p < 0.05$); and the improvement range of each indicator in the TCM treatment group was significantly better than that in the control group, with statistically significant differences ($p < 0.05$), indicating that TCM syndrome differentiation comprehensive treatment had more significant effects in relieving pain and reducing attacks (**Table 2**).

Table 2. Comparison of changes in main efficacy indicators before and after treatment between the two groups

Indicator	Group	Before treatment	After 3 months of treatment	After 6 months of treatment
Attack frequency (times/ month)	TCM treatment group	5.8 ± 1.6	2.2 ± 0.7△#	1.5 ± 0.5△#
	Control group	5.7 ± 1.5	3.5 ± 0.9△	2.8 ± 0.8△
Attack duration (hours / attack)	TCM treatment group	8.2 ± 2.3	3.1 ± 1.0△#	2.3 ± 0.8△#
	Control group	8.3 ± 2.2	4.8 ± 1.2△	3.9 ± 1.1△
NRS	TCM treatment group	7.6 ± 1.2	2.5 ± 0.6△#	1.8 ± 0.5△#
	Control group	7.5 ± 1.3	4.2 ± 0.8△	3.3 ± 0.7△

Note: Compared with before treatment in the same group, △ $p < 0.05$; compared with the control group at the same time point, #$p < 0.05$.

3.6.3. Comparison of changes in sf-36 scores before and after treatment between the two groups

At 3 months of treatment and 6 months of follow-up, the SF-36 Health Survey Scale scores of both groups were significantly increased compared with before treatment, with statistically significant differences ($p < 0.05$); further comparison showed that the SF-36 scores of the TCM syndrome differentiation comprehensive treatment group at the same time points were significantly better than those of the control group, with statistically significant inter-group differences ($p < 0.05$). This result suggests that the comprehensive treatment regimen guided by TCM syndrome differentiation has more advantages in improving the quality of life of migraine patients (**Table 3** for specific data).

Table 3. Comparison of changes in SF-36 scores before and after treatment between the two groups

Group	Before treatment	After 3 months of treatment	After 6 months of treatment
TCM treatment group (n = 60)	52.3 ± 8.5	72.5 ± 7.8△#	78.6 ± 7.2△#
Control group (n = 60)	51.8 ± 8.7	63.2 ± 8.1△	68.9 ± 7.5△

Note: Compared with before treatment in the same group, △ $p < 0.05$; compared with the control group at the same time point, #$p < 0.05$.

3.6.4. Comparison of changes in serum 5-HT and CGRP levels before and after treatment between the two groups

At 3 and 6 months of treatment, serum 5-HT level in the TCM treatment group was significantly increased and CGRP level was significantly decreased compared with before treatment ($p < 0.05$); serum 5-HT level in the control group was slightly increased and CGRP level had no significant change ($p > 0.05$); and the

improvement range of serum 5-HT and CGRP levels in the TCM treatment group was significantly better than that in the control group, with statistically significant differences ($p < 0.05$), indicating that TCM syndrome differentiation comprehensive treatment could effectively regulate the balance of neurotransmitters and vasoactive substances (**Table 4**).

Table 4. Comparison of changes in serum 5-HT and CGRP levels before and after treatment between the two groups

Indicator	Group	Before treatment	After 3 months of treatment	After 6 months of treatment
5-HT (ng/mL)	TCM treatment group	89.6 ± 12.3	128.5 ± 13.6△#	139.2 ± 14.1△#
	Control group	90.2 ± 12.1	102.3 ± 12.8△	108.6 ± 13.2△
CGRP (pg/mL)	TCM treatment group	128.5 ± 18.6	89.6 ± 14.2△#	78.3 ± 13.5△#
	Control group	129.3 ± 18.2	118.5 ± 16.7	112.8 ± 15.9

Note: Compared with before treatment in the same group, △$p < 0.05$; compared with the control group at the same time point, #$p < 0.05$.

3.6.5. Comparison of clinical efficacy between the two groups

After 3 months of standardized treatment, among 60 patients in the TCM treatment group, 32 cases reached the markedly effective standard, 23 cases were effective, 5 cases were ineffective, with a total effective rate of 91.67%; among 60 cases in the control group, 14 cases were ineffective, 21 cases were markedly effective and 25 cases were effective, with a total effective rate of 76.67%. Statistical analysis results showed that the total effective rate of the TCM treatment group was significantly higher than that of the control group, and the efficacy difference between the two groups was statistically significant ($p < 0.05$) (**Table 5**).

Table 5. Comparison of clinical efficacy between the two groups

Group	Markedly effective (cases)	Effective (cases)	Ineffective (cases)	Total effective rate (%)
TCM treatment group (n = 60)	32	23	5	91.67
Control group (n = 60)	21	25	14	76.67

4. Discussion on mechanism of action

Since the pathogenesis of migraine involves multiple interrelated pathological links such as neurotransmitter imbalance, vascular dysfunction, and neurogenic inflammation, the treatment mode targeting only a single target is often difficult to achieve the ideal therapeutic effect of comprehensively improving the condition and controlling recurrence. The core advantage of TCM syndrome differentiation treatment for migraine lies in "multi-target, multi-channel" comprehensive intervention, based on the "holistic concept", regulating Zang-fu function, balancing Qi and blood, and unblocking meridians to improve the pathological state from the root. Its mechanism of action is mainly closely related to the following aspects.

4.1. Regulating neurotransmitter metabolic balance

5-HT is one of the most key neurotransmitters in the pathogenesis of migraine, and its level fluctuation directly affects the law of headache attack, which has been widely recognized clinically. Combined with clinical observation, during migraine attack, platelets of patients release a large amount of 5-HT, leading to

intracranial vasoconstriction, followed by rapid depletion of 5-HT, abnormal vasodilation, triggering a pain chain reaction; in the remission stage, patients' serum 5-HT level remains at a low level, difficult to maintain intracranial vascular homeostasis, and easy to cause headache recurrence. As specific drugs for acute migraine, triptans sorely act by activating 5-HT1B/1D receptors, constricting intracranial blood vessels, and inhibiting neurogenic inflammation, thereby quickly relieving pain symptoms.

The results of this study showed that serum 5-HT level in the TCM treatment group was significantly increased after treatment, and the improvement range was better than that in the control group, suggesting that TCM could restore its normal serum level by regulating 5-HT metabolism, thus exerting an analgesic effect. Combined with TCM syndrome differentiation theory, the liver governs coursing and discharge, closely related to human emotional regulation. Clinically, patients with liver Yang hyperactivity migraine mostly show irritability, which is closely related to 5-HT hypofunction; patients with Qi and blood deficiency syndrome are often accompanied by low mood and listlessness, which may be related to insufficient 5-HT synthesis.

From clinical medication practice, in the prescriptions used for TCM syndrome differentiation, blood-activating and stasis-removing drugs such as *Angelica sinensis* and *Ligusticum chuanxiong* can promote 5-HT synthesis and release, improve neurotransmitter metabolism; Qi-replenishing drugs such as *Glycyrrhiza uralensis* and *Astragalus membranaceus* can inhibit 5-HT degradation and prolong its action time; liver-calming and wind-extinguishing drugs such as *Gastrodia elata* and *Uncaria rhynchophylla* can regulate central 5-HT receptor activity and enhance its analgesic effect. The synergistic effect of multiple drugs achieves balanced regulation of neurotransmitters and reduces headache attacks from the root.

4.2. Improving intracranial vascular dysfunction

As a potent vasodilator peptide, CGRP is a core vasoactive substance in the pathogenesis of migraine, mainly released by trigeminal ganglion neurons. Its excessive release can induce meningeal vasodilation, activate trigeminal nerve endings, release inflammatory mediators, aggravate neurogenic inflammatory reaction, form a vicious cycle of "vasodilation-inflammation activation-pain aggravation", and further aggravate headache symptoms. At present, drugs targeting CGRP and its receptors have become a new direction for migraine preventive treatment, but long-term clinical application has found that such drugs still have certain adverse reactions and high prices, with limited clinical popularity.

In this study, serum CGRP level in the TCM treatment group was significantly decreased after treatment, suggesting that TCM could relieve intracranial vasodilation and neurogenic inflammatory reaction and improve vascular dysfunction by inhibiting CGRP release and blocking its biological effect. Combined with clinical diagnosis and treatment experience, *Gastrodia elata* and *Uncaria rhynchophylla* in TCM syndrome differentiation treatment have clear analgesic and anti-inflammatory effects, which can down-regulate CGRP mRNA expression in trigeminal ganglion and reduce CGRP release; blood-activating and stasis-removing drugs such as *Ligusticum chuanxiong*, Peach Seed, and Safflower can improve intracranial blood circulation, regulate vascular systolic and diastolic function, reduce pain caused by abnormal vascular dilation; phlegm-resolving drugs such as *Pinellia ternata* and *Atractylodes macrocephala* can clear phlegm-turbidity, reduce its compression on blood vessels, improve vascular blood supply, indirectly regulate CGRP level, and break the pain vicious cycle.

4.3. Inhibiting neurogenic inflammatory reaction

Neurogenic inflammation is an important pathological link of migraine attack. Combined with clinical research, when the trigeminovascular system is activated, pro-inflammatory cytokines such as IL-1β, IL-6, and TNF-α can be released. On the one hand, these inflammatory mediators lower the pain threshold and prolong the pain course by sensitizing primary afferent neurons; on the other hand, mediate vasodilation, form a positive feedback loop of "pain-vasodilation", and finally aggravate the degree of headache. TCM has multi-target anti-inflammatory advantages. A variety of drugs in its compound prescription can reduce the expression of inflammatory factors, alleviate neurogenic inflammatory reaction, and relieve pain symptoms.

In this study, heat-clearing drugs such as *Scutellaria baicalensis* and *Gentiana scabra* in TCM syndrome differentiation prescriptions can inhibit the expression of inflammatory factors such as IL-6 and TNF-α, reduce the intensity of inflammatory reaction; blood-activating and stasis-removing drugs such as *Salvia miltiorrhiza* and *Angelica sinensis* can improve local blood circulation, promote the metabolism of inflammatory mediators, relieve nerve ending edema, and reduce its sensitivity; drugs such as *Gastrodia elata* and *Atractylodes macrocephala* can regulate the body's immune function, inhibit inflammatory cell infiltration, thereby reducing neurogenic inflammation and blocking pain transmission. In addition, acupuncture treatment can regulate central nervous system function by stimulating acupoints such as Baihui, Fengchi, and Hegu, inhibit overactivation of the trigeminovascular system, reduce the release of inflammatory factors, synergize with TCM to exert anti-inflammatory and analgesic effects, and improve therapeutic effect.

4.4. Regulating the function of related signaling pathways

(1) CGRP signaling pathway

As mentioned above, CGRP signaling pathway is the core pathway of migraine pathogenesis, and its abnormal activation is the key to vasodilation and aggravated inflammatory reaction. TCM can block downstream signal transduction by down-regulating CGRP level and inhibiting its binding to receptors, thereby relieving vasodilation and neurogenic inflammation, which is also one of the core mechanisms of action confirmed by this study, consistent with clinical diagnosis and treatment practice.

(2) TRPV1 signaling pathway

Transient receptor potential vanilloid 1 (TRPV1) channel is a key channel for pain signal transmission. During migraine attack, this channel is abnormally activated, leading to the release of inflammatory mediators and increased nerve ending sensitivity, aggravating pain symptoms. During migraine attack, this channel undergoes conformational change and opens abnormally, Ca^{2+} influx triggers the cascade release of neuropeptides (CGRP, SP) and pro-inflammatory factors, inducing peripheral sensitization and neurogenic inflammation, finally forming a positive feedback loop of "channel activation-inflammation amplification-pain aggravation". Combined with pharmacological research, effective components such as capsaicin and gastrodin in TCM can regulate TRPV1 channel activity. Long-term intervention can achieve channel desensitization, inhibit pain signal transmission, and exert long-term analgesic effect, which is also an important way of TCM in treating migraine.

5. Clinical treatment strategies and experience of traditional Chinese medicine

Combined with long-term clinical diagnosis and treatment practice, the core of TCM treatment for migraine

is “treatment based on syndrome differentiation”, emphasizing “treating both symptoms and root causes”. It is necessary to quickly relieve pain symptoms (treating symptoms) and regulate Zang-fu function, balance Qi and blood, and unblock meridians (treating root causes). An individualized comprehensive treatment plan should be formulated according to patients’ syndrome type, constitution, and age to achieve the best therapeutic effect and reduce recurrence. Combined with the clinical experience of our hospital, the clinical strategies and experience of TCM in treating migraine are summarized as follows.

5.1. TCM medication strategy

(1) Syndrome differentiation and compatibility, treating both symptoms and root causes: TCM prescriptions emphasize the compatibility principle of “monarch, minister, assistant, and guide”. For different syndrome types of migraine, core monarch drugs are selected, combined with minister, assistant, and guide drugs, to achieve the therapeutic goal of “treating symptoms and caring for root causes”. For example, hyperactivity of liver Yang syndrome takes *Gastrodia elata* and *Uncaria rhynchophylla* as monarch drugs to calm liver and subdue Yang, unblock collaterals and relieve pain (treating symptoms), combined with *Eucommia ulmoides* and *Angelica sinensis* to nourish liver and kidney, nourish blood and soothe nerves (treating root causes), avoiding further hyperactivity of liver Yang; obstruction of collaterals by blood stasis syndrome takes *Ligusticum chuanxiong* and Peach Seed as monarch drugs to promote blood circulation to remove blood stasis, unblock collaterals and relieve pain (treating symptoms), combined with *Angelica sinensis* and *Paeonia lactiflora* to nourish blood and promote blood circulation (treating root causes), avoiding damaging healthy Qi due to blood activation, ensuring safe and effective treatment [12].

(2) Individualized adjustment, flexible modification

In clinical diagnosis and treatment, even for the same syndrome type, the dosage and type of drugs should be flexibly adjusted according to patients’ age, constitution, and concurrent symptoms, avoiding “one-size-fits-all” treatment. For example, elderly patients with deficiency of Qi and blood syndrome have weak spleen and stomach function, so it is necessary to appropriately increase the dosage of *Astragalus membranaceus* and *Codonopsis pilosula* to enhance the effect of replenishing Qi, and reduce the dosage of *Ligusticum chuanxiong* to avoid excessive blood activation; patients with severe phlegm-dampness in obstruction by phlegm-turbidity syndrome are added with *Coix lacryma-jobi* and *Atractylodes lancea* to strengthen the effect of invigorating spleen and eliminating dampness; those with severe pain are added with *Corydalis yanhusuo* and Frankincense to enhance the analgesic effect and improve patients’ treatment compliance.

(3) Pay attention to the course of treatment, consolidate the curative effect

Migraine has a prolonged course and is easy to recur. TCM treatment needs to adhere to a sufficient course of treatment and should not be eager for success. Combined with clinical experience, generally continuous treatment for more than 3 months, after symptoms are relieved, the prescription can be appropriately adjusted to pills or powders for consolidation treatment for 1–2 months to reduce recurrence. At the same time, patients should be informed to take medicine according to the doctor’s advice during treatment, and should not stop or reduce medicine without permission to avoid affecting the therapeutic effect.

5.2. Key points of acupuncture treatment

Acupuncture treatment for migraine follows the principles of "unblocking meridians, harmonizing Qi and blood, relieving pain and calming nerves". It combines empirical key acupoints with syndrome differentiation matching acupoints, pays attention to standardized operation, and avoids adverse reactions. Main acupoints Baihui and Fengchi can elevate Yang and lift collapse, dispel wind and unblock collaterals, and improve intracranial blood circulation; Taiyang is an extra-meridian acupoint, which can soothe head meridian Qi and unblock collaterals to relieve pain, a key local acupoint; Hegu (source point of Hand Yangming Meridian), taken distally along the meridian, "Hegu governs face and mouth", with significant analgesic effect; Zusanli (he-sea point of Foot Yangming Meridian, lower he-sea point) is a key health-care acupoint, acupuncture can replenish Qi and blood, regulate the middle energizer, indirectly nourish brain marrow through "invigorating earth to generate metal". The combination of three acupoints, combining distant and local, local analgesia and overall tonification, synergistically exerts the effect of relieving headache; matching acupoints are selected according to syndrome types to achieve acupuncture based on syndrome differentiation and improve treatment pertinence.

Disposable sterile filiform needles (0.25 mm × 40 mm) were selected. After routine iodophor disinfection of acupoint skin, vertical insertion was performed to obtain Qi (degree of acid, numbness, distension, and heaviness), uniform reinforcing and reducing method was applied, needles were retained for 30 min, and needling was performed once during retention to maintain needle sensation. Treatment frequency: Qd (once a day) × 5 d/week. The stimulation amount was dynamically adjusted according to patients' tolerance during the course of treatment to strictly prevent adverse acupuncture events such as needle fainting and hematoma. For patients with needle fainting constitution, the needle retention time can be shortened (20–25 minutes) and stimulation intensity reduced; patients were instructed to lie flat and rest before acupuncture, avoiding acupuncture on an empty stomach; for elderly patients and those with weak constitution, the acupuncture depth was appropriately reduced to ensure treatment safety.

5.3. Comprehensive intervention measures

TCM treatment emphasizes "holistic conditioning". In addition to TCM and acupuncture treatment, it is necessary to combine emotional regulation and lifestyle guidance to improve efficacy and reduce recurrence, which is also an important link that cannot be ignored in clinical diagnosis and treatment.

(1) Emotional regulation

Patients with hyperactivity of liver Yang syndrome need to avoid emotional fluctuations, and can regulate emotions by listening to soothing music, meditation, growing flowers and plants, etc., to keep a comfortable mood;

(2) Dietary conditioning

Patients with obstruction by phlegm-turbidity syndrome avoid rich, greasy, raw and cold food, and eat more food for invigorating spleen and eliminating dampness (such as Chinese yam, coix seed, wax gourd, etc.); patients with deficiency of Qi and blood syndrome should choose food with Qi-replenishing and blood-nourishing effects (such as red dates, longan flesh, lean meat, etc.), avoid pungent, fragrant and dry food;

(3) Lifestyle intervention

Establish a regular sleep-wake cycle, fixed bedtime at 22:00–23:00, ensure 7–8 h of sleep, eliminate staying up late and overwork;

(4) Exercise conditioning

Low-to-moderate intensity aerobic exercise such as Baduanjin and brisk walking is recommended (target heart rate controlled at 50–60% of maximum heart rate), 30 min each time, ≥ 3 times a week to improve microcirculation and enhance body tolerance, competitive strenuous exercise is prohibited;

(5) Avoid inducing factors

Establish a headache diary to identify and avoid individual triggering factors (such as specific food, strong light, emotional fluctuation, etc.).

6. Discussion

Combined with the results of clinical randomized controlled trial in our hospital, the clinical efficacy of TCM syndrome differentiation comprehensive treatment for migraine is significantly better than conventional Western medicine treatment. The total effective rate of the TCM treatment group reaches 91.67%, which is significantly higher than 76.67% of the control group. It can effectively reduce migraine attack frequency, shorten attack duration, relieve pain degree, improve patients' quality of life, and significantly increase serum 5-HT level and decrease CGRP level, regulate the balance of neurotransmitters and vasoactive substances, with clear mechanism of action, consistent with clinical diagnosis and treatment practice.

Compared with simple Western medicine symptomatic treatment, the TCM syndrome differentiation and treatment system shows unique advantages in migraine management:

(1) Its intervention mechanism presents multi-target and multi-channel network regulation characteristics

The pathogenesis of migraine is complex, single Western medicine mostly targets a certain target with limited therapeutic effect, while TCM can simultaneously regulate neurotransmitters, improve vascular function, inhibit inflammatory reaction through compound compatibility and acupuncture synergy, achieve multi-dimensional intervention with more comprehensive and durable efficacy.

(2) Durable efficacy and low recurrence rate

TCM treatment focuses on "treating both symptoms and root causes", not only relieving pain symptoms, but also regulating Zang-fu function and improving constitution, solving the problems of Qi and blood disorder and meridian obstruction from the root. In terms of clinical outcome, TCM intervention can prolong the remission period and reduce the annual recurrence rate.

(3) Better safety, the incidence of adverse events is significantly lower than that of the conventional drug group

In this study, no obvious adverse reactions occurred in the TCM treatment group, while 8 patients in the control group had mild drowsiness and dizziness, indicating that TCM treatment has higher safety and is more suitable for long-term intervention.

(4) Individualized diagnosis and treatment, strong adaptability

TCM syndrome differentiation and treatment can flexibly adjust the plan according to patients syndrome type, constitution, and age, avoiding "one-size-fits-all" treatment, and more in line with clinical actual needs.

This study also has certain limitations: small sample size and single-center study, which may lead to bias in the research results; only 5-HT and CGRP were selected as observation indicators, and inflammatory factors such as IL-6 and TNF-α and related signaling pathway indicators were not detected, and the mechanism of action was not deeply explored; the follow-up time was only 6 months, and the long-term

efficacy and recurrence rate still need further observation.

7. Conclusion

TCM syndrome differentiation treatment for migraine has definite efficacy, which can effectively reduce migraine attack frequency, shorten attack duration, relieve pain degree, and improve patients' quality of life. Its mechanism of action may be related to regulating 5-HT/CGRP neurotransmitter balance, improving trigeminovascular system dysfunction, inhibiting neurogenic inflammation and related signaling pathways. TCM has the advantages of multi-target, durable efficacy, high safety, and strong individualized adaptability, which is an effective choice for clinical treatment of migraine and worthy of clinical promotion and application.

Disclosure statement

The authors declare no conflict of interest.

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Dyslipidemia in Kidney Transplant Recipients: Implications for Graft Prognosis and Lipid Management

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Abstract: Dyslipidemia is a common metabolic complication after kidney transplantation, affecting 75-95% of recipients. Increasing evidence links post-transplant lipid abnormalities to graft dysfunction and eventual graft loss. However, studies on conventional lipid markers have reported inconsistent associations with transplant outcomes. Emerging lipid indicators may better reflect the burden of atherogenic lipoproteins and provide additional value for risk stratification after transplantation. This review summarizes current evidence on the epidemiology, mechanisms, graft outcome associations, and management of dyslipidemia in kidney transplant recipients, with a focus on postoperative monitoring and prognostic assessment.

Keywords: Kidney transplantation; Dyslipidemia; Graft outcomes; Lipid management

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1. Introduction

Kidney transplantation is the preferred treatment for end-stage renal disease, offering better survival and quality of life than dialysis [1]. Although advances in surgical techniques and immunosuppressive therapy have improved outcomes [2], long-term graft survival remains a major clinical challenge. Identifying modifiable risk factors for graft loss, particularly those linked to metabolic injury, is a clinical priority.

Dyslipidemia is a common post-transplant complication [3], largely driven by immunosuppressive therapy [4]. Dyslipidemia has been associated with graft dysfunction and late graft loss [5,6], but conventional lipid indices show inconsistent associations with graft outcomes [7]. This inconsistency has prompted interest in emerging markers that better reflect atherogenic burden, including remnant cholesterol (RC), non-high-density lipoprotein cholesterol (non-HDL-C), and apolipoproteins [8]. This review examines the epidemiology, mechanisms, graft outcome associations, and management of dyslipidemia in kidney transplant recipients.

2. Dyslipidemia and graft injury

Dyslipidemia affects 75–95% of kidney transplant recipients after transplantation [3]. The typical pattern includes increased total cholesterol (TC), low-density lipoprotein cholesterol (LDL-C), and triglycerides (TG), with reduced high-density lipoprotein cholesterol (HDL-C) [4]. Qualitative abnormalities (e.g., small dense LDL, dysfunctional HDL) are also described but not captured by routine testing.

In addition to diet, obesity, and genetics, immunosuppressive therapy plays a major role: glucocorticoids induce TG and reduce HDL-C by inhibiting lipoprotein lipase activity; calcineurin inhibitors increase lipid levels by interfering with cholesterol metabolism and lipoprotein clearance pathways; mammalian target of rapamycin inhibitors elevate TC and TG possibly through inhibition of lipoprotein lipase activity and promotion of lipolysis [8,9]. Post-transplant weight gain, insulin resistance, and new-onset diabetes after transplantation may further aggravate post-transplant dyslipidemia [5,9].

Dyslipidemia affects the allograft via interconnected pathways: oxidative stress/inflammation, metabolic toxicity, and vascular injury. A cholesterol-rich environment promotes renal inflammation via macrophage cytokine release, and oxidized LDL further triggers inflammation, impairs vascular repair, and accelerates microvascular rarefaction and graft dysfunction [10]. Dyslipidemia may also disrupt insulin signaling via excess free fatty acids and lipotoxicity, worsening glomerular hyperfiltration and proteinuria [11]. Additionally, hypercholesterolemia contributes to intimal thickening and graft vascular sclerosis [10].

3. Conventional lipids and graft prognosis

Post-transplant hypercholesterolemia often coexists with impaired kidney function, reflected by lower estimated glomerular filtration rate (eGFR) [12]. Recipients with higher TC levels had lower 5-year and 10-year graft survival rates [13]. TC > 5.2 mmol/L was associated with more severe interstitial fibrosis in the graft [14].

Elevated LDL-C predicts adverse outcomes. A machine learning model identified pre-transplant LDL-C as a predictor of renal dysfunction [15]. Maintaining LDL-C < 2.6 mmol/L is an protective factor against early graft failure (graft loss within 5 years) [16], and early statin therapy is associated with lower graft loss risk [17].

The role of HDL-C is less clear, as studies show inconsistent associations with graft prognosis; this suggests that HDL particle functionality, rather than absolute concentration, may be more clinically relevant [15].

TG elevation has been linked to graft dysfunction and lower graft survival [18]. Metabolic abnormalities (≥ 2 of: hypertension, hyperglycemia, high TG, low HDL-C) increase graft dysfunction risk within 2 years [18]. TG levels have also been reported to correlate inversely with eGFR.

Overall, conventional parameters capture only part of the risk, and their mixed findings suggest they do not fully reflect lipid-related injury [7,19].

4. Emerging markers and graft prognosis

RC is derived mainly from triglyceride-rich lipoprotein remnants. In the FAVORIT trial, higher RC levels were associated with all-cause mortality, with a trend toward higher graft failure risk [20]. RC has also been associated with the urinary albumin-to-creatinine ratio, suggesting renal injury [21].

Non-HDL-C, a clinically useful marker of atherogenic burden, has shown prognostic value for post-transplant renal dysfunction [15]. In stable graft function recipients, non-HDL-C ≥ 4.2 mmol/L was a sig-

nificant risk factor for reduced eGFR [22].

Apolipoprotein B (ApoB) has been associated with late graft failure [6]. Apolipoprotein A1 (ApoA1) is considered anti-atherogenic [19]. Increased ApoB, decreased ApoA1, and a higher ApoB/ApoA1 ratio are associated with chronic kidney disease progression and post-transplant complications [19].

The triglyceride-glucose (TyG) index, a surrogate marker of insulin resistance, is associated with graft outcomes. The highest TyG quartile was associated with a 2.13-fold higher risk of death-censored graft loss and 1.46- and 1.78-fold higher risks of eGFR decline (≥ 30% and ≥ 50%, respectively) [23].

These markers better reflect atherogenic burden and insulin resistance, offering enhanced risk stratification, especially when conventional profiles are only mildly abnormal.

5. Lipid management

Lipid management should be part of long-term metabolic care, not an isolated effort to normalize values. The high prevalence of dyslipidemia and its implications for graft outcomes support regular monitoring [24]. Diet, exercise, and weight loss remain foundational: healthy dietary patterns lower TC and LDL-C; structured physical activity increases HDL-C and improves creatinine clearance; weight loss improves lipid-related abnormalities [25,26].

Statins are first-line. Meta-analyses show that statin therapy reduces all-cause mortality in kidney transplant recipients [17]. KDIGO guideline recommends statin therapy for recipients aged ≥ 30 years or those with cardiovascular risk factors [24]. For statin intolerance or inadequate response, proprotein convertase subtilisin/kexin type 9 (PCSK9) inhibitors are an alternative, reducing LDL-C without significant immunosuppressive interactions [27]. Adding ezetimibe to statin therapy may further reduce TC, whereas fibrates remain most effective for TG lowering [24].

Management needs to be individualized [24]. In patients with persistent dyslipidemia, emerging markers may help refine risk assessment but are not yet used as routine treatment targets. If lipid control remains suboptimal, modification of the immunosuppressive regimen may be considered, while carefully balancing the risk of rejection [5]. However, prospective studies are needed before emerging markers can guide routine treatment.

6. Conclusion

Dyslipidemia is highly prevalent after kidney transplantation and is associated with graft injury. Conventional lipid parameters remain clinically useful but have important limitations. Emerging markers may provide a more detailed view of risk related to graft outcomes. Current gaps include non-standardized measurement timing, heterogeneous cutoff values, and a lack of intervention trials targeting these emerging markers. Addressing these requires large multicenter prospective studies.

Disclosure statement

The authors declare no conflict of interest.

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Application and Effect Evaluation of Smart Blood Collection System in Outpatient Blood Collection in Oncology Specialty Hospitals

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Abstract: *Objective*: To explore the application effect of the intelligent blood collection system in the outpatient blood collection of cancer specialized hospitals, and to provide a basis for improving the quality of outpatient blood collection nursing and the medical experience of patients. *Methods*: 136,274 blood specimens collected using the traditional manual blood collection mode from January to June 2020 were selected as the control group, and 176,989 blood specimens collected using the intelligent blood collection system from January to June 2021 were selected as the observation group. The blood collection process time, blood specimen quality, incidence of adverse events and patient satisfaction of the two groups were compared. Measurement data were expressed as $\overline{x} \pm s$ and analyzed by *t*-test. Counting data were expressed as cases (%), and the χ^2 test was used. A p value < 0.05 was considered statistically significant. *Results*: The registration and number collection time, specimen submission time and total process time of the observation group were significantly shorter than those of the control group ($p < 0.001$). The total error rate of blood samples decreased from 0.374% to 0.050%, and the error rate of blood collection tube usage decreased from 3.8% to 0.7%. The patient satisfaction rate increased from 88% to 96%, and the differences were statistically significant ($p < 0.05$). *Conclusion*: The intelligent blood collection system can optimize the outpatient blood collection process, shorten the service duration, reduce the error rate of specimens, improve the efficiency of nursing and patient satisfaction, and has good application value in the outpatient blood collection management of tumor specialized hospitals.

Keywords: Smart healthcare; Intelligent blood collection; Outpatient nursing; Tumor hospital; Nursing quality; Specimen management

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1. Introduction

Outpatient venous blood collection is an indispensable part of the tumor diagnosis and treatment process. It is characterized by concentrated patient flow, diverse specimen types, strict quality requirements, and sensitive service experience. The process efficiency and nursing quality directly affect the overall service level of the hospital and patient satisfaction [1–3]. The traditional manual blood collection mode relies on nurses to complete the entire process of information verification, barcode printing, blood collection tube selection, labeling, classification, and submission for testing. It has problems such as many manual steps, high error risk, long process time, and difficulty in specimen traceability, which can easily lead to unqualified specimens, long waiting times, and poor patient experience [4].

With the construction of smart hospitals and the rapid development of medical information technology, automated and intelligent blood collection equipment has been gradually applied to the clinic, and through process reengineering and information technology fusion, the standardization, automation and traceability management of the whole blood collection process have been realized, which has provided a new path to improve the quality of nursing care [5–10]. In this study, the oncology outpatient blood collection center of the hospital is taken as a practical object, and the key indicators before and after the application of the smart blood collection system are compared and systematically evaluated. This study takes the oncology outpatient blood collection center of our hospital as the practice object, compares the key indexes of the intelligent blood collection system before and after its application, and systematically evaluates its role in optimizing the process, guaranteeing the quality of specimens, and enhancing the efficiency of the service, so as to provide a practical reference for the construction of outpatient blood collection intelligence of oncology hospitals [11].

2. Information and methodology

2.1. General information

The outpatient blood collection center of our hospital was selected as the study site, with 10 standard blood collection windows, 10 fixed blood collection nurses, and the working hours of 7:30–16:30. control group: traditional artificial vein blood collection was used from January to June 2020, with a total of 21,300 cases of blood collection and 136,274 blood specimens. Observation group: January–June 2021 using fully automatic intelligent blood collection system, a total of 23958 cases of blood collection, blood specimens 176989. The age, gender, tumor type, blood collection items, outpatient flow and nurse operation level of the two groups were balanced and comparable, and the difference was not statistically significant ($p > 0.05$).

2.2 Methodology

2.2.1. Control group blood collection procedure

Adopt traditional manual blood collection mode: manual call number → identity information verification → manual printing bar code → manual selection of blood collection tube → manual paste bar code → venous blood collection operation → manual classification of specimens → manual transfer to the laboratory.

2.2.2. Blood collection process in the observation group

Adopting i-pres with-C full-automatic intelligent blood collection system, seamlessly connecting with hospital HIS and LIS system, the process is as follows: patient self-help check-in → system automatic sorting

and calling number → intelligent tube preparation and automatic labeling → nurses' secondary verification → venous blood collection → automatic specimen transmission and sorting → real-time reception by the laboratory department. The details are as follows:

(1) Self-service check-in system

The self-service check-in system can realize the function of patients' self-service number taking. This system does not need to guide the operation of the doctor, the patient can take the number in the corresponding time period to the check-in machine after the payment of the blood collection order and appointment, the check-in machine supports the diagnosis and treatment card and ID card, enter the medical record number and scan the bar code of the appointment order to realize the multiple ways to take the number, and the successful check-in immediately prints the numbering paper, which corresponds to the patient's main identifying information (name, gender, age, medical record number) and queuing situation, and the patient waits at the window with the numbering paper to call for blood drawing. The patient will wait at the window with the numbered paper to call for a blood draw. When a patient fails to get a number, the reason for the failure will be displayed so that the patient can get the first information support.

(2) Automated call system

The automated sequencing and calling system is designed for patient triage, with the following primary functions: automatic patient sequencing with unique numbering to prevent call confusion; voice-based system calls displaying the current call number and patient information on the screen; multi-source patient prioritization: based on patient condition and age, the system sets up general calls, emergency calls, compassionate calls, peripheral blood calls, and emergency calls. Emergency calls and compassionate calls are dedicated to patients requiring urgent blood tests or elderly and frail individuals, avoiding physical discomfort (e.g., hypoglycemic syncope) caused by prolonged fasting. Peripheral blood calls are reserved for patients requiring only complete blood count (CBC) tests, allowing them to proceed directly to Window 1 for collection by laboratory staff. Emergency calls are reserved for special cases, with each source displaying the waiting queue to facilitate secondary triage. This multi-source design achieves intelligent diversion of outpatients for blood collection, reducing waiting time and preventing overcrowding and chaotic queues. Nursing staff can call patients via tablet devices, with corresponding blood collection window information displayed above to guide patients intuitively, eliminating concerns about call numbers and enabling them to queue confidently in the waiting area. Sample rollback function: nurses can perform rollback for duplicate items or items unnecessary for collection due to other reasons, ensuring closed-loop processing between the automated blood collection system and the hospital information system.

(3) Intelligent tube preparation system

The intelligent tube preparation system is designed for barcode generation, automatic tube selection, and automatic labeling, enabling automated tube dispensing after patient calling. While nursing staff call registered patients awaiting blood collection, the integrated tube preparation and labeling machine automatically generates barcodes, assigns collection tubes based on patient information, prints barcode labels, and automatically adheres them onto test tube trays. The bidirectional output design allows simultaneous blood collection by staff on both sides. After retrieving the trays, nursing staff verify patient information and procedures before proceeding with collection. Vacuum collection

tubes are stored in drawer-style units, with 8 slots accommodating 100 tubes for large-capacity storage of various specifications. These tubes feature a tube orientation recognition system, eliminating the need for directional separation during tube addition and simplifying operation. The vacuum collection tubes also incorporate patented concave butyl rubber stoppers, completely resolving issues of uneven vacuum pressure in vacuum tubes and ensuring blood collection quality. Standardized tube labeling eliminates manual labeling irregularities (e.g., wrinkles, skewing, or cornering), facilitating smooth automatic reading by subsequent testing equipment and reducing equipment alarms and re-labeling. The automated tube preparation system significantly enhances blood collection speed for nursing staff and simplifies the cumbersome procedures of traditional blood collection.

(4) Transmission and sorting system

The transmission and sorting system is used for specimen transmission, specimen sorting and scheduling, and specimen monitoring, realizing real-time immediate delivery of collected specimens. The speed of automated processing of vacuum blood collection tubes is 4 s/tube, which is fast and efficient. After the end of blood collection, the nursing staff directly put the blood collection tube into the high-speed transmission and transportation belt, and the specimen is automatically transmitted to the Laboratory Department for specimen testing through the transportation belt. The high-speed conveyor belt has the characteristics of high throughput and no “traffic jam”, and can continuously transport blood collection tubes without interruption. Compared with the traditional manual transportation, the conveyor belt protects the specimen from being shocked and damaging the test results during transportation [12]. Through the seamless connection of the transmission module, the system can automatically sort the specimens, and the chain combination of transmission and sorting guarantees the quality and safety of the specimens. Real-time monitoring of specimens in the collection of specimens lost or delayed delivery to affect the quality of the test can be traced and adjusted as needed, including single-item time limit warning according to the type of specimen time limit warning, time limit warning of the type of patients, etc. for transmission monitoring, if the specimen overtime transmission when the display is highlighted and the alarm, to avoid specimens lost tube overtime.

(5) Integrated management system

The integrated management system empowers administrators with operational permissions for data maintenance, query statistics, data analysis, and permission allocation, enabling effective configuration and control by both users and administrators. Key functionalities include: Data Maintenance: Managing client IP access, project tracking, user information, and interface configurations; User Permission Management: Controlling login access, personnel permissions, and interface access; Statistical Report Management: Providing data analysis, comprehensive queries, and workload tracking, which helps departments and management teams obtain accurate, real-time data to enhance intelligent management capabilities. Regarding equipment maintenance, the outpatient department has established a WeChat communication group for automated blood collection technology to facilitate issue feedback. The communication members primarily include nursing staff, laboratory personnel, and information technology engineers. When system issues such as failed call number generation, barcode printing failure, or tube dispensing machine malfunction occur, nursing staff may upload photos or videos to the communication group. Engineers promptly review the submissions and provide remote guidance, ensuring immediate analysis of fault causes, accelerated repair timelines, and avoidance of prolonged patient waiting.

(6) Interface docking module

The interface docking module monitors and records all the interfaces connected to the system. All systems interact in real time and synchronize various data, ensuring the integrity and uniformity of the data. Self-service check-in machine in the card reading according to the patient information to call the corresponding interface, query the valid test information, determine the timeliness of the appointment project, according to the number of source categories to generate queuing sequence number, check-in failure to be related to the prompts or by the staff to deal with. The nurse selects the number source corresponding to call the patient at the same time automatic tube preparation machine automatically generates bar code information, labeling out of the tube. The patient goes to the corresponding window to collect blood, and if the patient fails to arrive after repeated calls, he/she is regarded as having passed the number and needs to take the number again. The nurse completes the collection or puts the collected specimen into the collection conveyor belt and the conveyor belt automatically transfers it to the Laboratory Department, and the whole blood collection process ends.

2.2.3. Measures to manage quality and safety of care

Establish a blood collection specimen registration ledger to record non-compliant specimens and adverse events; strictly implement the “three checks and eight verifications”, aseptic techniques, and shift handover protocols; uniformly utilize disposable retractable safety needles; optimize the waiting environment by enforcing air disinfection and hospital infection control measures; develop emergency response plans for needle phobia, hypoglycemia, and equipment malfunctions to enhance emergency management capabilities.

2.3. Observation indicators

2.3.1. Average blood collection time per tube

Before the application of intelligent blood collection system, the average blood collection time t1 includes: the medical guide to take the collection order number printing barcode label time (T1) + collection nurse checking tube preparation time (T2) + collection and specimen sorting time (T3) after the collection of the whole process of the total time divided by the total number of specimens, to get the average time of blood collection per tube. After the application of intelligent blood collection system average blood collection time t2 from the patient self-service number, nurse end call, intelligent blood collection system ready tube, the nurse checking the project to the collection of the completion of the time used divided by the total number of specimens, to get the blood collection time per tube.

2.3.2. Classification of blood specimen quality issues

The quality problems of blood specimens in the study were categorized as: specimen retention problems (wrong sample retention, no specimen, no fasting blood collection, low specimen volume), barcode problems (substandard, reuse, error, no charge) and delivery problems (expired, timeout, sample coagulation).

2.3.3. Adverse events of venous blood collection

Mainly record the adverse events occurred in the process of outpatient venous blood collection, such as puncture failure, patient reaction, equipment failure, etc.

2.3.4. Assessment of patient satisfaction

Patient satisfaction is recorded and analyzed through self-compiled questionnaires by the department at each stage.

2.4. Statistical methods

Data analysis was conducted using SPSS 23.0 software. Measurement data were expressed as $\overline{x} \pm s$, and the independent sample *t*-test was used for comparison between groups. Counting data were expressed as the number of cases and composition ratio (%), and the χ^2 test was used for comparison between groups. A *p* value < 0.05 was considered statistically significant.

3. Results

3.1. Comparison of blood collection process time between the two groups

The observation group's time for reporting for number, specimen delivery and total process was significantly shorter than that of the control group, and the difference was statistically significant ($p < 0.001$); the difference in the average blood collection operation time between the two groups was not statistically significant ($p > 0.05$), as shown in **Table 1**.

Table 1. Comparison of time for each stage of blood collection between the two groups (min, $\overline{x} \pm s$)

Groups	Number of examples	Check-in number pick-up time	Mean time to blood collection	The time of specimen submission	Total process time
Control group	21300	21.35 ± 9.37	6.25 ± 2.54	3.01 ± 1.13	30.67 ± 13.87
Observation group	23958	10.25 ± 3.56	4.88 ± 1.35	1.25 ± 0.78	16.43 ± 5.54
t/Z	–	-10.146	1.520	-10.822	-6.532
p	–	< 0.001	0.145	< 0.001	< 0.001

3.2. Comparison of blood sample quality between the two groups

The observation group showed significantly lower rates of barcode issues, submission issues, and total error rates compared to the control group ($p < 0.05$), with statistically significant differences. The rate of retention issues decreased but remained statistically insignificant ($p > 0.05$), as shown in **Table 2**.

Table 2. Comparison of the quality of blood specimens between the two groups [cases (%)]

Groups	Total number of specimens	Barcode issues	Blood collection issues	Send specimens for inspection issues	Total
Control group	136274	25 (0.183)	18 (0.132)	8 (0.058)	51 (0.374)
Observation group	176989	4 (0.022)	2 (0.011)	1 (0.005)	9 (0.050)
χ^2	–	10.264	3.401	4.012	3.238
p	–	0.007	0.065	0.047	0.051

3.3. Workload and quality of care improvement

After the implementation of smart blood collection, the total number of blood samples collected increased by 27.81%, and the number of blood samples collected rose by 27.84%. The average monthly blood collection hours decreased by 14.91%. The error rate of blood collection tube usage dropped from 3.8% to 0.7%.

Patient satisfaction rose from 88% to 96%.

3.4. Adverse events related to blood collection

The total incidence of adverse events such as puncture failure, patient discomfort, equipment failure and complaints in the observation group was significantly lower than that in the control group, and the safety of blood collection and the comfort of patients were significantly improved.

4. Discussion

4.1. Intelligent blood collection system optimizes service processes and significantly improves blood collection efficiency

The smart blood collection system replaces manual repetitive operations with automation and informationization to achieve process reengineering and efficiency improvement [13,14]. Self-help check-in simplifies patient check-in, automatic numbering realizes orderly triage, intelligent tube preparation and labeling reduces nurses' manual operation time, and automatic specimen transmission eliminates manual transfer. This study shows that the total process time is shortened from 30.67 min to 16.43 min, which is a significant decrease in the working time under the simultaneous growth of outpatient volume and specimen volume, indicating that the intelligent blood collection system can effectively release nursing manpower, improve the overall operational efficiency of outpatient clinics, and alleviate the pressure of oncology clinics for blood collection.

4.2. Intelligent blood collection system reduces the error rate of specimens and guarantees the quality of tests

The quality of blood specimens is the core guarantee for the accuracy and reliability of test results [15]. In manual modes, issues such as barcode errors, non-standard labeling, substandard collection, and delayed submission are particularly prominent. The intelligent blood collection system reduces human errors at the source through automatic HIS/LIS information docking, intelligent matching of blood collection tubes, standardized labeling, full-process scanning verification, real-time specimen tracking, and timeout alerts, achieving closed-loop quality control before testing [16]. In this study, the total error rate of specimens decreased from 0.374% to 0.050%, with a significant reduction in the error rate of blood collection tubes, effectively lowering the rate of repeated blood collection, conserving medical resources, and enhancing medical safety levels.

4.3. Intelligent blood collection system improves the medical experience and increases patient satisfaction

Oncology patients need to collect blood for a long time and repeatedly, which requires higher waiting time, environmental comfort, operation safety and humanistic service [17,18]. Intelligent blood collection system can shorten the fasting waiting time and reduce the risk of hypoglycemia and fainting through hierarchical number diversion, reduce the crowding, overcrowding and anxiety by voice calling and large screen display, and reduce the pain and stress reaction of patients by the comfortable waiting environment, standardized operation and application of safe blood collection needles. Stress reaction of patients can be effectively reduced. The whole process is convenient, transparent and orderly, which significantly improves patients' experience and satisfaction and helps build a harmonious doctor-patient relationship.

4.4. Intelligent blood collection system promotes nursing management standardization and informatization

Intelligent blood collection system realizes the standardization of blood collection process, homogenization of operation and data management, reducing human differences and management loopholes [19]. The system is deeply integrated with the hospital information platform, and it can collect real-time data on workload, process time-consuming, specimen quality, adverse events, etc., which can provide an objective basis for departmental quality monitoring, efficiency analysis and performance assessment, and promote the transformation of outpatient care from traditional experience management to refined and intelligent management. It can promote the transformation of outpatient nursing from traditional experience management to refined and intelligent management, which is in line with the requirements for the high-quality development of modern hospitals and the construction of intelligent hospitals.

5. Shortcomings and prospects

This study is a single-center retrospective study and has certain limitations. During the operation of the system, occasional network delays, equipment failures and other issues still require continuous optimization of system stability and emergency maintenance mechanisms. In the future, multi-center and prospective studies can be carried out to extend the observation period, further evaluate the application value of the intelligent blood collection system in terms of cost-effectiveness, nurses' workload, and long-term service quality, and continuously improve the intelligent blood collection service system.

6. Conclusion

Smart blood collection system applied to outpatient blood collection in oncology hospitals can effectively optimize the blood collection process, shorten the service time, reduce the error rate of specimens, reduce the adverse events, improve the nursing efficiency and patient satisfaction, and significantly improve the quality of outpatient blood collection nursing care and management level, which is a mature practice of smart healthcare in outpatient nursing care scenarios, and is worthy of popularizing and applying in the blood collection centers of all levels of outpatient hospitals.

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Disclosure statement

The authors declare no conflict of interest.

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The Effect and Preliminary Exploration of Subcutaneous Immunotherapy with Dust Mites on Peripheral Blood Biomarkers in Children with Asthma

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Abstract: *Objective*: To analyze the differentially expressed genes in peripheral blood mononuclear cells (PBMCs) of asthmatic children before and after subcutaneous immunotherapy (SCIT), with the aim of screening potential biomarkers. *Methods*: This study collected clinical data and PBMCs from asthmatic children before and after treatment, and divided them into a differential gene screening group (7 cases) and a differential gene validation group (30 cases) for preliminary screening and subsequent validation, respectively. Transcriptome differential analysis was performed on PBMCs samples from 7 asthmatic children before and after treatment using RNA sequencing technology. After preliminary screening, candidate genes were validated by qReal-time PCR in the baseline group and the 16-week treatment group of 30 children undergoing SCIT. Spearman correlation analysis was used to investigate the correlation between the expression levels of candidate genes and clinical and pulmonary function indicators, and the biomarker efficacy was evaluated using ROC curves. *Results*: In the differential gene screening group, a total of 317 differentially expressed genes (166 upregulated and 151 downregulated) were identified in the 16-week SCIT group compared to the baseline period. qReal-time PCR validation revealed that the expression of SERPINB2 gene was significantly decreased after treatment compared to the baseline group ($p < 0.05$). Spearman correlation analysis indicated a significant correlation between the gene expression changes and reduced ACQ scores, CSMS scores, and increased C-ACT scores; the ROC curve suggested that this gene had good efficacy evaluation and predictive value. *Conclusion*: SERPINB2 expression was significantly downregulated after 16 weeks of SCIT treatment and was closely correlated with clinical improvement, suggesting that SERPINB2 could serve as a potential biomarker for evaluating the efficacy of SCIT in pediatric asthma, but further experimental validation is required.

Keywords: Asthma; Children; Biomarkers; Subcutaneous immunotherapy

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1. Introduction

Childhood allergic asthma is a respiratory disease driven by allergens such as dust mites, with chronic airway inflammation and airway hyperresponsiveness as its core characteristics. Type 2 immune disorder is one of the key mechanisms underlying its pathogenesis [1,2]. Allergen immunotherapy targeting dust mites is currently the only etiological treatment that can alter the natural course of allergic asthma and induce immune tolerance [3,4]. It primarily includes subcutaneous specific immunotherapy and sublingual specific immunotherapy, which can provide long-term symptom control, reduce acute exacerbations, and improve lung function [4–6]. However, there are significant individual differences in the efficacy of SCIT, and there is a lack of objective and stable biomarkers for early assessment and efficacy monitoring in clinical practice [2]. Transcriptome sequencing enables high-throughput analysis of gene expression profile changes, providing a scientific basis for candidate gene screening [2].

Therefore, this study included 37 children with dust mite allergic asthma, and analyzed the differentially expressed genes in PBMCs before and after SCIT through transcriptome sequencing. Potential biomarkers related to SCIT efficacy were preliminarily screened, providing research evidence for monitoring the efficacy of immunotherapy for childhood asthma.

2. Objects and methods

2.1. Research subject

This study selected pediatric patients with bronchial asthma who visited the Allergy Department of the Affiliated Hospital of Qingdao University from September 2023 to December 2024.

2.1.1. Inclusion criteria

(1) Patients must meet the requirements of the "Chinese Medical Association's Recommendations for the Standardized Diagnosis and Treatment of Bronchial Asthma in Children (2020 Edition)" and have a disease duration of ≥ 1 year [7].
(2) Patients must be aged 6–11 years.
(3) The results of allergen skin prick test and specific immunoglobulin E (sIgE) detection indicate that dust mites (house dust mites and/or powder dust mites) are the main allergens for the patient.
(4) Patients must not have any contraindications to immunotherapy.
(5) Parents or other legal guardians of the study subjects must agree to participate in this study and sign the informed consent form.

2.1.2. Exclusion criteria

(1) Severe or uncontrolled asthma with FEV_1 < 70% of predicted value.
(2) Current use of beta blockers or angiotensin-converting enzyme inhibitors.
(3) Patients with severe cardiovascular and cerebrovascular diseases, immune diseases (including autoimmune diseases and immunodeficiency diseases), malignant tumors, or chronic infectious diseases.
(4) Children with severe psychological disorders, lack of compliance, or inability to understand the risks and limitations of treatment.

(5) Previous history of severe allergic reactions, indicating potential danger for immunotherapy.

Subcutaneous injection of house dust mite allergen preparation (Atoda, Denmark ALK company) was used, and the treatment plan was divided into two stages: the initial treatment stage lasted for 15 weeks, with the dose gradually increasing from 20 SQ-U to 100000 SQ-U; Starting from the 17th week, the patient enters the maintenance treatment phase with a fixed dose of 100000 SQ-U, and the injection interval gradually extends to 4–8 weeks. Observe for 30 minutes after each injection. All subjects signed the informed consent form, and the study was approved by the Ethics Committee of the Affiliated Hospital of Qingdao University (QYFYWZLL29359) and conformed to the principles of the Declaration of Helsinki.

2.2. Method

2.2.1. Skin prick test

The allergen preparations provided by the Allergen Preparation Laboratory of Peking Union Medical College Hospital were used, including house dust mite and powder dust mite. The positive control solution was 0.1 mg/mL histamine phosphate, and the negative control solution was allergen solvent, produced by Taiyuan Pharmaceutical Factory in Shanxi. The result evaluation criteria were divided into five levels: –, +, ++, +++, +++++, with +, ++, +++, ++++ indicating positive results.

2.2.2. Detection of total immunoglobulin E (Tige) and sIgE in serum

The reagents used were provided by Phadia, and the detection was performed using the Phadia Immuno CAP system (fluorescence enzyme-linked immunosorbent assay). The serum sIgE detection values were divided into 7 levels, namely Level 0 (< 0.35 kUA/L), Level 1 (≥ 0.35 kUA/L and < 0.7 kUA/L), Level 2 (≥ 0.7 kUA/L and < 3.5 kUA/L), Level 3 (≥ 3.5 kUA/L and < 17.5 kUA/L), Level 4 (≥ 17.5 kUA/L and < 50 kUA/L), Level 5 (≥ 50 kUA/L and < 100 kUA/L), and Level 6 (≥ 100 kUA/L). Level 0 indicates negative, while levels above Level 1 indicate positive.

2.2.3. Pulmonary ventilation function test

The pulmonary function was measured using the EasyOne pulmonary function tester from NDD Company in Switzerland. The main ventilation function indicators were forced expiratory volume in first second (FEV_1) and peak expiratory flow (PEF). Patients with abnormal pulmonary ventilation function at initial diagnosis underwent bronchodilation testing. The positive criteria were an increase in FEV_1 of > 12% and an absolute increase in FEV_1 of > 200 mL after inhaling bronchodilators, indicating variable airflow obstruction.

2.2.4. Clinical evaluation

In this study, children with dust mite-induced asthma were enrolled and underwent clinical assessments during the baseline period of SCIT treatment and after 16 weeks of treatment. The clinical evaluation utilizes a subjective scoring system to assess the severity of the disease, encompassing the Childhood Asthma Control Questionnaire, the Childhood Asthma Control Test scale, and symptom medication scoring. A change of ≥ 0.5 points in the Childhood Asthma Control Questionnaire score before and after treatment is defined as clinically effective [8–10].

The Asthma Control Questionnaire (ACQ) is used to assess the asthma control status of pediatric patients over the past week, including symptoms, rescue medication use, activity limitation, and lung function

items [10]. The total score ranges from 0 to 6 points, calculated as the average score of each item. A score of ≤ 0.75 indicates complete control, while a score of > 1.25 indicates uncontrolled asthma. The Childhood Asthma Control Test (C-ACT) is completed jointly by the patient and parents, assessing symptoms, activities, and medication use over the past 4 weeks [11]. The total score ranges from 0 to 27 points, with higher scores indicating better control. A score of ≥ 20 indicates good control, while a score of ≤ 15 indicates uncontrolled asthma. The Combined Symptom and Medication Score (CSMS) is a combined score for symptoms and medication, commonly used in the evaluation of asthma and allergic rhinitis, especially the efficacy of immunotherapy [12]. Symptom scores and medication scores are recorded daily, with a total score ranging from 0 to 6 points. Lower scores indicate better control, and a decrease in score indicates effective treatment.

2.2.5. Transcriptome sequencing

For the enrolled children with dust mite allergic asthma, this study divided them into a differential gene screening group and a differential gene verification group, which were used for preliminary screening and subsequent verification, respectively. In the SCIT baseline group and the 16-week treatment group, peripheral blood mononuclear cells (PBMCs) samples were collected from all children. The specific methods are as follows: PBMCs were isolated by Ficoll density gradient centrifugation, and after confirming the purity and viability of the cells, they were stored at low temperature; total RNA was extracted from PBMCs and quality-controlled by Nanodrop, Agilent 2100, and agarose gel electrophoresis to eliminate unqualified samples.

To conduct differential gene analysis, RNA sequencing (RNA-seq) was performed on PBMCs samples from children in the SCIT baseline group and the 16-week treatment group. The method is as follows: For PBMC total RNA that passes quality control, an rRNA removal strategy is selected based on research needs. After RNA fragmentation, reverse transcription to synthesize cDNA, end repair, A-tailing, ligation of sequencing adapters, and PCR amplification, a standardized cDNA sequencing library is constructed. After the library passes quality control, high-throughput sequencing is performed using mainstream platforms such as Illumina to obtain raw data. Subsequently, bioinformatics analyses such as quality control filtering, sequence alignment, gene quantification, differential gene screening, and functional enrichment are performed on the raw data. The criteria for differential gene screening are typically [|Log2（Fold change，Log2FC）|≥ 2] and $p < 0.05$.

2.2.6. qReal-time PCR detection and verification

To validate the RNA-seq results, real-time quantitative polymerase chain reaction (qRT-PCR) was employed in PBMCs samples from the SCIT baseline group and the 16-week treatment group in the differential gene validation group. The specific steps are as follows: Candidate biomarkers were screened and specific primers were designed (**Table 1**). Using the MA-6000 system, RNA extracted from PBMCs was reverse transcribed into cDNA according to the kit instructions. Each sample was set up in three replicates for qPCR detection. GAPDH was used as an internal reference, and the relative gene expression was calculated using the $2^{-\Delta\Delta Ct}$ method. The data were expressed as $\bar{x} \pm$ s and compared with the gene expression trends obtained from transcriptome sequencing to verify the reliability of the sequencing results. The validated genes were analyzed with clinical efficacy indicators to assess their potential as predictors of SCIT efficacy.

Table 1. Verify gene primer sequence

Gene	Positive primer sequence	Reverse primer sequence
SERPINB2	GCTGTTTGTGTGAGAGAGTCTGCG	CTGCACATTCTAGGAAGTCTACTG
TLR4	CCCTGAGGCATTTAGGCAGCTA	AGGTAGAGGTGGGTGTGTGT
TLR2	CTTCACTCAGGAGCAGCAAGCA	ACACCAGTGCTGTCCTGTGACA
NFKBIA	TCCACTCCATCCTGAAGGCTAC	CAAGGACACCAAAAGCTCCACG
RELA	TGAACCGAAACTCTGGCAGCTG	CATCAGCTTGCGAAAAGGAGCC
CCL17	TTCTCTGCAGCACATCCACGCA	CTGGAGCAGTCCTCAGATGTCT
CCL22	TCCTGGGTTCAAGCGATTCTCC	GTCAGGAGTTCAAGACCAGCCT
CCL26	GGGAGTGACATATCCAAGACCTG	CAGACTTTCTTGCCTCTTTTGGTA
CDH26	TGGTCATCACCGTGGAGCCAAT	GACAGGAAGAGCATTAGGGTCC
ANXA10	CAGAGACCTCAGGACACTTCAG	TCTGCTGACAGGCTTCCCATAG
IL6	AGACAGCCACTCACCTCTTCAG	TTCTGCCAGTGCCTCTTTGCTG
IL13	ACGGTCATTGCTCTCACTTGCC	CTGTCAGGTTGATGCTCCATACC

2.3. Statistical analysis

This study employed SPSS 24.0 and GraphPad Prism 7.0 for statistical analysis. After normality testing, measurement data conforming to a normal distribution were expressed as mean ± standard deviation ($\overline{x} \pm s$) sand inter-group comparisons were conducted using *t*-tests (paired or independent samples). Data with non-normal distribution were presented as median (range) and tested using Mann-Whitney U test or Wilcoxon test. Categorical variables were described as frequency (percentage), and inter-group comparisons were conducted using χ^2 test or Fisher's exact test. Correlation analysis was performed using Spearman's rank correlation. ROC curve analysis was used to evaluate the predictive performance of biomarkers for the therapeutic efficacy of SCIT, calculating the area under the curve (AUC) and the optimal cutoff value. The significance level was set at $p < 0.05$ (two-tailed test).

3.Result

3.1. General information of the research subjects

In this study, a total of 7 asthmatic children were included in the differential gene screening group, including 4 males with an average age of (7.86 ± 1.35) years. In the differential gene verification group, there were 30 asthmatic children, including 18 males with an average age of (8.00 ± 1.20) years. The specific details are shown in **Table 2**.

Table 2. Basic characteristics of research subjects

Feature	Differentially expressed gene screening group (n = 7)	Differentially expressed gene validation group (n = 30)	*p* value (Screening group)	*p* value (Validation group)
Gender (Male/ Female)			–	–
Baseline group	4/3	18/12		
16-Week Treatment group	4/3	18/12		
Age (years)			–	–
Baseline group	7.86 ± 1.35	8.00 ± 1.20		

Feature	Differentially expressed gene screening group (n = 7)	Differentially expressed gene validation group (n = 30)	*p* value (Screening group)	*p* value (Validation group)
16-Week Treatment group	7.86 ± 1.35	8.00 ± 1.20		
tIgE (kU/L)			0.81	0.71
Baseline group	303.00 (135.00, 529.00)	309.50 (99.40, 794.00)		
16-week treatment group	263.00 (104.20, 493.00)	239.50 (79.40, 524.00)		
House dust mite sIgE (Ku/L)			0.25	0.85
Baseline group	26.40 (20.60, 59.10)	69.77 (53.55, 90.13)		
16-week treatment group	20.60 (13.10, 22.90)	65.00 (53.55, 88.43)		
Dust mite sIgE (Ku/L)			0.16	0.33
Baseline group	61.80 (41.50, 81.00)	58.31 (37.98, 73.10)		
16-week treatment group	27.50 (21.40, 100.00)	56.70 (40.73, 76.55)		

3.2. Clinical efficacy

This study analyzed the clinical efficacy of SCIT in a differential gene verification group consisting of 30 children with SCIT at baseline and after 16 weeks of SCIT treatment (**Table 3**). Compared with the SCIT baseline period, ACQ scores and CSMS scores decreased after 16 weeks of treatment, while PEF, FEV_1, and C-ACT scores increased after 16 weeks of treatment, with statistically significant differences ($p < 0.05$). In terms of ACQ scores (**Figure 1**), 30 children (80.0%) showed a change of ≥ 0.5 in scores before and after SCIT treatment, indicating the effectiveness of SCIT treatment.

Table 3. Changes in various indicators and scores before and after SCIT treatment in pediatric patients

Scale	Baseline group	16 weeks of treatment group	*p* value
ACQ	1.98 ± 0.43	0.87 ± 0.47	< 0.001
C-ACT	16.83 ± 2.12	22.70 ± 1.74	< 0.001
CSMS	4.31 ± 1.50	2.78 ± 1.21	< 0.001
PEF (%)	91.50 ± 4.03	100.40 ± 3.692	< 0.001
FEV_1 (%)	94.87 ± 4.61	96.67 ± 5.97	0.0171

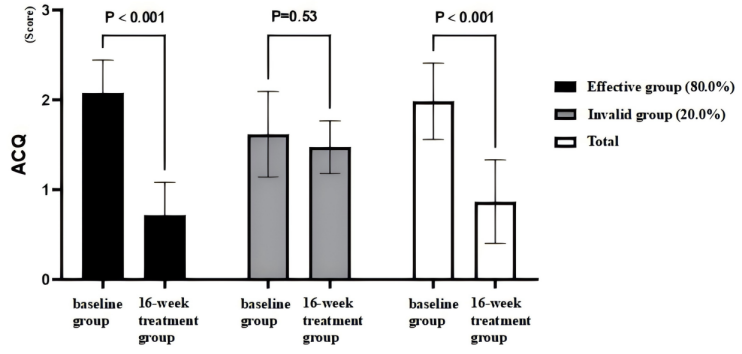


Figure 1. Comparison of ACQ scores before and after SCIT treatment.

3.3. Screening of differentially expressed genes before and after SCIT treatment

In the differential gene screening group, when comparing the 16-week SCIT treatment group to the baseline period, a total of 317 differential genes were identified (**Figure 2**), including 151 downregulated genes and 166 upregulated genes. With the restriction condition of a differential fold change ≥ 2, 93 mRNAs were obtained, of which 63 were upregulated and 30 were downregulated.

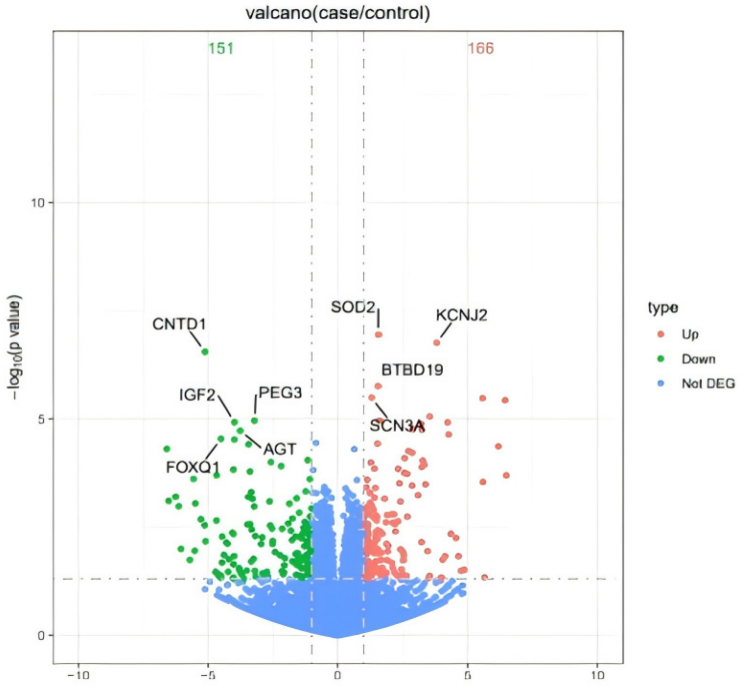


Figure 2. Differentially expressed genes in the 16-week SCIT treatment group compared to the baseline period.

3.4. qReal-time PCR verification of candidate differential genes

In the transcriptome sequencing data, differentially expressed mRNAs in PBMCs that meet two conditions were initially screened:

(1) mRNA expression levels ≥10 copies in pediatric asthma patients;

(2) [|Log2（ Fold change, Log2FC）|≥ 2] and $p < 0.05$. Twelve candidate genes were identified: TLR4, TLR2, NFKBIA, RELA, CCL17, CCL22, CCL26, SERPINB2, CDH26, ANXA10, IL6, and IL13 ($p < 0.05$).

To verify the reliability of RNA-seq sequencing results, qReal-time PCR was conducted on 12 candidate genes, including TLR4, TLR2, and NFKBIA, in a differential gene verification group of 30 asthmatic children before and after SCIT treatment. It was identified that the SERPINB2 gene showed differential expression. Compared with the baseline group, the SERPINB2 gene was significantly decreased in the 16-week treatment group ($p < 0.01$) (**Figure 3**), suggesting that SERPINB2 is involved in the pathophysiological process of SCIT treatment for asthma.

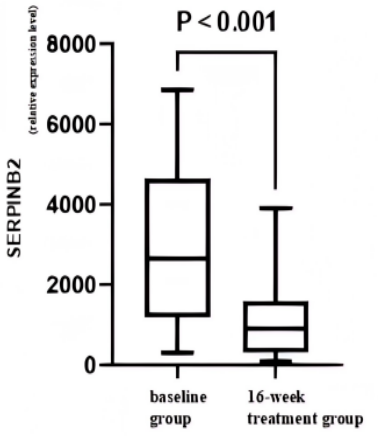


Figure 3. Candidate differential genes verified by qReal-time PCR.

3.5. Correlation analysis between SERPINB2 level and clinical score

Spearman correlation analysis was conducted on the SERPINB2 gene expression levels and ACQ, C-ACT, and CSMS scores before and after SCIT treatment in 30 asthmatic children in the differential gene validation group. The results showed that SERPINB2 was positively correlated with ACQ and CSMS scores, and negatively correlated with C-ACT scores, and the differences were statistically significant ($p < 0.05$) (**Figure 4**).

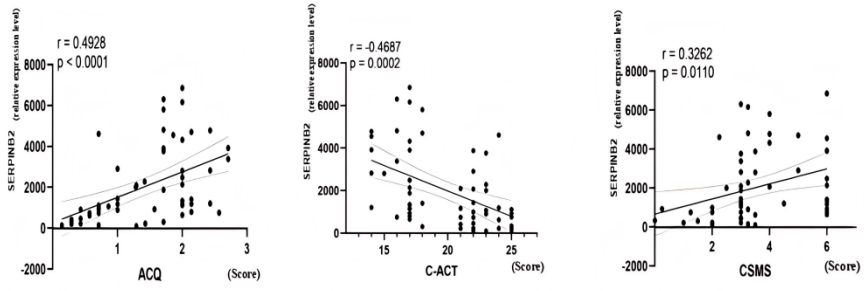


Figure 4. Spearman correlation analysis.

3.6. Analysis of predictive value of therapeutic effect in children with asthma

In the differential gene validation group, ROC analysis was performed on the baseline SERPINB2 gene expression level. The results showed that the area under the SERPINB2 gene curve (AUC) was 0.771, and the predicted value for SCIT efficacy in asthmatic children was 1641.024886 relative expression level. The sensitivity and specificity were 75.0% and 100.0%, respectively (see **Figure 5** and **Table 3**). When the relative expression level of SERPINB2 is below 1641.024886, the likelihood of achieving satisfactory therapeutic effect at week 16 may be low. This indicates that SERPINB2 levels play an important role in predicting clinical efficacy.

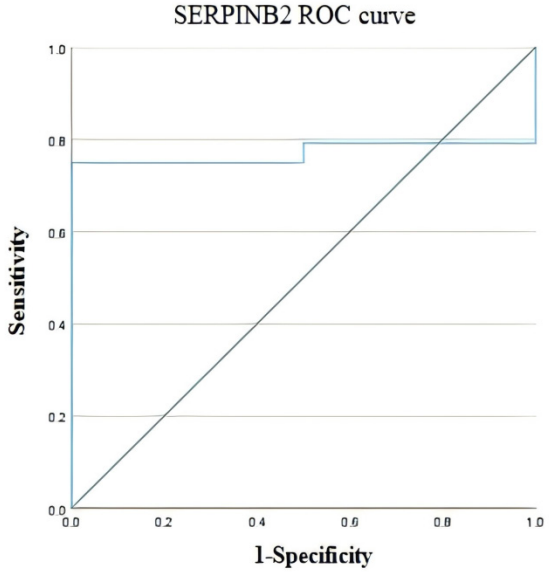


Figure 5. ROC curve for predicting the efficacy of SCIT.

Table 3. SERPINB2 possesses certain predictive value for therapeutic efficacy

Gene	Optimal cutoff point (relative expression level)	Sensitivity (%)	Specificity (%)	95%CI (relative expression level)	AUC
SERPINB2	1641.024886	75.0	100.0	0.606–0.936	0.771

4. Discussion

To explore potential biomarkers of SCIT in children with asthma, this study focused on the efficacy related biomarkers of SCIT in children with dust mite allergy and asthma. The included children were divided into a differential gene screening group (7 cases) and a differential gene validation group (30 cases). The gene expression changes of PBMCs before and after SCIT treatment were systematically analyzed by combining transcriptome sequencing and qPCR validation. The results showed that a total of 317 differentially expressed genes were screened before and after SCIT treatment, and 12 candidate genes were identified through screening. The selected candidate genes were further validated by qReal time PCR in 30 pediatric patients, and the SERPINB2 gene was identified to have significant differential expression. After 16 weeks of SCIT treatment, it was significantly downregulated and closely related to clinical symptom scores and lung function improvement. This suggests that it can be used as a candidate biomarker for monitoring the efficacy of SCIT.

SERPINB2 belongs to the serpin superfamily, whose primary function is to regulate the balance between proteases and antiproteases, thereby participating in the activation of immune cells and the release of inflammatory mediators [13,14]. In the airway inflammatory response of asthma, SERPINB2 can regulate the secretion of type 2 inflammation-related cytokines such as IL-4, IL-13, and TNF-α by inhibiting the activity of serine proteases, thereby participating in the amplification and maintenance of airway inflammation [14–16]. At the same time, its expression level is also closely related to the degree of airway remodeling. Highly expressed SERPINB2 can promote the proliferation of airway smooth muscle cells and collagen

deposition, exacerbating airway stenosis [17]. In this study, SERPINB2 was significantly downregulated after SCIT treatment and was correlated with clinical symptom improvement, further supporting the idea that SERPINB2 expression levels can reflect the activity status of allergic airway inflammation and can serve as a candidate biomarker for monitoring SCIT efficacy.

The expression change of SERPINB2 is closely correlated with the clinical efficacy after SCIT treatment. The Spearman correlation analysis results show that the gene expression level is significantly positively correlated with ACQ score and CSMS score, and significantly negatively correlated with C-ACT score, indicating that it can objectively reflect the treatment response of SCIT. ROC curve analysis further confirms that this gene exhibits good efficacy evaluation performance, with a statistically significant area under the curve (AUC), suggesting its feasibility as a potential biomarker for evaluating the efficacy of SCIT in pediatric asthma. It can provide objective evidence for early clinical judgment of SCIT treatment effectiveness and optimization of treatment plans.

Correlation analysis shows that SERPINB2 expression is positively correlated with ACQ and CSMS scores, and negatively correlated with C-ACT scores, which can objectively reflect the trend of short-term treatment response; The ROC curve suggests that it has a certain short-term therapeutic efficacy, which can provide a reference for early clinical judgment of SCIT response trends, and cannot be directly used for clinical decision-making.

This study still has certain limitations. Firstly, this study is a single-center study with a limited sample size, and no healthy control group was included for analysis, which may lead to insufficient representativeness of the research results and difficulty in generalizing to a wider population of children with asthma. Secondly, this study only investigated the expression changes of one gene before and after SCIT treatment and its correlation with clinical efficacy, without conducting protein level validation, independent external cohort validation, or in-depth exploration of the biological function and molecular mechanism of this gene. Lastly, the follow-up period in this study was only 16 weeks, and no tracking observation was conducted on the long-term expression changes of the gene and its predictive value for the long-term efficacy of SCIT, making it difficult to determine the long-term stability of the gene as a biomarker.

5. Conclusion

In summary, the SERPINB2 gene is significantly downregulated after SCIT treatment and is closely related to clinical symptom improvement and lung function enhancement, making it a potential biomarker for evaluating the efficacy of SCIT in children with asthma. In the future, the biomarker value of this gene can be further validated by expanding the sample size, conducting multi center studies, exploring molecular mechanisms in depth, and extending follow-up time, providing more solid theoretical support for immunotherapy of childhood asthma.

Disclosure statement

The authors declare no conflict of interest.

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Application Effect of Emotional Nursing Combined with Comfort Nursing in the Perioperative Period of Percutaneous Coronary Intervention in Patients with Coronary Heart Disease

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Abstract: *Objective*: To explore the effect of applying emotional nursing combined with comfort nursing in the perioperative period of percutaneous coronary intervention (PCI) in patients with coronary heart disease. *Methods*: A total of 84 patients with coronary heart disease who underwent PCI treatment from January 2024 to December 2025 were selected and randomly divided into a control group receiving routine perioperative care and a study group receiving emotional nursing combined with comfort nursing, with 42 cases in each group. The intervention effects of the two groups were compared. *Results*: After the intervention, the GCQ score of the study group was significantly higher than that of the control group ($p < 0.05$); the SAS and SDS scores of the study group were significantly lower than those of the control group after the intervention ($p < 0.05$); the GCQ score of the study group was significantly better than that of the control group after the intervention ($p < 0.05$). *Conclusion*: Emotional nursing combined with comfort nursing can effectively improve negative emotions in patients with coronary heart disease during the perioperative period of PCI, enhance comfort, and improve the quality of life related to angina pectoris.

Keywords: Coronary heart disease; Perioperative period; Comfort nursing; Emotional nursing

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1. Introduction

Percutaneous coronary intervention (PCI), as a core method for revascularization in coronary heart disease, offers advantages such as minimal trauma and rapid recovery, and has been widely applied in clinical practice. However, patients in the perioperative period of PCI are prone to negative emotions such as anxiety and depression due to fear of the surgery and concerns about the prognosis, which not only affect the

patient's treatment compliance but may also induce complications [1]. Conventional perioperative care pays insufficient attention to the psychological needs and comfort of patients, making it difficult to achieve ideal intervention effects. Emotional nursing, derived from the traditional Chinese medicine theory of "emotions causing diseases", improves the patient's psychological state through psychological counseling and emotional regulation, and has been proven to have a positive effect on the rehabilitation of patients with cardiovascular diseases [2]. Comfort nursing, centered on the patient, meets the patient's physiological, psychological, and social comfort needs through optimized nursing measures, reducing surgical stress responses [3]. In recent years, the application of combined nursing models in clinical care has gradually increased, but systematic application research on emotional nursing combined with comfort nursing in the perioperative period of PCI still needs to be improved. This study aims to explore the application effect of this combined nursing model in the perioperative period of PCI in patients with coronary heart disease and provide practical evidence for clinical care.

2. Materials and methods

2.1. General information

A total of 84 patients with coronary heart disease who underwent PCI treatment from January 2024 to December 2025 were selected and randomly divided into a control group and a study group, with 42 cases in each group. The general information of the two groups was comparable ($p > 0.05$), as shown in **Table 1**.

Table 1. Comparison of general information

Group	Number of cases	Gender		Age (years)	Disease duration (years)	Lesion type	
		Male	Female			Stable Angina Pectoris	Unstable Angina Pectoris
Control group	42	20 (47.62)	22 (52.38)	62.35 ± 7.42	5.26 ± 2.13	23 (54.76)	19 (45.24)
Study group	42	22 (52.38)	20 (47.62)	63.12 ± 7.56	5.48 ± 2.25	22 (52.38)	20 (47.62)
χ^2/t		0.191		0.471	0.460	0.048	
p		0.663		0.639	0.647	0.827	

2.2. Inclusion and exclusion criteria

2.2.1. Inclusion criteria

(1) Meeting the diagnostic criteria [4];
(2) Undergoing PCI treatment for the first time;
(3) Having clear consciousness and being able to cooperate in completing scale assessments;
(4) Providing informed consent signed by both the patient and their family members.

2.2.2. Exclusion criteria

(1) Having severe heart failure, severe arrhythmia, or being in the acute phase of myocardial infarction;
(2) Having severe underlying conditions such as liver or kidney failure, or malignant tumors;
(3) Having cognitive dysfunction or a history of mental illness;
(4) Having an infection at the puncture site or coagulation dysfunction.

2.3. Methods

The control group received conventional nursing care: preoperative preparation included completing relevant examinations and informing patients about the surgical procedure and precautions. Patients were instructed to fast for 6 hours and refrain from drinking water for 2 hours before surgery, complete skin preparation at the puncture site, and undergo bedside urination training. Medications were administered as prescribed before surgery. During the procedure, patients were assisted in adopting appropriate positions, intravenous access was established, vital signs were monitored, and patient responses were observed. Postoperatively, close observation was made for bleeding or hematoma at the puncture site, and radial/dorsal pedal artery pulsation was monitored. Adverse drug reactions were observed, and patients were guided on postoperative diet and activity.

The study group received emotional nursing combined with comfort nursing in addition to the conventional care provided to the control group

2.3.1. Emotional nursing

(1) Preoperative emotional intervention

Assess the patient's emotional state and identify core negative emotions. For patients primarily experiencing anxiety, use the "emotional dominance method" with "thought overcoming fear" and "joy overcoming sadness", guiding patients to think about postoperative rehabilitation plans to divert their emotions; play traditional Chinese medicine (TCM) wellness music every morning and before bedtime, combined with acupoint massage; instruct patients to practice TCM breathing techniques.

(2) Intraoperative emotional intervention

Nurses accompanied patients throughout the procedure, pressing the Hegu and Neiguan acupoint for 1 minute each with a sterile cotton swab before puncture to relieve instant tension; closely observe the patient's complexion and sweating during the procedure, and immediately press the Renzhong acupoint with the thumb to awaken the patient if signs of excessive emotional excitement such as pallor and excessive sweating appear.

(3) Postoperative emotional intervention

Use the "emotion diversion method", such as guiding patients to appreciate TCM wellness graphics and practice simplified Baduanjin exercises; for patients experiencing irritability due to pain, apply Wuzhuyu plaster to the Yongquan acupoint to draw fire downward and calm the mind; instruct family members to provide emotional support.

2.3.2. Comfort nursing

(1) Physiological comfort intervention

Postoperatively, dynamically assess the degree of pain. For patients with significant pain, administer analgesic medications as prescribed, and use physical interventions such as cold or hot compresses to relieve pain. Maintain the ward temperature at 22–25 ℃ and humidity at 50–60%, regularly ventilate the room, reduce noise interference, and ensure patients' sleep quality. For patients with difficulty urinating in bed, provide warm water rinsing of the perineum, listening to running water sounds, and other methods to induce urination; use indwelling catheters if necessary.

(2) Social comfort intervention

Promptly provide feedback to patients and their families on changes in the patient's condition and

rehabilitation progress, respecting the patient's right to be informed and make decisions. For patients with special needs, try to meet them as much as possible, provide rehabilitation guidance manuals, inform them of community rehabilitation resources, and help patients better reintegrate into their families and society.

2.4. Observation indicators

2.4.1. Comfort status

Assessed using the Kolcaba Comfort Status Scale (GCQ), which includes 4 dimensions and a total of 24 items, with a total score ranging from 24 to 96. A higher score indicates better comfort status.

2.4.2. Psychological state

Assessed using the SAS and SDS scales. Both scales have 20 items and use a 4-point scoring system. Anxiety and depression are indicated by scores of ≥ 50 and ≥ 53, respectively, with higher scores indicating more severe anxiety or depression.

2.4.3. Quality of life

Assessed using the Seattle Angina Questionnaire (SAQ), which includes 5 dimensions and a total of 18 items. Raw scores for each dimension are converted into standardized scores (0–100) using a formula, with higher scores indicating better quality of life for the patient.

2.5. Statistical methods

In the study, measurement data were expressed as ($\overline{x} \pm s$) and analyzed using *t*-tests. Statistical software (SPSS 24.0) was used for analysis, with $p < 0.05$ considered statistically significant.

3. Results

3.1. Comparison of GCQ scores

After intervention, the GCQ score in the study group was significantly higher than that in the control group ($p < 0.05$). See **Table 2**.

Table 2. Comparison of GCQ scores ($\overline{x} \pm s$, points)

Group	No. of cases	Physiological		Psychological/ Mental		Sociocultural		Environmental	
		Pre-intervention	Post-intervention	Pre-intervention	Post-intervention	Pre-intervention	Post-intervention	Pre-intervention	Post-intervention
Control group	42	12.18 ± 2.09	15.68 ± 2.35	20.42 ± 3.55	26.85 ± 3.82	8.63 ± 1.78	11.32 ± 1.92	5.26 ± 1.23	7.42 ± 1.36
Study group	42	12.35 ± 2.16	18.96 ± 2.58	20.15 ± 3.48	32.65 ± 4.12	8.45 ± 1.72	14.58 ± 2.13	5.13 ± 1.18	9.35 ± 1.42
t		0.367	6.091	0.352	6.690	0.471	7.367	0.494	6.361
p		0.715	< 0.001	0.726	< 0.001	0.639	< 0.001	0.622	< 0.001

3.2. Comparison of SAS and SDS scores

After the intervention, the SAS and SDS scores in the study group were significantly lower than those in the control group ($p < 0.05$). See **Table 3**.

Table 3. Comparison of SAS and SDS scores ($\overline{x} \pm s$, points)

Group	Number of cases	SAS		SDS	
		Before intervention	After intervention	Before intervention	After intervention
Control group	42	56.32 ± 6.85	48.63 ± 6.12	57.15 ± 6.92	47.85 ± 6.03
Study group	42	55.87 ± 6.73	41.26 ± 5.35	56.92 ± 6.85	40.18 ± 5.25
t		0.304	5.876	0.146	6.217
p		0.762	< 0.001	0.884	< 0.001

3.3. Comparison of GCQ scores

After the intervention, the GCQ score of the study group was significantly better than that of the control group ($p < 0.05$). See **Table 4**.

Table 4. Comparison of GCQ Scores ($\overline{x} \pm s$, points)

Group	No. of cases	Physical activity limitation		Angina stability status		Angina frequency		Treatment satisfaction		Disease cognition	
		Before intervention	After intervention	Before intervention	After intervention	Before intervention	After intervention	Before intervention	After intervention	Before intervention	After intervention
Control group	42	45.32 ± 8.65	62.53 ± 9.12	42.15 ± 9.36	65.42 ± 9.57	38.68 ± 10.21	68.75 ± 10.03	52.42 ± 9.75	70.35 ± 9.82	48.35 ± 10.13	66.42 ± 10.25
Study group	42	44.85 ± 8.52	78.65 ± 9.56	41.87 ± 9.25	82.32 ± 9.68	38.23 ± 10.16	85.85 ± 10.25	51.87 ± 9.68	86.42 ± 9.87	47.92 ± 10.05	84.85 ± 10.46
t		0.251	7.907	0.138	8.046	0.202	7.728	0.259	7.480	0.195	8.156
p		0.803	< 0.001	0.891	< 0.001	0.840	< 0.001	0.796	< 0.001	0.846	< 0.001

4. Discussion

PCI is an important means of revascularization for coronary heart disease (CHD), but perioperative physiological and psychological stress responses can affect the treatment outcomes and rehabilitation process of patients. Comfort care is a holistic, personalized, and creative nursing model aimed at achieving the highest state of pleasure for patients in terms of physiology, psychology, society, and environment [5]. Emotional nursing, rooted in traditional Chinese medicine (TCM) theory, emphasizes the role of the "seven emotions" in causing and treating diseases. Through methods such as reasoning and persuasion, emotional diversion, and mutual restraint of emotions, it actively regulates patients' emotions and promotes physical and mental harmony [6]. Studies have shown that the combination of comfort care and psychological intervention can significantly improve negative emotions in patients and enhance their quality of life [7].

In this study, the total GCQ score of the study group was significantly higher than that of the control group after intervention. TCM emotional nursing improved psychological and mental comfort by "harmonizing Qi and blood and calming the mind", enhancing psychological pleasure. Comfort care specifically optimized physiological and environmental comfort, and the combined intervention effectively

improved patient comfort. Su Min and other researchers pointed out that CHD patients are often affected by long-term illness, leading to high expression of negative emotions [8]. According to TCM, "the heart governs the mind" and "emotional imbalance leads to Qi and blood disorders". Negative emotions such as anxiety and depression can cause Qi stagnation and heart vessel obstruction, exacerbating myocardial ischemia [9]. Studies have shown that TCM emotional nursing fully utilizes the theory of mutual restraint among the seven emotions, such as "joy overcoming sorrow", to improve negative emotions in patients [10]. In this study, the SAS and SDS scores of the study group were lower after intervention. Based on the TCM theories of "the five internal organs corresponding to the five emotions" and "mutual restraint among emotions", dialectical nursing care was implemented. Through precise assessment of emotional states, emotional regulation methods such as "contemplation overcoming fear" and "joy overcoming sorrow" were specifically employed. A full-cycle TCM emotional intervention system was formed through characteristic TCM interventions before, during, and after surgery, effectively alleviating patients' negative emotions. The SAQ score of the study group was significantly better than that of the control group. TCM emotional nursing alleviated negative emotions such as anxiety and fear through dialectical nursing care, reducing angina pectoris induced by Qi stagnation caused by emotional imbalance and lowering the frequency of attacks. Interventions such as acupoint massage regulated autonomic nervous function and improved the stability of angina pectoris. Comfort care alleviated physical discomfort through personalized pain management and posture optimization, enhancing physical activity endurance and improving the degree of physical activity limitation. Social comfort interventions strengthened family support and disease awareness, improving treatment satisfaction. The synergy of both approaches comprehensively optimized the quality of life related to angina pectoris.

5. Conclusion

In summary, the application of emotional nursing combined with comfort care during the perioperative period of PCI in CHD patients effectively improves patients' psychological states, enhances perioperative comfort, and improves the quality of life related to angina pectoris, making it worthy of clinical promotion and application. However, this study had a relatively small sample size and was a single-center study, resulting in certain limitations. Future studies could expand the sample size and conduct multi-center studies to further validate the research findings.

Disclosure statement

The authors declare no conflict of interest.

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Research on the Construction Method of Famous TCM Physicians' Academic Knowledge Graph Based on Multimodal Deep Learning — Application of the AGBAN Model

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Abstract: Aiming at the problems of knowledge fragmentation and opaque reasoning in the digital inheritance of famous TCM physicians' academic thoughts and diagnosis-treatment experience, a multimodal knowledge graph construction method based on the AGBAN model is proposed. Using more than 3,000 outpatient medical records of famous TCM physicians as the data source, multimodal information is integrated to construct a clinical knowledge graph through ontology design, entity-relationship extraction, and knowledge storage. The graph attention network and reinforcement learning mechanism of the AGBAN model are introduced to optimize the diagnosis-treatment path. The results show that the knowledge graph contains 3,089 entities and 1,461 relationships, with an average degree of 2.49; the average reciprocal rank of link prediction of the AGBAN model is 0.973, which is 165.4% higher than that of the TransE model, the diagnosis success rate is 59.19%, and the average reasoning path is 5 steps; cluster analysis verifies the core TCM principles such as "drug-syndrome correspondence". The conclusion indicates that this method realizes the structured representation and intelligent reasoning of famous TCM physicians' clinical experience, providing a feasible path for TCM academic inheritance and clinical decision support.

Keywords: Multimodal deep learning; Knowledge graph; AGBAN model; Inheritance of famous TCM physicians' experience; Clinical reasoning

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1. Introduction

1.1. Research background and significance

With the wide application of hospital information systems and electronic medical records, a large amount of

diagnosis-treatment data of famous TCM physicians has been accumulated. However, such data is mostly stored in fragmented "record-field" forms, lacking explicit modeling of semantic relationships between core elements such as "symptoms-syndromes-prescriptions", which is prone to forming data silos. Existing analysis methods mostly stay at the basic statistical level, making it difficult to support in-depth association mining and causal inference, resulting in insufficient interpretability of diagnosis-treatment experience and limited inheritance efficiency.

The State Administration of Traditional Chinese Medicine has issued a number of policies to promote TCM teacher-apprentice inheritance, and has selected 3,404 instructors and trained 6,562 successors [1,2]. However, traditional teacher-apprentice inheritance has problems such as low efficiency, difficulty in knowledge management, and limited scope. As a national demonstration pilot city for the inheritance and innovative development of traditional Chinese medicine, Zhongshan urgently needs scientific methods to support the digital preservation and intelligent application of famous TCM physicians' experience.

1.2. Research status at home and abroad

Knowledge graphs construct a semantically interconnected knowledge network with "entity-relationship" triples as the basic unit, providing an effective framework for integrating multi-source heterogeneous clinical data of famous TCM physicians. In recent years, Yang Haici from Peking University and others used knowledge graph technology to construct the academic inheritance ontology of the Song Dynasty, and Chen Yingxuan from Guangzhou University of Chinese Medicine and others constructed the knowledge graph of TCM ancient books based on the original text of *Lingshu*, verifying the application potential of knowledge graphs in the field of TCM [3,4]. However, traditional knowledge graphs still face important challenges in the diagnosis-treatment reasoning process, insufficient reasoning transparency and interpretability, especially in clinical decision-making, it is difficult to effectively solve the problem of "drugs not matching syndromes".

With the development of multimodal learning, integrating multi-source data such as text, images, and videos has become an important direction to improve knowledge representation capabilities. The AGBAN (Attention-guided Graph Neural Network for Multi-modal Data Representation Learning) model, proposed by the Institute of Automation, Chinese Academy of Sciences, combines graph neural networks and attention mechanisms, which can effectively handle the association and interaction between different modal data, providing a new theoretical framework for the construction of multimodal knowledge graphs [5].

1.3. Research objectives and innovations

This study aims to solve the deficiencies of current TCM knowledge graphs in reasoning transparency and interpretability, propose a multimodal knowledge graph construction method based on the AGBAN model, and realize the modeling of complete knowledge links from symptoms to treatment plans. The main innovations include: first, integrating text and image information in the outpatient medical records of famous TCM physicians to construct multimodal knowledge representation; second, introducing attention-enhanced graph neural networks and reinforcement learning mechanisms to realize adaptive learning and reasoning optimization of diagnosis-treatment paths; third, constructing the causal structure of "symptoms → core pathogenesis → syndromes → prescriptions" through a path planning model to improve the reasoning transparency of intelligent diagnosis systems [6].

2. Methods and technologies

2.1. Overview of research process

Integrate more than 3,000 anonymized TCM outpatient medical records from Zhongshan Hospital of Traditional Chinese Medicine from 2022 to 2024, and construct a clinical TCM knowledge graph containing 3,089 entities and 1,461 relationships through data preprocessing, ontology design, knowledge extraction, knowledge storage and other steps, using Neo4j graph database for storage; on this basis, apply the graph attention network and reinforcement learning mechanism of the AGBAN model to simulate the cognitive process of famous TCM physicians and realize the optimization of diagnostic reasoning [7].

2.2. Data source and preprocessing

The research data are outpatient medical records from the famous TCM physician studio of Zhongshan Hospital of Traditional Chinese Medicine, covering full-process information such as main complaints, diagnoses, syndromes, and prescriptions. Clinical logical rules are used to evaluate data quality, checking the consistency between gender, age and diagnosis, and the matching degree between tongue signs and syndromes. The proportion of logical conflict records is less than 10%, and the data quality is reliable after expert review.

Data preprocessing adopts a dual-feature lexicon method to classify integrated TCM-WM prescriptions; regular expressions are used to parse TCM names, extract the “name-dose-unit” pattern, hierarchically clean WM names, and remove dosage form and trade name annotations [8].

2.3. Knowledge extraction

2.3.1. Entity extraction

Combined with the structured characteristics of clinical Excel tables, seven types of entities are defined: TCM disease names, TCM syndromes, symptoms, signs, TCM medicines, WM medicines, and tongue sign features. The indication function of table headers and table names is used to improve extraction accuracy, and a total of 3,089 entities are extracted.

2.3.2. Attribute extraction

Identify attribute-value pairs of entities and convert them into edges of the knowledge graph. For example, extract attributes such as tongue color and tongue shape from the “tongue signs” column to form “entity-attribute-value” triples.

2.3.3. Relationship extraction

A rule-based method is adopted to define seven types of entity relationships, such as “symptoms point to syndromes”, “syndromes are treated with TCM medicines”, and “diseases are treated with WM medicines”, and finally 1,461 relationship edges are constructed [9].

2.4. Knowledge graph storage and update

The Neo4j graph database is used to store the knowledge graph, with nodes representing entities, relationships representing semantic connections, and attributes describing entity features; the Cypher query language is used to support syndrome inference based on symptom combinations, realize intelligent reasoning of TCM

syndrome differentiation, and support dynamic updates of the graph to improve the knowledge system [10].

2.5. Application of the AGBAN model: Knowledge graph embedding and reasoning optimization

2.5.1. Graph attention network architecture

A four-head graph attention network is adopted to assign differentiated importance to neighboring nodes to learn adaptive entity representations. After linear transformation of node features, the transformed features of source and target nodes are concatenated, dotted with the attention vector, activated by LeakyReLU and normalized by Softmax to obtain attention coefficients [11]. The four attention heads focus on four types of relationships: symptom-syndrome, syndrome-TCM treatment, TCM-TCM interaction, and general semantic relevance.

2.5.2. Construction of reinforcement learning diagnostic environment

The TCM diagnosis-treatment process is formalized as a Markov decision process [12]. The state space integrates distributed representations of symptoms and syndromes, path history, and target progress, and the action space is the transfer of adjacent nodes in the graph. A structured reward function is designed, including six components: basic path reward, target achievement reward, graph structure reward, diversity exploration reward, efficiency reward, and cycle penalty, to guide the model to learn the optimal diagnosis-treatment path.

2.5.3. Phased training strategy

A progressive curriculum learning strategy is adopted to train the model in four phases: the first phase is the intensive exploration phase, with 12 steps, the exploration rate ε decreases from 1.0 to 0.8, extensively exploring graph structures and basic diagnostic patterns; the second phase is the balanced learning phase, with 10 steps, the exploration rate decreases to about 0.5, balancing exploration and pattern utilization; the third phase is the strategy optimization phase, with 8 steps, the exploration rate decreases to about 0.3, refining the optimization of diagnosis-treatment strategies; the fourth phase is the refined utilization phase, with 6 steps, the exploration rate decreases to 0.1, optimizing path efficiency and stabilizing diagnostic strategies.

3. Results

3.1. Statistics of knowledge graph construction

Seven types of entities total of 3,089 are extracted from clinical data, and 1,461 relationship edges mainly focusing on clinical associations are constructed. Among them, “symptoms point to syndromes”, “TCM medicines treat syndromes”, and “TCM medicines treat diseases” are the top three relationships; the average degree of the graph is 2.49, with a dense structure, realizing the systematic representation of famous TCM physicians’ diagnosis-treatment knowledge.

3.2. Training results and analysis of the AGBAN model

The TransE model converges well after 200 rounds of training, with the loss stabilizing at 4.5280, the learning rate smoothly decaying from 0.001 to 0.000063, the entity embedding norm maintained at 1.0, and

the normalization effect is significant [13].

Principal component analysis visualization shows that drugs and syndromes form a continuous semantic spectrum in the vector space without obvious type boundaries, verifying the TCM principle of "drug-syndrome correspondence"; cluster analysis shows a silhouette coefficient of 0.973 and a CH index of 6,012.21, confirming eight semantic clusters with strong cohesion.

In the AGBAN model test, the diagnosis success rate is 59.19%, and the average reasoning path length is 5 steps, which is 11.6% higher than that of the random strategy. In the link prediction task, the average reciprocal rank of the model is 0.0252, which is 165.4% higher than that of the TransE model; embedding diversity analysis shows that its distribution is more concentrated (0.9173 compared with 1.0001 of TransE), and the ability to capture semantic relationships is better.

3.3. Visualization analysis

3.3.1. Association network between TCM diagnosis and WM use

Through the analysis of co-occurrence relationships between TCM diagnosis and WM entities, this study constructs a clinical knowledge association network combining TCM and WM (**Figure 1**). The analysis results show that one WM may correspond to multiple TCM diagnoses and vice versa. This phenomenon suggests that famous TCM physicians do not simply correspond WMs to specific diseases in clinical practice, but select WMs based on TCM syndrome differentiation results. This syndrome differentiation-based medication model reflects the individualized thinking in integrated TCM-WM diagnosis and treatment, and also provides visual decision support for collaborative TCM-WM treatment in the context of precision medicine.

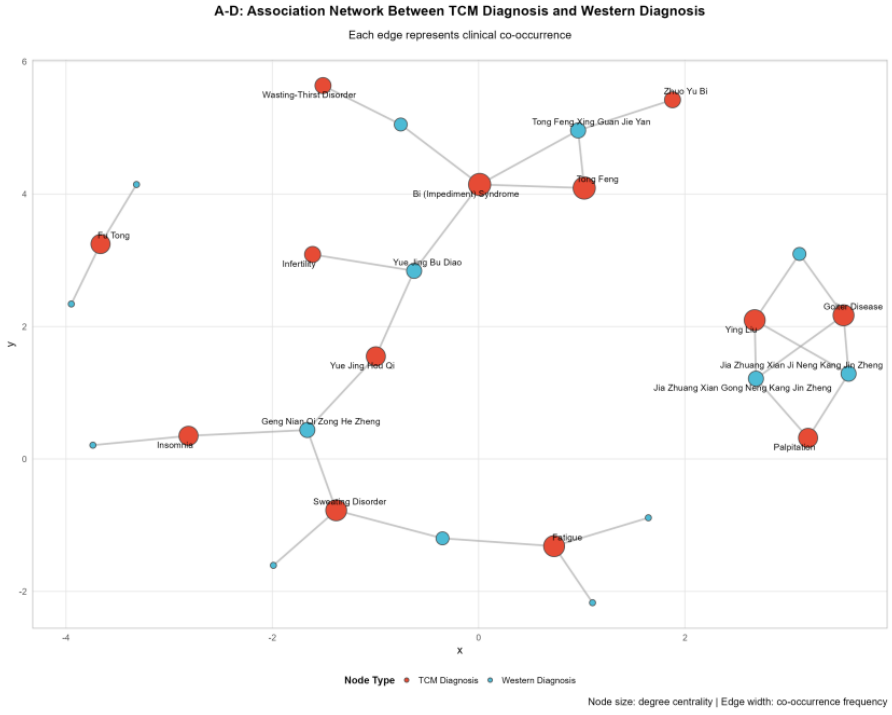


Figure 1. The association network between traditional Chinese medicine diagnosis and the use of Western medicine.

3.3.2. Nodal relationship between TCM diagnosis and patient symptoms

Figure 2 show the network relationship between TCM diagnoses and symptoms. From the network structure, it can be seen that the same TCM diagnosis can correspond to multiple symptom combinations, and different diagnoses may also have common symptoms. This complex network relationship intuitively reflects the core TCM principles of "treating different diseases with the same method" and "treating the same disease with different methods", the key to diagnosis and treatment lies in identifying the core pathogenesis rather than simply addressing symptoms. This network structure helps learners understand the clinical thinking characteristics of famous TCM physicians in "grasping main symptoms and recognizing pathogenesis".

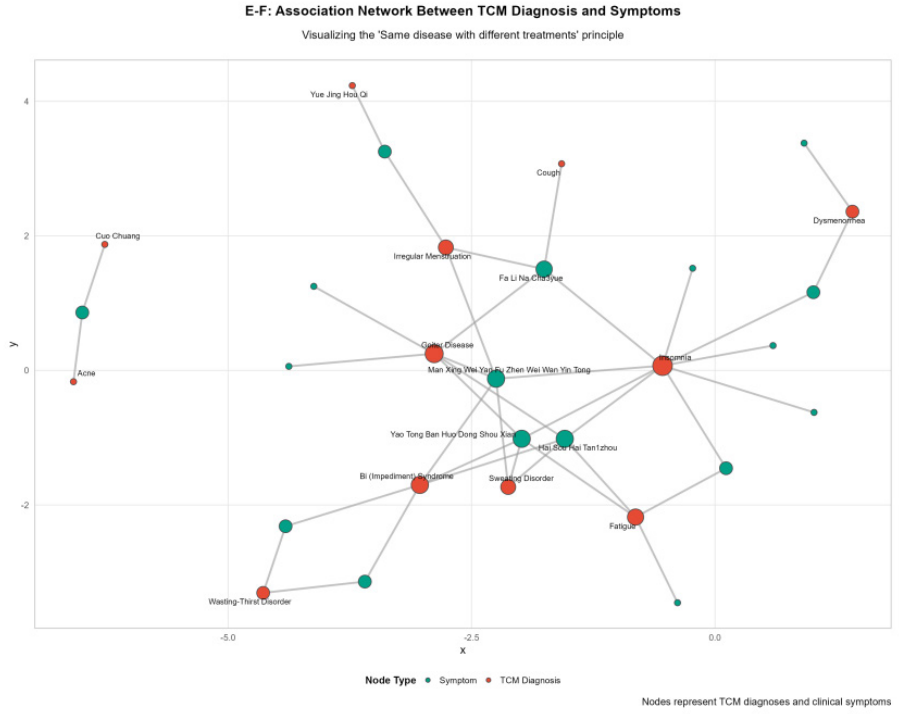


Figure 2. The nodal relationship between traditional Chinese medicine diagnosis and the patient's symptom.

3.3.3. Association network between symptoms and tongue manifestations

Figure 3 also show the association network between symptoms and tongue manifestations [14]. TCM emphasizes "comprehensive four diagnostic methods", and tongue diagnosis, as an important part of inspection, has significant value in syndrome differentiation. From the network analysis, it can be seen that the same symptom may correspond to different tongue manifestation patterns, which may reflect diagnostic differences among different physicians or academic schools; on the other hand, different symptoms may also present the same tongue manifestations, which confirms the diagnostic principle of "tongue diagnosis for root cause", tongue manifestations reflect internal pathogenesis rather than simply corresponding to superficial symptoms. This network provides a basic support for the standardized research of tongue diagnosis and the development of intelligent diagnosis systems.

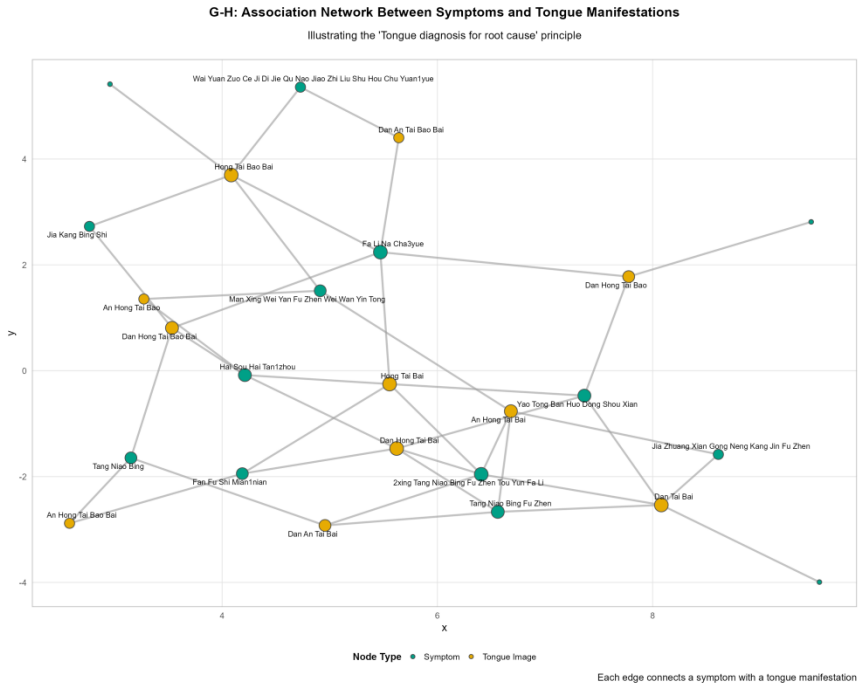


Figure 3. The correlation between symptom nodes and tongue image nodes.

4. Discussion

4.1. Main research results

The large-scale clinical knowledge graph constructed in this study realizes the digital and systematic inheritance of famous TCM physicians' diagnosis-treatment experience. The core results are reflected in three aspects: first, constructing a "digital mirror" of famous TCM physicians' diagnosis and treatment, converting fragmented records into traceable visual decision paths through the "disease-syndrome-symptom-drug" semantic network, and the graph attention network simulates the cognitive focus of physicians, approaching the clinical decision-making process; second, realizing the transformation from "prescription inheritance" to "thinking inheritance", the model learns efficient diagnosis-treatment paths, completing the upgrade from static prescription records to dynamic clinical reasoning simulation, and verifying the drug-syndrome correspondence theory; third, establishing an evolving knowledge inheritance ecosystem, the knowledge graph can be dynamically updated to integrate new clinical data, transforming personal experience into continuously evolving collective wisdom, realizing the "living inheritance" of famous physicians' experience.

4.2. Research limitations and future directions

This study still has certain limitations: first, the current multimodal data fusion mainly focuses on text information, and the in-depth mining of image data such as tongue signs and facial signs is insufficient; second, there are certain inconsistencies in the entity annotation process, which may introduce noise interference; finally, the semantic interference caused by the mixed use of TCM and WM needs to be further addressed.

Future research can be further carried out in the following directions: first, deepen knowledge representation and reasoning mechanisms, explore more advanced embedding models such as RotatE

and ComplEx, as well as neuro-symbolic methods integrating logical rules and neural networks; second, strengthen multimodal data fusion, integrate image data such as tongue signs and pulse signs, and construct a more complete diagnostic evidence chain; third, promote the practical application of clinical decision support systems, develop tools such as intelligent question answering, syndrome differentiation assistance, and prescription generation; fourth, use graph mining, causal inference and other methods to extract potential drug pairs, syndrome evolution laws, and prescription combinations from the knowledge graph, promoting the evolution and innovation of TCM theory.

5. Conclusion

Based on more than 3,000 real outpatient medical records of famous TCM physicians, this study constructs a multimodal clinical knowledge graph containing 3,089 entities and 1,461 relationships, systematically representing the clinical diagnosis-treatment experience of famous TCM physicians. The AGBAN model combining graph attention network and reinforcement learning mechanism is introduced to realize adaptive learning and reasoning optimization of diagnosis-treatment paths [15]. The model is significantly superior to traditional methods in diagnosis accuracy, path efficiency, and interpretability.

Through visualization analysis, the complex associations between TCM diagnosis and WM use, TCM diagnosis and symptoms, and symptoms and tongue manifestations are revealed, intuitively presenting the clinical thinking characteristics of famous TCM physicians. This study verifies the feasibility of the multimodal knowledge graph combined with the AGBAN model in TCM academic inheritance and intelligent application, providing new ideas and methods for the digital development of TCM, clinical decision support, and innovation in teacher-apprentice education, and having important practical value for promoting the modern inheritance of TCM.

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Disclosure statement

The authors declare no conflict of interest.

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Real Experiences of Low Back Pain in Nursing Students During Nursing Operations: A Qualitative Study

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Abstract: *Objective*: To explore the authentic experiences of low back pain among nursing students during clinical practice and provide evidence for prevention and management. *Methods*: Twenty-three nursing students were recruited between November 1 and December 31, 2024. Semi-structured face-to-face focus group interviews were conducted, and data were analyzed using Colaizzi's seven-step method. *Results*: Five main themes and five sub-themes were identified: influencing factors of low back pain; high-risk procedures exacerbating pain; insufficient preventive knowledge; dual impacts on learning and psychology; and expectations for equipment improvement. *Conclusion*: Optimizing the training environment, standardizing operation protocols, and strengthening ergonomic training can reduce occupational low back pain and improve health protection awareness among nursing students.

Keywords: Nursing students; Low back pain; Muscle fatigue; Occupational protection; Qualitative research; Clinical practice; Ergonomics

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1. Introduction

With continuous advancements in medical technology, nursing professionals, as a critical component of the healthcare system, have drawn increasing societal attention to occupational health issues. Nursing work involves prolonged standing, frequent gait transitions, and patient handling, characterized by high intensity and repetitive motions, which elevate the risk of lumbar and back injuries among nursing staff [1]. Although research on occupational diseases among nursing personnel has grown in recent years, qualitative studies examining lumbar and back muscle fatigue experienced by nursing students during practical training remain relatively scarce. Nursing students undergo extensive hands-on training during their academic years but often lack knowledge and experience in lumbar protection measures, resulting in a high incidence of low

back pain among this population [2]. This not only impacts students' academic performance and quality of life but may also reduce their willingness to pursue careers in nursing, thereby adversely affecting professional development [3]. Therefore, in-depth exploration of the authentic experiences of lumbar and back muscle fatigue during nursing operations holds significant practical value. This study employs qualitative research methods, conducting in-depth interviews with nursing students at our university to analyze influencing factors and propose recommendations regarding muscle fatigue associated with lumbar and back-related tasks.

2. Study subjects and methods

2.1. Study subjects

Using purposive sampling method, nursing students enrolled in higher education institutions from November 1, 2024 to December 31,2024 were selected as study subjects. Inclusion criteria included: nursing students participating in nursing-related practical courses; those capable of clearly expressing their perceptions and experiences during lumbar and back-related tasks, and voluntarily signing informed consent forms. Exclusion criteria included: nursing students with recent major lumbar or back disorders. Sample size was determined based on data saturation principles to ensure no new topics emerged during interviews. A total of 3 group interviews were conducted with 23 nursing students, and their demographic data are presented in **Table 1**. This study has been approved by the hospital ethics committee (Ethics Approval Number: 202415) and strictly adhered to confidentiality principles.

Table 1. General characteristics of study subjects (n = 23)

Number	Age	Sex	Stature	Education	School year	Period of schooling
N1	23	woman	165 cm	upgrade from junior college student to university student	Grade 2	5 years
N2	22	woman	157 cm	upgrade from junior college student to university student	Grade 2	5 years
N3	23	woman	168 cm	upgrade from junior college student to university student	Grade 2	5 years
N4	24	woman	163 cm	upgrade from junior college student to university student	Grade 2	5 years
N5	22	woman	157 cm	upgrade from junior college student to university student	Grade 2	5 years
N6	23	woman	158 cm	upgrade from junior college student to university student	Grade 2	5 years
S1	23	woman	156 cm	upgrade from junior college student to university student	Grade 2	5 years
S2	22	woman	157 cm	upgrade from junior college student to university student	Grade 2	5 years
S3	23	woman	158 cm	upgrade from junior college student to university student	Grade 2	5 years
S4	23	woman	164 cm	upgrade from junior college student to university student	Grade 2	5 years
S5	22	woman	170 cm	upgrade from junior college student to university student	Grade 2	5 years

Number	Age	Sex	Stature	Education	School year	Period of schooling
S6	24	man	165 cm	upgrade from junior college student to university student	Grade 2	5 years
S7	21	man	185 cm	undergraduate course	Grade 2	3 years
H1	24	woman	155 cm	upgrade from junior college student to university student	Grade 2	5 years
H2	23	woman	167 cm	upgrade from junior college student to university student	Grade 2	5 years
H3	21	woman	158 cm	upgrade from junior college student to university student	Grade 2	8 years
H4	23	woman	169 cm	upgrade from junior college student to university student	Grade 2	8 years
H5	19	woman	150 cm	undergraduate course	Grade 3	3 years
H6	20	woman	150 cm	undergraduate course	Grade 3	3 years
H7	21	man	178 cm	undergraduate course	Grade 3	3 years
H8	21	man	181 cm	undergraduate course	Grade 3	3 years
H9	21	man	183 cm	undergraduate course	Grade 3	3 years
H10	21	man	179 cm	undergraduate course	Grade 3	3 years

2.2. Research methods

2.2.1. Development of interview outline

The research team initially drafted an interview outline based on literature review and group discussions to align with the study objectives. Three senior experts (associate senior level or above) with over 15 years of experience in nursing management, ergonomics, and rehabilitation medicine were consulted to analyze and evaluate the outline, with subsequent revisions made according to their feedback. Preliminary interviews with five nursing students were conducted, and the outline was further refined based on the results. The final interview outline is as follows:

(1) Have you ever experienced lower back pain during practical training operations?
(2) What do you consider to be the primary cause of low back pain?
(3) What methods do you typically employ to alleviate or reduce pain when experiencing lumbar and back pain?
(4) Which courses on practical training operations have you attended? Have the content and format of these courses had an impact on your lumbar and back health?
(5) Among these procedures, which ones are more likely to cause lumbar and back pain? What physical and subjective sensations have these pains brought you?
(6) During the procedure, which postures or movements may exacerbate your lower back pain?
(7) Do you think the surrounding environment has affected your working posture?
(8) When participating in practical training courses, would you adopt certain self-protection measures to mitigate the occurrence of lumbar and back pain?

2.2.2. Data collection and quality control

Data collection was conducted using semi-structured face-to-face group focus interviews in the nursing practice training laboratory at the school. Prior to interviews, participants were thoroughly informed about the research objectives, methodology, and content, with scheduled interview times agreed upon. With

informed consent, all sessions were recorded audio-visually. Researchers maintained neutral and respectful attitudes to ensure participants could freely express thoughts and feelings in a comfortable environment, listened attentively without interruption, and avoided leading questions. Each interview lasted 20-40 minutes. Adhering to qualitative research's data saturation principle, the team conducted three interviews. Post-interview, team members cross-checked transcripts, revisiting ambiguous or questionable sections for verification. Two researchers collaboratively reviewed, analyzed, coded, and refined transcripts, then compared them with original data to establish research themes.

2.2.3. Data analysis

Data analysis was conducted using NVIVO 12.0 software. After interviews, collected data were transcribed by two team members and verified by the research group. The Colaizzi seven-step analysis method [4] was employed for data processing, involving repeated word-by-word and sentence-by-sentence reviews of interview transcripts to extract theme-relevant statements and code recurring perspectives. Codified viewpoints were aggregated to identify common characteristics, with each emerging theme described in detail and similar viewpoints distinguished. In case of discrepancies during data analysis, the final conclusions were determined through group discussion by the research team.

3. Results

3.1. Major influencing factors of low back pain in nursing students

3.1.1. Environmental factors

Responding students commonly reported issues with practical training environments, including excessively low beds, insufficient bed spacing, overcrowded classrooms, and inappropriate temperature or lighting conditions. These factors compel them to adopt poor postures or increase physical exertion, thereby elevating the risk of lumbar and back pain. S1: "The bed height is too low, making each procedure inconvenient and requiring frequent bending". H3: "The narrow spacing between beds in the training room limits my ability to maintain proper posture when pushing the treatment cart during procedures". H4: "Crowded spaces with limited room often restrict movement range". N3: "Excessive heat and ineffective air conditioning exacerbate fatigue during operations". H10: "Poor lighting conditions during blood draws make visual assessment difficult, significantly increasing effort requirements".

3.1.2. Repetitive operations induce muscle fatigue

Multiple technical procedures in nursing practice, such as catheterization and cardiopulmonary resuscitation (CPR), require repetitive operations, leading to lumbar and back muscle fatigue. H5: "During catheterization disinfection for patients, repeated bending and standing up causes significant strain on the lumbar region, resulting in inability to maintain posture for extended periods". S2: "During CPR, the high-frequency compressions required by the procedure typically last approximately 5 minutes, necessitating sustained arm extension and lumbar force application. Post-procedure, lumbar and back muscle fatigue becomes particularly pronounced".

3.1.3. Improper operating postures increase injury risk

Nursing students commonly report experiencing back pain or soreness during activities such as bending,

squatting, prolonged standing, and sustained single-posture operations. Basic nursing and skill training procedures, including bed making, intravenous infusion, and cardiopulmonary resuscitation (CPR), are high-risk scenarios. H10: "I feel my back becomes sore after prolonged bending or extended operation time". N3: "During CPR procedures involving continuous chest compressions, I experience significant back fatigue afterward". N6: "Non-standard postures increase pain susceptibility due to uneven force distribution".

3.2. High-risk procedures exacerbate the occurrence of low back pain

Students consistently identified basic nursing procedures as the most common cause of low back pain. Tasks such as cardiopulmonary resuscitation (CPR), bed making, catheterization, and sponge baths, due to their complex and repetitive movements requiring bending or squatting, became high-risk points for low back pain. H4: "CPR procedures are frequent, and both during and after the process, I distinctly experience low back pain". S1: "Bed making is the most exhausting, especially when folding bed corner covers, which requires prolonged bending and weight-bearing". S5: "During urinary catheter insertion, maintaining prolonged bending in a fixed posture often causes discomfort and pain in the lower back". H5: "During catheter insertion, constant bending in one position over extended periods leads to severe lower back pain". H10: "Body wiping for patients (using hand gestures) involves leg elevation and patient turning, which significantly strains the lumbar spine".

3.3. Insufficient awareness of prevention and delayed implementation of mitigation measures

Most students lack effective preventive measures against back discomfort, often only taking action after experiencing pain. Common relief methods include stretching, massage, using lumbar support belts, or resting, but few adopt proactive protective behaviors. N1: "We usually don't take preventive steps—only resort to massage or lying down when in pain. Typically, we only notice back pain after class ends". S5: "I've used lumbar support belts, but only when experiencing soreness". N2: "Sometimes I stretch and twist my back to alleviate discomfort". In summary, nursing students still face challenges such as insufficient knowledge and weak behavioral execution in preventing back injuries, urgently requiring systematic education and training to enhance their proactive prevention awareness and protective capabilities.

3.4. Dual effects of low back pain on learning outcomes and psychological state

3.4.1. Decline in operational efficiency and learning quality

Persistent lumbar and back discomfort significantly impacts nursing students 'operational performance during practical training, manifesting as slowed movements and reduced learning motivation. N5: "If I have back pain, performing these procedures will definitely be affected—my movements become uncoordinated or I can't sustain them for long. I'm afraid I won't master these operations". N6: "Sometimes the pain is so severe that even sitting to read becomes uncomfortable. I just want to lie in bed resting, which inevitably delays my learning".

3.4.2. Negative emotions and learning anxiety

Frequent physical discomfort triggers emotional fluctuations, with some nursing students experiencing negative emotions such as anxiety, worry, and a sense of helplessness, even doubting their academic abilities and future prospects. N5: "I'm already exhausted from the heavy course load, and my back pain persists. After class, I have no energy left to study—I just want to relax. The thought of having so much professional

knowledge to learn makes me genuinely worried about falling behind, and it's terrifying to think about it". N1: "I'm anxious and fearful of not keeping up with my classmates".

3.5. Students expect improved facilities and greater support

Students proposed multiple improvement suggestions, including adjustable-height beds, more ergonomic chairs and tools, as well as optimized practical training spaces. They aimed to reduce back pain caused by poor posture through environmental and equipment enhancements. H3: "We hope the bed height can be adjusted; otherwise, our operations would be too strenuous". N2: "It would be great if the school provided lumbar support belts". S4: "With more space and better equipment arrangement, we could adopt more relaxed postures".

4. Discussion

This study systematically analyzed the primary influencing factors and practical experiences of low back pain during nursing operations among 23 nursing students. The findings revealed that adverse working environments (e.g., confined spaces, suboptimal equipment design, inappropriate temperature/humidity conditions, insufficient lighting), repetitive tasks, and improper operational postures were the main causes of lumbar muscle fatigue and pain in nursing students. High-risk procedures such as cardiopulmonary resuscitation (CPR), bed-making, urinary catheter insertion, and patient transportation significantly increased the risk of lumbar injuries. Additionally, nursing students generally lacked adequate protective knowledge and behavioral competence, adopting passive approaches to pain prevention that often relied on post-class rest or temporary relief measures. Lumbar pain not only reduced learning efficiency and quality among nursing students but also induced negative emotions and occupational burnout. This situation warrants attention through targeted interventions, including enhanced occupational health education on lumbar pain management, strengthened self-protection awareness, rational improvements in environmental equipment (e.g., energy-efficient devices), optimized workspace organization, and scientifically designed work surfaces.

4.1. Environmental and equipment conditions exacerbate lumbar and back strain

Nursing students have identified factors such as excessively low bed heights, insufficient bed spacing, overcrowded training laboratories, and suboptimal temperature conditions as contributors to lumbar fatigue and pain. These findings align with existing research indicating that non-ergonomic bed heights and spatial configurations compel nursing staff to adopt poor postures like bending or twisting during procedures, thereby exacerbating lumbar load [5]. Studies have demonstrated that when nursing bed heights cannot be adjusted according to operator height, lumbar muscle activity intensity significantly increases [6]. Additionally, environmental factors such as excessive temperature and poor ventilation reduce nursing students' comfort levels and tolerance, indirectly increasing operational burden. Therefore, improving training environments and equipment conditions holds practical significance for alleviating lumbar pain among nursing students.

4.2. Poor posture and prolonged operation duration are major predisposing factors for low back pain

Nursing students generally consider bending, squatting, prolonged standing, and maintaining a single posture for extended periods as significant causes of low back pain. This finding is consistent with previous studies.

Multiple surveys indicate that nurses experience a significantly increased risk of musculoskeletal disorders (MSDs) in the lumbar and back regions due to prolonged bending, twisting, and sustained exertion during basic nursing care and operational training [7]. For instance, cardiopulmonary resuscitation (CPR), which requires repeated and continuous chest compressions, is recognized as a high-risk procedure for nursing staff experiencing low back pain [8]. The results of this study suggest that this trend manifests even during the practical training phase, underscoring the importance of incorporating ergonomics education and posture training into early stages of nursing education.

4.3. High-risk procedures are concentrated in basic nursing and emergency skills

Interview results revealed that students generally perceive cardiopulmonary resuscitation (CPR), bed-making, catheterization, and intravenous infusion as high-risk procedures associated with low back pain. This finding aligns closely with clinical studies indicating high-risk tasks. Literature reports that basic nursing care (e.g., repositioning, bed baths, and bed-making) and emergency nursing interventions are categorized as high-intensity movements frequently linked to lumbar spine injuries [9]. Additionally, CPR, due to its stringent requirements for pressure intensity and frequency, has been proven to impose significant strain on nurses' lumbar, back, and upper limb regions [10]. Therefore, this study provides student-derived clinical evidence, further demonstrating that basic and emergency procedures represent ergonomically critical risk points requiring special attention.

Most students lack effective preventive measures before experiencing lumbar and back discomfort, resorting to reactive strategies such as stretching, massage, or wearing lumbar belts only after pain occurs. This "post-event relief" pattern has also been observed in other studies. Surveys reveal that nursing students demonstrate insufficient self-protection awareness regarding musculoskeletal injuries, with low implementation rates of preventive behaviors including warm-ups, posture adjustments, and core muscle exercises [11]. Instead of addressing issues proactively, they often rely on lumbar support or brief rest only after pain onset, which fails to fundamentally reduce injury risks. This highlights the need to incorporate lumbar pain prevention knowledge and skills into nursing education, encouraging students to adopt proactive protective measures prior to clinical interventions.

Students expressed preferences for adjustable-height beds, more rational spatial layouts, and lumbar support belts. These demands are corroborated by existing literature. Studies indicate that providing height-adjustable nursing beds and transfer assistive devices can significantly reduce the incidence of lumbar and back injuries [12]. Concurrently, management's emphasis on ergonomics correlates negatively with occupational injury rates among nursing staff [13]. Therefore, the findings not only reflect students' individual experiences but also provide references for nursing institutions in teaching facility development and student health protection policies.

5. Summary

In summary, nursing students, as the core reserve of future nursing professionals, have become a "high-risk group" for occupational low back pain during clinical training and skill practice. Occupational low back pain during the nursing student phase not only directly compromises their current physiological health but may also exert latent impacts on future career development through issues such as "fixed incorrect operational postures" and "occupational health anxiety". Low back problems among nursing students should not be

overlooked, and nursing administrators and practitioners must prioritize addressing these concerns by implementing targeted interventions. Establishing protective mechanisms to reduce the incidence of low back pain can thereby enhance the learning quality of nursing students.

Disclosure statement

The authors declare no conflict of interest.

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The Impact of Metabolic Equivalent-Based Exercise Rehabilitation Nursing Combined with Exercise-Psychological-Sleep Nursing on Mental Health and Cardiac Rehabilitation in Elderly Patients with Coronary Heart Disease and Heart Failure

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Abstract: *Objective*: To explore the effects of integrating metabolic equivalent-based exercise rehabilitation with exercise-psychological-sleep nursing in elderly patients with coronary heart disease complicated by heart failure. *Methods*: A total of 70 patients meeting the inclusion criteria were selected and randomly divided into a control group (n = 35, receiving conventional cardiac rehabilitation nursing) and an observation group (n = 35, receiving metabolic equivalent-based exercise rehabilitation nursing combined with exercise-psychological-sleep integrated intervention) using a random number table method. Mental health indicators, cardiac rehabilitation indicators, and sleep quality indicators were observed and compared between the two groups before and after nursing. *Results*: After nursing, the observation group had significantly lower SAS scores, SDS scores, and PSQI scores, as well as higher 6MWT and METs levels compared to the control group ($p < 0.05$). *Conclusion*: Metabolic equivalent-based exercise rehabilitation nursing combined with exercise-psychological-sleep integrated intervention can effectively alleviate anxiety and depression in patients, promote cardiac function recovery, optimize sleep status, and demonstrate clear long-term effects, indicating significant value for clinical promotion.

Keywords: Metabolic equivalent; Exercise rehabilitation nursing; Exercise-psychological-sleep nursing; Elderly coronary heart disease with heart failure; Mental health; Cardiac rehabilitation

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1.Introduction

Elderly patients with coronary heart disease and heart failure are in a severe stage of coronary heart

disease progression, characterized by a long and recurrent course, decreased cardiac function, and reduced exercise tolerance. Patients often experience anxiety and depression due to physical suffering and concerns about prognosis, and most suffer from sleep disorders, significantly impacting their quality of life and rehabilitation progress [1]. Conventional cardiac rehabilitation primarily focuses on disease nursing and basic exercise guidance, lacking systematic interventions in psychological and sleep aspects, and lacks scientific quantification standards for exercise intensity, making it difficult to meet individual needs and resulting in unsatisfactory long-term outcomes [2]. Metabolic equivalents (METs) can be used to develop individualized exercise plans based on age and cardiac function classification, avoiding cardiac injury caused by inappropriate intensity. Exercise-psychological-sleep integrated nursing breaks the vicious cycle of "disease-negative emotions-sleep disorders" through multidimensional collaborative interventions. The combination of the two holds promise for compensating for the deficiencies of conventional nursing, although relevant research is limited and lacks evidence from long-term follow-up [3]. This study selected 70 elderly patients with coronary heart disease and heart failure to explore the impact of METs-based exercise rehabilitation nursing combined with integrated nursing on mental health and cardiac rehabilitation. The details are as follows.

2. Materials and methods

2.1. General information

Inclusion period: January 2024 to December 2025; Inclusion criteria: 70 elderly patients with coronary heart disease and heart failure; Research method: Patients were randomly divided into two groups (control group and observation group) using a random number table method, with 35 cases in each group. The male-to-female ratio in the control group was 20/15, with a median age of (71.23 ± 5.18) years and a median disease duration of (4.92 ± 1.17) years; the male-to-female ratio in the observation group was 21/14, with a median age of (71.43 ± 5.22) years and a median disease duration of (4.78 ± 1.13) years. There were no statistically significant differences in baseline data between the groups ($p > 0.05$), indicating comparability.

2.1.1. Inclusion criteria

(1) Clinically diagnosed with coronary heart disease complicated by heart failure [4];
(2) Aged ≥ 60 years;
(3) Cardiac function classification of II–III; clear consciousness and able to cooperate with interventions and follow-up; signed informed consent by patients and their families.

2.1.2. Exclusion criteria

Severe liver and kidney damage; malignant tumors; severe arrhythmias; acute myocardial infarction; cognitive dysfunction; mental illness or inability to cooperate with exercise rehabilitation.

2.2. Methods

2.2.1. Control group

The control group received conventional cardiac rehabilitation nursing:

(1) Exercise guidance

Recommended low-intensity exercises such as walking and Tai Chi for 30–40 minutes daily, 5 times a week, without quantifying intensity based on metabolic equivalents, only adjusting according to

subjective feelings;

(2) Psychological nursing

Daily communication and brief explanation of disease knowledge to alleviate concerns, without systematic intervention;

(3) Sleep nursing

Guidance on regular sleep schedules and creating a quiet environment, without targeted treatment for sleep disorders.

2.2.2. Observation group

The observation group received metabolic equivalent-oriented exercise rehabilitation combined with exercise-psychological-sleep integrated intervention, with the following specific measures:

(1) Metabolic equivalent-based exercise rehabilitation nursing

① Pre-exercise assessment: Before the intervention, the 6-minute walk test (6MWT) was used to comprehensively assess the patient's exercise tolerance, and metabolic equivalent thresholds were calculated based on age, cardiac function classification, and physical condition to select appropriate exercise intensity. ② Exercise plan formulation: A stepwise plan was developed based on metabolic equivalent thresholds. a. Phase 1 (1–3 months): Low-intensity aerobic exercises, including slow walking and sit-to-stand alternating training, for 20–30 minutes daily, 5 times a week; b. Phase 2 (4–12 months): Moderate-intensity exercises, including Tai Chi and dumbbell exercises, for 30–40 minutes daily, 5–6 times a week; c. Phase 3 (13–24 months): Maintain appropriate intensity and increase exercise diversity, such as square dancing and jogging, for 40–50 minutes daily, 6 times a week. ③ Exercise monitoring: Vital signs were closely monitored during exercise, and exercise was immediately stopped if discomfort such as chest tightness, shortness of breath, or palpitations occurred. Exercise tolerance and metabolic equivalent levels were assessed weekly to dynamically adjust the plan.

(2) Exercise-psychological-sleep integrated nursing

① Psychological nursing: Individualized psychological profiles were established based on psychological assessments (SAS, SDS scales). For anxious and depressed patients, cognitive-behavioral therapy, relaxation training, and music therapy were implemented twice a week for 30 minutes each session; meanwhile, strengthened doctor-patient communication was provided to offer sufficient emotional support and share rehabilitation cases to enhance confidence. For solitary and less educated patients, communication frequency was increased, and disease knowledge was explained in simple terms to alleviate psychological concerns. ② Sleep nursing: The PSQI scale was used to assess sleep quality and analyze inducing factors for sleep disorders, followed by targeted interventions: creating a quiet, comfortable, and appropriately humid and temperature-controlled rest environment; guiding patients to avoid high-intensity exercise and intense emotional fluctuations within 1 hour before bedtime; relaxing the body and mind through soothing music and warm foot baths; adjusting medication times to avoid nighttime use of diuretics to reduce nocturia; and providing auxiliary measures under physician guidance for severe sleep disorders. ③ Collaborative intervention: Attention was paid to psychological states during exercise and timely guidance was provided; patients were guided to release stress through exercise during psychological interventions; sleep nursing was combined with exercise routines to adjust exercise times and avoid exercise affecting sleep, achieving synergistic promotion of physical and mental rehabilitation among the three aspects.

2.3. Observation indicators

The following indicators were assessed before nursing and 3 months after nursing:

(1) Mental health indicators

Quantitatively assessed using the Self-Rating Anxiety Scale (SAS) and Self-Rating Depression Scale (SDS), with total scores ranging from 0 to 100, and scores positively correlated with the severity of negative emotions.

(2) Cardiac rehabilitation indicators

Exercise tolerance was measured using the 6-minute walk test (6MWT), recording the maximum walking distance within 6 minutes, with distance positively correlated with exercise tolerance; cardiac function and exercise capacity were detected using a cardiopulmonary exercise testing instrument to measure metabolic equivalents (METs), with increased values indicating improved cardiac function.

(3) Sleep quality indicators

Evaluated using the Pittsburgh Sleep Quality Index (PSQI), with total scores ranging from 0 to 21, and scores positively correlated with the severity of sleep disorders.

2.4. Statistical methods

Comparisons were made using SPSS 23.0 software. Count data were expressed as percentages (%) and tested using the χ^2 test. Measurement data conforming to a normal distribution were expressed as $\bar{x} \pm s$ and tested using the *t*-test. A *p*-value < 0.05 indicated a statistically significant difference.

3. Results

3.1. Comparison of mental health indicators

As shown in **Table 1**, after nursing, the observation group had significantly lower SAS scores and SDS scores, with $p < 0.05$ indicating a significant difference.

Table 1. Comparison of SAS scores and SDS scores between groups before and after nursing [$\bar{x} \pm s$, points]

Group name	Number of cases (n)	SAS score		SDS score	
		Before care	After care	Before care	After care
Observation group	35	61.82 ± 5.16	25.81 ± 3.23a	58.34 ± 4.33	23.32 ± 3.31a
Control group	35	61.92 ± 5.21	30.56 ± 3.28a	58.29 ± 4.29	29.45 ± 3.22a
t value	-	0.081	6.104	0.049	7.853
p value	-	0.936	0.001	0.961	0.001

Note: For comparisons within each group before and after nursing, $p^a < 0.05$.

3.2. Comparison of cardiac rehabilitation indicators

As shown in **Table 2**, after nursing, the observation group had significantly higher values for both the 6-Minute Walk Test (6MWT) and Metabolic Equivalents (METs), with $p < 0.05$ indicating a significant difference.

Table 2. Comparison of 6MWT and METs between groups before and after nursing [$\overline{x}$ ± s]

Group	Number of cases (n)	6MWT (m)		METs	
		Before care	After care	Before care	After care
Observation group	35	361.92 ± 10.65	475.34 ± 11.23[b]	2.82 ± 0.16	4.97 ± 0.22[b]
Control group	35	362.16 ± 10.89	403.16 ± 11.28[b]	2.78 ± 0.14	3.66 ± 0.29[b]
t value	-	0.093	26.828	1.113	21.291
p value	-	0.926	0.001	0.270	0.001

Note: Comparison within the group before and after nursing care, $p^b < 0.05$.

3.3. Comparison of sleep quality indicators

As shown in **Table 3**, after nursing care, the PSQI score of the observation group was lower, with $p < 0.05$, indicating a significant difference.

Table 3. Comparison of PSQI scores before and after nursing care between groups [$\overline{x}$ ± s, points]

Group	Number of cases (n)	PSQI score	
		Before care	After care
Observation group	35	15.45 ± 2.16	6.45 ± 1.34c
Control group	35	15.38 ± 2.14	9.65 ± 1.23c
t value	-	0.136	10.408
p value	-	0.892	0.001

Note: Comparison within the group before and after nursing care, $p^c < 0.05$.

4. Discussion

Elderly patients with coronary heart disease (CHD) and heart failure are prone to negative emotions such as anxiety and depression due to impaired cardiac function, reduced exercise tolerance, recurrent episodes of the disease, and long-term symptoms. These negative emotions can stimulate the sympathetic nervous system, increase cardiac load, and further deteriorate cardiac function [5]. Simultaneously, manifestations of cardiac insufficiency such as chest tightness and shortness of breath, along with accompanying negative psychological states, can significantly disrupt patients' sleep rhythms. Sleep disorders, in turn, exacerbate patients' emotional disturbances, forming a vicious cycle of decreased cardiac function, negative emotions, and sleep disorders. This cycle hinders the cardiac rehabilitation process and reduces the quality of life for patients. Therefore, rehabilitation nursing for elderly patients with CHD and heart failure should focus not only on improving cardiac function but also on regulating mental health and sleep quality, achieving comprehensive intervention in multiple aspects [6].

Data analysis in this study indicates that after intervention measures, the SAS and SDS scores of patients in the observation group were significantly lower than those in the control group ($p < 0.05$). The results demonstrate that this nursing model is more effective in alleviating negative emotions, primarily because the observation group received holistic psychological intervention, which differs from the simple communication in the control group. The observation group utilized personalized psychological profiles, conducted regular scale assessments, implemented precise interventions, combined rehabilitation cases with

family support, enhanced patients' rehabilitation confidence, and laid a psychological foundation for cardiac rehabilitation [7]. Regarding cardiac rehabilitation indicators, after intervention, the 6MWT and METs levels in the observation group were higher than those in the control group ($p < 0.05$). The key difference lies in the observation group's use of metabolic equivalents (METs) as a quantitative standard to establish personalized exercise thresholds based on different cardiac function classifications and adopt a stepwise, phased training approach that balances safety and effectiveness [8]. In contrast, the control group's exercise guidance lacked quantification, often resulting in inappropriate intensity levels, further highlighting the significant value of METs. In terms of sleep quality, after intervention, the total PSQI score in the observation group was lower than that in the control group ($p < 0.05$). The observation group conducted regular PSQI assessments, adjusted medication times accordingly, optimized the sleep environment, guided pre-sleep relaxation, and combined these efforts with psychological intervention to form a positive cycle. The control group only provided routine guidance, which failed to fundamentally improve sleep, demonstrating the auxiliary role of sleep intervention. Considering the results of the three core indicators, this model breaks through the limitations of traditional rehabilitation, which emphasizes physiology while neglecting the mind and body. It integrates the scientific nature of METs with the comprehensiveness of holistic intervention, addressing the issues of lacking quantitative standards and insufficient psychological and sleep support in conventional rehabilitation. This approach achieves multidimensional precise intervention and promotes the synergistic improvement of psychological and cardiac rehabilitation [9,10].

5.Conclusion

In summary, combining MET-based exercise rehabilitation nursing with integrated exercise-psychological-sleep nursing can effectively improve anxiety and depression in elderly patients with CHD and heart failure, enhance cardiac rehabilitation levels, and improve sleep quality, demonstrating its value for widespread application.

Disclosure statement

The authors declare no conflict of interest.

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Clinical Study of FGF8 as a Biomarker in Sepsis

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Abstract: *Objective*: To explore the application and predictive value of FGF8 as a biomarker in sepsis. *Methods*: A total of 44 patients with sepsis who were diagnosed and treated in our hospital from December 2024 to February 2026 were selected as the study subjects, and another 44 volunteers who underwent health check-ups in our hospital during the same period were selected as the control group. Clinical data and levels of FGF8, procalcitonin (PCT), C-reactive protein (CRP), white blood cell count (WBC), red blood cell count (RBC), hemoglobin (Hb), and platelet (PLT) in peripheral venous blood were collected from both groups. Univariate analysis was performed, and variables with statistical significance in the univariate analysis were included in the multivariate logistic regression analysis. ROC curves were plotted to explore the predictive value of FGF8 as a biomarker in sepsis. *Results*: Univariate analysis revealed that APACHE II score, SOFA score, FGF8 level, and PLT were statistically significant. After inclusion in the multivariate logistic regression analysis, APACHE II score, SOFA score, and FGF8 level were positively correlated with sepsis, while PLT was negatively correlated with sepsis. Subsequent ROC curve plotting showed that FGF8 had a sensitivity of 82.67%, a specificity of 78.50%, and an AUC of 0.840 in sepsis, indicating certain predictive value. *Conclusion*: FGF8, as a biomarker, has certain predictive value in sepsis, providing a potential new candidate marker for the auxiliary diagnosis of sepsis, which deserves clinical attention.

Keywords: FGF8; Biomarker; Sepsis; Clinical application; Predictive value

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1. Introduction

Sepsis, a life-threatening organ dysfunction syndrome caused by the host's dysregulated response to infection, has become one of the leading causes of death in intensive care unit (ICU) patients worldwide. Epidemiological studies have found that nearly 50 million new cases of sepsis occur globally each year, with a mortality rate of 20% [1]. Despite significant advances in early identification, fluid resuscitation, anti-infective therapy, and organ function support in recent years, the mortality rate of sepsis remains high. FGF8, a member of the fibroblast growth factor (FGF) family with 23 members, binds to FGF receptors and regulates cell proliferation, differentiation, migration, and survival [2]. FGF8 plays a crucial role in embryonic

development, participating in neural crest cell migration, organogenesis, and tissue repair. Recent studies have found that FGF8 not only has angiogenic and neuroprotective functions but also participates in immune regulation and inflammatory responses [3]. The core pathophysiology of sepsis is the host's uncontrolled inflammatory response to infection, leading to multiple organ dysfunction. This process involves multiple links, including immune cell activation, inflammatory cytokine release, coagulation system activation, and microcirculation disorders. By regulating the function of macrophages and neutrophils, it inhibits excessive inflammatory responses [4]. However, the clinical value of FGF8 in sepsis remains unclear. Based on this, this study selected patients with sepsis diagnosed and treated in our hospital from December 2024 to February 2026 as the study subjects and selected volunteers who underwent health check-ups in our hospital during the same period as the control group to explore the predictive value of FGF8 in sepsis. The specific report is as follows.

2. Materials and methods

2.1. General information

A total of 44 patients with sepsis diagnosed and treated in our hospital from December 2024 to February 2026 were selected as the case group, and another 45 volunteers who underwent health check-ups in our hospital during the same period were selected as the control group.

2.1.1. Inclusion criteria

(1) Diagnosed with sepsis by our hospital;
(2) Age > 18 years;
(3) Complete clinical data;
(4) Hospitalized in the ICU;
(5) High treatment compliance of patients;
(6) Patients and their families signed informed consent forms.

2.1.2. Exclusion criteria

(1) Complicated with other malignancies;
(2) Complicated with autoimmune diseases;
(3) Complicated with liver and kidney dysfunction;
(4) Pregnant women;
(5) Users of immunosuppressive agents.

2.2. Methods

2.2.1. Research methods

In this study, patients with sepsis were used as the case group, and healthy volunteers were used as the control group.

Clinical data and peripheral venous blood indicators were selected as independent variables. Clinical data included patient gender, age, heart rate, respiratory rate, blood pressure, arterial oxygen saturation, mental state, Acute Physiology and Chronic Health Evaluation II (APACHE II) score, and Sequential Organ Failure Assessment (SOFA) score.

Peripheral blood indicators included FGF8 level, PCT, CRP, WBC, RBC, Hb, and PLT.

2.2.2. ELISA detection of FGF8

The expression level of FGF8 was detected by enzyme-linked immunosorbent assay (ELISA), with the following specific steps:

(1) Coat specific antibodies on the enzyme-labeled plate to form solid-phase antibodies;
(2) Add the sample to be tested, and the FGF8 in the sample binds to the solid-phase antibodies;
(3) Add biotinylated anti-FGF8 antibodies to form immune complexes with the bound FGF8;
(4) Add horseradish peroxidase-labeled avidin to bind to the biotinylated antibodies;
(5) Add TMB substrate for color development, with the color intensity proportional to the FGF8 concentration;
(6) Add stop solution to terminate the reaction buffer, and measure the absorbance value using an enzyme-labeled instrument [5].

2.3. Statistical methods

The results of this study were analyzed using SPSS 25.0 statistical software. Measurement data were expressed as (mean ± standard deviation) or median and interquartile range {M (QR)}. Comparisons within groups were performed using *t*-tests or Mann-Whitney U tests. Categorical data were expressed as percentages, and comparisons between groups were performed using the χ^2 test. Multivariate logistic analysis was performed, and ROC curves were plotted to explore the predictive value of FGF8 as a biomarker in sepsis.

3.Results

3.1. Univariate analysis results

In this study, 44 cases were included in both the case group and the control group. Univariate analysis revealed that APACHE II score, SOFA score, FGF8 level, and PLT were statistically significant, while other variables were not statistically significant in the univariate analysis ($p > 0.05$), as shown in **Table 1**.

Table 1. Univariate analysis results

Variable	Category	Control group(n = 44)	Case group(n = 44)	χ^2/t	*p*
Gender (%)	Male (n = 47)	24	23	0.046	0.831
	Female (n = 41)	20	21		
Age (years)	Mean	52.41 ± 8.85	53.10 ± 9.03	0.362	0.718
Heart rate (beats/min)	Mean	85.19 ± 7.79	87.21 ± 7.82	1.214	0.228
Respiratory rate (breaths/min)	Mean	17.22 ± 3.06	17.67 ± 3.25	0.669	0.506
Diastolic blood pressure (mmHg)	Mean	82.19 ± 6.28	84.03 ± 6.23	1.380	0.171
Systolic blood pressure (mmHg)	Mean	135.25 ± 10.21	136.92 ± 10.34	0.762	0.448
Arterial oxygen saturation (%)	Mean	98.12 ± 1.05	97.82 ± 1.02	1.359	0.178
Mental status (%)	Normal (n = 81)	42	39	1.397	0.237
	Abnormal (n = 7)	2	5		
APACHE II score	Mean	13.25 ± 1.16	17.47 ± 1.29	16.135	< 0.001
SOFA score	Mean	1.27 ± 0.21	6.84 ± 1.01	35.815	< 0.001
FGF8 level	Mean	23.84 ± 3.56	69.50 ± 6.39	41.406	< 0.001
PCT (ng/mL)	Mean	0.07 ± 0.01	0.13 ± 0.02	17.799	< 0.001
CRP (mg/L)	Mean	8.95 ± 1.23	9.31 ± 1.35	1.308	0.195

Variable	Category	Control group(n = 44)	Case group(n = 44)	χ^2/t	p
WBC ($\times 10^9$/L)	Mean	9.04 ± 1.07	9.21 ± 1.05	0.752	0.454
RBC ($\times 10^{12}$/L)	Mean	5.13 ± 0.84	5.36 ± 0.92	1.225	0.224
Hb (g/L)	Mean	156.85 ± 13.34	161.21 ± 12.99	1.553	0.124
PLT ($\times 10^9$/L)	Mean	297.26 ± 15.64	301.27 ± 12.60	1.324	0.189

3.2. Multifactorial logistic regression analysis

Variables that demonstrated statistical significance in the aforementioned univariate analysis were included in the multifactorial logistic regression analysis. Four variables were incorporated: APACHE II score, SOFA score, FGF8 level, and PLT. The analysis revealed that the APACHE II score (OR = 2.140, 95% CI: 1.889–2.408), SOFA score (OR = 2.469, 95% CI: 2.055–2.833), and FGF8 level (OR = 2.812, 95% CI: 2.347–3.226) were positively correlated with sepsis, while PLT (OR = 0.651, 95% CI: 0.448–0.769) was negatively correlated with sepsis, as detailed in **Table 2**.

Table 2. Multifactorial logistic regression analysis

Variable	β	S.E	p	OR	95% CI
APACHE II score	0.84	0.81	< 0.05	2.140	1.889–2.408
SOFA score	0.89	0.88	< 0.05	2.469	2.055–2.833
FGF8 level	0.93	0.90	< 0.05	2.812	2.347–3.226
PLT	0.64	0.61	< 0.05	0.651	0.448–0.769

3.3. Predictive value analysis

Based on the results of the multifactorial logistic regression analysis, an ROC curve was plotted. FGF8 demonstrated a sensitivity of 82.67% and a specificity of 78.50% for sepsis, with an AUC of 0.840, which was higher than that of other indicators, indicating a superior predictive value. The details are shown in **Figure 1**.

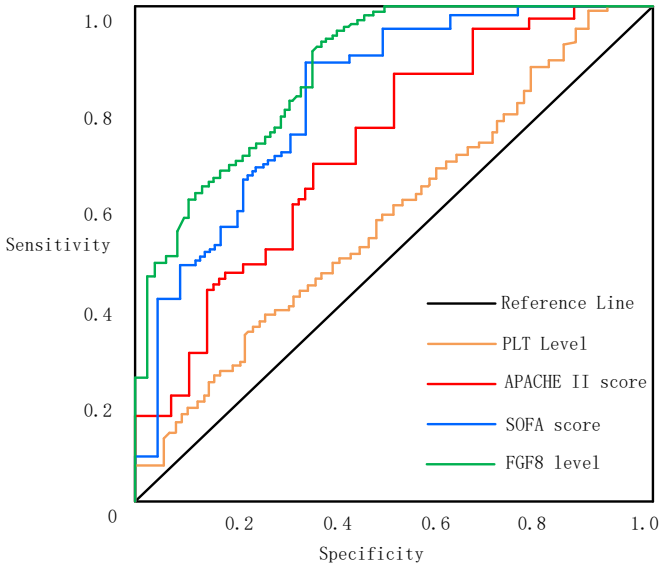


Figure 1. ROC curve of FGF8 expression level in predicting the value of sepsis.

4. Discussion

Sepsis is a common clinical condition characterized by organ dysfunction, with both high incidence and mortality rates, which is detrimental to favorable patient prognosis [6]. Early identification of sepsis is crucial for promoting favorable patient outcomes. However, at present, clinical diagnosis of sepsis still relies on clinical manifestations and laboratory tests, lacking biomarkers with high specificity [7]. Therefore, there is an urgent clinical need for biomarkers with both high sensitivity and specificity. Fibroblast growth factor 8 (FGF8), a member of the FGF family, possesses various biological activities. Related studies have indicated that FGF8 is closely associated with the prognosis of sepsis, although the specific mechanism remains unclear [8]. In addition to serving as a biomarker, FGF8 also exhibits certain immunomodulatory effects. It significantly enhances the phagocytic and bactericidal capabilities of macrophages against bacteria through the FGFR1 pathway, thereby strengthening the host's anti-infective immune defense [9]. Furthermore, FGF8 can increase the autophagy levels in the lung and intestinal tissues of septic mice while inhibiting tissue cell apoptosis, thereby reducing tissue damage and improving the survival rate of septic mice. These findings provide a theoretical basis for the potential application of FGF8 in sepsis treatment. By administering exogenous recombinant FGF8 protein or upregulating endogenous FGF8 expression, it may be possible to improve the immune status of sepsis patients, reduce tissue damage, and enhance survival rates [10].

Based on this, the present study explored the application and predictive value of FGF8 as a biomarker in sepsis. Sepsis patients and healthy volunteers were enrolled, and univariate analysis revealed that the APACHE II score, SOFA score, FGF8 level, and PLT were statistically significant ($p < 0.05$), suggesting that these factors could serve as independent predictors of sepsis. Subsequently, these factors were included in a multifactorial logistic regression analysis, which found that the APACHE II score, SOFA score, and FGF8 level were positively correlated with sepsis, while PLT was negatively correlated with sepsis. This indicates that as the APACHE II score, SOFA score, and FGF8 level increase, and PLT decreases, the incidence of sepsis rises. After plotting the ROC curve, it was found that FGF8 had a sensitivity of 82.67%, a specificity of 78.50%, and an AUC of 0.840 for sepsis, indicating a high predictive value.

5. Conclusion

In summary, FGF8, as a biomarker, has certain predictive value in sepsis, providing a potential novel candidate marker for the auxiliary diagnosis of sepsis, which warrants clinical attention.

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Disclosure statement

The authors declare no conflict of interest.

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Research on the Construction of an Evaluation Index System for Nursing Quality in Patients with Diabetes Mellitus Complicated by Coronary Heart Disease Based on the Structure-Process-Outcome Three-Dimensional Quality Evaluation Model

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Abstract: *Objective*: To construct an evaluation index system for nursing quality in patients with diabetes mellitus complicated by coronary heart disease based on the structure-process-outcome three-dimensional quality evaluation model. *Methods*: Using Donabedian's three-dimensional quality evaluation model as the theoretical foundation, an initial index system was formed through literature analysis and interviews. The Delphi method was employed to solicit opinions from 24 experts over two rounds of correspondence to screen the indicators. Subsequently, the Analytic Hierarchy Process (AHP) was used to determine the weights of indicators at all levels, establishing an evaluation index system for nursing quality in patients with diabetes mellitus complicated by coronary heart disease. *Results*: The response rates for both rounds of expert correspondence were 100.00%. The expert authority coefficients were 0.873 and 0.892, respectively, with Kendall's coefficients of concordance being 0.231 and 0.318 ($p < 0.05$). The final nursing quality evaluation system comprised 3 primary indicators, 11 secondary indicators, and 32 tertiary indicators. Among the primary indicators, process quality had the highest weight (0.467), followed by structural quality (0.284) and outcome quality (0.249). Within the secondary indicators, blood glucose management and cardiovascular risk management had relatively high weights. *Conclusion*: The constructed evaluation index system for nursing quality in patients with diabetes mellitus complicated by coronary heart disease demonstrates good scientific validity and systematicness, providing a reference basis for evaluating and continuously improving nursing quality in these patients.

Keywords: Diabetes mellitus; Coronary heart disease; Nursing quality; Structure-process-outcome; Index system

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1.Introduction

Diabetes mellitus and coronary heart disease are both prevalent chronic non-communicable diseases in clinical practice today, with a relatively close association in terms of pathogenesis and pathological progression [1]. When patients are in a state of prolonged hyperglycemia, symptoms such as endothelial dysfunction, enhanced oxidative stress, and activated inflammatory responses accelerate atherosclerosis, thereby significantly increasing the risk of coronary heart disease [2]. Previous epidemiological studies have shown that the risk of coronary heart disease in diabetic patients is significantly higher than that in non-diabetic populations, while the proportion of patients with confirmed coronary heart disease who also have abnormal glucose metabolism continues to rise [3,4]. These patients often exhibit characteristics such as significant blood glucose fluctuations, decreased cardiac functional reserve, and multisystem metabolic disorders. The disease progresses insidiously with a high incidence of adverse cardiovascular events, imposing higher demands on clinical treatment and nursing management [5]. Typically, clinical nursing for patients with diabetes mellitus complicated by coronary heart disease is complex, requiring long-term management of blood glucose control and lifestyle interventions. The combined use of multiple treatment regimens, including insulin, antiplatelet drugs, and statins, necessitates regular risk assessments and medication management. Therefore, any inadequate nursing in any aspect may affect the overall treatment outcome [6]. Nursing quality evaluation is an important component of nursing management, and a scientific and objective evaluation index system is the foundation for quantifying nursing quality and achieving continuous improvement. The “structure-process-outcome” three-dimensional quality evaluation model proposed by American scholar Donabedian reflects the quality of medical and nursing services from three perspectives: resource allocation, nursing behaviors, and outcome indicators. This model has been widely applied in nursing quality evaluations across multiple disciplines [7,8]. However, for patients with diabetes mellitus complicated by coronary heart disease, a common chronic disease comorbidity, existing research lacks a specialized nursing quality evaluation index system constructed based on this theoretical framework. Therefore, this study established a nursing quality evaluation index system suitable for patients with diabetes mellitus complicated by coronary heart disease using Donabedian’s structure-process-outcome three-dimensional quality evaluation model as the theoretical framework, providing a scientific basis for objective evaluation and refined management of nursing quality in these patients.

2. Materials and methods

2.1. Study subjects

2.1.1. Interviewed experts

A total of 9 experts from the endocrinology department, cardiovascular department, and nursing management-related fields in our hospital were selected for interviews using purposive sampling from March to April 2024. This included 3 endocrinologists, 2 cardiovascular physicians, 2 nursing administrators, and 2 specialist nurses. The experts’ ages ranged from 32 to 56 years, with an average age of (43.78 ± 7.21) years. Their work experience ranged from 10 to 31 years, with an average of (19.56 ± 6.84) years. Six held associate senior or higher titles, and 3 held intermediate titles.

2.1.2. Inclusion criteria

(1) Possession of medical or nursing practitioner qualifications;
(2) Engagement in clinical diagnosis and treatment, specialist nursing, or nursing management related to diabetes mellitus or coronary heart disease for ≥ 5 years;
(3) Holding an intermediate or higher title;
(4) Informed consent and voluntary participation in this study.

2.1.3. Exclusion criteria

(1) Failure to fully participate in the interviews;
(2) Incomplete interview data.

2.1.4. Correspondence experts

In May 2024, 24 experts from relevant fields were selected for correspondence using the Delphi method, coming from our hospital, six surrounding tertiary hospitals, and one institution of higher education. This included 6 clinical medical experts, 10 nursing management experts, 6 clinical nursing experts, and 2 nursing education experts.

2.1.5. Inclusion criteria

(1) Bachelor's degree or higher;
(2) Intermediate or higher title;
(3) Engagement in work related to endocrinology, cardiovascular disease, nursing management, or clinical nursing for ≥ 8 years;
(4) Familiarity with nursing management content for patients with diabetes mellitus complicated by coronary heart disease;
(5) Voluntary participation in this study and completion of questionnaires on time.

2.1.6. Exclusion criteria

(1) Failure to complete questionnaires within the specified time;
(2) Withdrawal from the study midway.

2.2. Research methods

2.2.1. Drafting evaluation indicators

Based on Donabedian's "structure-process-outcome" three-dimensional quality evaluation model as the theoretical foundation, literature searches were conducted in databases including CNKI, Wanfang Data, VIP Database, and the Chinese Biomedical Literature Database, with the search period extending from database establishment to February 2024. Chinese search terms included "diabetes mellitus", "coronary heart disease", "nursing quality", "evaluation index", "sensitive indicator", "structure-process-outcome", and "Delphi method", while English search terms included "diabetes mellitus", "coronary heart disease", "nursing quality", "evaluation index", "sensitive indicator", "structure-process-outcome", and "Delphi". Relevant guidelines, expert consensus, systematic reviews, evidence summaries, and studies on index system construction were included, while duplicate publications, unavailable full texts, incomplete data, and literature with low relevance to the research topic were excluded. The indicator items, evaluation dimensions,

and indicator expressions in the included literature were summarized and organized. Simultaneously, based on literature analysis, interviews were conducted with 9 experts from relevant fields. The interview content included the core content covered by nursing quality evaluation for patients with diabetes mellitus complicated by coronary heart disease; key aspects of blood glucose management, cardiovascular risk management, and medication management during hospitalization; deficiencies in existing single-disease nursing quality indicators for comorbid patients; and outcome indicators that should be prioritized in nursing outcome evaluation. The interviews were conducted face-to-face by two uniformly trained researchers, lasting 30–45 minutes each. The interview data were transcribed into text within 24 hours, with coding and theme extraction performed separately by two researchers. Consensus was reached through discussion within the research team.

Ultimately, combining literature analysis and interview results, a preliminary evaluation index system for nursing quality in patients with diabetes mellitus complicated by coronary heart disease was established, including 3 primary indicators, 11 secondary indicators, and 35 tertiary indicators. An expert correspondence questionnaire was further drafted.

2.2.2. Expert selection and consultation

Subsequently, the Delphi method was employed to solicit opinions from 24 correspondence experts. The expert consultation questionnaire consisted of three parts: the first part included general information about the experts, such as age, educational background, title, work experience, and professional field; the second part was an indicator scoring table; and the third part was an expert opinion section, which included suggestions for indicator modification, additions or deletions, and indicator classification opinions. The importance of indicators was evaluated using a Likert 5-point scale, with 1–5 points representing “very unimportant”, “unimportant”, “average”, “important” and “very important”, respectively. The expert judgment basis coefficient (Ca) was primarily assigned based on literature review, theoretical analysis, and work experience; the expert familiarity coefficient (Cs) was assigned based on the level of familiarity with the research content. The first round of expert correspondence was conducted in June 2024. After the first round, the research team deleted, merged, modified, or supplemented relevant indicators based on the mean importance, full score rate, coefficient of variation, and written opinions of the experts. The second round of expert correspondence was conducted in July 2024, and the final index system was determined.

The indicator screening criteria were set as follows: mean importance ≥ 3.50, full score rate ≥ 0.20, and coefficient of variation ≤ 0.25. For indicators that did not fully meet the screening criteria but were identified by multiple experts as having significant clinical value, the research team discussed whether to retain them.

2.3. Statistical methods

Data organization and statistical analysis were performed using Excel 2021 and SPSS 26.0 software. Expert enthusiasm was represented by the questionnaire response rate; indicator importance was described using the mean, standard deviation, full score rate, and coefficient of variation; expert authority was represented by the authority coefficient (Cr), calculated as Cr = (Ca + Cs)/2; expert opinion coordination was tested using Kendall’s coefficient of concordance (W), with a higher W value indicating better consistency of expert opinions and $p < 0.05$ representing a statistically significant difference. The Analytic Hierarchy Process (AHP) was used to calculate the weights of indicators at all levels and perform a consistency test. When the consistency ratio (CR) < 0.10, the judgment matrix was considered to have satisfactory consistency, and the

weight results were acceptable.

3. Results

3.1. General information of experts

A total of 24 experts were included in the study for correspondence consultation, among whom 3 held full professor titles (12.50%), 9 held associate professor titles (37.50%), and 12 held intermediate titles (50.00%). In terms of educational background, 1 had a doctoral degree (4.17%), 8 had master's degrees (33.33%), and 15 had bachelor's degrees (62.50%). The experts' ages ranged from 33 to 57 years, with an average age of (44.38 ± 5.94) years. Their work experience in relevant fields ranged from 9 to 30 years, with an average of (18.72 ± 6.15) years.

3.2. Expert enthusiasm, authority, and coordination

In the first round of expert correspondence consultation, 24 questionnaires were distributed and 24 were returned, resulting in an effective response rate of 100.00%. In the second round, 24 questionnaires were distributed and 24 were returned, also yielding an effective response rate of 100.00%.

The expert authority coefficients were 0.873 in the first round and 0.892 in the second round, both exceeding 0.70. The expert judgment basis coefficient (Ca) was 0.89 and the familiarity coefficient (Cs) was 0.86 in the first round; in the second round, they were 0.91 and 0.87, respectively. Meanwhile, in the first round of correspondence consultation, the coordination coefficients for primary, secondary, and tertiary indicators were 0.214, 0.226, and 0.231, respectively. In the second round, they were 0.297, 0.305, and 0.318, respectively, with statistically significant differences ($p < 0.05$).

3.3. Results of indicator screening

The initial indicator system comprised 3 primary indicators, 10 secondary indicators, and 35 tertiary indicators. After the first round of expert correspondence consultation, indicator revisions included: deleting 2 tertiary indicators, merging 3 indicators with similar content, revising 10 indicators with unclear expressions or insufficient operability, and adding 2 new tertiary indicators.

The revised indicator system formed the questionnaire for the second round of correspondence consultation. In the second round, the importance scores for each indicator stabilized, with no further deletions or additions of indicators. The final evaluation indicator system for nursing quality in patients with diabetes mellitus complicated by coronary heart disease was established, including 3 primary indicators, 11 secondary indicators, and 32 tertiary indicators. See **Table 1**.

Table 1. Evaluation indicator system for nursing quality in patients with diabetes mellitus complicated by coronary heart disease

First-level indicator	Second-level indicator	Third-level indicator
Structural quality	Human resource allocation	Specialty nurse staffing rate
		Nurse-to-patient ratio compliance rate
		Specialty training coverage rate
	Professional competence	Diabetes management knowledge test pass rate
		Cardiovascular emergency identification competence rate

First-level indicator	Second-level indicator	Third-level indicator
Process quality	Nursing system and support	Nursing quality management system perfection rate
		Blood glucose management protocol compliance rate
		Medication safety management system implementation rate
	Admission assessment and risk stratification	Blood glucose risk assessment completion rate
		Cardiovascular risk stratification assessment rate
	Blood glucose management and monitoring	Blood glucose monitoring protocol compliance rate
		HbA1c testing implementation rate
		Hypoglycemia identification and management timeliness rate
	Cardiovascular risk management	ECG monitoring protocol compliance rate
		Blood pressure monitoring protocol compliance rate
		Angina Pectoris identification and management timeliness rate
	Medication management	Insulin use protocol compliance rate
		Antiplatelet medication management protocol compliance rate
		Statin medication adherence assessment rate
	Health education and behavioral intervention	Dietary guidance implementation rate
		Exercise intervention implementation rate
		Self-monitoring education compliance rate
	Discharge and follow-up management	Discharge guidance completion rate
		Follow-up implementation rate
Outcome quality	Clinical outcome indicators	Blood glucose target rate
		HbA1c target rate
		Cardiovascular adverse event rate
		Rehospitalization rate
		Hypoglycemia incidence rate
	Behavioral and perceptual outcomes	Medication adherence score
		Self-management ability score
		Patient satisfaction

3.4. Results of indicator weights

Meanwhile, the weights of indicators at all levels were calculated using the Analytic Hierarchy Process (AHP), and the results indicated that all consistency test results for the judgment matrices met the criterion of CR < 0.10. Among the primary indicators, process quality had the highest weight (0.467), followed by structural quality (0.284) and outcome quality (0.249). The weight distribution of secondary indicators is shown in **Table 2**:

Table 2. Weight distribution of secondary indicators

First-level indicator	Second-level indicator	Weight
Structural quality	Human resource allocation	0.102
	Professional competence	0.098

First-level indicator	Second-level indicator	Weight
	System development	0.084
Process quality	Admission assessment and risk stratification	0.080
	Blood glucose management and monitoring	0.121
	Cardiovascular risk management	0.115
	Medication management	0.098
	Health education and behavioral intervention	0.073
	Discharge and follow-up management	0.060
Outcome quality	Clinical outcome indicators	0.143
	Behavioral and perceptual outcomes	0.106

4. Discussion

Patients with diabetes mellitus complicated by coronary heart disease (CHD) often experience a state of impaired vascular endothelial function and persistent activation of inflammatory responses due to the interaction between long-term hyperglycemia and the atherosclerotic process. Patients in this stage are characterized by high volatility and risk in disease progression and adverse cardiovascular events [9]. Faced with this situation, nursing management for these patients must concurrently address glycemic control and cardiovascular risk prevention and control throughout the entire process of assessment, intervention, and follow-up. Constructing an indicator system based on the structure-process-outcome three-dimensional quality evaluation model represents a comprehensive indicator system that integrates three levels: resource allocation, nursing implementation, and outcome evaluation. Its application facilitates the systematic evaluation of nursing quality [10].

The results of this study indicate that process quality holds the highest weight among primary indicators, followed by structural quality and outcome quality. This implies that variations in nursing quality primarily stem from the implementation process of nursing measures. Given that both blood glucose levels and cardiovascular status in patients with diabetes mellitus complicated by CHD exhibit dynamic changes, the effectiveness of nursing interventions depends more on the timeliness of monitoring and the degree of implementation of intervention measures. Additionally, the results show that blood glucose management and cardiovascular risk management have relatively high weights, indicating their central roles in nursing quality. Typically, persistent hyperglycemia can exacerbate vascular endothelial damage and promote plaque formation, while hypoglycemia can induce sympathetic nervous system excitation, increasing the risk of arrhythmias and cardiovascular events. Therefore, maintaining stable blood glucose levels and reducing fluctuations are of great significance for patients' health.

Through the Delphi method, this study screened and revised indicators, achieving a high expert authority coefficient and a gradually increasing coordination coefficient over two rounds, demonstrating good consistency in expert opinions regarding this nursing quality evaluation indicator system. However, it should be noted that the experts consulted in this study were primarily from tertiary medical institutions, and the applicability at the primary care level still requires further validation.

5. Conclusion

In summary, the nursing quality evaluation indicator system for diabetes mellitus complicated by CHD

constructed in this study demonstrates good systematicness and pertinence, providing a reference basis for nursing quality evaluation and continuous improvement.

Disclosure statement

The authors declare no conflict of interest.

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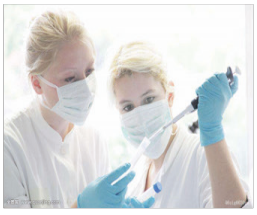


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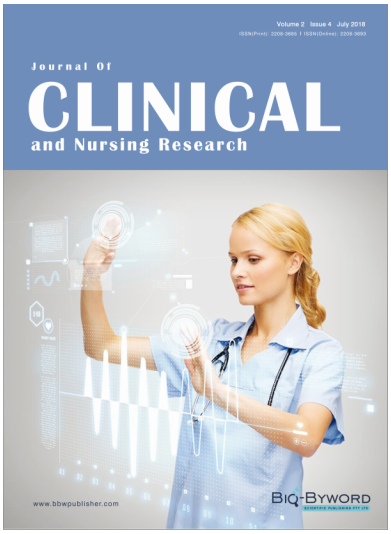
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