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# Journal of Clinical and Nursing Research

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Journal of Clinical and Nursing Research (JCNR) is an international, peer reviewed and open access journal that seeks to promote the development and exchange of knowledge which is directly relevant to all clinical and nursing research and practice. Articles which explore the meaning, prevention, treatment, outcome and impact of a high standard clinical and nursing practice and discipline are encouraged to be submitted as original article, review, case report, short communication and letters.

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Patients and family experiences of health care
Clinical and nursing research to enhance patient safety and reduce harm to patients
Ethics
Clinical and Nursing history
Medicine

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# Effect of Acupuncture at Points of the Bladder Meridian of Foot-Taiyang on Serum Inflammatory Factors in Rabbit Models of Cervical Spondylosis

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**Abstract:** *Objective*: Based on the theory of "Taiyang governs tendons", to explore the effect of acupuncture at points of the Bladder Meridian of Foot-Taiyang on the expression of serum inflammatory factors in rabbit models of cervical spondylosis. *Methods*: Thirty New Zealand white rabbits were randomly divided into a blank group, a model group, and a treatment group, with 10 rabbits in each group. The models of cervical spondylosis in the model group and treatment group were established by long-term head-down flexion combined with cold-damp stimulation. After modeling, the treatment group received acupuncture at three points (Kunlun, Weizhong, and Feishu) on the Bladder Meridian of Foot-Taiyang, once a day for 20 minutes each time, for 14 consecutive days; the model group and blank group received no therapeutic intervention. After the intervention, cardiac blood was collected from all rabbits to detect the expression levels of serum inflammatory factors IL-6, TNF-α, and IL-1β. Meanwhile, cervical muscle tissue was collected, stained with HE, and the morphological changes of the posterior cervical muscle tissue in each group were observed under an optical microscope. *Results*: After modeling, the levels of inflammatory factors in the serum of rabbits in the model group and treatment group were significantly increased compared with those before modeling, with a statistically significant difference ($p < 0.01$). After intervention, the serum inflammatory factors in the treatment group decreased significantly compared with those in the model group, and the difference was statistically significant ($p < 0.01$). *Conclusion*: Acupuncture at points of the Bladder Meridian of Foot-Taiyang in rabbit models of cervical spondylosis can reduce the serum levels of inflammatory factors TNF-α, IL-1β, and IL-6.

**Keywords:** Cervical spondylosis; Bladder meridian of foot-Taiyang; Acupuncture; Inflammatory factors

**Online publication:** Jan 9, 2026

## 1. Introduction

With the rapid development of the current network era and the popularization of various electronic digital products

such as computers, mobile phones, and tablets, the incidence of cervical spondylosis has been increasing year by year, showing an increasingly younger trend [1]. According to statistics, the incidence of cervical spondylosis in China is close to 20%, among which nearly 40% of patients are under 30 years old. Therefore, exploring effective treatment methods for cervical spondylosis is of great significance. Cervical spondylosis is a disease governed by the Bladder Meridian of Foot-Taiyang. Huangdi Neijing (Yellow Emperor's Internal Classic), a famous ancient Chinese medical classic, established the basic theoretical system of traditional Chinese medicine (TCM) and has important guiding significance for the development of TCM [2].

Many theories proposed in it are well-known to TCM scholars and widely used in clinical practice, such as the classic theory of "the liver governs tendons and the kidney governs bones". It also records that "the Gallbladder Meridian of Foot-Shaoyang governs diseases related to bones" and "the Bladder Meridian of Foot-Taiyang governs diseases related to tendons".

Among them, the theory of "Shaoyang governs bones" has been extensively studied by later physicians and has become a research hotspot among TCM scholars in recent years. However, there are very few studies on the theory of "Taiyang governs tendons", and there are no basic research reports on the application of this theory in the treatment of cervical spondylosis to date. Based on the theory of "Taiyang governs tendons", this study conducted animal experiments to investigate the effect of acupuncture at points of the Bladder Meridian of Foot-Taiyang on the expression of serum inflammatory factors in rabbit models of cervical spondylosis, and to clarify its mechanism in treating cervical spondylosis. The results were reported as follows.

## 2. Experimental materials

### 2.1. Experimental animals

Thirty 6-month-old New Zealand white rabbits, weighing about 2 kg, half male and half female, were purchased from Guizhou Yikedada Biotechnology Co., Ltd., with the animal license number of SCXK (Qian) 2021-0001. The animal experiment was approved by the Animal Experiment Ethics Review Committee of Yunnan University of Traditional Chinese Medicine, with approval number: R-062021LH038. Animal feeding and experimental operations were carried out at Yunnan Luoyu Biotechnology Co., Ltd. Throughout the experiment, the animals were raised in accordance with the standard for experimental animal feeding, and all animal experimental operations were performed in compliance with the provisions of the Regulations on the Administration of Experimental Animals.

### 2.2. Reagents

Rabbit interleukin-1β (IL-1β) enzyme-linked immunosorbent assay (ELISA) kit (catalog number: ml027836-2), rabbit interleukin-6 (IL-6) ELISA kit (catalog number: ml027844-2), and rabbit tumor necrosis factor-α (TNF-α) ELISA kit (catalog number: ml028087-2) were all purchased from Shanghai Enzyme-Linked Biotechnology Co., Ltd.

### 2.3. Instruments

Pannoramic MIDI holographic scanner, HistoCore BloCu7 rotary microtome, HistoCore ArCadia H paraffin embedding machine, JT-12S automatic tissue dehydrator, JK-6 tissue flaking and baking machine, surgical instruments (Shanghai Jinzhong), rabbit fixator (zh-tgx-i), acupuncture needles (Wujiang Yunlong Medical Devices Co., Ltd.), Shanghai Senxin DGG-9140B electric thermostatic blast drying oven, Thermo Scientific

high-speed refrigerated centrifuge, Eppendorf pipettes, Haier 4 ℃/-20 ℃ refrigerators, and SPECTRA MAX190 microplate reader.

# 3. Methods

## 3.1. Grouping of experimental animals

Thirty 6-month-old New Zealand white rabbits were randomly divided into 3 groups using a random number table: blank group, model group, and treatment group, with 10 rabbits in each group.

## 3.2. Model establishment

For rabbits in the model group and treatment group, the non-invasive method for establishing a rabbit model of cervical spondylosis proposed by Zhang Xin et al. was adopted. The specific operation steps were as follows: First, the hair on the posterior cervical region of the rabbits was shaved with a hair clipper, and then the rabbits were fixed in a rabbit fixation box.

Next, the rabbit's neck was adjusted to a 45° head-down flexion position to keep the posterior cervical muscles in a stretched state [3,4]. Afterwards, a self-made ice pack was placed on the posterior cervical region of the rabbit, once a day for 5 hours each time, for 4 consecutive weeks. Rabbits in the blank group were fixed in the same fixator, allowing free movement of the neck for the same duration.

After modeling, the expression levels of serum IL-1β, TNF-α, and IL-6 in each group were detected and compared with those before modeling. Meanwhile, 2 rabbits were randomly selected from each group and sacrificed, and the posterior cervical muscle tissue was quickly collected, stained with HE, and the morphological changes of the posterior cervical muscle tissue were observed under an optical microscope to comprehensively evaluate the success of modeling.

## 3.3. Intervention

(1) Treatment group

After modeling, the acupuncture sites were disinfected. Referring to the acupoint localization methods in Experimental Acupuncture and Handbook of Experimental Animal Acupuncture, acupuncture was performed at three points (Kunlun, Weizhong, and Feishu) on the Bladder Meridian of Foot-Taiyang, once a day, with the needles retained for 20 minutes each time, for 14 days.

(2) Model group and blank group

Rabbits were fixed on a self-made rabbit platform for 20 minutes every day without any therapeutic intervention.

## 3.4. Sample collection and processing

(1) On the day before modeling, the 1st day after modeling, and the 1st day after intervention, cardiac blood was collected from all rabbits, centrifuged at 4 ℃ at 3000 r/min for 30 minutes in a timely manner, and the supernatant was aspirated to detect the expression levels of serum inflammatory factors IL-1β, TNF-α, and IL-6 by ELISA.

(2) After blood collection on the 1st day after modeling, 2 rabbits were randomly selected from each group, sacrificed by exsanguination via the heart after cardiac blood collection, and the posterior cervical muscle tissue was quickly collected, stained with HE, and the morphological changes of the posterior cervical

muscle tissue were observed under an optical microscope.

(3) After the intervention, the remaining rabbits were first subjected to cardiac blood collection, then sacrificed by exsanguination via the heart, and the posterior cervical muscle tissue was quickly collected, stained with HE, and the morphological changes of the posterior cervical muscle tissue were observed under an optical microscope.

### 3.5. Statistical analysis

The detection results of serum inflammatory factors TNF-α, IL-1β, and IL-6 were statistically analyzed. SPSS 21.0 statistical software was used for data analysis, and GraphPad Prism 9.0.0 software was used for graph plotting. One-way analysis of variance (ANOVA) was used for comparison between groups, and LSD-*t* test was further used for pairwise comparison if there were significant differences. $p < 0.05$ was considered statistically significant, and $p < 0.01$ was considered extremely statistically significant.

## 4. Results

### 4.1. Comparison of inflammatory factors among groups at the same time point

Before modeling, the levels of TNF-α, IL-1β, and IL-6 in each group were comparable, with no statistically significant differences. After modeling, the levels of TNF-α, IL-1β, and IL-6 in the model group and treatment group were significantly higher than those in the blank group, with extremely statistically significant differences ($p < 0.01$), indicating successful modeling; however, there was no statistically significant difference in the levels of inflammatory factors between the treatment group and the model group after modeling ($p > 0.05$) [5].

After treatment, the levels of TNF-α, IL-1β, and IL-6 in the treatment group were significantly lower than those in the model group, and the difference was statistically significant. See **Tables 1**, **2** and **3** and **Figures 1**, **2** and **3**.

**Table 1.** Levels of inflammatory factors in each group before modeling

| Group/Indicator (pg/mL) | TNF-a | IL-1β | IL-6 |
|---|---|---|---|
| Blank group | 41.6 ± 4.56 | 129.98 ± 21.73 | 38.61 ± 6.99 |
| Model group | 44.08 ± 3.01 | 151.9 ± 17.91 | 38.96 ± 8.13 |
| Treatment group | 41.46 ± 6.92 | 130.64 ± 20.1 | 33.09 ± 7.39 |

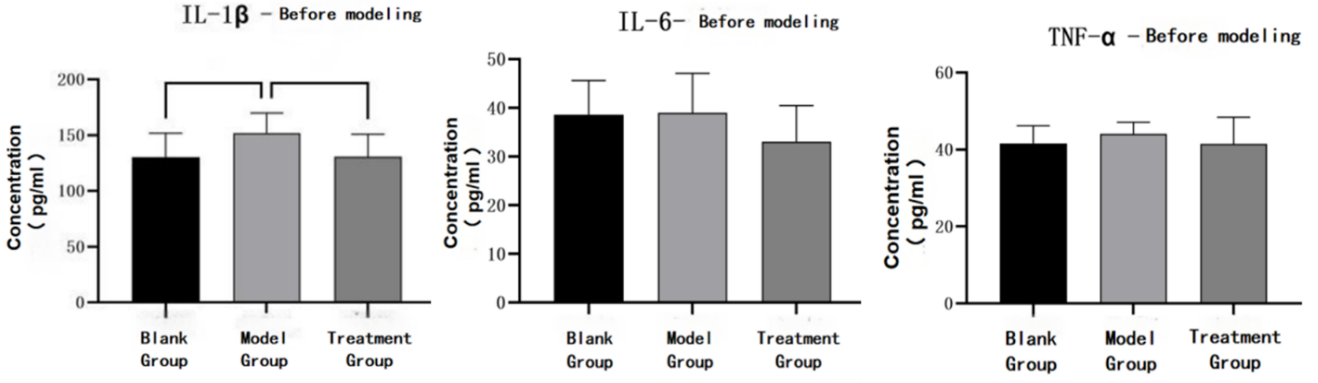



**Figure 1.** Levels of inflammatory factors in each group before modeling. A. Detection results of IL-1β in each group before modeling; B. Detection results of IL-6 in each group before modeling; C. Detection results of TNF-α in each group before modeling.

**Table 2.** Levels of inflammatory factors in each group after modeling

| Group/Indicator (pg/mL) | TNF-a | IL-1β | IL-6 |
|---|---|---|---|
| Blank group | 38.67 ± 6.49 | 144.68 ± 31.59 | 37.1 ± 5.51 |
| Model group | 89.55 ± 6.68 | 340.22 ± 32.01 | 84.11 ± 7 |
| Treatment group | 86.82 ± 6.24 | 360.51 ± 28.65 | 90.26 ± 5.44 |

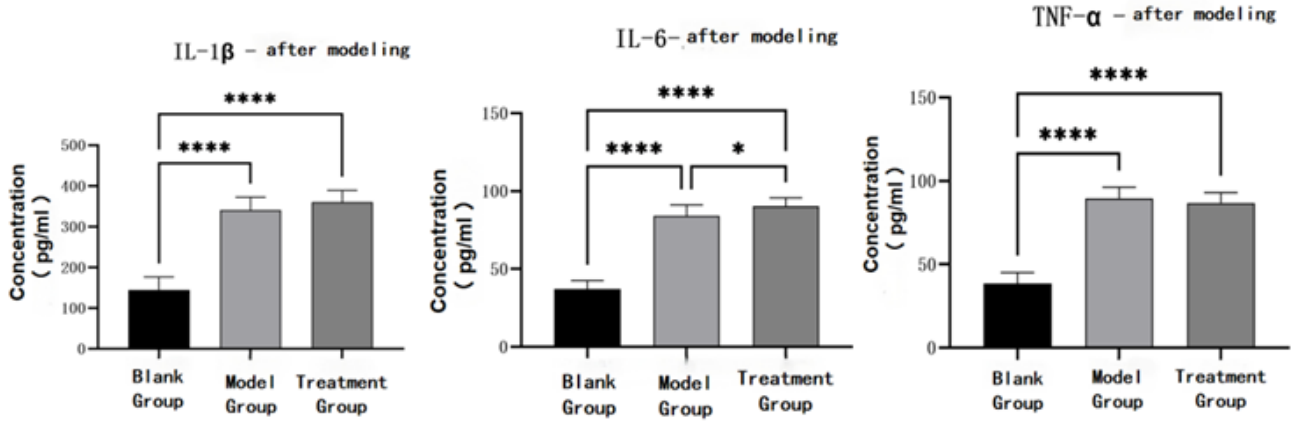



**Figure 2.** Levels of inflammatory factors in each group after modeling. A. Detection results of IL-1β in each group after modeling; B. Detection results of IL-6 in each group after modeling; C. Detection results of TNF-α in each group after modeling; *$p < 0.05$, ****$p < 0.0001$.

**Table 3.** Levels of inflammatory factors in each group after treatment

| Group/Indicator (pg/mL) | TNF-a | IL-1β | IL-6 |
|---|---|---|---|
| Blank group | 43.21 ± 7.04 | 135.07 ± 22.75 | 37.31 ± 6.39 |
| Model group | 81.79 ± 3.68 | 338.56 ± 27.94 | 82.69 ± 8.65 |
| Treatment group | 59.97 ± 4.21 | 239.24 ± 18.34 | 59.05 ± 7.53 |

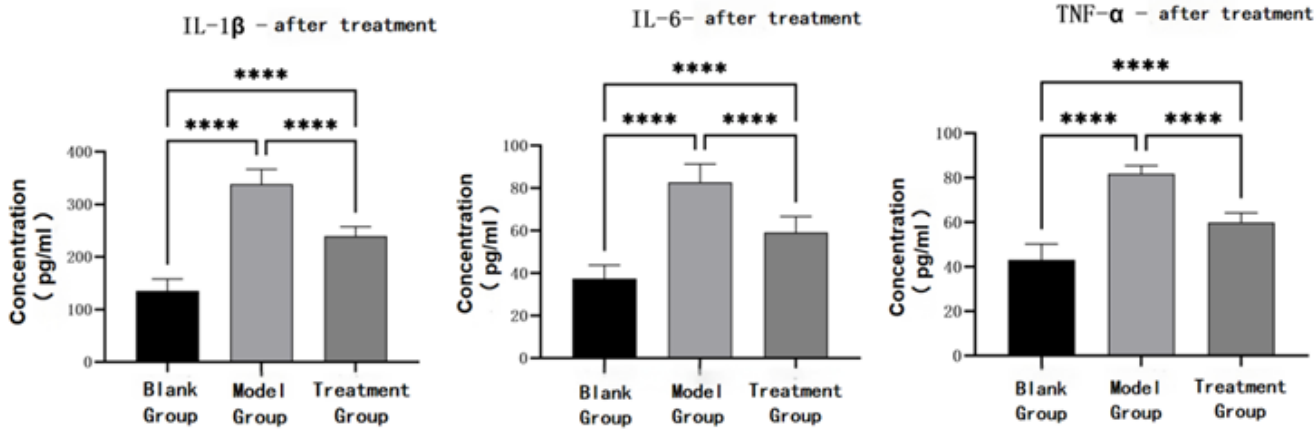



**Figure 3.** Levels of inflammatory factors in each group after treatment. A. Detection results of IL-1β in each group after treatment; B. Detection results of IL-6 in each group after treatment; C. Detection results of TNF-α in each group after treatment; *$p < 0.05$, ****$p < 0.0001$.

## 4.2. Comparison of inflammatory factors in the same group at three time points

In the blank group, the levels of TNF-α, IL-1β, and IL-6 before modeling, after modeling, and after treatment were comparable, with no statistically significant differences ($p > 0.05$).

In the model group, the levels of TNF-α, IL-1β, and IL-6 after modeling and after treatment were significantly higher than those before modeling, with extremely statistically significant differences ($p < 0.01$); there was no statistically significant difference in the levels of IL-1β and IL-6 between after modeling and after treatment, but the level of TNF-α was statistically different ($p < 0.05$).

In the treatment group, the levels of TNF-α, IL-1β, and IL-6 after modeling and after treatment were significantly higher than those before modeling, with extremely statistically significant differences ($p < 0.01$); after treatment, the levels of TNF-α, IL-1β, and IL-6 were significantly lower than those after modeling, with extremely statistically significant differences ($p < 0.01$). See **Tables 4**, **5** and **6** and **Figures 4**, **5** and **6** .

**Table 4.** Levels of inflammatory factors in the blank group across three time points

| Group/Indicator (pg/mL) | TNF-a | IL-1β | IL-6 |
|---|---|---|---|
| Before modeling | 41.6 ± 4.56 | 129.98 ± 21.73 | 38.61 ± 6.99 |
| After modeling | 38.67 ± 6.49 | 144.68 ± 31.59 | 37.1 ± 5.51 |
| After treatment | 43.21 ± 7.04 | 135.07 ± 22.75 | 37.31 ± 6.39 |

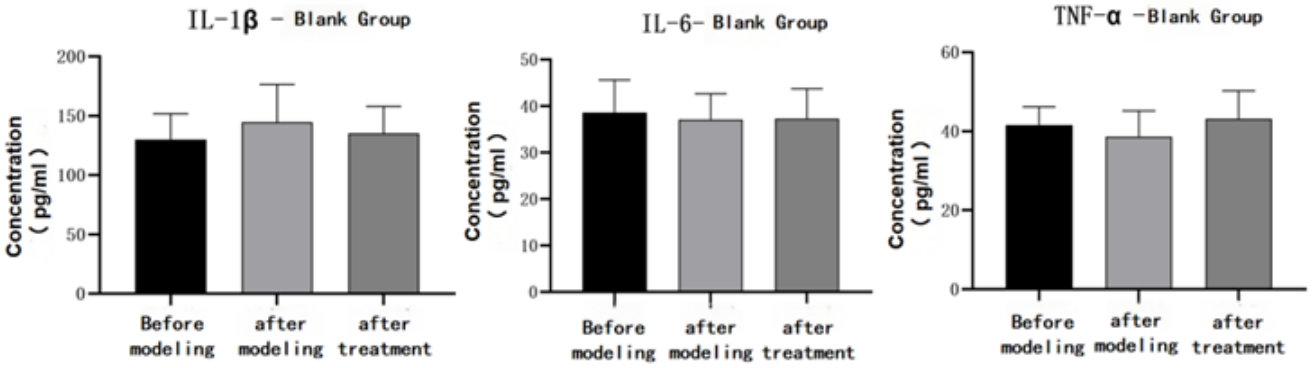



**Figure 4.** Levels of inflammatory factors in the blank group. A. Detection results of IL-1β in the blank group at three time points; B. Detection results of IL-6 in the blank group at three time points; C. Detection results of TNF-α in the blank group at three time points.

**Table 5.** Levels of inflammatory factors in the model group across three time points

| Group/Indicator (pg/mL) | TNF-a | IL-1β | IL-6 |
|---|---|---|---|
| Before modeling | 44.08 ± 3.01 | 151.9 ± 17.91 | 38.96 ± 8.13 |
| After modeling | 89.55 ± 6.68 | 340.22 ± 32.01 | 84.11 ± 7 |
| After treatment | 81.79 ± 3.68 | 338.56 ± 27.94 | 82.69 ± 8.65 |

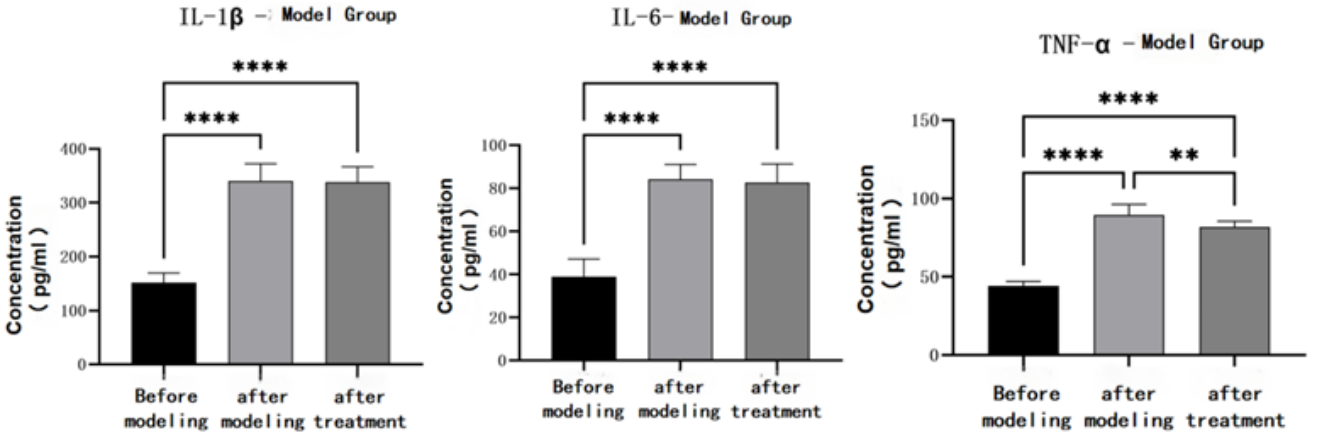



**Figure 5.** Levels of inflammatory factors in the model group. A. Detection results of IL-1β in the model group at three time points; B. Detection results of IL-6 in the model group at three time points; C. Detection results of TNF-α in the model group at three time points; $^{**}p < 0.005$, $^{****}p < 0.0001$.

**Table 6.** Levels of inflammatory factors in the treatment group across three time points

| Group/Indicator (pg/mL) | TNF-a | IL-1β | IL-6 |
|---|---|---|---|
| Before modeling | 41.46 ± 6.92 | 130.64 ± 20.1 | 33.09 ± 7.39 |
| After modeling | 86.82 ± 6.24 | 360.51 ± 28.65 | 90.26 ± 5.44 |
| After treatment | 59.97 ± 4.21 | 239.24 ± 18.34 | 59.05 ± 7.53 |

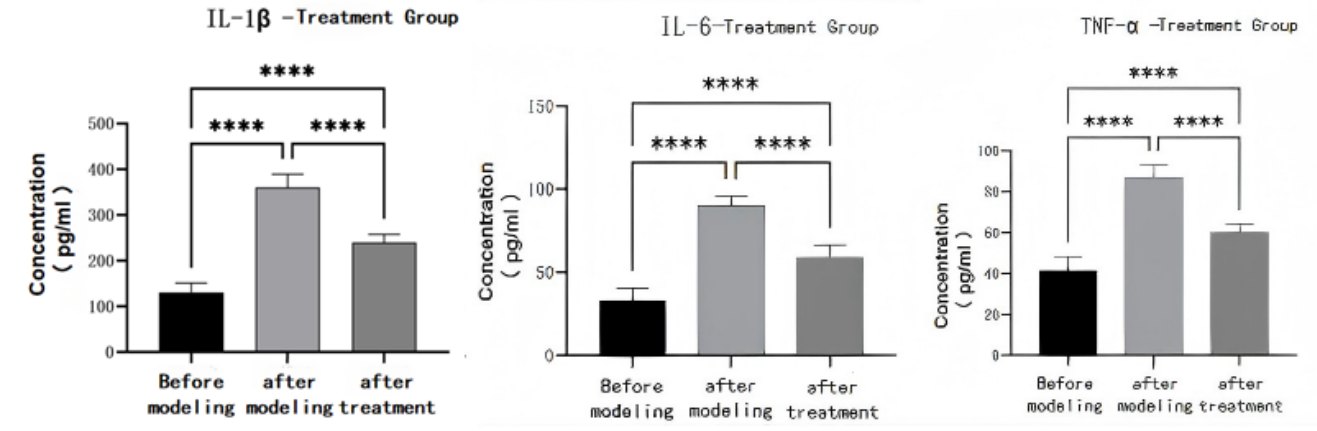



**Figure 6.** Levels of inflammatory factors in the treatment group. A. Detection results of IL-1β in the treatment group at three time points; B. Detection results of IL-6 in the treatment group at three time points; C. Detection results of TNF-α in the treatment group at three time points; $^{****}p < 0.0001$.

## 4.3. Morphological changes of posterior cervical muscle tissue

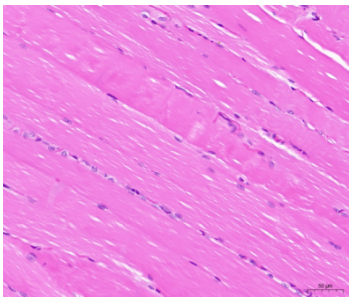
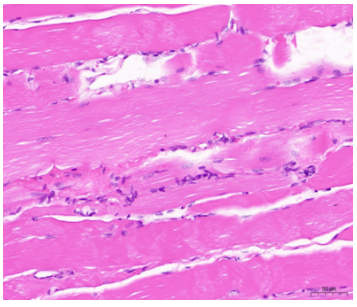
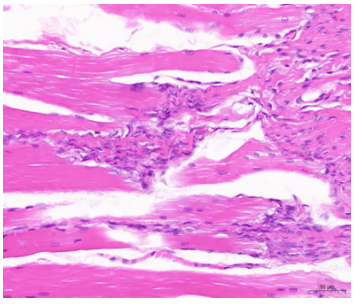
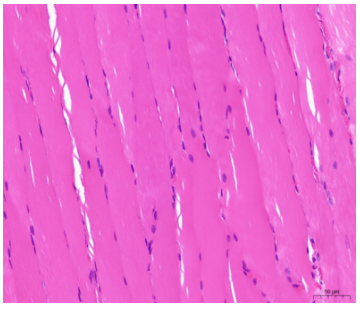
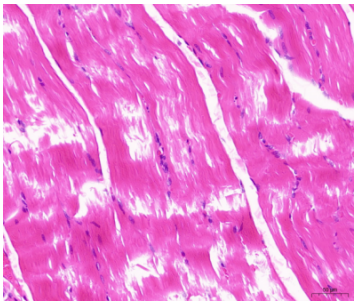
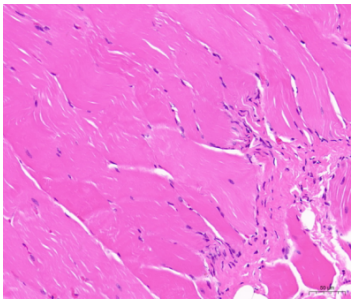
After the rabbits were sacrificed, the posterior cervical muscle tissue was collected, stained with HE, and the morphological changes were observed under an optical microscope.

In the blank group, the posterior cervical muscle fibers had a clear structure, neat arrangement, similar thickness, no inflammatory cell infiltration, and no myocyte degeneration or edema. After modeling, in the model group and treatment group, uneven staining of muscle fibers, disordered arrangement, muscle fiber rupture and

torsion, accompanied by inflammatory cell infiltration, and disordered arrangement of collagen fibers were observed [6].

After treatment, the treatment group showed mild proliferation of connective tissue, relatively uniform distribution of myonuclei, mild torsion of myocytes, and no swelling. See **Table 7**.

**Table 7.** Morphological changes of posterior cervical muscle tissue in each group observed under an optical microscope

| | Blank group | Model group | Treatment group |
|---|---|---|---|
| Before treatment |  |  |  |
| After treatment |  |  |  |

## 5. Discussion

"Cervical spondylosis" is not clearly recorded in TCM monographs. According to its pathogenesis and related symptoms, the disease belongs to the categories of "neck bi" and "bi syndrome" in TCM [7]. The occurrence of neck bi is closely related to the Bladder Meridian of Foot-Taiyang. Lingshu·Jingmai (Spiritual Pivot·Meridians) states: "The Bladder Meridian of Foot-Taiyang... Diseases related to tendons governed by it include hemorrhoids, malaria, mania, epilepsy, pain in the head, fontanelle, and neck, yellow eyes, lacrimation, epistaxis, pain in the neck, back, waist, buttocks, popliteal fossa, calves, and feet, and inability to use the little toe", which puts forward the theory of "Taiyang governs tendons" [8]. It describes that the symptoms of diseases of the Bladder Meridian of Foot-Taiyang include pain and dysfunction from the head and neck along the meridian to the waist and buttocks, especially pain and discomfort in the head, neck, and nape, as well as dysfunction, which is consistent with the clinical symptoms of cervical spondylosis. The Twelve Muscle Meridians are the peripheral accessory parts of the Twelve Meridians, and muscles and joints are nourished by the Qi and blood of the Twelve Meridians [9]. Therefore, the meridians and muscle meridians of the Foot-Taiyang Meridian are interdependent in physiology and interact in pathology [10]. Zhang Jiebin also believed that "the muscles and tendons all over the body are mostly and largely distributed along the Foot-Taiyang Meridian. Its lower parts connect to the heels, calves, popliteal fossae, and buttocks; its upper parts cling to the waist and spine, connect to the shoulders and neck, and extend to the head

as the superior orbital ridge [11]. Therefore, all conditions such as spasm, flaccidity, and opisthotonos are caused by insufficient fluid of the Foot-Taiyang Meridian, which governs diseases related to tendons" [12]. Therefore, cervical spondylosis is also a disease governed by the Bladder Meridian of Foot-Taiyang and is closely related to this meridian. Cai Gengxi et al. conducted data analysis on the acupoint selection rules of acupuncture for treating cervical spondylosis at home and abroad and found that the acupoints of the Bladder Meridian of Foot-Taiyang accounted for 16.62% of the total therapeutic acupoints, with the highest proportion. This indicates that the Bladder Meridian of Foot-Taiyang is the most commonly used meridian in the treatment of cervical spondylosis. Huang Hongxi's research found that the muscle meridian lesions of patients with cervical spondylosis are divided into three categories: point-like, linear, and planar lesions, with point-like muscle meridian lesions being the main type, and various muscle meridian lesions are mainly concentrated in the muscle meridian of the Foot-Taiyang Meridian. Therefore, the treatment should also start with the Bladder Meridian of Foot-Taiyang. Acupuncture has a long history in the treatment of cervical spondylosis. As early as Lingshu·Zabing (Spiritual Pivot·Miscellaneous Diseases), it was recorded that "for neck pain with inability to bend forward and backward, puncture the Foot-Taiyang Meridian; for inability to turn the head, puncture the Hand-Taiyang Meridian" [13]. Acupuncture in the treatment of cervical spondylosis has the characteristics of obvious, long-lasting, and stable curative effect, with few adverse reactions. As a traditional external therapy of TCM, acupuncture regulates Qi and blood, dredges meridians, and balances Yin and Yang by stimulating meridians and acupoints [14].

Acupuncture treatment has the effects of improving Qi and blood circulation, restoring patients' functions, and relieving spasm, while Tuina (massage) also has the effects of dredging meridians, nourishing tendons, and relieving pain by regulating tendons [15]. Modern studies have found that acupuncture in the treatment of cervical spondylosis can not only reduce inflammation and pain, dredge meridians and tendons, but also relieve cervical muscle spasm. Acupuncture can effectively promote and enhance cervical blood circulation and metabolism, help patients absorb local inflammation, thereby better eliminating existing edema, and exert a good advantage in relieving neck and shoulder pain [16]. Zhang Wanyu et al. found that the eight-confluent points compatibility therapy can effectively improve the Visual Analogue Scale (VAS) score, self-made symptom and sign score, and Neck Pain Questionnaire (NPQ) score of patients with cervical spondylosis. Wu Zhongliang et al. adopted the quick puncture method, which had a better effect in reducing neck pain, alleviating inflammatory response, and improving hemorheology in patients with cervical spondylosis. Chen Youyi established a model of cervical spondylosis and found that after electroacupuncture at the "Dazhui" point, the contents of SOD, GSH-Px, and Glu were significantly higher than those in the model group, while the content of MDA was significantly lower. He believed that the mechanism of acupuncture in the treatment of cervical spondylosis may be to reduce muscle damage by improving the free radical scavenging ability of tissue cells and the content of Glu, thereby achieving the effect of relieving neck and shoulder pain. He Jian et al. used the same modeling method and found that the contents of nitric oxide synthase (NOS) and NO in the serum and muscle tissue homogenate were significantly decreased, suggesting that long-term head-down flexion of the cervical spine can inhibit information transmission [17]. Guided by the theory of "Taiyang governs tendons", this study selected three points (Kunlun, Weizhong, and Feishu) on the Bladder Meridian of Foot-Taiyang for acupuncture in the treatment of cervical spondylosis. Among them, Feishu is located locally in the neck and nape, following the principle of "acupoints correspond to local disorders", guiding the local Qi to "reach the affected area", dredging local meridian Qi and blood, improving blood microcirculation, inhibiting the release of pain mediators, and stimulating peripheral nerves, thereby reducing neck and shoulder pain in patients [18]. Nanjing·Liushiba Nan (Classic of Difficult Issues·Sixty-Eighth Difficulty) states: "Jing (Well) points

treat stuffiness in the chest and hypochondrium; Ying (Spring) points treat body heat; Shu (Stream) points treat heaviness and joint pain; Jing (River) points treat cough, asthma, cold, and heat; He (Sea) points treat adverse Qi and diarrhea" [19]. Kunlun and Weizhong points are acupoints of the Bladder Meridian of Foot-Taiyang. According to Huangdi Neijing·Lingshu·Jingmai (Yellow Emperor's Internal Classic·Spiritual Pivot·Meridians): "The Bladder Meridian of Foot-Taiyang originates from the inner canthus of the eye. Its straight branch enters the brain from the top of the head, exits and descends to the neck". The Bladder Meridian of Foot-Taiyang runs from the head to the back and then to the feet, and the entire neck and back of the human body are mainly traversed by the Bladder Meridian. According to the principle of "meridians govern disorders along their pathways", it can treat diseases along the Foot-Taiyang Meridian [20].

## 6. Conclusion

In summary, since meridians transport Qi and blood to nourish muscle meridians, enabling muscle meridians to bind bones and regulate joints, the occurrence of cervical spondylosis is related to meridians, and most closely related to the muscle meridians of the Hand-Taiyang and Foot-Taiyang Meridians; from the perspective of the distribution of the muscle meridian of the Foot-Taiyang Meridian, it highly overlaps with the lesion site of cervical spondylosis [21]. Secondly, the Foot-Taiyang Meridian is the one with the most abundant defensive Yang among the Twelve Meridians. Defensive Yang originates from the Foot-Taiyang Meridian. Abundant defensive Yang warms and nourishes the muscle meridians; if defensive Yang is insufficient, the cervical muscle meridians lose warmth, resulting in symptoms such as pain and stiffness of cervical spondylosis. Therefore, cervical spondylosis is also a disease governed by the Bladder Meridian of Foot-Taiyang and is closely related to this meridian [22]. Modern medical studies have shown that the imbalance of cervical biomechanical balance and inflammatory damage of cervical muscle tissue are closely related to the occurrence of cervical spondylosis [4]. People who work at their desks for a long time or have bad living habits are prone to imbalance of cervical biomechanical balance and inflammatory damage of cervical muscle tissue. In the occurrence and development of cervical spondylosis, inflammatory factors such as IL-1β, IL-6, and TNF-α play key roles. Relevant studies have shown that the expression level of TNF-α is significantly increased after cervical disc degeneration. This increase not only promotes the contact between macrophages and degenerated disc tissue, thereby triggering an inflammatory response, but also is the initiating factor leading to the inflammatory response of degenerated discs. As a pro-inflammatory factor, the expression and release of IL-6 can be regulated by muscle contraction. At the same time, muscle contraction can also promote the expression and release of inflammatory factors such as IL-1β, and promote the release and expression of other inflammatory cytokines such as TNF-α, ultimately aggravating the degree of inflammatory damage. In this experiment, the expression levels of IL-1β, IL-6, and TNF-α in rabbits were significantly increased after modeling, and after treatment with acupuncture at points of the Bladder Meridian of Foot-Taiyang, the expression levels of the above inflammatory factors were lower than those in the model group. In conclusion, acupuncture at points of the Bladder Meridian of Foot-Taiyang may exert a therapeutic effect by reducing the release of inflammatory factors such as IL-1β, IL-6, and TNF-α and inhibiting the inflammatory damage of cervical muscles. Therefore, in the treatment of cervical spondylosis, acupuncture can be used under the guidance of the theory of "Taiyang governs tendons".

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## Disclosure statement

The authors declare no conflict of interest.

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# Research on the Impact of Evidence-Based Predictive Nursing on Elderly Cataract Patients During the Perioperative Period

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**Abstract:** Objective: To explore the impact of evidence-based predictive nursing intervention on psychological stress and physiological indicator stability of elderly cataract patients during the perioperative period (1 day before surgery to 1 day after surgery), and to provide a basis for optimizing clinical nursing plans for elderly cataract surgery. Methods: A retrospective selection of 90 elderly patients (aged ≥ 60 years) who underwent cataract surgery in the Ophthalmology Department of our hospital from August 2024 to December 2024 was conducted. They were divided into an observation group (n = 45) and a control group (n = 45) using a random number table method. The control group received routine nursing for cataract surgery, while the observation group implemented evidence-based predictive nursing intervention (including the establishment of a multidisciplinary evidence-based team, hierarchical psychological intervention, perioperative environment optimization, intraoperative personalized cooperation, and video-based health education). Psychological stress indicators [Self-Rating Anxiety Scale (SAS), Self-Rating Depression Scale (SDS), General Self-Efficacy Scale (GSES)] on the 1st day before surgery and 1st day after surgery, and fluctuations of physiological indicators [Heart Rate (HR), Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP)] on the 1st day before surgery and during surgery were compared between the two groups. *Results:* Before intervention, there were no statistically significant differences in SAS, SDS, GSES scores, HR, SBP, or DBP between the two groups ($p > 0.05$); after intervention, the SAS score (33.62 ± 5.72) and SDS score (32.14 ± 4.86) of the observation group on the 1st day after surgery were significantly lower than those of the control group [(41.05 ± 5.56), (43.59 ± 4.75)], and the GSES score (31.15 ± 3.28) was significantly higher than that of the control group (24.84 ± 3.52) (all $p < 0.05$); during surgery, the fluctuations of HR (74.0 ± 6.0) beats/min, SBP (127.0 ± 15.8) mmHg, and DBP (75.0 ± 5.9) mmHg in the observation group were significantly smaller than those in the control group (all $p < 0.05$). *Conclusion:* Evidence-based predictive nursing intervention can effectively alleviate anxiety and depression in elderly cataract patients during the perioperative period, improve self-efficacy, stabilize intraoperative physiological status, and enhance surgical cooperation, which is worthy of clinical promotion.

**Keywords:** Evidence-based nursing; Predictive nursing; Elderly patients; Cataract; Perioperative period; Psychological stress; Physiological stability; Self-efficacy

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# 1. Introduction

Cataract is a common degenerative ophthalmic disease in the elderly. The incidence of cataract in people over 60 years old in China reaches 80%, accounting for more than 50% of the causes of visual impairment. Surgery is currently the only effective clinical treatment for this disease [1]. Due to factors such as declining physical function, insufficient understanding of surgery, and unfamiliarity with the operating room environment, elderly patients are prone to obvious psychological stress reactions during the perioperative period. Preoperative anxiety and depression can lead to increased blood pressure and heart rate during surgery, which not only reduces surgical cooperation but also may increase the risk of postoperative complications [2]. Evidence-based nursing, with "best scientific research evidence + clinical experience + patient needs" as the core, formulates personalized intervention plans through systematic retrieval and evaluation of evidence, which can effectively improve nursing accuracy [3]; predictive nursing emphasizes "early assessment - advance intervention" and formulates measures for potential risks to reduce the incidence of adverse events [4]. This study combines the two to construct a multidisciplinary evidence-based predictive nursing model, exploring its impact on psychological stress and physiological stability of elderly cataract patients during the perioperative period, aiming to provide practical reference for elderly ophthalmic surgical nursing.

# 2. Materials and methods

## 2.1. Research objects

A retrospective inclusion of 90 elderly patients who underwent phacoemulsification combined with intraocular lens implantation for cataracts in the Ophthalmology Department of our hospital from August 2024 to December 2024 was conducted.

### 2.1.1. Inclusion criteria

(1) Meets the diagnostic criteria for cataracts in Ophthalmology and plans to undergo elective surgery;
(2) Aged ≥ 60 years
(3) Clear consciousness and able to complete scale scoring independently
(4) No severe dysfunction of heart, liver, kidney and other organs
(5) Informed consent from patients and their families.

### 2.1.2. Exclusion criteria

(1) Complicated with mental illness or cognitive impairment (Mini-Mental State Examination score < 24 points);
(2) Has a history of ophthalmic surgery or other severe ophthalmic diseases (such as glaucoma, retinal detachment);
(3) Unable to cooperate with intraoperative body position fixation (such as severe spinal deformity).

### 2.1.3. Grouping method

Patients were divided into an observation group and a control group using a random number table method, with 45 cases in each group. There were no statistically significant differences in baseline data such as age, gender, educational level, history of hypertension, and lens opacity degree (LOCS III classification) between the two

groups ($p > 0.05$), which were comparable, as shown in **Table 1**.

**Table 1.** Comparison of baseline data of elderly cataract patients in two groups

| Group | Number of cases | Average age (Years, $\bar{x} \pm s$) | Male [n (%)] | Average educational level (Years, $\bar{x} \pm s$) | History of hypertension [n(%)] | Lens opacity degree (LOCS III Classification, n) Grade II |
|---|---|---|---|---|---|---|
| Observation group | 45 | 68.41 ± 13.26 | 33(62.23) | 13.37 ± 2.40 | 15(33.33) | 12 |
| Control group | 45 | 66.90 ± 13.04 | 31(68.88) | 12.92 ± 2.85 | 13(28.95) | 14 |
| $t/\chi^2$ value | - | 0.915 | 2.094 | 0.736 | 1.763 | 0.382 |
| $p$-value | - | > 0.05 | > 0.05 | > 0.05 | > 0.05 | > 0.05 |

## 2.2. Nursing methods

### 2.2.1. Control group: Routine nursing

(1) Preoperative

Verbally inform patients of the surgical process, intraoperative precautions (such as keeping the head fixed), and postoperative nursing key points; assist in completing preoperative examinations (such as intraocular pressure, corneal curvature).

(2) Intraoperative

Monitor vital signs (HR, SBP, DBP), observe the patient's mental state, and provide simple comfort when obvious restlessness occurs.

(3) Postoperative

Guide patients in eye medication (such as antibiotic eye drops) and inform them of taboos such as avoiding rubbing eyes, bowing, and bending over after surgery.

### 2.2.2. Observation group: Evidence-based predictive nursing intervention

Follow the process of "evidence-based question - evidence retrieval - evidence evaluation - plan formulation - implementation of intervention", as follows:

(1) Establish a multidisciplinary evidence-based nursing team

Led by the deputy head nurse of the operating room (leader) and the head nurse of ophthalmology (deputy leader), the team includes 2 senior nurses from ophthalmology, 2 senior nurses from the operating room, 1 attending physician from anesthesiology, 1 attending physician from ophthalmology, and 2 secretaries (1 undergraduate from the operating room and 1 graduate student from ophthalmology, responsible for literature retrieval and data statistics); invite directors of ophthalmology and anesthesiology to serve as consultants to ensure the professionalism of the plan.

(2) Evidence-based practice steps

① Raise questions: Focus on core issues such as "influencing factors of psychological stress in elderly cataract patients during the perioperative period" and "effects of predictive nursing intervention on the psychological and physiological status of cataract surgery patients". ② Retrieve Evidence: Retrieve CNKI, Wanfang, VIP, and PubMed databases from January 2019 to December 2024 with keywords including "cataract", "elderly patients", "perioperative nursing", "evidence-based nursing", "predictive nursing", "psychological stress", and "anxiety". A total of 86 literatures were retrieved. After excluding low-quality (JBI

evidence grade ＜ Grade B) and duplicate literatures, 12 core literatures were included [3–12]. ③ Evaluate Evidence: Using the JBI Evidence-Based Nursing Center's evidence grading standards, "video-based health education can improve elderly patients' disease cognition", "hierarchical psychological intervention can targetedly relieve anxiety", and "intraoperative music + physical comfort can stabilize physiological indicators" were adopted as Grade A evidence and included in the nursing plan.

(3) Specific intervention measures

Preoperative: Hierarchical Psychological Assessment and Education: ① Assess psychological status using SAS and SDS scales 1 day before surgery, divided into mild (SAS 50–59 points / SDS 53–62 points), moderate (SAS 60–69 points / SDS 63–72 points), and severe (SAS ≥ 70 points / SDS ≥ 73 points) stress; ② Mild stress: Conduct one-on-one communication, explaining safety combined with surgical diagrams (such as "the operation only takes 15–20 minutes, with no obvious pain during the operation"); Moderate Stress: Arrange postoperative recovered patients to share experiences, and simultaneously guide deep breathing relaxation training, 3 times a day, 10 minutes each time; Severe Stress: Conduct joint anesthesiology assessment, recommend general anesthesia, and provide psychological counseling 2 hours before surgery; ③ Produce a short video of "the whole process of cataract surgery", including the operating room environment, surgical operations, and postoperative rehabilitation cases, generate a QR code, and patients can scan and watch repeatedly to eliminate unfamiliarity with the environment [5]. Intraoperative: Environment Optimization and Personalized Cooperation: ① Adjust the operating room temperature to 23–25 ℃ and humidity to 50–60% 30 minutes before surgery, play soft piano music with a volume of 30–40 decibels [13]. ② After the patient enters the operating room, the nurse holds the patient's non-surgical hand and gently informs "the operation is about to start, and I will be with you throughout"; inform the patient of the surgical progress every 5 minutes during the operation, such as "lens emulsification has been completed, and intraocular lens implantation is about to begin"; ③ Closely observe changes in HR and SBP. If SBP > 150 mmHg or HR > 90 beats/min, suspend the operation and provide verbal comfort, and continue after the indicators stabilize. Postoperative: Continuous Support: Conduct a follow-up visit 1 day after surgery, assess self-efficacy using the GSES scale, and encourage patients with low scores (< 25 points): "You are recovering well now, and you can recover smoothly by taking medication as guided" to strengthen treatment confidence.

## 2.3. Observation indicators

### 2.3.1. Psychological stress indicators

Evaluated using the following scales on the 1st day before surgery and 1st day after surgery:

(1) SAS: 20 items, standard score ≥ 50 points indicates anxiety, with higher scores indicating more severe anxiety;

(2) SDS: 20 items, standard score ≥ 53 points indicates depression, with higher scores indicating more severe depression;

(3) GSES: 10 items, using a 1–4 grade scoring method, total score 10–40 points, with higher scores indicating stronger self-efficacy [14].

### 2.3.2. Physiological indicators

Record HR (beats/min), SBP (mmHg), and DBP (mmHg) on the 1st day before surgery and during surgery, and

calculate the difference (fluctuation range) between intraoperative indicators and preoperative baseline in the two groups.

### 2.4. Statistical methods

SPSS 22.0 software was used for data analysis. Measurement data were expressed as "$\bar{x} \pm s$", and inter-group comparison was conducted using independent sample *t*-test; count data were expressed as "n(%)", and inter-group comparison was conducted using $\chi^2$ test. A $p$ value < 0.05 was considered statistically significant.

## 3. Results

### 3.1. Comparison of perioperative psychological stress indicators between the two groups

Before intervention, there were no statistically significant differences in SAS, SDS, or GSES scores between the two groups ($p > 0.05$); after intervention, the SAS and SDS scores of the observation group were significantly lower than those of the control group, and the GSES score was significantly higher than that of the control group (all $p < 0.05$), as shown in **Table 2**.

**Table 2.** Comparison of perioperative psychological stress indicators of elderly cataract patients in two groups (scores, $\bar{x} \pm s$)

| Group | Number of cases | SAS | SDS | GSES |
|---|---|---|---|---|
| | | 1st day before surgery | 1st day after surgery | 1st day before surgery |
| Observation group | 45 | 53.62 ± 4.88 | 33.62 ± 5.72 | 51.27 ± 5.06 |
| Control group | 45 | 52.86 ± 5.21 | 41.05 ± 5.56 | 50.96 ± 4.93 |
| *t* value | - | 0.706 | 6.178 | 0.291 |
| *p* value | - | 0.482 | < 0.001 | 0.772 |

### 3.2. Comparison of perioperative physiological indicators between the two groups

Before intervention, there were no statistically significant differences in HR, SBP, or DBP between the two groups ($p > 0.05$); during surgery, the fluctuations of HR, SBP, and DBP in the observation group were significantly smaller than those in the control group (all $p < 0.05$), as shown in **Table 3**.

**Table 3.** Comparison of perioperative physiological indicators of elderly cataract patients in two groups ($\bar{x} \pm s$)

| Group | Number of cases | HR (Beats/min) | SBP (mmHg) | DBP (mmHg) |
|---|---|---|---|---|
| | | 1st day before surgery | Intraoperative | 1st day before surgery |
| Observation group | 45 | 78.9 ± 6.5 | 74.0 ± 6.0 | 137.0 ± 11.6 |
| Control group | 45 | 80.4 ± 7.8 | 78.8 ± 7.4 | 145.0 ± 9.9 |
| *t* value | - | 1.018 | 3.490 | 1.360 |
| *p* value | - | 0.332 | 0.001 | 0.206 |

# 4. Discussion

## 4.1. Evidence-based predictive nursing can effectively alleviate perioperative psychological stress

The results of this study showed that the postoperative SAS and SDS scores of the observation group were significantly lower than those of the control group, and the GSES score was significantly higher than that of the control group ($p < 0.05$), which is consistent with the research conclusion of Liu Shuangdan et al. [8]. The reasons are as follows:

(1) Through "hierarchical psychological intervention", differentiated measures are formulated for patients with mild, moderate, and severe stress, avoiding the limitations of "one-size-fits-all" nursing - mild patients build confidence through cognitive education, moderate patients strengthen psychological resilience through peer experience + relaxation training, and severe patients reduce fear through anesthesia assessment + professional counseling [4];

(2) Video-based health education intuitively presents the surgical process, solving the problem of "poor memory of verbal education" in elderly patients, improving disease cognition and reducing anxiety caused by "unknown" [5];

(3) Continuous verbal comfort and physical contact during surgery make patients feel "cared for", further relieving intraoperative tension and ultimately improving self-efficacy [12].

## 4.2. Evidence-based predictive nursing can stabilize intraoperative physiological status

Elderly patients have weak cardiovascular regulation ability, and perioperative psychological stress is prone to cause severe fluctuations in HR and SBP, increasing the risk of intraoperative cardiovascular accidents [2]. In this study, the fluctuations of HR, SBP, and DBP in the observation group during surgery were significantly smaller than those in the control group ($p < 0.05$). The mechanism lies in:

(1) Preoperative relaxation training reduces sympathetic nerve excitability through "breathing regulation - autonomic nerve balance", reducing the release of stress hormones (such as cortisol) [15];

(2) Intraoperative environment optimization (temperature, humidity, music) directly acts on the sensory system, relieves physical tension, and indirectly stabilizes physiological indicators [13];

(3) Nurses dynamically monitor indicators throughout the operation and intervene in abnormal fluctuations in a timely manner, avoiding the vicious cycle of "stress - increased indicators - more anxiety" [9].

## 4.3. Clinical value and limitations of the multidisciplinary evidence-based model

The "operating room - ophthalmology - anesthesiology" multidisciplinary evidence-based team constructed in this study achieves the complementary advantages of "familiarity with surgical processes (operating room) + professional disease knowledge (ophthalmology) + anesthesia risk control (anesthesiology)", ensuring that the nursing plan takes into account both "safety and practicality" [9]. However, the study has limitations:

(1) It is a single-center retrospective study with a small sample size (90 cases), which limits the extrapolation of results;

(2) Long-term indicators (such as visual acuity recovery and complication rate) 3 months after surgery were not followed up. In the future, multi-center, prospective studies need to be conducted for further verification;

(3) Grassroots hospitals may be unable to replicate the "multidisciplinary team" model due to insufficient

human resources, and the plan needs to be simplified to improve promotion feasibility.

## 5. Conclusion

Evidence-based predictive nursing intervention can effectively alleviate anxiety and depression in elderly cataract patients during the perioperative period, improve self-efficacy, and stabilize intraoperative physiological status through "hierarchical psychological intervention, perioperative environment optimization, and intraoperative personalized cooperation". It provides an operable practical plan for the perioperative nursing of elderly cataract surgery patients, and is worthy of promotion and application in ophthalmology departments of secondary and above hospitals.


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# Application of Whole Slide Imaging Technology in Clinical Pathological Diagnosis

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**Abstract:** Whole Slide Imaging (WSI) technology, as a revolutionary digital technology in the field of pathology, is gradually changing the traditional clinical pathological diagnosis model. By converting traditional glass pathological sections into complete digital images through high-resolution scanning, it provides a new method for pathological diagnosis. Based on this, this paper studies the application of WSI technology in clinical pathological diagnosis, elaborates on its application value, analyzes the current application status, and proposes corresponding application countermeasures, aiming to provide reference for the standardized and popularized development of this technology in clinical pathological diagnosis.

**Keywords:** Whole slide imaging (WSI) technology; Clinical pathological diagnosis; Application value; Current status; Application countermeasures

**Online publication:** Feb 9, 2026

## 1. Introduction

With the rapid development of digital pathology, Whole Slide Imaging (WSI) technology has emerged. It converts traditional glass pathological sections into complete digital images through high-resolution scanning, opening a new chapter for pathological diagnosis work. This technology not only completely retains the original information of pathological sections but also breaks the time and space limitations of traditional optical microscopes with its digital, storable, and easily shareable characteristics [1]. Against the background of precision medicine and "Internet + Healthcare", WSI technology has shown enormous potential in improving the quality and efficiency of pathological diagnosis, optimizing the allocation of medical resources, and promoting medical education and scientific research. Therefore, this paper systematically sorts out the application value of WSI technology, objectively analyzes its current application status and existing bottlenecks, and discusses feasible application countermeasures accordingly, aiming to provide theoretical reference and practical ideas for promoting the deeper and wider application of this technology in clinical pathological diagnosis in China.

## 2. Application value of whole slide imaging technology in clinical pathological diagnosis

### 2.1. Conducive to improving diagnostic accuracy

Whole Slide Imaging technology achieves diagnostic upgrading through high-precision optical imaging systems, specific staining technologies, high-resolution digital conversion, and artificial intelligence-assisted diagnosis. The optical system ensures image clarity; technologies such as HE staining and immunohistochemistry make lesion areas easy to distinguish; digital imaging converts sections into efficiently processable digital signals; AI technology automatically identifies lesions through deep learning. Multiple links collaborate to lay the foundation for diagnostic accuracy [2]. In contrast, WSI technology can convert entire pathological sections into high-resolution digital images, allowing doctors to observe images comprehensively and multi-dimensionally on computer screens. Through image browsing software, doctors can easily zoom in, zoom out, and pan images without missing any subtle lesion features.

### 2.2. Conducive to conducting teleconsultation and academic exchange

In terms of teleconsultation, WSI technology plays an indispensable key role. By digitizing pathological sections and relying on high-speed and stable network transmission technology, these digital sections can be instantly transmitted to experts around the world. Experts can carefully observe and in-depth analyze digital sections anytime and anywhere through terminal devices such as computers and tablets, just like viewing pathological sections on-site [3]. The emergence of this teleconsultation model has greatly broken the time and space constraints of traditional consultation methods, providing patients with more convenient and efficient medical services. For example, when a hospital in a remote area encounters difficulties in diagnosing rare lymphoma, it can digitize and upload sections to a teleconsultation platform through this technology, and link with experts in big cities to complete accurate diagnosis and treatment plan formulation within hours. This effectively breaks the regional barriers of medical resources and improves the fairness and accessibility of medical services.

### 2.3. Conducive to promoting teaching and scientific research

In medical education, WSI technology has created a digital learning database, breaking the form of relying on a few physical specimens. Students can freely view digital samples of common and rare cases using computer equipment, and use tools such as zooming and annotation to independently explore the nature of abnormalities, so as to enhance their ability to observe and solve problems [4]. From a scientific perspective, such a large number of digital samples can provide basic data for cancer research. For example, scientists can further explore the morphology, growth rate of cancer cells and their relationship with surrounding tissues by viewing digital samples, which can be used as a reference for early diagnosis and precise treatment of cancer; in drug development research, images of the experimental group and control group in clinical trials can be compared to better understand the effects of drugs on biological cells and possible adverse consequences, accelerating the research and development process of new drugs and improving the success rate.

## 3. Current application status of whole slide imaging technology in clinical pathological diagnosis

### 3.1. Limited application scope

At present, the application scope of WSI technology in clinical pathological diagnosis is still relatively

limited. Although the technology has been recognized to a certain extent in the pathological community, its main application scenarios are concentrated in the diagnosis and analysis of a small number of difficult cases and typical teaching cases, and it has not been widely integrated into every link of daily pathological diagnosis work [5]. At the technical specification level, there is a lack of unified industry standards. There are differences in image acquisition parameters, storage formats, transmission protocols, etc. The performance of equipment from different manufacturers varies, and the quality and compatibility of digital sections are difficult to guarantee, which hinders the wide application of the technology.

### 3.2. Technical and equipment issues

Slow scanning speed is a prominent problem. Scanning a single section in high-resolution mode takes 10–30 minutes, which is difficult to meet the needs of processing a large number of sections in pathological laboratories and affects the timeliness of diagnosis. Image quality is affected by sample preparation and equipment performance. Uneven section thickness, poor staining, or defects in the optical system can easily lead to blurred digital sections, artifacts, and other problems, reducing diagnostic value. Data storage and transmission face challenges. A single high-resolution digital section can reach tens of GB to hundreds of GB, requiring large-capacity storage equipment. Moreover, network bandwidth limitations lead to slow transmission, increasing management costs and complexity [6]. When existing computer hardware and software process large-scale pathological image data, there are problems such as slow operation speed and limited analysis functions, which are difficult to meet the clinical requirements for real-time and accurate data processing.

### 3.3. Doctors' habits and acceptance

Doctors' reliance on microscope diagnosis stems from the intuitive operational experience accumulated during long careers. Operations such as fine-tuning the focal length and moving sections can quickly focus on regions of interest. This traditional model has been integrated into their work thinking and skill system. During technology promotion, doctors' acceptance is not high. On the one hand, they are worried that digital sections may affect image authenticity after conversion and processing, leading to the omission of pathological information; on the other hand, some doctors have weak computer foundations and face difficulties in learning new operational skills, reducing their willingness to accept [7]. It is necessary to change doctors' concepts through strengthened publicity and training, making them recognize the advantages and complementarity of digital sections; at the same time, carry out systematic training covering computer basics, software operations, etc., to help doctors master new technologies and improve their application confidence and capabilities.

## 4. Application countermeasures of whole slide imaging technology in clinical pathological diagnosis

### 4.1. Consolidate hardware and software foundations and build a stable and efficient digital platform

The application of technology is inseparable from a solid foundation. In the application of WSI technology, it is necessary to solve the problems of hardware setup and software construction to promote the effective application of the technology. First, select and configure scanning equipment. According to the workload of pathological examination in the hospital (such as the number of pathological sections per day), inspection types (such as

smears, biopsy sections, surgical frozen sections, etc.), and diagnostic accuracy requirements, select equipment supporting combinations with different speeds and analysis capabilities. For large-scale testing in big cities or routine disease inspection and diagnosis, high-throughput rapid scanning machines can be selected first; but at the same time, high-quality scanning instruments can be prepared for the processing of difficult cases and scientific research; for hospitals in small cities, start with a medium-speed scanning machine and gradually expand. The key is to ensure that the resolution of scanned images meets the diagnostic accuracy requirements, avoiding the risk of misdiagnosis due to poor scanned image quality. Second, upgrade storage and network systems. Given that each individual WSI image file is very large (several GB or even dozens of GB), how to efficiently store, manage, and quickly access massive information is crucial [8]. Solutions include: building an efficient and scalable data server and Storage Area Network (SAN) system; implementing hierarchical storage, placing images requiring current diagnosis on high-speed storage media, and transferring previous data to relatively cheap low-speed storage media. In addition, it is necessary to improve the hospital's internal network speed to ensure that pathologists do not experience delays or pauses when browsing digital sections on computers, with an experience close to observing with a microscope [9]. Third, integration and interoperability of software systems. Digital sections should not be information islands. The WSI information system should be automatically integrated into the hospital's Hospital Information System (HIS), Laboratory Information System (LIS) of the inspection system, and Pathology Information System (PIS) database. The software should have a user-friendly operation interface, a large number of image analysis functions (such as calculating length, area, cell count, etc.), and support standard formats (such as DICOM) and databases, laying the foundation for future data research and the application of artificial intelligence [10].

## 4.2. Optimize diagnostic workflow to achieve a balance between efficiency and safety

The introduction of WSI technology is not simply replacing microscopes with computer screens, but requires optimizing and adjusting the entire pathological diagnosis workflow. First, reset the diagnosis and review processes. Strategies such as "digital first, then work" and "using both digital and microscope" can be implemented. For general pathological examinations, junior doctors can immediately make judgments on digital sections, and senior doctors can verify and confirm them online to improve review efficiency. For complex problems, digital sections can be fully used to gather many experts for centralized or decentralized remote discussions to pool ideas. Second, strengthen quality control links. Before section scanning, a strict quality control position should be set up to inspect the quality of prepared glass sections (such as depth, thickness, presence of folds, presence of stains, etc.), and only qualified sections can participate in the scanning process. After scanning, special personnel should check the digital photos to see if they are fully covered and free of blurriness. These two quality control steps are the first pass to ensure the accuracy of digital diagnosis [11].

## 4.3. Carry out relevant technical training to improve doctors' operational capabilities

Training doctors on WSI technology is an important measure to promote the wide application of the technology. Medical institutions should attach importance to technical training, introduce WSI technology training into the continuing education and training system for doctors, and formulate comprehensive and systematic training plans. The training should include two stages: theoretical knowledge teaching and practical operation, to ensure a comprehensive overall understanding of this new technology, familiarity with its methods, means, and principles [12]. Theoretical training should explain its scientific mechanism, advantages, applicable scenarios, and advantages compared with conventional methods, aiming to help doctors clearly understand the application

value and eliminate doubts; in the practical operation stage, there should be independent venues and equipment, and professional technical personnel should personally guide the operation. Through the application of specific cases, doctors can familiarize themselves with scanning, processing, analysis, and other steps. Practical operation is the most important stage. Medical institutions should independently set up a training venue and equipment to ensure that doctors have sufficient experience opportunities. Technical personnel composed of experts provide real-time guidance and training to assist doctors in mastering the use and skills of image acquisition equipment and image optimization software. Doctors can personally experience the shooting, image processing, recognition, interpretation, and other skills in practical applications, thereby improving their ability to conduct pathological evaluation on the digital platform. A series of practice cases can be designed to help doctors gradually accumulate application experience and proficiently master the skills of using the new technology [13].

### 4.4. Expand diversified application scenarios and release the great potential of digital pathology

The value of WSI technology is far more than simulating microscopes, and its extended applications should be actively expanded. First, develop telepathology and consultation. Establish regional pathological diagnosis centers to provide real-time remote diagnosis services for medical cooperation member units through the Internet, narrowing the regional differences in medical quality. Second, promote teaching and scientific research innovation. In terms of teaching, a standard digital section teaching resource library can be established to allow students to learn anytime and anywhere. In the field of scientific research, a large amount of WSI data is a valuable resource, which can be used for quantitative research on disease morphology, mining of disease prognostic indicators, and providing huge data support for the development and training of artificial intelligence algorithms [14]. Third, introduce artificial intelligence-assisted diagnosis. AI can automatically identify tumor locations in digital images, perform pathological classification (such as Gleason scoring), calculate the number of favorable cells, etc., becoming a “partner” of physicians, improving diagnostic consistency and efficiency, and reducing physicians’ repetitive labor. Pathology departments should adopt an open attitude to evaluate and verify the effectiveness of AI tools for clinical applications together with AI development teams [15].

## 5. Conclusion

In summary, Whole Slide Imaging technology has brought innovations to clinical pathological diagnosis, playing a key role in improving diagnostic accuracy, assisting teleconsultation and academic exchange, and promoting teaching and scientific research. In practical work, further study should focus on consolidating infrastructure, optimizing work processes, conducting systematic training, expanding application scenarios, and establishing unified standards to ensure diagnostic reliability, so as to break through the bottlenecks of technology application and release its potential in the field of pathological diagnosis. With the deepening of technological research and development, this technology should be continuously optimized and popularized to further improve diagnostic efficiency and medical quality, promote the normalization of teleconferences, and assist the development of medical teaching and research.

## Disclosure statement

The authors declare no conflict of interest.

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# The Impact of Combined Health Education and Dietary Guidance on the Speed of Postoperative Recovery in Patients with Gastrointestinal Polyps

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**Abstract:** This study aims to explore the impact of combined health education and dietary guidance on the speed of postoperative recovery in patients with gastrointestinal polyps. A specific number of patients who underwent gastrointestinal polyp resection were selected and randomly divided into a control group and an experimental group. The control group received routine nursing, while the experimental group implemented combined health education and dietary guidance on this basis. By comparing the recovery indicators of the two groups, it was found that the recovery speed of the experimental group was significantly faster than that of the control group, indicating that this combined intervention method can effectively promote patient recovery.

**Keywords:** Health education; Dietary guidance; Postoperative gastrointestinal polyps; Recovery speed

**Online publication:** Feb 3, 2026

## 1. Introduction

Gastrointestinal polyps are common lesions of the digestive system. The quality of postoperative recovery in patients after endoscopic resection is directly related to long-term prognosis and quality of life. Traditional nursing models mostly focus on symptom control and complication prevention, but often ignore the profound impact of patients' subjective initiative and lifestyle intervention on the recovery process. Health education can significantly improve patients' compliance with postoperative management plans through systematic knowledge transmission; individualized dietary guidance can accurately regulate nutrient intake and provide metabolic support for tissue repair. The synergistic effect of the two not only conforms to the modern medical model of "biological-psychological-social" but also is highly consistent with the concept of Enhanced Recovery After Surgery (ERAS). This study takes patients after gastrointestinal polyp resection as the research object, explores the quantitative impact of combined health education and dietary guidance on recovery speed, aiming to provide evidence-

based basis for optimizing perioperative management strategies, shortening hospital stay, and improving patient prognosis, making the research content more referential [1].

## 2. Materials and methods

### 2.1. General information

A total of 120 patients who underwent gastrointestinal polyp resection in our hospital from January 2024 to December 2024 were selected as the research objects.

#### 2.1.1. Inclusion criteria

Diagnosed with gastrointestinal polyps by pathological examination and underwent surgical treatment; aged between 18–75 years old; conscious and able to communicate normally; the study has obtained the consent of patients and their families, and informed consent forms have been signed.

#### 2.1.2. Exclusion criteria

Having other major diseases affecting the operation; Allergic to relevant drugs; Unable to cooperate with dietary standards; Undergoing multiple mutually exclusive surgeries [2].

#### 2.1.3. Study design

Patients were divided into a control group and an experimental group according to different ages, with 60 patients in each group. Among them, the control group included 34 males and 16 females, with an age range of (45.2 ± 10.5) years and a polyp diameter of (5.8 ± 2.1) mm; the experimental group included 30 males and 30 females, with an age range of (44.8 ± 11.2) years and a polyp diameter of (5.5 ± 2.3) mm. The control group and the experimental group were compared in the above dimensions to comprehensively understand and better grasp the research situation [3].

### 2.2. Research methods

#### 2.2.1. Control group

Received routine care, including monitoring patients' recovery and wound conditions after surgery, administering drug treatment as prescribed by doctors, and guiding patients to rest and exercise reasonably [4].

#### 2.2.2. Experimental group

In addition to the routine care of the control group, combined health education and dietary guidance were implemented.

(1) Health education

Admission education: Nurses should introduce the hospital environment, attending doctors, and managing nurses to patients admitted to the hospital, so that patients can better integrate into the hospital and adapt to the hospital environment as soon as possible. Disease knowledge education: Through distributing publicity brochures, holding health lectures, and one-on-one explanations, patients and their families are detailly informed about the causes of gastrointestinal polyps, treatment methods, preoperative diet, postoperative management methods, and relevant prevention and treatment measures, so that patients and their families

can have a deeper understanding of gastrointestinal polyps. Postoperative rehabilitation education: Explain to patients the importance of postoperative rehabilitation and precautions, such as precautions for postoperative activities. Focus on rest within 1–2 days after surgery, avoid prolonged walking, straining during defecation, and lifting heavy objects, and avoid strenuous exercise within a week. At the same time, inform patients to promptly inform medical staff if abnormal conditions such as abdominal pain, bloating, and hematochezia occur [5]. Psychological education: Patients after gastrointestinal polyp surgery often have varying degrees of anxiety, fear, and other psychological problems, that is, worrying about their future conditions [6]. Hospital staff should communicate with patients and their families according to different situations of patients. This can not only reduce patients' tension but also enable patients' families to better comfort patients' anxiety, thereby better ensuring the conditions before, during, and after surgery. Patients are more willing to receive physical and psychological treatment, so as to overcome the disease with a positive attitude [7].

(2) Dietary guidance

Early postoperative period (1–3 days after surgery): Patients' gastrointestinal function has not yet fully recovered. At this time, fasting or warm liquid food such as rice soup, vegetable soup, and fruit juice should be given. Avoid gas-producing foods such as milk and soybean milk to prevent bloating. Do not eat too much at one time; follow the principle of small and frequent meals, with 5–6 meals a day [8]. Mid-postoperative period (4–7 days after surgery): With the gradual recovery of gastrointestinal function, patients can gradually transition to semi-liquid food such as porridge, noodles, and wontons. The food should be light, easy to digest, and rich in protein and vitamins, such as lean meat porridge, egg custard, and vegetable puree. At the same time, pay attention to the appropriate temperature of food to avoid cold or overheated food stimulating the gastrointestinal tract. Late postoperative period (more than 1 week after surgery): Patients' gastrointestinal function has basically recovered to normal, and they can gradually resume a normal diet. However, they should also eat according to the proportion of protein and vegetables provided by doctors to better promote the gastrointestinal tract to develop in a healthy direction. Spicy, greasy, and irritating foods should not be eaten, and smoking and drinking should be quit to reduce stimulation to the gastrointestinal tract [9].

## 2.3. Observation indicators

### 2.3.1. Recovery speed indicators

(1) First defecation time

Record the time of the first defecation of patients in both groups after surgery, in hours.

(2) Hospital stays

The time from patients' admission for surgical treatment to discharge, in days.

(3) Complication occurrence

Observe and record the conditions of the control group and the experimental group, such as physical conditions, bleeding, abdominal pain, bloating, etc., and calculate the complication rate.

### 2.3.2. Patient satisfaction

The hospital can use questionnaires to investigate patients' satisfaction with doctors' services, health education, postoperative education, psychological education, etc., with a full score of 100 points. According to the satisfaction

level, it is divided into four grades: Very satisfied (above 95 points), Satisfied (85–94 points), Average (60–84 points), and Dissatisfied (below 60 points). Final satisfaction rate = (number of very satisfied patients + number of satisfied patients) / total number of patients × 100%.

### 2.4. Statistical methods

SPSS 25.0 statistical software was used for data analysis. Measurement data were expressed as mean ± standard deviation ($\bar{x} \pm s$), and independent sample *t*-test was used for inter-group comparison; count data were expressed as rate (%), and $\chi^2$ test was used for inter-group comparison. $p < 0.05$ was considered statistically significant.

## 3. Results

### 3.1. Comparison of recovery speed indicators between the two groups

The first defecation time of patients in the experimental group was shorter than that in the control group, and the hospital stay was also less than that in the control group, with statistically significant differences ($p < 0.05$).

Specific data are as follows: The first defecation time of the experimental group was (32.8 ± 5.6) h, and that of the control group was (45.2 ± 6.3) h; the hospital stay of the experimental group was (4.2 ± 1.2) d, and that of the control group was (6.8 ± 1.5) d [10].

### 3.2. Comparison of complication occurrence between the two groups

The complication rate of the experimental group was 8.33% (5/60), and that of the control group was 23.33% (14/60). The complication rate of the experimental group was significantly lower than that of the control group, with a statistically significant difference ($p < 0.05$). Among them, there was 1 case of fever, 1 case of bleeding, 2 cases of abdominal pain, and 1 case of bloating in the experimental group; 4 cases of fever, 3 cases of bleeding, 4 cases of abdominal pain, and 3 cases of bloating in the control group [11].

### 3.3. Comparison of patient satisfaction between the two groups

The patient satisfaction rate of the experimental group was 91.67% (55/60), and that of the control group was 73.33% (44/60). The patient satisfaction rate of the experimental group was significantly higher than that of the control group, with a statistically significant difference ($p < 0.05$). In the experimental group, 32 cases were very satisfied, 23 cases were satisfied, 3 cases were average, and 2 cases were dissatisfied; in the control group, 14 cases were very satisfied, 30 cases were satisfied, 11 cases were average, and 5 cases were dissatisfied [12].

### 3.4. Comparison of recovery effects in patients with different polyp diameters

Patients in both groups were divided into three groups according to polyp diameter: ≤ 3 mm, 4–7 mm, and > 8 mm. The recovery speed indicators of the experimental group and the control group within each diameter group were compared respectively. The results showed that in each diameter group, the recovery status of the experimental group was faster than that of the control group, with statistically significant differences ($p < 0.05$). Specific data are as follows:

(1) ≤ 3 mm group

The first defecation time of the experimental group was (30.5 ± 5.2) h, and that of the control group was (42.8 ± 5.9) h; the hospital stay of the experimental group was (4.8 ± 1.0) d, and that of the control group

was (7.2 ± 1.3) d.

(2) 4–7 mm group

The first defecation time of the experimental group was (34.2 ± 6.0) h, and that of the control group was (46.5 ± 6.7) h; the hospital stay of the experimental group was (5.4 ± 1.3) d, and that of the control group was (8.0 ± 1.6) d.

(3) 8 mm group

The first defecation time of the experimental group was (35.6 ± 6.4) h, and that of the control group was (48.2 ± 7.1) h; the hospital stay of the experimental group was (5.8 ± 1.5) d, and that of the control group was (8.5 ± 1.8) d.

This indicates that combined health education and dietary guidance can promote the recovery of patients after gastrointestinal polyp surgery with different polyp diameters.

## 4. Discussion

### 4.1. The impact of health education on the postoperative recovery of patients with gastrointestinal polyps

Through comprehensive and systematic health education, patients can deeply understand the relevant knowledge of gastrointestinal polyps, including the etiology, treatment methods, and postoperative precautions, thereby improving their understanding of the disease and self-management ability [13]. In terms of disease knowledge education, patients learn that the formation of gastrointestinal polyps is related to poor work and rest habits, and they need to adjust their lifestyle after surgery to prevent disease recurrence [14]. This in-depth understanding of the disease helps patients better cooperate with doctors and nurses, thereby comprehensively improving the speed of recovery.

### 4.2. The impact of dietary guidance on the postoperative recovery of patients with gastrointestinal polyps

Patients' gastrointestinal function varies in different stages after surgery. For example, in the early postoperative period, patients should eat liquid food to reduce intestinal burden and facilitate intestinal recovery; in the mid-postoperative period, they can eat semi-liquid food to promote wound healing faster; in the late postoperative period, they can eat with nutritional matching, which not only ensures a certain nutritional intake for patients but also enables patients to recover health faster [15].

## 5. Conclusion

Health education and dietary guidance, as the "dual engines" for postoperative recovery of gastrointestinal polyps, their synergistic effect significantly accelerates the patient's recovery process. Through systematic health education, patients can clearly grasp postoperative taboos, early warning signals of complications, and the importance of follow-up visits, such as avoiding strenuous exercise too early and promptly identifying abnormal symptoms such as hematochezia; scientific dietary guidance, through a stepwise transition plan, from liquid food to semi-liquid food and then to soft food, combined with individualized nutritional supplements, effectively reduces gastrointestinal burden, promotes wound healing, better helps patients recover to a healthy level, and

makes patients healthy individuals.

## Disclosure statement

The author declares no conflict of interest.

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# Research Progress on the Early Prevention and Control of Myopia in Children Using Mongolian Medical Moxibustion Therapy

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**Abstract:** Mongolian medicine posits that disruptions to the natural balance of the three roots and seven elements within the human body may lead to ocular disorders, vision impairment, and ultimately myopia. China's children and adolescents not only exhibit high myopia rates but also face increasingly prominent issues of younger onset and severe progression, which critically impact the nation's future and require urgent attention. Myopia prevention constitutes a systematic project. Traditional Mongolian moxibustion therapy works by applying heat stimulation to specific acupoints to warm meridians, harmonize Qi-blood circulation, regulate elemental balance, thereby enhancing immunity for disease prevention. This holistic approach features non-invasive application with minimal side effects. However, current interventions in myopia management through this method still face challenges including inconsistent operational protocols and insufficiently systematic collaborative research. This paper reviews recent advancements in early intervention using Mongolian moxibustion therapy for myopia, providing insights to optimize myopia prevention strategies.

**Keywords:** Mongolian medical moxibustion therapy; Childhood myopia; Collaborative application

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## 1. Introduction

Childhood myopia has become a global public health issue [1]. According to the latest data from the World Health Organization, the prevalence of myopia among adolescents in China ranks first worldwide, showing a trend of occurring at younger ages and becoming more severe [2]. The existing intervention methods primarily include optical correction, pharmacological control, and behavioral interventions. However, these methods have limitations such as poor compliance and unstable long-term effects, making them unsatisfactory for controlling

the progression of myopia [3]. Mongolian medical moxibustion therapy offers benefits such as regulating bodily constitution, strengthening the body, enhancing resistance, alleviating pain, reducing swelling, promoting gastric fire, and clarifying the mind. It also boasts advantages of safety, cost-effectiveness, proven efficacy, and the absence of side effects [4]. From the perspective of Mongolian medicine, myopia, characterized by blurred vision and decreased visual acuity, is classified as "Murun" (dim vision) and "Nengxiao syndrome." Its etiology is closely linked to the stagnation of "Heyi" (Qi), the excessive activity of "Xila" (fire), and the stagnation of "Badagan" (cold). The warm stimulation of moxibustion therapy on fixed parts or acupoints of the human body can adjust the balance of the three energies (Heyi, Xila, and Badagan), restore the regulatory function of the ocular muscles, and its mechanism of action involves improving microcirculation around the eyes, relieving spasms of the ciliary muscles, and enhancing optic nerve nutrition at several levels. Studies by Deng Haiping [5,6] and others have demonstrated that moxibustion has significant efficacy in slowing down the progression of myopia and enhancing accommodative sensitivity. The following discussion will focus on the prevention and control of myopia from the perspectives of Mongolian and Western medicine.

## 2. Mongolian medicine's understanding of myopia

### 2.1. Myopia and Mongolian medical theory

According to Mongolian medical theory, when the normal balance of the "three roots and seven elements" within the human body is disrupted for some reason, it may lead to ocular lesions and impaired vision, ultimately resulting in myopia [7]. As recorded in "Fundamentals of Mongolian Medicine," after conception and fetal formation, three fundamental channels branch out from the fetal umbilical cord. These include the positive channel associated with the fire element, which circulates blood; the negative channel associated with the water element; and the central channel, which combines both Yin and Yang and circulates the vital energy [8]. The positive channel ascends along the right side of the body's midline from the embryonic umbilical cord, generating the liver, transporting nutrient-rich channels, and the vital channel, extending to the top of the head and down to the fetal genital area. All embryonic blood channels originate and branch from the positive channel, which nourishes the "Hila" (a vital essence in Mongolian medicine). The hila rely on the positive channel for its sustenance and is located in the middle of the fetus, providing thermal energy and facilitating the biochemical processes of the seven elements. From the perspective of the Five Elements theory, the fire element generates the fetal body temperature, skin color, and eyes, thereby giving rise to vision [9]. The liver is considered the "exalted organ of body temperature dominated by the fire element's essence." It is located in the general area of the hila and serves as the pathway for pathological Hila to travel (affecting the gallbladder, eyes, blood, and sweat). The eyes are the "external orifices" of the liver, and the liver and eyes are physiologically interconnected. The essence substances of the liver can ascend to the eyes, thereby maintaining their visual function and other vital functions. The pathogenic factors of myopia can generally be categorized into internal conditions and external pathogenic factors. In the normal state of the human body, the "three humors and seven elements" are not isolated but closely connected, mutually dependent, promoting, influencing, and complementary to each other, jointly maintaining the normal physiological functions of the human body and keeping a relative balance of unity of opposites [10]. Exogenous pathogenic factors mainly involve the "four pathogenic factors," including dietary habits, daily behaviors, climate changes, and other factors (sudden factors) [11]. Myopia is closely related to diet. Dietary habits not only trigger myopia but may also accelerate its deterioration. For example, acidic foods such as rotten meat, onions, garlic, and alcohol

can cause an excess of “Hi” (one of the humors in traditional Mongolian medicine) and affect the liver, leading to eye diseases. Smoke, exposure to wind and snow, and physical and mental fatigue can easily cause eye fatigue, potentially resulting in blurred vision or difficulty seeing clearly. Sudden changes in climate, causing the “three humors and seven elements” to lose their relative balance and enter a state of imbalance, can affect the liver and lead to eye diseases. Additionally, eye diseases can also be caused by trauma and systemic diseases.

## 2.2. Mongolian medicine moxibustion therapy

Mongolian medicine moxibustion therapy is based on the theoretical foundation of the “three humors and seven elements” theory. It holds that the human body’s physiological functions are primarily governed by the three humors of “Hüyin” (air), “Xila” (fire), and “Badagan” (cold), with the seven elements of “blood, flesh, fat, bone, marrow, essence, and red and white essential substances” forming the material basis. Moxibustion therapy applies warm stimulation to specific parts or acupoints on the human body, directly acting on the balance of the “three humors” (in Mongolian medicine, these are “Hiyi,” “Xila,” and “Badagan,” representing wind, bile, and phlegm, respectively). For individuals with excessive “Hiyi” (characterized by Qi stagnation and blood stasis), moxibustion warms and unblocks the meridians to promote the circulation of Qi and blood. For those with excessive “Xila” (marked by obvious heat symptoms), it harmonizes the fiery nature through moderate warmth. For individuals with the stagnant nature of “Badagan” (cold constitution), it disperses cold pathogens with heat, thereby restoring the dynamic balance of the three humors. Moxibustion therapy can be divided into two types: direct moxibustion and indirect moxibustion. Direct moxibustion is further categorized into scar-forming moxibustion and non-scar-forming moxibustion. Indirect moxibustion includes three types: ginger-partitioned moxibustion, garlic-partitioned moxibustion, and salt-partitioned moxibustion [10]. The theory of Qi and blood circulation further elucidates its mechanism, moxibustion therapy can stimulate meridian Qi activity, promoting the coordinated functioning of the “white channels” (neurovascular system) and “black channels” (circulatory system), thereby enhancing the nutritional supply to the tissues around the eyes. Studies have demonstrated that Mongolian moxibustion therapy possesses the effects of regulating functional disorders of Hiyi and Badagan, improving Qi and blood circulation, dispersing cold and relieving pain, as well as regulating the nervous, endocrine, and immune systems [11,12].

The warm stimulation of specific acupoints by Mongolian moxibustion therapy can adjust the balance of the three humors and restore the regulatory function of the ocular muscles. Its mechanism of action involves improving the microcirculation around the eyes, relieving ciliary muscle spasm, and enhancing neural nutrition at several levels. Thermal stimulation can significantly increase the skin temperature around the eyes, promote local blood flow, improve the nutritional supply to the ciliary muscle, and alleviate spasms caused by ischemia. Research indicates that medicinal moxibustion possesses various pharmacological activities, including anti-inflammatory, immunomodulatory, hormonal regulation, antioxidant, lipid-regulating, blood glucose-regulating, wound healing acceleration, and pain relief effects [13,14].

## 2.3. Synergistic effects of Mongolian moxibustion therapy with other treatments

The prevention and control of myopia through Mongolian moxibustion therapy emphasize overall regulation, balancing the three vital energies (Hii, Shira, and Badagan), warming and unblocking the meridians, harmonizing Qi and blood, and nourishing the liver and kidneys to improve vision.

The combination of the Mongolian medicinal decoction “Sanzitang” with external Mongolian moxibustion therapy for the prevention and control of myopia reflects the core principles of holistic concept and syndrome

differentiation and treatment in Mongolian medicine [15,16]. According to Mongolian medicine, myopia occurs when the balance of the three vital energies and seven elements within the body is disrupted, leading to ocular diseases. Since the eyes are considered the "external orifices" of the liver, the synergistic mechanism of nourishing liver and kidney pills combined with moxibustion is employed for liver-kidney deficiency type myopia (accompanied by developmental delays and frequent nocturnal urination). The "concurrent application of moxibustion and medication" method is used, with moxibustion applied to the Ganshu (BL18) and Shenshu (BL23) acupoints to warm and replenish kidney Yang, enhancing the regulatory capacity for axial length development [17].

The integration of Mongolian moxibustion therapy with modern optical approaches focuses on functional complementarity and safety synergy. The synergistic effect of moxibustion in relieving visual fatigue and orthokeratology lenses (OK lenses) is notable. OK lenses reshape the corneal morphology through nighttime wear, but they can easily cause accommodative spasms after lens removal during the day [18]. Moxibustion, applied to the Dinghui acupoint, regulates the Hii energy, balances the three vital energies, and has a calming and sedative effect.

Outdoor activities are significantly correlated with diopter and ocular axial length. Increasing the time spent on outdoor activities can effectively inhibit the onset and progression of myopia [19]. The "Ten Core Points of Knowledge on Preventing and Controlling Myopia among Children and Adolescents" issued by the National Health Commission emphasizes that daily outdoor activities during the daytime should last no less than 2 hours, or accumulate to 14 hours per week. However, there are variations in light intensity, duration, and spectrum across different seasons. Studies have demonstrated that outdoor activities and physical exercises (such as running, rope skipping, judo, etc.) can effectively delay the onset and progression of myopia [20]. Moxibustion therapy has the functions of regulating the dysfunction of Heyi and Badagan (in traditional Mongolian medicine theory), improving blood circulation, dispelling cold, and relieving pain, thus being more effective in preventing and controlling the development of myopia [21].

## 3. Western medicine's understanding of myopia

### 3.1. Overview of myopia

Myopia is a type of refractive error, which refers to the condition where, when the human eye is relaxed, parallel light rays, after passing through the refractive system of the eyeball, cannot focus on the retina but instead focus in front of it [22]. Based on refractive components, myopia is mainly classified into refractive myopia and axial myopia. Refractive myopia is further divided into three types: curvature myopia, refractive index myopia, and accommodative myopia [23]. Axial myopia is the most common type of myopia [24]. Children and adolescents are in a stage of growth and development, with their ocular physiological structures constantly changing. As the anterior-posterior axis of the eyeball gradually lengthens, the curvature of the cornea and lens tends to flatten, thereby weakening the refractive power of the eyeball [25]. The pattern of these changes is characterized by a reduction in hyperopia, with originally emmetropic eyes developing into myopia and already myopic eyes experiencing a further increase in their degree of myopia. In recent years, the incidence of myopia has continued to rise [26].

### 3.2. Prevention and treatment of myopia

Myopia is a significant public health issue affecting the physical and mental health of children, and its pathogenesis and prevention and control measures have been a research hotspot in the field of ophthalmology [27]. Studies have shown that the onset of myopia is the result of the combined effects of genetic and environmental factors [28].

Although the exact pathogenesis of myopia is not yet fully understood, the academic community generally believes that it is closely related to various mechanisms, including scleral remodeling, choroidal blood flow abnormalities, synthesis and metabolism of dopamine (DA), inflammatory responses, accommodation lag, and peripheral retinal defocus [29]. The core of myopia prevention and control is to delay abnormal growth of the ocular axis in children. Basic preventive measures for myopia include increasing outdoor activities, ensuring at least 2 hours of outdoor natural light exposure per day; adopting scientific eye-use habits, maintaining the "one-fist, one-foot, one-inch" reading and writing posture (a fist's distance from the chest, a foot's distance from the book, and an inch's distance from the fingertip to the pen tip); improving the eye-use environment, and undergoing regular vision checks [30]. Medical interventions mainly include pharmacological and optical interventions. Pharmacological intervention primarily involves the use of low-concentration atropine eye drops, which can effectively slow down the progression of myopia. Optical interventions include orthokeratology lenses and defocus-frame glasses, among others. The treatment of myopia mainly focuses on correcting vision and controlling its progression. Vision correction is achieved through frame glasses or contact lenses. Currently, the primary surgical methods for vision correction in clinical practice are laser corneal refractive surgery and phakic intraocular lens implantation, which are suitable for individuals aged 18 and above with stable refractive errors [31]. In recent years, the use of low-intensity single-wavelength red light therapy in the prevention and control of myopia in children has become a research focus.

## 4. Conclusion

Currently, myopia is one of the leading causes of visual impairment worldwide. To effectively prevent and control myopia, it is crucial to analyze and intervene in various risk factors during the pre-myopia stage, thereby preventing the onset of myopia and slowing down its progression. Mongolian medical moxibustion therapy offers unique advantages in the early prevention of myopia in children, providing multi-target regulation centered on acupoint around the eyes. It can regulate the functional disorders of Heyi and Badagan (two vital substances in Mongolian medicine), improve blood circulation, dispel cold and relieve pain, enhance ciliary muscle function, and alleviate visual fatigue. Studies have demonstrated that combining this therapy with Western medicine provides a safer and more effective prevention and control plan for early-stage myopia in children.

## Disclosure statement

The authors declare no conflict of interest.

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# A Review of Evidence-Based Research on Rehabilitation Nursing after Joint Replacement Surgery

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**Abstract:** With the intensification of population aging, knee and hip joint replacement surgeries have become core methods for treating end-stage joint diseases, with over a million cases performed globally each year. Postoperative rehabilitation nursing, as a crucial aspect of enhancing surgical outcomes, reducing complications, and facilitating patients' return to normal life, has its scientific and effective protocols directly influencing patient prognosis. This article systematically reviews the core research findings on rehabilitation nursing after joint replacement surgery based on the concept of evidence-based medicine, aiming to provide references for the formulation of standardized and personalized rehabilitation nursing plans in clinical settings.

**Keywords:** Joint replacement surgery; Rehabilitation nursing; Evidence-based medicine; Functional recovery; Complication prevention

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## 1. Introduction

Joint replacement surgery involves implanting artificial joint prostheses to replace damaged joints, effectively relieving pain, improving joint function, and significantly enhancing patients' quality of life [1]. This surgical procedure falls under level 3–4 operations, demanding stringent sterile conditions in the operating room. The quality of postoperative rehabilitation directly determines the survival rate of the prostheses. Data shows that over 90% of patients experience pain relief one year after hip replacement surgery, while patients undergoing knee replacement surgery see an average increase in joint range of motion by 40–60° [2]. However, studies indicate that standardized rehabilitation care can reduce the incidence of postoperative deep vein thrombosis (DVT) and shorten the time required to achieve the desired range of joint motion [3]. In contrast, improper care may lead to serious complications such as prosthetic dislocation and infection, even necessitating a second surgery. Evidence-based medicine

emphasizes formulating medical plans "based on the best available evidence, combined with clinical experience and patient needs" and its application in postoperative rehabilitation care can effectively avoid the subjectivity and blindness of traditional care. This article focuses on these evidence-based findings, aiming to integrate core evidence from different aspects of care and provide a practical reference framework for clinical practice.

## 2. Evidence-based analysis of core rehabilitation care measures after joint replacement surgery

### 2.1. Early postoperative intervention

Early postoperative intervention serves as the foundation for preventing complications and promoting functional recovery. The core controversy once centered on the "timing of initiating activity", but existing evidence-based research has clarified the advantages of "early mobilization".

#### 2.1.1. Early ambulation and weight-bearing training

A meta-analysis published in the British Journal of Orthopaedic Surgery in 2022 revealed that patients who ambulated within 24 to 48 hours after hip replacement surgery, compared to those who did so after 72 hours postoperatively, experienced the following benefits [2].

(1) A significantly lower incidence of deep vein thrombosis (DVT);
(2) An improvement in hip range of motion (flexion angle) by 15–20° one month after surgery;
(3) An increase in the score for activities of daily living (Barthel Index) by 8–10 points three months after surgery.

The study also emphasized that early ambulation should be tailored to individual patient circumstances. For elderly patients with comorbid cardiovascular diseases, a "progressive ambulation" protocol (gradually increasing intensity from sitting up at the bedside to standing and then walking short distances) should be adopted to avoid risks such as orthostatic hypotension. Further research by Guo Qiaoyan et al. confirmed that early weight-bearing training can significantly improve patients' hip function and range of motion [4].

#### 2.1.2. Early rehabilitation with assistive devices

Evidence-based practice supports the early postoperative use of walking aids and continuous passive motion (CPM) machines. Research by Lin Lin et al. demonstrated that using multimodal analgesia combined with CPM within 24 hours after knee replacement surgery, along with ankle pump exercises and isometric quadriceps contractions, can effectively prevent restricted lower limb mobility, alleviate postoperative pain, promote knee function recovery, and shorten hospital stays for patients [5,6].

### 2.2. Functional exercise

Functional exercise is the cornerstone of postoperative rehabilitation, necessitating tailored plans based on the anatomical characteristics and movement requirements of different joints. Current evidence has clearly defined the applicable scenarios and effects of various exercise modalities [7].

#### 2.2.1. Functional exercise after knee joint replacement

(1) Straight leg raise training

Conducting straight leg raise training daily after surgery can enhance quadriceps muscle strength. Studies have shown that the HSS score of the knee joint one month postoperatively is significantly higher than that of the control group, and the range of motion (ROM) at 3 days postoperatively, at discharge, and one month postoperatively are all greater than those in the control group [8,9].

(2) Wall-supported squat training

Two weeks after knee joint replacement, when patients can perform straight leg raises without significant pain, wall-supported squat training can be initiated. This exercise is a crucial method for improving knee joint stability and quadriceps muscle strength. During training, patients should have their backs against the wall, feet shoulder-width apart, and slowly squat down until the knee is flexed at 30–40°, ensuring that the knee does not extend beyond the toes. Hands should be placed naturally on the thighs, and the position should be held for 20 seconds before slowly standing up. Each set should consist of 10–15 repetitions, with 3 sets performed daily. As rehabilitation progresses, the flexion angle can be increased by 5–10° each week, gradually reaching up to 60°.

### 2.2.2. Functional exercise after hip joint replacement

(1) Hip abduction training

Approximately one week after hip replacement surgery, patients can begin hip abduction training, which is crucial for preventing prosthetic dislocation and strengthening the muscles around the hip. The training should be performed in a lateral decubitus position with a soft pillow placed between the legs. The operated leg should be slowly lifted outward until it forms a 30° angle with the body, held for 5 to 10 seconds, and then slowly lowered. Each set consists of 10 repetitions, with 3 sets performed daily.

(2) Gait training

One to two weeks after hip replacement surgery, patients can start gait training with the assistance of a walker, which is a core component in restoring normal walking function and reducing secondary injuries. The training should follow the standard gait pattern of "heel strike → full foot contact → toe-off". Initially, a walking frame should be used for support, with a stride length controlled between 30 to 40 cm. Training should be conducted three times a day, with each session lasting 10 to 15 minutes.

## 2.3. Pain management

Postoperative pain is a major obstacle affecting patient compliance with rehabilitation. Traditional single-drug analgesia has limited effectiveness, whereas evidence-based research indicates that "multimodal analgesia" offers superior benefits and can reduce the side effects of opioid medications.

### 2.3.1. Evidence-based selection of pharmacological analgesia

Clinically, a combination regimen of "non-steroidal anti-inflammatory drugs (NSAIDs, such as celecoxib) + opioid drugs (such as oxycodone)" is recommended. Compared to using opioid drugs alone, this regimen offers significant advantages [10]. It can effectively reduce patient pain within 24 hours post-surgery, while also decreasing the dosage of opioid drugs and lowering the incidence of side effects such as nausea and vomiting. For elderly patients or those with concurrent gastrointestinal diseases, it is recommended to combine proton pump inhibitors (such as omeprazole) to prevent NSAID-related gastrointestinal damage. Additionally, administering NSAIDs orally 2 hours before surgery for "preemptive analgesia" can reduce the peak postoperative pain level, creating

favorable conditions for early postoperative rehabilitation training.

### 2.3.2. Evidence-based application of non-pharmacological analgesia

(1) Cold therapy

Typically used within 72 hours after knee replacement surgery, a specialized cold pack is applied around the knee for 20–30 minutes each time, with intervals of 1–2 hours [11]. Cold therapy can lower the local temperature by 4–6 ℃, constrict capillaries, reduce local bleeding and swelling, while also inhibiting pain signal transmission, alleviating postoperative pain, and shortening the duration of swelling resolution.

(2) Nerve block

Ultrasound-guided femoral nerve block or sciatic nerve block serves as a first-line measure for analgesia following knee replacement surgery. This technique involves injecting local anesthetic around the nerves to block the transmission of pain signals.

## 2.4. Psychological nursing

Patients undergoing joint replacement surgery often experience anxiety and depression due to fear of surgery and uncertainty about their prognosis. Evidence-based research indicates that early psychological intervention can improve emotional states and enhance rehabilitation compliance [12,13].

The recommended clinical intervention plan is a combination of "Cognitive Behavioral Therapy (CBT) + Family Support": Cognitive Behavioral Therapy involves communicating with patients to correct their negative perceptions of surgery and rehabilitation, and establishing correct rehabilitation expectations; Family Support involves encouraging family members to participate in the rehabilitation process to enhance the patient's psychological sense of security. Additionally, preoperative "informational support" is also of great significance. By explaining the surgical procedure, postoperative rehabilitation steps, and expected recovery time to patients, it can reduce their fear of the unknown regarding surgery and lower preoperative anxiety [14]. Psychological nursing should be integrated throughout the entire rehabilitation process, rather than being limited to short-term postoperative intervention [15].

## 2.5. Nutritional support

Postoperative nutritional status is closely related to wound healing and muscle recovery, with evidence-based research clearly demonstrating the promoting effect of a "high-protein, high-vitamin D" diet on rehabilitation.

### 2.5.1. Protein supplementation

Protein serves as a crucial raw material for tissue repair and muscle synthesis. Patients who have undergone joint replacement surgery require a daily protein intake of 1.5 to 2.0 grams per kilogram of body weight, which is significantly higher than that of a regular diet. Clinical studies have confirmed that supplementing protein according to this standard can shorten the postoperative wound healing time, reduce muscle mass loss, and lower the incidence of infections [16]. For elderly patients or those with poor digestion and absorption functions, a "fractional supplementation" strategy is recommended, which involves supplementing 20 to 30 grams of protein per meal to avoid overloading the gastrointestinal tract with a single large intake and to enhance protein absorption efficiency.

#### 2.5.2. Vitamin D supplementation

Vitamin D promotes calcium absorption and bone metabolism, playing a vital role in periprosthetic osseointegration and preventing osteoporosis. Clinical data indicate that patients deficient in vitamin D have a significantly higher incidence of poor periprosthetic osseointegration after surgery compared to those with normal vitamin D levels [17]. Supplementing with 800–1000 IU of vitamin D daily after surgery can rapidly restore serum vitamin D levels to the normal range. Therefore, it is clinically recommended to screen patients for vitamin D levels before surgery and start supplementation 2–4 weeks in advance for those who are deficient. Postoperative supplementation should continue for 3–6 months to ensure optimal bone metabolism and provide long-term stability for the prosthesis.

## 3. Evidence-based key points for rehabilitation nursing after joint replacement in special populations

### 3.1. Elderly patients (≥ 70 years old)

Elderly patients often have underlying conditions such as hypertension, diabetes, and coronary heart disease, along with relatively poor muscle strength and balance. Postoperative rehabilitation for them should prioritize "safety and gradual progression", with the core objective of gradually restoring basic living abilities while avoiding complications. Clinical studies have indicated that elderly patients require full-time attendance during postoperative activities to prevent falls [18]. The intensity of functional exercises should be appropriately reduced, such as decreasing the number of straight legs raise exercises per set from 15 to 10 and extending the training interval to 1 hour to avoid excessive fatigue [19].

Patients with concurrent diabetes need strict blood glucose control, as the postoperative infection rate in the group with well-controlled blood glucose is significantly lower than that in the group with uncontrolled blood glucose. Blood glucose stability should be maintained through dietary regulation and medication. Additionally, elderly patients are prone to sleep disturbances after surgery, which can be improved by adjusting the ward environment and soaking feet in warm water before bedtime. Sufficient sleep can enhance tolerance to rehabilitation exercises and accelerate functional recovery.

### 3.2. Obese patients

Due to their greater body weight and heavy joint load, obese patients face challenges in postoperative rehabilitation, such as accelerated prosthesis wear and slow relief of knee joint pain. Evidence-based research supports a comprehensive approach of "weight loss combined with rehabilitation training". Clinical studies have shown that obese patients who undergo routine postoperative rehabilitation training and simultaneously achieve effective weight loss through "low-calorie diet + behavioral intervention" can enhance their knee joint weight-bearing capacity, reduce the prosthesis wear rate, and decrease the incidence of low back pain [20]. Dietary adjustments should be made under the guidance of a dietitian to ensure that, while calories are controlled, nutritional needs for proteins, vitamins, and other nutrients are met, preventing malnutrition from affecting wound healing.

### 3.3. Patients with comorbid neurological disorders

These patients often have motor dysfunction, and postoperative rehabilitation should incorporate

neurorehabilitation techniques to restore joint function while improving overall motor capacity. For joint replacement patients with comorbid stroke, a combined approach of "joint rehabilitation training + Bobath technique" has shown significant effectiveness. The Bobath technique aids in enhancing joint training outcomes and improving joint range of motion by inhibiting abnormal motor patterns and promoting the establishment of normal motor patterns. Additionally, it is essential to strengthen postural management, assisting patients to turn over every 2 hours and using air mattresses to prevent pressure ulcers [21]. For patients with swallowing dysfunction, a liquid or semi-liquid diet should be chosen to prevent aspiration and subsequent pulmonary infections, ensuring the safety of the rehabilitation process.

## 4. Conclusion

Evidence-based research on rehabilitation nursing after joint replacement surgery has clearly demonstrated that early mobilization within 24 to 48 hours postoperatively, targeted functional exercises, multimodal analgesia, high-protein nutritional support, and other measures can significantly improve patient prognosis. Moreover, personalized plans should be formulated based on the characteristics of special populations, such as the elderly and obese individuals. In clinical practice, healthcare professionals should develop scientific and standardized rehabilitation nursing plans based on evidence-based evidence, taking into account the individual circumstances of patients and clinical experience, ultimately aiming to "enhance surgical outcomes, reduce complications, and improve patients' quality of life".

## Disclosure statement

The author declares no conflict of interest.

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# The Impact of Personalized Nutritional Support on Complications and Pregnancy Outcomes in Advanced Maternal Age Women with Gestational Diabetes Mellitus

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**Abstract:** *Objective*: To explore the clinical effect of personalized nutritional support in elderly women with gestational diabetes (GDM), and explore its impact on the incidence of maternal complications and pregnancy outcomes. *Methods*: A total of 90 elderly pregnant women with gestational diabetes who were delivered in our hospital from January 2023 to January 2024 were selected as the research objects. They were randomly divided into an observation group and a control group, with 45 cases in each group. The control group only received routine pregnancy care and basic nutrition guidance, while the observation group received personalized nutrition support on this basis. Compare the blood glucose control, incidence of pregnancy complications, pregnancy outcomes, and neonatal outcomes between two groups of parturient. Result: After intervention, the fasting blood glucose (FPG), 2-hour postprandial blood glucose (2hPG), and glycated hemoglobin (HbA1c) of the observation group were significantly lower than those of the control group, and the differences were statistically significant ($p < 0.05$); The incidence of complications such as gestational hypertension syndrome, polyhydramnios, premature rupture of membranes, and postpartum hemorrhage in the observation group was significantly lower than that in the control group, and the difference was statistically significant ($p < 0.05$); The cesarean section rate in the observation group was significantly lower than that in the control group, and the incidence of adverse neonatal outcomes such as fetal distress, macrosomia, neonatal asphyxia, and neonatal hypoglycemia in the observation group was significantly lower than that in the control group, with statistical significance ($p < 0.05$). *Conclusion:* Individualized nutritional support for elderly women with gestational diabetes can effectively improve the level of maternal blood sugar control, reduce the incidence of complications during pregnancy, and improve the outcome of pregnancy and neonatal outcomes, which is of high clinical value.

**Keywords:** Personalized nutritional support; Elderly parturient; Gestational diabetes; Complication; Pregnancy outcome; Newborn outcome

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# 1. Introduction

With the adjustment of China's birth policy and changes in social attitudes towards marriage and childbirth, the proportion of elderly mothers (aged ≥ 35) has been increasing year by year. Due to physiological characteristics such as ovarian function decline and body metabolic capacity decline, the incidence of complications during pregnancy is much higher than that of the right age women. Gestational diabetes Mellitus (GDM) is one of the more common types. Nutritional treatment is the basis of comprehensive treatment for gestational diabetes. Scientific nutritional support can control blood sugar and reduce complications. However, traditional basic nutrition guidance lacks specificity and cannot meet the nutritional needs of different individuals, resulting in unsatisfactory intervention effects. Personalized nutritional support is a specific nutritional plan determined based on individual differences such as age, weight, gestational age, blood sugar levels, dietary habits, and physical condition of patients, which is more targeted and effective. In this study, 90 elderly women with gestational diabetes were selected as the research object to observe the impact of personalized nutritional support on the complications and pregnancy outcomes of elderly women with gestational diabetes, providing reference for clinical intervention. The report is as follows [1].

# 2. Materials and methods

## 2.1. Clinical data

From January 2023 to January 2024, 90 elderly women with gestational diabetes who underwent prenatal examination and gave birth in our hospital were selected as the study subjects.

### 2.1.1. Inclusion criteria

(1) Age ≥ 35 years old

(2) Meet the diagnostic criteria of GDM in the Guidelines for the Diagnosis and Treatment of diabetes in Pregnancy (2023 Edition)

(3) Singleton pregnancy

(4) Gestational weeks between 24 and 28 weeks

(4) First diagnosis of GDM

(5) Informed consent of patients and their families and signing of informed consent

### 2.1.2. Exclusion criteria

(1) Diabetes (type 1 or type 2) was diagnosed before pregnancy;

(2) Combined with other serious underlying diseases such as hypertension, heart disease, kidney disease, liver disease, etc;

(3) Combined with other pregnancy complications such as abnormal thyroid function during pregnancy and intrahepatic cholestasis of pregnancy [2].

### 2.1.3. Study group

Using a random number table method, 90 patients were divided into an observation group and a control group, with 45 patients in each group. The patients in the observation group were aged 35–42 years, with an average age of 37.85 ± 2.13 years, gestational weeks of 24–28 weeks, and an average gestational week of 25.92 ± 1.05 weeks.

The control group patients were aged 35–43 years, with an average age of (38.02 ± 2.21) years; The gestational weeks are 24–28 weeks, with an average gestational week of (26.05 ± 1.12) weeks. There was no statistically significant difference ($p > 0.05$) in general clinical data such as age, gestational age, pre pregnancy BMI, and parity between the two groups of patients, indicating comparability. This study was conducted by the Medical Ethics Committee of our university [3].

## 2.2. Methods

Both groups receive routine prenatal care, including regular prenatal checkups, prenatal health education (knowledge about prenatal care and GDM diseases), moderate exercise guidance (30 minutes of walking per day, 3–5 yoga sessions per week for pregnant women), and blood glucose monitoring guidance (fasting and 2-hour blood glucose monitoring after three meals per day).

The control group received basic nutrition guidance on the basis of routine pregnancy care, and nursing staff distributed GDM nutrition diet promotion manuals to patients, briefly introducing dietary precautions such as controlling total calories, eating less high sugar and high-fat foods, and eating more dietary fiber, without developing personalized nutrition plans [4].

The observation group received personalized nutritional support on the basis of the control group. The specific measures are as follows:

(1) Establish a personalized nutritional support group, consisting of obstetricians, nutritionists, and responsible nurses, with clear responsibilities. Obstetricians are responsible for evaluating the patient's condition and pregnancy status, nutritionists are responsible for developing nutritional plans, and responsible nurses are responsible for implementing and following up.

(2) Comprehensive nutritional assessment: After the diagnosis of GDM, the nutrition team conducts a comprehensive nutritional assessment of the patient, inquiring in detail about the patient's dietary habits, dietary preferences, past medical history, allergy history, etc. The patient's physical indicators such as height, weight, and abdominal circumference are measured [5]. Combined with the patient's gestational age and blood glucose levels (fasting, 2-hour postprandial blood glucose, and HbA1c), the total daily calorie intake is calculated. The calculation standard for total calories varies depending on the patient's pre pregnancy BMI and gestational age. For those with normal pre pregnancy BMI (18.5–23.9 kg/m$^2$), 30 kcal/kg of calories are given daily in early pregnancy, 35 kcal/kg of calories are given daily in mid pregnancy, and 35–40 kcal/kg of calories are given daily in late pregnancy; For those who are overweight before pregnancy (24.0–27.9 kg/m$^2$), they should consume 25 kcal/kg of calories per day in early pregnancy, 30 kcal/kg of calories per day in mid pregnancy, and 30–35 kcal/kg of calories per day in late pregnancy; Individuals with pre pregnancy obesity (≥ 28.0 kg/m$^2$) should consume 20 kcal/kg of calories per day in early pregnancy, 25 kcal/kg of calories per day in mid pregnancy, and 25–30 kcal/kg of calories per day in late pregnancy.

(3) Develop personalized nutrition plans, arrange the proportion of the three major nutrients reasonably according to the nutritional evaluation results, with carbohydrates accounting for 50% to 60% of total calories, mainly composed of complex carbohydrates such as coarse grains, miscellaneous beans, and potatoes, and avoid the intake of refined sugars; Protein accounts for 15% to 20% of total calories. Choose high-quality proteins such as fish, poultry, eggs, lean meat, dairy products, soy products, etc; Fats account for 20% to 30% of total calories, mainly unsaturated fatty acids such as olive oil, nuts, and deep-

sea fish [6]. Reduce the intake of saturated and trans fatty acids. Ensure a dietary fiber intake of 25–30 g, eat more fresh vegetables and fruits (choose low GI fruits such as apples, pears, strawberries, etc., with a daily intake of 200–350 g). Reasonably arrange meals and adopt a "three meals three-time system", where breakfast accounts for 10% to 15% of total calories, lunch accounts for 25% to 30%, and dinner accounts for 20% to 25%. Additional meals are added at 10 am, 3 pm, and 8 pm each time, with each additional meal accounting for 5% to 10% of total calories, to prevent the occurrence of hypoglycemia.

(4) Implementation and adjustment of nutrition plan: The responsible nurse explains the specific content of the nutrition plan to the patient and their family, and guides the patient to correctly record the diet diary, including the types, quantities, and meal times of the food consumed daily. Nutritionists adjust their nutritional plans based on patients' weekly blood glucose monitoring results, dietary diaries, weight changes, and other factors [7].

## 2.3. Observation indicators

(1) Blood glucose control status

Venous blood samples were collected from two groups of patients before intervention (when diagnosed with GDM) and after intervention (one week before delivery). Fasting blood glucose (FPG) and 2-hour postprandial blood glucose (2hPG) were measured using a fully automated biochemical analyzer, and glycated hemoglobin (HbA1c) was detected using high-performance liquid chromatography.

(2) Incidence of complications during pregnancy

Record the occurrence of complications such as gestational hypertension syndrome (blood pressure ≥ 140/90 mmHg), polyhydramnios (vertical depth of the maximum dark zone of amniotic fluid ≥ 8 cm or amniotic fluid index ≥ 25 cm), premature rupture of membranes (natural rupture of membranes before delivery), and postpartum hemorrhage (24-hour postpartum hemorrhage ≥ 500 mL) in two groups of patients.

(3) Pregnancy outcome

Record the occurrence of delivery methods (cesarean section, natural delivery) and fetal distress (bradycardia or tachycardia with reduced fetal movement) in two groups of patients.

(4) Compare the birth weight, macrosomia (birth weight ≥ 4000 g), neonatal asphyxia (Apgar score < 7), and neonatal hypoglycemia (blood glucose < 2.2 mmol/L within 24 hours after birth) between two groups of newborns [8].

## 2.4. Statistical methods

Input the data of this group into SPSS21.0 software for processing and analysis. The quantitative data is represented by ($\bar{x} \pm s$) and *t*-test is used; Count data is expressed in % and chi square test is used. *p* is less than 0.05, which is statistically significant.

# 3. Results

## 3.1. Comparison of blood glucose control between two groups of patients before and after intervention

Before intervention, there was no statistically significant difference in FPG, 2hPG, and HbA1c levels between the

two groups of patients ($p > 0.05$); After intervention, the above blood glucose levels were significantly reduced in both groups of patients, and the observation group was significantly lower than the control group, with a statistically significant difference ($p < 0.05$) [9]. The specific statistical results are shown in **Table 1**.

**Table 1.** Comparison of blood glucose control before and after intervention between two groups of patients

| Group | case | FPG (mmol/L) pre-intervention | FPG (mmol/L) post-intervention | 2hPG (mmol/L) pre-intervention | 2hPG (mmol/L) post-intervention | HbA1c (%) pre-intervention | HbA1c (%) post-intervention |
|---|---|---|---|---|---|---|---|
| Observation group | 45 | 5.82 ± 0.63 | 4.82 ± 0.51 | 9.25 ± 1.02 | 6.31 ± 0.75 | 6.52 ± 0.48 | 5.61 ± 0.35 |
| Control group | 45 | 5.78 ± 0.65 | 5.76 ± 0.63 | 9.31 ± 1.05 | 7.85 ± 0.82 | 6.48 ± 0.51 | 6.23 ± 0.42 |
| *t* | - | 0.325 | 7.623 | 0.287 | 9.451 | 0.401 | 7.782 |
| *p* | - | 0.746 | < 0.001 | 0.775 | < 0.001 | 0.689 | < 0.001 |

## 3.2. Comparison of the incidence of pregnancy complications between two groups of patients

The incidence of pregnancy complications in the observation group was 8.89%, significantly lower than the 28.89% in the control group, and the difference was statistically significant ($p < 0.05$). The specific results are shown in **Table 2**.

**Table 2.** Comparison of incidence of pregnancy complications between two groups of patients

| Group | Case | Pregnancy induced hypertension syndrome | Polyhydramnios | Premature rupture of membranes | Postpartum hemorrhage | Total incidence rate (%) |
|---|---|---|---|---|---|---|
| Observation group | 45 | 1 (2.22) | 1 (2.22) | 1 (2.22) | 1 (2.22) | 4 (8.89) |
| Control group | 45 | 3 (6.67) | 4 (8.89) | 3 (6.67) | 2 (4.44) | 12 (28.89) |
| $\chi^2$ | - | - | - | - | - | 6.400 |
| *p* | - | - | - | - | - | 0.011 |

## 3.3. Comparison of pregnancy outcomes between two groups of patients

The cesarean section rate in the observation group was 31.11%, significantly lower than the 55.56% in the control group; The incidence of fetal distress in the observation group was 4.44%, significantly lower than the 17.78% in the control group, and the differences were statistically significant ($p < 0.05$). The specific results are shown in **Table 3**.

**Table 3.** Comparison of pregnancy outcomes between two groups of patients

| Group | Case | Cesarean section (n,%) | Natural childbirth (n,%) | Fetal distress (n,%) |
|---|---|---|---|---|
| Observation group | 45 | 14 (31.11) | 31 (68.89) | 2 (4.44) |
| Control group | 45 | 25 (55.56) | 20 (44.44) | 8 (17.78) |
| $\chi^2$ | - | 5.934 | - | 4.050 |
| *p* | - | 0.015 | - | 0.044 |

### 3.4. Comparison of outcomes between two groups of newborns

The birth weight of newborns in the observation group was significantly lower than that in the control group. The incidence of macrosomia, neonatal asphyxia, and neonatal hypoglycemia was 6.67%, which was significantly lower than that of the control group (22.22%), and the differences were statistically significant ($p < 0.05$) [10]. The specific results are shown in **Table 4**.

**Table 4.** Comparison of neonatal outcomes between two groups

| Group | Case | Birth weight ($\bar{x} \pm s$, g) | Giant (n,%) | Neonatal asphyxia (n,%) | Neonatal hypoglycemia (n,%) | Total incidence of adverse outcomes (%) |
|---|---|---|---|---|---|---|
| Observation group | 45 | 3256.82 ± 312.54 | 1 (2.22) | 1 (2.22) | 1 (2.22) | 3 (6.67) |
| Control group | 45 | 3689.75 ± 356.82 | 4 (8.89) | 3 (6.67) | 3 (6.67) | 10 (22.22) |
| $t/\chi^2$ | - | 6.025 | - | - | - | 4.594 |
| p | - | < 0.001 | - | - | - | 0.032 |

## 5. Discussion

Gestational diabetes is one of the common complications of pregnancy in elderly women. The occurrence of this disease is closely related to insulin resistance, insulin secretion deficiency and malnutrition. Due to the decline in physiological function and insulin sensitivity, as well as the antagonistic effect of hormones such as progesterone and estrogen secreted by the placenta during pregnancy on insulin, it becomes more difficult for elderly mothers to control their blood sugar [11]. If blood sugar remains at a high level for a long time, it can cause metabolic disorders in the mother, increase the risk of complications such as gestational hypertension syndrome and polyhydramnios, and also have adverse effects on fetal development through the placenta, leading to adverse consequences such as macrosomia and fetal distress. Therefore, it is necessary to strengthen the nutritional management of elderly pregnant women with GDM, improve blood sugar control levels, and ensure the safety of mother and baby. Traditional nutrition guidance mostly uses unified dietary recommendations, without considering individual differences of patients, and cannot meet the nutritional needs of different patients, resulting in poor blood sugar control effects. Personalized nutrition support takes “individualization” as its core, and through comprehensive evaluation of the patient’s physical condition, blood sugar levels, dietary habits, and other factors, develops an exclusive nutrition plan that can more accurately control total calorie intake, allocate nutrient ratios appropriately, and effectively improve blood sugar control levels [12]. From the results of this study, it can be seen that the FPG, 2hPG, and HbA1c levels in the observation group were significantly lower than those in the control group after intervention ($p < 0.05$).

The occurrence of complications during pregnancy is closely related to the level of blood glucose control, and the higher the blood glucose level, the greater the risk of complications. Personalized nutritional support can effectively control blood sugar and reduce the occurrence of complications during pregnancy. The results of this study showed that the incidence of pregnancy complications in the observation group was significantly lower at 8.89% compared to the control group at 28.89% ($p < 0.05$) [13]. The incidence of gestational hypertension syndrome is significantly reduced, possibly due to personalized nutritional support controlling total calorie intake, reducing fat accumulation, and lowering vascular wall pressure. The control of blood sugar has a significant impact on both pregnancy and neonatal outcomes. Poor blood sugar control can keep the fetus in a high blood sugar environment

for a long time, stimulating the secretion of insulin and promoting fetal growth and development, leading to an increase in the incidence of macrosomia. However, macrosomia can also increase the risk of cesarean section and fetal distress. At the same time, newborns will be released from the high blood sugar environment of the mother after birth, and insulin secretion will still be at a high level, which is prone to neonatal hypoglycemia [14]. From the research results, it can be seen that the cesarean section rate, fetal distress rate, and incidence of adverse neonatal outcomes in the observation group were significantly lower than those in the control group ($p < 0.05$), and the birth weight of newborns was significantly lower than that in the control group ($p < 0.05$). Personalized nutrition support requires multidisciplinary teamwork to complete tasks such as nutritional assessment, development, implementation, and modification. Obstetricians, nutritionists, and responsible nurses each complete their own tasks [15].

## 6. Conclusion

To sum up, personalized nutritional support for elderly women with diabetes in pregnancy can improve their blood sugar control level, reduce the incidence of complications in pregnancy, reduce the cesarean section rate and the incidence of adverse neonatal outcomes, and improve pregnancy outcomes [16].

## Disclosure statement

The author declares no conflict of interest.

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# Progress in the Application of Digital Health Interventions in Oral Health Management

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**Abstract:** Objective: To systematically sort out the application forms and effects of digital health intervention technologies in oral health management, and provide references for the digital development of stomatology. Methods: By reviewing relevant domestic and foreign studies and clinical practices, this paper summarizes and analyzes the main application forms of digital health interventions, including digital health education, intelligent detection equipment, telemedicine platforms, oral health big data platforms, and school-hospital collaborative screening robots. *Results:* Studies have shown that digital health interventions can effectively improve the public's oral health knowledge level, optimize personal health behaviors, enhance clinical diagnosis efficiency, reduce overall medical costs, and promote the innovation and upgrading of oral health management models. *Conclusion:* Digital health intervention represents an inevitable trend in the future development of stomatology. In the future, it is still necessary to improve data security and privacy protection, technology adaptability and popularity, as well as relevant policies and norms, to give full play to its potential value.

**Keywords:** Digital health intervention; Oral health management; Application progress

**Online publication:** Feb 9, 2026

## 1. Introduction

Oral health is an important part of human health, directly affecting people's quality of life and overall sense of well-being. However, the incidence of oral diseases in China remains high, with common oral diseases such as periodontitis and dental caries exerting continuous pressure on public health. According to the Report on the Status of Oral Health in China released by the Chinese Stomatological Association in 2024, the prevalence of periodontitis among people aged 35–74 in China is as high as 68.7%, and about 72% of adults have poor dental plaque control. The traditional oral health management model mainly relies on regular clinical examinations and patients' subjective feelings, which often has limitations such as discontinuous data recording, lack of targeted interventions, and limited management efficiency. With the rapid development and cross-field integration of digital technologies, digital health intervention has provided new ideas and powerful technical tools for innovating oral health management, showing broad application prospects [1].

## 2. Overview of digital health interventions and oral health management

### 2.1. Digital health intervention

Digital health intervention mainly refers to the use of digital technology means such as big data, artificial intelligence, and the Internet of Things to continuously monitor, record, and evaluate an individual's oral health status, and provide personalized health management plans based on the evaluation results [2]. This process covers multiple links including oral health data collection, dynamic risk assessment, knowledge popularization and education, and rehabilitation follow-up guidance. Its core goal is to achieve early detection, early warning, and early intervention of oral diseases through modern and digital management methods, thereby enhancing the scientificity and forward-looking of oral health management. Applying digital health interventions to oral health management can leverage technological advantages to provide the public with more convenient, efficient, and personalized health services [3].

### 2.2. Importance of oral health management

As the starting point of the digestive system and the gateway to the respiratory tract, the oral cavity undertakes important physiological functions such as chewing, pronunciation, and facial maintenance. At the same time, numerous studies have confirmed that oral health is closely related to systemic diseases, for example, there is a two-way promoting relationship between periodontal disease and diabetes, cardiovascular diseases, respiratory infections, etc. Therefore, strengthening oral health management is not only necessary for maintaining the health of local organs but also an important part of preventing and controlling systemic diseases and improving the overall health level of individuals [4].

### 2.3. Limitations of traditional oral health management models

The traditional oral health management model, dominated by periodic outpatient examinations and patient self-reports, has limitations mainly reflected in the following aspects: first, the source of health data is single and discontinuous, making it difficult to form a complete personal health profile; second, health guidance tends to be generalized, making it difficult to meet the personalized needs of people of different ages and risk groups; finally, the management model is passive and inefficient, failing to adapt to people's demands for convenience and immediacy of health services in modern fast-paced life [5].

## 3. Application forms of digital health interventions in oral health management

### 3.1. Digital health education

Digital health education is an important form of digital health intervention. With the help of technologies such as artificial intelligence, virtual reality (VR), and augmented reality (AR), it transforms abstract and complex oral health knowledge into intuitive and vivid video content, thereby significantly enhancing the public's learning interest and understanding depth. For example, by building a digital oral health education center, 3D animation technology is used to simulate the formation process of dental caries or the development stages of periodontal disease, allowing the public to intuitively understand the principles of diseases. At the same time, VR/AR technology is used to create immersive interactive experiences, enabling users to "personally" experience the consequences of bad oral habits, effectively strengthening their health awareness. This educational method not only enriches popular science means but also reduces the cost of carrying out long-term health education [6].

### 3.2. Intelligent detection equipment

Intelligent detection equipment realizes real-time monitoring of daily oral health behaviors through integrated sensors and data transmission modules. For example, smart toothbrushes can record users' brushing time, coverage, intensity, and other data, generate visual reports through mobile phone apps, and provide personalized brushing improvement suggestions. In addition, some advanced oral detection equipment can quickly screen the temperature, pH value, and specific bacterial markers in the oral cavity, providing users with preliminary risk warnings and prompting them to seek professional diagnosis and treatment in a timely manner [7].

### 3.3. Telemedicine platforms

Telemedicine platforms break the time and space limitations of oral medical services using communication technology. Patients can upload oral photos, describe symptoms, and share past medical records through mobile applications or computer-based platforms, communicate online with doctors, and obtain preliminary diagnostic opinions and medical guidance. For example, the children's oral health management platform developed by Qingdao Stomatological Hospital integrates remote consultation functions, facilitating communication between parents and doctors, especially suitable for follow-up consultations and chronic disease management, effectively saving patients' time and economic costs [8].

### 3.4. Oral health big data platforms

Oral health big data platforms are committed to aggregating massive data from multiple sources such as clinical diagnosis and treatment, intelligent equipment, and public health surveys. By using big data analysis and machine learning algorithms, the platform can deeply tap data value, reveal disease prevalence rules, evaluate intervention effects, and predict individual disease risks, thereby providing strong data support for formulating precise public health strategies and personalized clinical treatment plans [9].

### 3.5. School-hospital collaborative screening robots

The introduction of screening robots equipped with artificial intelligence visual recognition technology into campuses is an innovative application of digital health interventions in group screening. Robots can automatically collect and analyze students' oral images, quickly identify common problems such as dental caries, dental plaque, and gingivitis, and generate screening reports. This method helps realize large-scale, standardized early screening among children and adolescents, achieving early detection and early intervention. At the same time, it liberates professional medical staff and improves public health efficiency [10].

## 4. Application effects of digital health interventions in oral health management

### 4.1. Improve the effect of oral health knowledge promotion

Digital health education methods, with their vividness and interactivity, have significantly improved the attractiveness and dissemination efficiency of health information. By visualizing and interesting complex knowledge, they effectively overcome the tediousness of traditional text-based promotion, enhance the understanding and memory of the public of different ages and educational backgrounds, and thus comprehensively improve the effect of oral health knowledge popularization [11–13].

### 4.2. Optimize oral health behaviors

The real-time feedback and personalized guidance provided by intelligent detection equipment create a continuous behavioral intervention mechanism. When users can intuitively see that their brushing effect is poor or certain oral indicators are abnormal, they are more motivated to adjust their behaviors. This immediate, visual positive or negative feedback helps urge users to develop good oral hygiene habits, realizing the transformation from "knowledge" to "action".

### 4.3. Enhance diagnosis efficiency

Telemedicine platforms optimize the allocation of medical resources, enabling expert resources to serve a wider population, reducing unnecessary offline outpatient visits, and improving service accessibility. At the same time, oral health big data platforms can assist doctors in diagnostic decision-making. By retrieving and analyzing patients' panoramic data, they shorten diagnosis time and improve the accuracy and consistency of diagnosis.

### 4.4. Reduce medical costs

Digital health interventions fundamentally reduce medical expenditures through "front-end prevention" and "early intervention". For example, the application of campus screening robots can detect and address simple oral problems as early as possible, preventing them from developing into complex severe diseases and saving high treatment costs in the later stage. For individuals and society, this proactive health management method can reduce the loss of work and study time caused by oral diseases, generating significant economic benefits [14].

### 4.5. Promote the innovation of oral health management models

Digital health interventions are driving the transformation of oral health management from "treatment-centered" to "health-centered". They make continuous, dynamic health monitoring possible, and the management method becomes more precise and personalized. For example, a municipal stomatological hospital has innovated a regional oral health management model by building a three-level oral disease prevention and control network and using digital tools to achieve data intercommunication and linkage between communities and hospitals [15].

## 5. Conclusion

In summary, digital health intervention technologies have brought revolutionary changes to oral health management, injecting new connotations of precision, personalization, and efficiency. However, their widespread application still faces a series of challenges: first, the security of health data and the protection of personal privacy are top priorities, requiring strong laws, regulations, and technical means as guarantees; second, attention must be paid to the universality of digital technologies, striving to address the "digital divide" faced by people of different ages and regions; finally, the charging standards, effect evaluation systems of digital medical products, and their connection with existing medical insurance payment policies still need to be further clarified and improved. Looking forward, efforts should be made to build a collaborative innovation ecosystem covering technology R&D, clinical verification, policy support, and market application, promoting the in-depth integration and standardized development of digital health interventions in the field of stomatology, and ultimately providing core driving force for achieving the grand goal of "national oral health".

## Disclosure statement

The author declares no conflict of interest.

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# Research on the Application of Digital Intraoral Scanning Impression Technique in Oral Implant Restoration for Periodontitis Patients and Its Impact on VAS Scores

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**Abstract:** *Objective*: To explore the application effect of digital intraoral scanning impression technique in oral implant restoration for periodontitis patients and analyze its impact on patients' Visual Analogue Scale (VAS) scores. *Methods*: A total of 80 periodontitis patients who received implant restoration in our hospital from May 2023 to May 2025 were selected as research subjects. They were randomly divided into an observation group and a control group using a random number table method, with 40 cases in each group. The observation group used the digital intraoral scanning impression technique to obtain impressions, while the control group used the traditional silicone rubber impression technique. The impression-taking time, the number of prostheses try-ins, implant survival rate, periodontal health indicators (probing depth, gingival index, bleeding index), and VAS scores (pain during treatment and comfort after restoration) were compared between the two groups. *Results:* The observation group was superior to the control group in terms of impression-taking time, the number of prostheses try-ins, and implant survival rate ($p < 0.05$). Six months after restoration, the improvement in periodontal health indicators in the observation group was significantly better than that in the control group ($p < 0.05$). In addition, the pain VAS score of the observation group during treatment was lower than that of the control group, and the comfort VAS score after restoration was higher than that of the control group ($p < 0.05$). *Conclusion:* Digital intraoral scanning impression technology can effectively enhance the efficiency and success rate of implant restoration in periodontitis patients, improve periodontal health, alleviate patients' discomfort during treatment, and increase post-restoration comfort, demonstrating high clinical application value.

**Keywords:** Digital intraoral scanning impression technology; Periodontitis; Oral implant restoration; Visual analog scale; Implant survival rate

**Online publication:** Feb 10, 2026

## 1. Introduction

Periodontitis is a common chronic oral inflammatory condition that can lead to tooth loss. Oral implant restoration

is the primary treatment method, and impression taking directly influences the restoration outcome [1].

The traditional silicone rubber impression process is cumbersome, and its accuracy is easily affected by the oral environment, increasing the number of restorations try-ins [2]. In recent years, digital technology has been increasingly applied in the field of dentistry, and digital intraoral scanning impression technology has gradually garnered attention due to its advantages of being model-free, highly precise, and efficient [3–5]. This study took 80 periodontitis patients who underwent implant restoration in our hospital from May 2023 to May 2025 as the research subjects. It comparatively analyzed the application effects of digital intraoral scanning impression technology and traditional silicone rubber impression technology and explored their impacts on patients' VAS scores, providing a reference basis for clinical treatment.

## 2. Materials and methods

### 2.1. General information

Eighty patients with periodontitis undergoing dental implant restoration in our hospital from May 2023 to May 2025 were selected as the study subjects. They were randomly divided into an observation group and a control group, with 40 cases in each group, according to the random number table method.

#### 2.1.1. Inclusion criteria

(1) All patients met the relevant diagnostic criteria in Periodontology [6]
(2) All had single-tooth loss with good bone conditions
(3) They were able to actively cooperate with the doctors to complete this clinical trial and undergo long-term follow-up examinations
(4) They had no absolute or relative contraindications related to implant surgery
(5) They had signed informed consent forms.

#### 2.1.2. Exclusion criteria

(1) Patients with severe systemic diseases or oral diseases
(2) Patients with a history of head and neck radiation exposure or orthodontic treatment
(3) Patients in special physiological periods such as pregnancy or menstruation
(4) Patients with mental illnesses or those in a state of unconsciousness due to other reasons, making them unable to cooperate with this study.

#### 2.1.3. Study group

Based on the above criteria, stratified sampling was conducted on all eligible subjects, and they were ultimately divided into the observation group and the control group, with 40 subjects in each group participating in this clinical comparative analysis.

In the observation group, there were 22 males and 18 females, with ages ranging from 35 to 68 and an average age of (48.56 ± 7.23). The severity of periodontitis was as follows: 15 mild cases, 18 moderate cases, and 7 severe cases. The control group consisted of 23 males and 17 females, with an age range of 36 to 69 and an average age of (49.12 ± 7.58). The severity of periodontitis in this group was: 14 mild cases, 19 moderate cases, and 7 severe cases. Comparison of general data between the two groups ($p > 0.05$) indicated comparability. This

study was approved by the Medical Ethics Committee of our hospital.

## 2.2. Methods

### 2.2.1. Preoperative preparation

Both groups underwent oral examinations and CBCT assessments, completed basic periodontal treatments such as supragingival scaling, and proceeded with surgery after periodontal stability was achieved (negative bleeding on probing and periodontal pocket depth ≤ 3 mm).

### 2.2.2. Impression taking method

The control group employed the traditional silicone rubber impression technique: An addition-cured silicone rubber impression material was selected, mixed according to the ratio specified in the material instructions, placed into a tray, and then inserted into the patient's mouth. It was accurately positioned and secured, and after the material had fully cured, it was removed. The integrity of the impression was checked, and once confirmed to be error-free, it was sent to the dental laboratory for fabrication of a plaster model, which was used for the production of the prosthesis.

The observation group utilized digital intraoral scanning impression technology: A TRIOS intraoral scanner was selected, which is based on ultra-fast optical sectioning technology and confocal microscopy, capable of capturing over 3,000 two-dimensional images per second and synthesizing them into a three-dimensional digital impression. Before scanning, the patient's mouth was cleaned with a mouthwash to remove food debris and dental plaque. The operator held the scanning head and slowly scanned the edentulous area and adjacent teeth in the patient's mouth, observing the completeness of the three-dimensional image on the screen in real time. Areas with unclear scans were rescanned to ensure complete data of the dentition and soft and hard tissues were obtained. After scanning was completed, the data was transmitted in STL format to a CAD/CAM system for direct design and production of the prosthesis.

### 2.2.3. Implant restoration procedure

The same group of doctors implanted Straumann implants, administered postoperative anti-infection treatment, and provided nursing guidance. After 3 to 6 months of stable osseointegration, the prosthesis was installed, and follow-up records were kept.

## 2.3. Observation indicators

(1) Indicators related to implant restoration

Impression-making time, number of attempts to fit the prosthesis, and implant retention rate. Among them, impression-making time refers to the duration from surgery to obtaining the impression; the number of attempts to fit the prosthesis indicates how many times it takes to fully secure the denture onto the abutment; the implant retention rate is calculated as the number of implants remaining 6 months postoperatively divided by the total number of implants placed during surgery, multiplied by 100%.

(2) Periodontal health indicators

These are assessed 6 months after restoration completion and include probing depth around the implant (measured as the distance from the implant neck to the deepest point of probing using a periodontal probe), gingival index (using the Loe-Silness gingival index criteria, where 0 indicates normal gingiva, 1 indicates mild gingival inflammation, 2 indicates moderate gingival inflammation, and 3 indicates severe

gingival inflammation), and bleeding index (using the Mazza bleeding index criteria, where 0 indicates no bleeding upon probing, 1 indicates punctate bleeding after probing, 2 indicates linear bleeding after probing, and 3 indicates significant bleeding after probing).

(3) VAS scoring indicators

These include the pain VAS score during treatment and the comfort VAS score after restoration [7]. Among them, the VAS score for pain during treatment refers to the pain experienced during the impression-taking process (VAS visual analog scale, ranging from 0 to 10, with 0 indicating no pain and 10 indicating the most severe pain); the VAS score for comfort after restoration was assessed one month after the completion of the restoration, with patients evaluating the usage of their intraoral dentures based on their own sensations (VAS visual analog scale, ranging from 0 to 10, with 0 indicating extreme discomfort and 10 indicating great comfort).

## 2.4. Statistical methods

Data were analyzed using SPSS 26.0. Continuous data ($\overline{x} \pm s$) were subjected to *t*-tests, while categorical data [n (%)] were analyzed using $\chi^2$ tests. A *p*-value less than 0.05 was considered statistically significant.

# 3. Results

## 3.1. Comparison of implant restoration-related indicators between the two groups

The impression-taking time in the observation group was shorter than that in the control group, the number of prostheses try-ins was fewer in the observation group than in the control group, and the implant survival rate was higher in the observation group than in the control group ($p < 0.05$). See **Table 1**.

**Table 1.** Comparison of implant restoration-related indicators between the two groups ($\overline{x} \pm s$)

| Group | Impression time (min) | Prosthesis try-in times (times) | Implant survival rate (%) |
|---|---|---|---|
| Observation group (n = 40) | 5.23 ± 1.05 | 1.08 ± 0.27 | 39 (97.50%) |
| Control group (n = 40) | 12.67 ± 2.18 | 1.89 ± 0.43 | 33 (82.50%) |
| Statistical value ($t/\chi^2$) | 19.447 | 10.090 | 5.000 |
| *p*-value | 0.000 | 0.000 | 0.025 |

## 3.2. Comparison of periodontal health indicators between the two groups

Six months after restoration completion, the probing depth around implants, gingival index, and bleeding index in the observation group were all lower than those in the control group ($P<0.05$). See **Table 2**.

**Table 2.** Comparison of periodontal health indicators between the two groups ($\overline{x} \pm s$)

| Group | Probing depth (mm) | Gingival index (score) | Bleeding index (score) |
|---|---|---|---|
| Observation group (n = 40) | 2.15 ± 0.32 | 0.52 ± 0.16 | 0.48 ± 0.15 |
| Control group (n = 40) | 3.26 ± 0.45 | 1.23 ± 0.28 | 1.15 ± 0.26 |
| *t*-value | 12.714 | 13.924 | 14.117 |
| *p*-value | 0.000 | 0.000 | 0.000 |

### 3.3. Comparison of VAS scores between the two groups

The pain VAS score during treatment in the observation group was lower than that in the control group, while the comfort VAS score after restoration was higher in the observation group than in the control group ($p < 0.05$). See **Table 3**.

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

| Group | Intraoperative pain VAS score | Postoperative comfort VAS score |
|---|---|---|
| Observation group (n = 40) | 2.13 ± 0.65 | 8.67 ± 0.72 |
| Control group (n = 40) | 4.89 ± 1.02 | 6.23 ± 0.89 |
| *t*-value | 14.432 | 13.480 |
| *p*-value | 0.000 | 0.000 |

## 4. Discussion

Digital intraoral scanning generates high-precision impressions by collecting three-dimensional oral data through optical technology. The TRIOS scanner used in this study has an accuracy of 50 μm and does not require reflective powder. Compared with traditional techniques, its mold-free process shortens the cycle, its high precision fits complex anatomical structures, and its compact scanning head enhances the patient experience.

The results of this study showed that the impression-taking time in the observation group was significantly shorter than that in the control group, and the core reason for this data difference lies in the procedural differences between the two techniques. Traditional silicone rubber impressions require multiple steps, including material preparation, seating, curing, and removal, with the material curing time alone taking 3 to 5 minutes. In contrast, digital scanning can complete data acquisition in real time without waiting for material curing, thus significantly reducing operation time. The number of prostheses try-ins in the observation group was less than that in the control group (1.89 ± 0.43 times), and the implant survival rate was higher than that in the control group, which was directly related to the high precision of digital impressions. Regarding conventional impression-taking methods, factors such as the limited fluidity of the materials themselves or improper operation can easily lead to defects like air bubbles, thereby affecting the quality of the models. This undoubtedly has an adverse impact on the subsequent denture fabrication. In contrast, digital scanning can precisely capture these subtle structures, significantly improving the fit between the prosthesis and adjacent teeth as well as the implant, thereby reducing the number of try-ins, lowering the risk of peri-implant infection, and increasing the survival rate [8].

In terms of periodontal health indicators, the probing depth around implants, gingival index, and bleeding index in the observation group were all significantly lower than those in the control group. This result reflects the indirect protective effect of digital technology on periodontal health [9]. Accurate prosthesis fabrication can effectively prevent food impaction and reduce the likelihood of plaque accumulation around implants, as bacterial plaque attachment is a major cause of peri-implantitis. Traditional impression-making techniques cannot accurately record the patient's anatomical morphology and interproximal conditions, resulting in prostheses with edges that are not tightly fitted, creating plaque retention areas and triggering gingival inflammation and probing bleeding. However, the high-precision edge design of digital prostheses can effectively circumvent this issue, thereby improving periodontal health status [10].

The results of the VAS scores revealed that the observation group experienced lower pain scores during

treatment and higher comfort levels after restoration, which was closely related to the operational characteristics of digital technology. Traditional silicone rubber impression trays are large and cumbersome, and their insertion into a patient's mouth can easily compress the periodontal tissues and mucosa, causing discomfort. In contrast, digital scanning heads are smaller and more agile, allowing for accurate three-dimensional data acquisition by simply placing them gently in the mouth and sliding them slowly along the teeth, significantly reducing damage to the oral soft and hard tissues. Furthermore, precise prosthesis design ensures harmonious occlusal relationships, preventing occlusal trauma and thereby enhancing oral comfort after restoration.

## 5. Conclusion

In conclusion, the application of digital intraoral scanning impression technology in oral implant restoration for periodontitis patients can significantly shorten impression-taking time, reduce the number of prostheses try-ins, and improve implant survival rates. Simultaneously, it can enhance periodontal health, alleviate pain and discomfort during treatment, and improve post-restoration comfort, making it worthy of clinical promotion and application.

## Disclosure statement

The authors declare no conflict of interest.

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# Application of Quantitative Assessment Intervention Based on the Kano Model in Postoperative Nursing Care Following Laparoscopic Radical Surgery for Patients with Early-Stage Ovarian Cancer

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**Abstract:** *Objective*: To analyze the impact of nursing interventions based on quantitative assessment using the Kano model on the quality of rehabilitation in patients with early-stage ovarian cancer following laparoscopic radical surgery. *Methods*: A prospective clinical study was conducted involving 96 patients with newly diagnosed early-stage ovarian cancer who underwent laparoscopic radical surgery from December 2023 to December 2025. Patients were randomly assigned to groups using a random number table method before surgery. After surgery, the control group (n = 48) received routine quantitative assessment nursing interventions, while the observation group (n = 48) received nursing interventions based on quantitative assessment using the Kano model. Both groups received continuous nursing care until discharge. Differences between the groups were compared in terms of negative emotions, quality of life scores before and after postoperative intervention, postoperative recovery indicators, and nursing satisfaction evaluations on the day of discharge. *Results:* After intervention, the observation group had lower scores on the Self-Rating Anxiety Scale (SAS) and Self-Rating Depression Scale (SDS), as well as shorter recovery times for gastrointestinal function and food intake, and a shorter hospital stay compared to the control group. Additionally, the observation group had higher scores on the Quality-of-Life Instrument for Cancer Patients-Ovarian Cancer (QLICP-OV) than the control group, with statistically significant differences ($p < 0.05$). The overall satisfaction with nursing care in the observation group was also higher than that in the control group, with a statistically significant difference ($p < 0.05$). *Conclusion:* Implementing quantitative evaluation nursing interventions based on the Kano model for patients with early-stage ovarian cancer after laparoscopic radical surgery can, by addressing their postoperative basic health, disease awareness, and other intervention content needs to a comprehensive degree, actively promote postoperative recovery and improve their mental health and quality of life.

**Keywords:** Early-stage ovarian cancer; Laparoscopic radical surgery; Postoperative nursing; Kano model

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# 1. Introduction

Ovarian cancer, a common malignant tumor of the female reproductive system, has a high incidence rate among women aged 50 to 70. Clinical recommendations suggest that early-stage patients (TNM staging ≤ IIa) should undergo radical surgery as soon as possible to improve disease prognosis [1]. The quality of recovery, as a major factor influencing the postoperative safety of these patients, can be affected by multiple clinical factors that determine the actual postoperative recovery quality. It is necessary to formulate reasonable nursing plans and optimize the effects of nursing interventions by considering the actual needs of patients for different nursing services and the impact of nursing evaluations [2,3]. Therefore, to analyze the impact of nursing interventions based on quantitative evaluation using the Kano model on the recovery quality of patients with early-stage ovarian cancer after laparoscopic radical surgery, this study was conducted, with details as follows.

# 2. Materials and methods

## 2.1. Clinical data

A prospective clinical study was conducted on 96 patients with newly diagnosed early-stage ovarian cancer who were admitted to the hospital for laparoscopic radical surgery from December 2023 to December 2025. These patients were randomly divided into a control group (n = 48) and an observation group (n = 48) using a random number table method before surgery. In the control group, the patients ranged in age from 43 to 68 years (55.54 ± 5.61 years), with a disease duration of 5 to 15 months (10.24 ± 1.06 months). The pathological staging was as follows: 13 cases in stage I and 35 cases in stage IIa. In the observation group, the patients ranged in age from 45 to 65 years (55.21 ± 5.58 years), with a disease duration of 6 to 14 months (10.32 ± 1.02 months). The pathological staging was as follows: 16 cases in stage I and 32 cases in stage IIa. There were no statistically significant differences in age, the proportion of pathological staging, and disease duration between the two groups ($p > 0.05$).

### 2.1.1. Inclusion criteria

(1) Preoperative diagnosis met the diagnostic criteria for ovarian cancer, with TNM staging of stage I to IIa;
(2) Met the indications for laparoscopic radical surgery;
(3) Had an educational level of junior high school or above and were able to complete clinical questionnaire assessments and cooperate accordingly;
(4) Confirmed surgery, voluntarily joined the group, and signed the “Informed Consent Form”.

### 2.1.2. Exclusion criteria

(1) Accompanied by severe systemic diseases or cardiovascular and cerebrovascular diseases;
(2) Accompanied by a history of previous malignant tumors;
(3) Accompanied by a history of long-term analgesic medication;
(4) Estimated survival period of less than 6 months;
(5) Accompanied by severe psychological trauma within 6 months before surgery.

## 2.2. Methods

### 2.2.1. Control group

Conventional quantitative assessment nursing intervention:

(1) Risk quantification

Based on information such as patients' preoperative examinations and surgical conditions, as well as clinical risk assessment tools (e.g., pain assessment, negative emotion scoring, complication risk assessment, etc.), comprehensively evaluate the postoperative safety risk level of patients and develop clinical nursing content for patients at different risk levels.

(2) Nursing implementation

After the assessment, assign nursing staff to patients based on the assessment results, i.e., one nurse for every two patients with low risk, one nurse for each patient with medium risk, and one head nurse and one nurse for each patient with high risk. During the postoperative rehabilitation period, nurses will perform psychological interventions, dietary guidance, functional exercises, and other nursing tasks, as well as provide medication guidance in accordance with medical advice.

### 2.2.2. Observation group

Quantitative assessment nursing intervention based on the Kano Model:

(1) Kano model quantitative assessment

A research team composed of specialist head nurses, nurses, doctors, and psychologists will be established. Based on the Kano model theory and recent literature research findings, a comprehensive Kano model assessment scale will be developed to quantitatively evaluate the nursing needs of patients based on their age, underlying conditions, pathological stage, emotional health scores (including SAS and SDS scores), and postoperative 24-hour vaginal bleeding volume. After the assessment, the degree of demand for related nursing content will be classified based on the scores of each evaluation item, including five levels: like, expected, indifferent, tolerable, and dislike. Based on the degree of demand, the satisfaction coefficient (SI) of related service items will be calculated. If the SI is positive and the larger the value, the stronger the impact of the related nursing service items on improving nursing satisfaction. After completing the aforementioned questionnaire assessment, a comprehensive nursing plan should be formulated in detail, which requires relevant nursing to be carried out on the basis of routine quantitative assessment and nursing intervention for patients.

(2) Nursing implementation

① Health Education: Utilize personalized methods such as pictures and videos to educate patients on disease knowledge, surgical treatment, and other related content. Use the publicity board in the ward area to create and display promotional materials on disease and surgical management, enhancing the accessibility of health knowledge for patients. ② Nutritional Intervention: During the postoperative recovery period, a comprehensive assessment of the patient's postoperative nutritional health status and nutrient requirements should be conducted by a nutritionist. Individualized nutritional rehabilitation guidance should then be provided to ensure the healthy recovery of gastrointestinal function and postoperative nutritional health. ③ Treatment Guidance: Provide detailed treatment education and safety management cooperation to patients regarding their postoperative treatment plans. ④ Psychological Intervention: Based on postoperative health education, nurses are required to communicate with patients on a "one-on-one" basis daily, provide psychological counseling and intervention based on the patient's psychological changes, and adjust nursing intervention content as needed based on an understanding of the patient's changing needs. ⑤ Rehabilitation Guidance: Develop feasible intervention plans tailored to the postoperative exercise rehabilitation needs of

ovarian cancer patients, guiding them in traumatic exercises within 6 hours post-surgery, getting out of bed within 12 hours post-surgery, and engaging in other postoperative exercise rehabilitation activities.

## 2.3. Observation indicators

(1) Negative emotions

The Self-Rating Anxiety Scale (SAS) and Self-Rating Depression Scale (SDS) were employed to evaluate patients' anxiety and depression before and after intervention. Both scales are 20-item versions with a total score range of 20 to 80. A SAS score ≥ 50 indicates the presence of anxiety, while an SDS score ≥ 53 suggests the presence of depression. Higher scores indicate more severe anxiety or depression [4].

(2) Quality of life score

The Quality-of-Life Instrument for Cancer Patients-Ovarian Cancer (QLICP-OV) was used to assess patients' quality of life before and after intervention. It encompasses four domains: physical function, psychological function, social function, and common symptoms and side effects, with a total of 42 items. A Likert 5-point scoring method was used for assignment, and the raw scores obtained were converted into standardized scores using the range normalization method. The total score ranges from 0 to 100, with higher scores indicating a higher level of quality of life [5].

(3) Postoperative recovery indicators

The mean values of the first anal exhaust, defecation time, first feeding time, and discharge time during hospitalization after surgery were calculated for each group.

(4) Nursing satisfaction evaluation

The Newcastle Nursing Service Satisfaction Scale (NSNS) was used to evaluate nursing satisfaction on the day of discharge, with a total score ranging from 19 to 95. Satisfaction levels were classified based on the scoring results, including very satisfied (95 points), satisfied (76–94 points), average (57–75 points), and dissatisfied (19–56 points). The overall satisfaction rate was calculated as (number of very satisfied cases + number of satisfied cases) / n × 100%.

## 2.4. Statistical methods

Data were statistically analyzed using SPSS 25.0 software. For normally distributed measurement data, descriptions were presented in the form of ($\overline{x} \pm s$). Independent sample *t*-tests were conducted for comparisons between groups, and paired sample *t*-tests were used for comparisons within groups. For count data, descriptions were given as n (%). For data on composition ratios, chi-square tests were performed, and for ordinal data, rank-sum tests were applied. A *p*-value less than 0.05 indicated a statistically significant difference.

# 3. Results

## 3.1. Comparison of negative emotions and quality of life scores

Before the intervention, there was no statistically significant difference in negative emotions and quality of life scores between the two groups ($p > 0.05$). After the intervention, the SAS and SDS scores of patients in both groups decreased compared to those before the intervention, while the QLICP-OV score increased compared to that before the intervention. Moreover, the changes in the above scores in the observation group were more significant than those in the control group, with statistically significant differences ($p < 0.05$). See **Table 1**.

**Table 1.** Comparison of negative emotions and quality of life scores ( $\overline{x} \pm s$)

| Group | SAS (Score) | | SDS (Score) | | QLICP-OV (Score) | |
|---|---|---|---|---|---|---|
| | Pre-intervention | Post-intervention | Pre-intervention | Post-intervention | Pre-intervention | Post-intervention |
| Control (n = 48) | 57.68 ± 4.31 | 38.95 ± 4.21* | 61.47 ± 5.12 | 42.58 ± 4.35* | 62.36 ± 5.74 | 74.31 ± 5.52* |
| Observation (n = 48) | 58.02 ± 4.25 | 33.16 ± 3.97* | 61.45 ± 5.23 | 35.65 ± 4.08* | 62.42 ± 5.58 | 80.26 ± 4.97* |
| *t*-value | 0.389 | 6.159 | 0.019 | 8.050 | 0.052 | 5.549 |
| *p*-value | 0.698 | < 0.001 | 0.985 | < 0.001 | 0.959 | < 0.001 |

Note: *A *p*-value less than 0.05 indicates a statistically significant difference compared to the same group.

## 3.2. Comparison of postoperative recovery indicators

The time to first anal exhaust, first defecation, first intake of food, and the length of hospital stay in the observation group were all shorter than those in the control group, with statistically significant differences ($p < 0.05$). See **Table 2**.

**Table 2.** Comparison of postoperative recovery indicators ( $\overline{x} \pm s$)

| Group | Time to first flatus (d) | Time to first defecation (d) | Time to first oral intake (d) | Hospital stays (d) |
|---|---|---|---|---|
| Control (n = 48) | 2.32 ± 0.48 | 2.97 ± 0.78 | 2.54 ± 0.55 | 11.12 ± 2.15 |
| Observation (n = 48) | 1.45 ± 0.52 | 2.09 ± 0.65 | 1.67 ± 0.48 | 9.15 ± 1.85 |
| *t*-value | 8.517 | 6.005 | 8.257 | 4.812 |
| *p*-value | < 0.001 | < 0.001 | < 0.001 | < 0.001 |

## 3.3. Comparison of nursing satisfaction evaluation

The overall satisfaction rate and the proportions of "very satisfied" and "satisfied" in the observation group were higher than those in the control group, with statistically significant differences ($p < 0.05$). See **Table 3**.

**Table 3.** Comparison of nursing satisfaction evaluation (n, %)

| Group | Very satisfied | Satisfied | Fair | Dissatisfied | Total satisfaction |
|---|---|---|---|---|---|
| Control group (n = 48) | 14 (29.17) | 26 (54.17) | 6 (12.50) | 2 (4.17) | 40 (83.33) |
| Observation group (n = 48) | 20 (41.67) | 27 (56.25) | 1 (2.08) | 0 | 47 (97.92) |
| $\chi^2$ (Chi-square) | | 1.978 | | | 6.008 |
| *p*-value | | 0.048 | | | 0.014 |

# 4. Discussion

The Kano model, widely applied in corporate management in recent years, has a definitive effect on optimizing customers' actual service experiences. This model may also be applicable to the healthcare service industry. Related studies have indicated that the implementation of nursing under the guidance of the Kano model, after analyzing patients' actual intervention needs and classifying them into categories such as expected, attractive, and

essential needs, can delve deeper into patients' potential needs from the perspectives of the degree and nature of these needs. This, in turn, enhances nursing content and intervention outcomes, with proven clinical effectiveness [6].

Based on the above background, after formulating and applying a quantitative evaluation nursing intervention based on the Kano model, it was found that the SAS and SDS scores, postoperative gastrointestinal function, time to resume eating, and length of hospital stay in the observation group were all lower than those in the control group, while the QLICP-OV score was higher in the observation group, with statistically significant differences ($p < 0.05$). Analysis shows that, based on the quantitative assessment of the Kano model, on the foundation of conventional risk quantitative assessment, after analyzing the actual demand levels of different nursing intervention measures involved in the factors influencing the quality of postoperative rehabilitation in patients, as well as their impact on the evaluation of nursing services, the nursing implementation content and details for patients with different risk levels can be further refined. This, in turn, can actively promote the recovery of patients' postoperative gastrointestinal function by improving measures such as health education, psychological intervention, and nutritional intervention, thereby assisting in enhancing the overall quality and efficiency of rehabilitation, and positively improving patients' postoperative emotional health and quality of life [7].

Furthermore, this study indicates that the overall satisfaction rate, as well as the proportions of "very satisfied" and "satisfied" in the observation group, are higher than those in the control group, with statistically significant differences ($p < 0.05$). The aforementioned conclusions align with the application objectives of the Kano model. After clarifying the impact of different nursing intervention effects on patients' nursing evaluations, by strengthening the intensity of relevant interventions, the satisfaction level of patients' actual nursing service evaluations can be actively optimized.

## 5. Conclusion

In summary, implementing quantitative assessment nursing interventions based on the Kano model after laparoscopic radical surgery for early-stage ovarian cancer patients can actively promote postoperative rehabilitation and improve their mental health and quality of life, based on the demand levels of intervention content such as basic postoperative health and disease awareness.

## Disclosure statement

The authors declare no conflict of interest.

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# The Impact of Systematic Stepwise Rehabilitation Nursing Intervention on the Prognosis and Disease Uncertainty of Patients with Hypertensive Intracerebral Hemorrhage

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**Abstract:** Objective: To explore the impact of systematic stepwise rehabilitation nursing intervention on the prognosis and disease uncertainty of patients with hypertensive intracerebral hemorrhage, and to provide feasible strategies for clinical nursing. Methods: Eighty patients with hypertensive intracerebral hemorrhage admitted to our hospital from January 2023 to June 2025 were selected and randomly divided into an observation group (n = 40, receiving systematic stepwise rehabilitation nursing) and a control group (n = 40, receiving conventional nursing). The intervention effects were analyzed by comparing changes in the National Institutes of Health Stroke Scale (NIHSS) scores for neurological recovery, Short Form 36 Health Survey (SF-36) scores for quality of life, Exercise of Self-Care Agency Scale (ESCA) scores for self-management ability, compliance, and the Mishel Uncertainty in Illness Scale (MUIS) scores between the two groups. *Results:* All scores in the observation group were significantly better than those in the control group after the intervention ($p < 0.05$). Specifically, the NIHSS scores decreased more significantly, the total SF-36 scores increased, the ESCA scores increased significantly, while the MUIS scores decreased significantly, and compliance improved markedly, indicating a reduction in disease uncertainty among patients. *Conclusion:* Systematic stepwise rehabilitation nursing intervention can significantly improve neurological recovery, quality of life, self-management ability, and compliance in patients with hypertensive intracerebral hemorrhage, while effectively reducing disease uncertainty. It is worthy of clinical promotion and application.

**Keywords:** Hypertensive intracerebral hemorrhage; Rehabilitation nursing; Stepwise intervention; Uncertainty in illness; Prognosis

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## 1. Introduction

Hypertensive intracerebral hemorrhage (HICH) is a prevalent form of stroke, with its incidence rate rising annually, significantly impacting patients' lives and quality of life [1]. Particularly among the elderly, HICH exhibits a higher incidence rate and is often accompanied by multiple chronic diseases, complicating the rehabilitation

process. HICH is characterized by its acute onset, pronounced neurological deficits, and high risk of complications. Patients frequently experience long-term blood pressure fluctuations and underlying health conditions, factors that increase the complexity of rehabilitation and the difficulty of nursing care. Concurrently, patients and their families often endure substantial psychological stress due to the sudden onset of the condition, posing additional challenges to nursing management. In recent years, advancements in imaging and minimally invasive techniques have led to a decline in mortality rates during the acute phase. However, suboptimal long-term functional recovery, impaired quality of life, and increased psychological burden remain significant clinical challenges. Nursing interventions play a crucial role in patient rehabilitation, with their scientific and systematic nature directly influencing prognosis and psychological well-being. Traditional routine nursing care primarily focuses on monitoring vital signs and preventing complications, while often neglecting patients' rehabilitation awareness and psychological adaptability. This oversight results in low self-management skills and inadequate disease awareness among discharged patients, frequently leading to anxiety and uncertainty in illness [2]. Uncertainty in illness refers to the psychological state arising from patients' unclear cognition of disease progression, treatment outcomes, and rehabilitation prospects. This state often manifests as anxiety, fear, or behavioral avoidance. A high level of uncertainty can increase psychological burden and affect rehabilitation compliance and quality of life. Studies have shown that reasonable rehabilitation nursing, through phased, goal-oriented interventions, can promote the recovery of neurological function while improving disease cognition and psychological adaptability [3].

Systematic stepwise rehabilitation nursing is a novel nursing intervention model that has garnered attention in the field of stroke rehabilitation in recent years. Its core concept is to design progressive nursing plans in stages based on patients' disease progression, rehabilitation needs, and individual differences. Its content primarily includes focusing on monitoring vital signs and implementing measures to prevent complications during the acute phase; conducting functional training and providing guidance on daily living skills during the subacute phase; and emphasizing psychological support and enhancing self-management abilities during the rehabilitation phase [4]. This model emphasizes the continuity and systematic nature of the nursing process while incorporating multidisciplinary collaboration to tailor rehabilitation plans for patients. Related studies both domestically and internationally have indicated that stepwise rehabilitation nursing has a positive effect on improving neurological function and quality of life in stroke patients. However, there is still a relative lack of research on patients with cerebral hemorrhage, particularly with limited reports on interventions for uncertainty in illness. Clinical observations have shown that patients with hypertensive cerebral hemorrhage often experience a high level of uncertainty in illness after discharge due to insufficient knowledge about the disease and a lack of rehabilitation guidance, which consequently affects their quality of life and long-term rehabilitation compliance [5].

Based on this, the subjects of this study are 80 patients with hypertensive intracerebral hemorrhage (HICH) admitted to our hospital, aiming to evaluate the impact of systematic stepwise rehabilitation nursing on neurological function, quality of life, self-management ability, and disease uncertainty in patients with HICH. The study seeks to provide a scientific and reliable reference for clinical medicine. Additionally, it attempts to explore the long-term effects of nursing interventions on patients' psychological adaptation, with the goal of offering practical guidance for optimizing HICH rehabilitation models.

## 2. Materials and methods

### 2.1. General information

Eighty patients with HICH admitted to our hospital from January 2023 to June 2025 were included in this study

and randomly divided into an observation group and a control group, with 40 patients in each group. There were no significant differences in general information such as gender, age, bleeding volume, and previous duration of hypertension between the two groups ($p > 0.05$), indicating comparability.

#### 2.1.1. Inclusion criteria

(1) Aged between 18 and 80 years old and diagnosed with hypertensive intracerebral hemorrhage;
(2) Confirmed by imaging (CT or MRI) after admission;
(3) Conscious or in a mild coma, able to cooperate with nursing interventions;
(4) Signed informed consent.

#### 2.1.2. Exclusion criteria

(1) Patients with severe cardiac, hepatic, or renal dysfunction or other systemic diseases;
(2) Previous severe stroke disability affecting functional assessment;
(3) Mental illness or cognitive impairment affecting cooperation;
(4) Life expectancy less than 6 months or at high risk of severe complications.

### 2.2. Methods

#### 2.2.1. Control group

Routine nursing care was implemented, which included monitoring vital signs, providing basic nursing care, preventing complications, and offering dietary and medication guidance. Psychological intervention, disease education, and self-management training were not systematically conducted during the nursing process.

#### 2.2.2. Observation group

On the basis of routine nursing care, a systematic stepped rehabilitation nursing intervention was implemented, with an emphasis on multidisciplinary collaboration (nursing department, rehabilitation department, and psychological department). The specific steps are as follows:

(1) Acute phase (from admission to the 7th day)
Focus on monitoring vital signs, changes in neurological function, and the risk of complications; establish nursing files and provide psychological comfort; guide family members to cooperate with nursing care, conduct education on basic disease management, and enhance the awareness of patients and their families regarding HICH and hypertension control; assess the patients' initial self-management abilities to provide a reference for formulating subsequent rehabilitation goals.

(2) Subacute phase (from the 8th day to discharge)
Carry out individualized limb function training, language rehabilitation, and life skills training; gradually cultivate patients' self-management abilities, including medication management, blood pressure monitoring, and self-care in daily life; regularly evaluate rehabilitation outcomes and adjust training plans; a joint evaluation by the multidisciplinary team should be conducted once a week to ensure the targeted and feasible nature of the intervention.

(3) Convalescence phase (follow-up at 3 months after discharge)
Follow-up was conducted via telephone calls, online video consultations, or outpatient visits to guide patients in their rehabilitation training; provide psychological support, disease education, and guidance on

rehabilitation adherence; and assess changes in quality of life and uncertainty about the disease. Family members were encouraged to participate in the follow-up guidance, forming a collaborative "physician-patient-family" rehabilitation model to enhance adherence.

## 2.3. Observational indicators

(1) Neurological function score

The NIHSS score was used, with lower scores indicating better neurological recovery. Assessment time points were at admission, discharge, and the 3-month follow-up.

(2) Quality of life

The SF-36 scale was used to measure quality of life, with higher total scores indicating better physiological function, social adaptability, and mental health status in patients.

(3) Self-management ability

The ESCA score was used, with higher total scores indicating stronger self-management abilities, focusing particularly on daily living abilities and adherence to rehabilitation training.

(4) Adherence indicators (newly added)

Completion rate of rehabilitation training, follow-up participation rate, and family cooperation level were used to assist in evaluating the intervention effect.

(5) Uncertainty about the disease

The MUIS scale was used, with higher total scores indicating stronger feelings of uncertainty. Changes in patients' perceptions of the disease and rehabilitation expectations were also recorded.

## 2.4. Statistical methods

This study utilized SPSS 26.0 statistical analysis software. Continuous data were presented as mean ± standard deviation ($\overline{x} \pm s$), with independent sample *t*-tests used for comparisons between groups and paired *t*-tests for comparisons within groups. Categorical data were presented as case numbers and percentages, with $\chi^2$ tests used for comparisons between groups. A $p$-value < 0.05 was considered statistically significant.

# 3. Results

## 3.1. Comparison of neurological function recovery (NIHSS scores)

There was no statistically significant difference in NIHSS scores between the two groups before intervention ($p > 0.05$). After intervention, the scores in the observation group were significantly lower than those in the control group ($p < 0.05$), suggesting that systematic stepwise rehabilitation nursing intervention can significantly promote neurological function recovery, as shown in **Table 1**.

**Table 1.** Comparison of neurological function recovery (NIHSS scores) between the two groups ($\overline{x} \pm s$)

| Group | Before intervention | After intervention |
|---|---|---|
| Control group (n = 40) | 14.24 ± 3.53 | 10.86 ± 3.22 |
| Observation group (n = 40) | 14.20 ± 3.35 | 7.25 ± 2.87 |
| *t*-value | 0.321 | 4.873 |
| *p*-value | 0.757 | < 0.001 |

## 3.2. Comparison of quality of life (total SF-36 scores)

There was no significant difference in quality-of-life scores between the two groups before intervention ($p > 0.05$). After intervention, the total SF-36 score in the observation group was significantly higher than that in the control group ($p < 0.05$), indicating that stepwise nursing intervention has a significant effect on improving quality of life, as shown in **Table 2**.

**Table 2.** Comparison of quality of life (total SF-36 scores) between the two groups ( $\overline{x} \pm s$)

| Group | Before intervention | After intervention |
|---|---|---|
| Control group (n = 40) | 56.31 ± 8.55 | 64.79 ± 9.20 |
| Observation group (n = 40) | 55.79 ± 8.23 | 75.46 ± 8.77 |
| *t*-value | 0.232 | 5.312 |
| *p*-value | 0.830 | < 0.001 |

## 3.3. Comparison of self-management ability (ESCA scores) and compliance

Before intervention, there was no significant difference in self-management ability and compliance between the two groups ($p > 0.05$). After intervention, the observation group significantly outperformed the control group, with a greater improvement ($p < 0.05$). The results indicate that systematic stepwise rehabilitation nursing can effectively encourage patients to actively participate in rehabilitation and daily management, as shown in **Table 3**.

**Table 3.** Comparison of self-management ability (ESCA scores) and compliance between the two groups ( $\overline{x} \pm s$)

| Group | Self-management ability | | Compliance rate | |
|---|---|---|---|---|
| | Pre-intervention | Post-intervention | Pre-intervention | Post-intervention |
| Control group (n = 40) | 62.52 ± 7.85 | 69.52 ± 8.19 | 74.01 ± 4.91 | 80.51 ± 5.34 |
| Observation group (n = 40) | 63.04 ± 7.57 | 79.54 ± 7.96 | 73.61 ± 4.51 | 87.53 ± 6.81 |
| *t*-value | 0.334 | 6.231 | 0.618 | 7.791 |
| *p*-value | 0.742 | < 0.001 | 0.518 | < 0.001 |

## 3.4. Comparison of illness uncertainty (measured by MUIS)

There was no significant difference in MUIS scores between the two groups before the intervention ($p > 0.05$). After the intervention, the score in the observation group was significantly lower than that in the control group ($p < 0.05$), suggesting that stepped care intervention can effectively reduce patients' uncertainty in illness, as shown in **Table 4**.

**Table 4.** Comparison of illness uncertainty (MUIS scores) between the two patient groups ( $\overline{x} \pm s$)

| Group | Before intervention | After intervention |
|---|---|---|
| Control group (n = 40) | 84.63 ± 9.31 | 76.35 ± 8.76 |
| Observation group (n = 40) | 85.40 ± 9.04 | 62.80 ± 7.85 |
| *t*-value | 0.182 | 7.932 |
| *p*-value | 0.862 | < 0.001 |

## 4. Discussion

Hypertensive intracerebral hemorrhage is an acute cerebrovascular disease characterized by sudden onset, significant damage, and a prolonged recovery period. This condition not only leads to neurological deficits but also severely impacts patients' quality of life, imposing substantial psychological stress [6]. Particularly among elderly patients and those with comorbid chronic conditions, rehabilitation is more challenging, often resulting in anxiety, depression, and uncertainty about the illness, thereby increasing the complexity of nursing management. While acute-phase treatment and routine nursing care can stabilize the condition and prevent complications, interventions for long-term rehabilitation, recovery of daily living skills, and psychological adaptation remain limited. Therefore, exploring a scientific and practical nursing model holds significant value for optimizing patient outcomes. Systemic nursing interventions not only improve physiological function but also enhance overall adaptability through behavioral interventions, cognitive education, and psychological support. The results of this study indicate that systemic stepped rehabilitation nursing intervention can significantly enhance neurological recovery, improve quality of life and self-management abilities, and effectively alleviate uncertainty about the illness [7]. After intervention, the NIHSS scores of patients in the observation group were significantly lower than those in the control group, indicating a more rapid and stable recovery of neurological function in the observation group. The underlying mechanisms may include the following aspects:

(1) Physiological mechanisms
Phased rehabilitation training promotes brain plasticity and neural reorganization, accelerating the recovery of motor function; stabilizing the condition during the acute phase to reduce secondary brain injury and create conditions for neural repair;

(2) Psychological mechanisms
Psychological counseling, health education, and family involvement reduce anxiety, fear, and behavioral avoidance, enhancing patient motivation and self-efficacy;

(3) Behavioral mechanisms
Individualized training and self-management guidance help patients establish regular rehabilitation behaviors, improve adherence, and reduce the risk of recurrence and complications.

In terms of quality of life, the SF-36 scores of patients in the observation group were significantly higher than those in the control group, indicating that nursing intervention not only aids physiological recovery but also has a positive impact on psychological well-being and social functioning [8]. Particularly in the social functioning dimension, the introduction of family and social support enhances patients' confidence in participating in social activities, contributing to the long-term maintenance of rehabilitation outcomes. The improvement in ESCA scores suggests enhanced self-management abilities among patients, facilitating adherence to rehabilitation training, medication adherence, and blood pressure control in daily life, thereby reducing the risk of recurrence. Disease-related uncertainty is a key factor exacerbating psychological stress in patients with hypertensive intracerebral hemorrhage. During the acute phase and rehabilitation process, patients often experience uncertainty due to a lack of clear understanding of their condition and prognosis. The study results show that patients in the observation group had significantly lower MUIS scores, indicating that stepped nursing intervention has a notable effect in alleviating uncertainty. This effect may stem from the following factors:

(1) Systematic health education enhances patients' understanding of their disease and the rehabilitation process;

(2) Psychological interventions combined with family involvement establish a robust support system and

strengthen patients' coping strategies;

(3) Remote follow-up and multidisciplinary collaboration maintain the continuity of interventions, reducing anxiety caused by insufficient information [9].

Related research findings both domestically and internationally indicate that phased rehabilitation training aids in accelerating the recovery of motor functions, enhancing self-care abilities, and alleviating negative emotions such as anxiety and depression, thereby strengthening psychological adaptability. Additionally, integrating a stepped-care nursing model with telemedicine and intelligent monitoring tools allows for real-time assessment of patients' rehabilitation progress, dynamic adjustment of intervention plans, and improved long-term adherence and rehabilitation outcomes.

It is noteworthy that the implementation of stepped-care nursing requires multidisciplinary collaboration, involving neurology nursing, rehabilitation therapy, and psychological guidance, and necessitates dynamic adjustments based on changes in patients' conditions, family resources, and social support to achieve individualized and sustainable rehabilitation management [10]. However, this study is limited by a small sample size, single-center design, and short-term follow-up, making it impossible to evaluate the long-term effects and adherence of the interventions. It is recommended that future research conduct large-sample, multicenter, and long-term follow-up studies to further assess the effectiveness of the stepped-care nursing model.

## 5. Conclusion

In summary, stepped rehabilitation nursing, through phased, systematic, and individualized interventions, not only improves neurological function, quality of life, and self-management abilities but also effectively reduces disease uncertainty. It promotes overall rehabilitation through multiple mechanisms involving physiology, psychology, and behavior, providing a sustainable and comprehensive rehabilitation plan for patients with hypertensive intracerebral hemorrhage. This approach holds high clinical application value and is worthy of promotion.

## Disclosure statement

The author declares no conflict of interest.

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# The Application of Artificial Intelligence in Smart Education for Nursing Students

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**Abstract:** Nursing education is undergoing a paradigm shift from skill training to clinical thinking cultivation. The integration of artificial intelligence technology offers technical possibilities for this transformation, but it also brings about a deep tension between the cultivation of humanistic qualities and a standardized training. Based on the analysis of the practical forms of nursing smart education, this paper examines the cognitive gap between the deterministic feedback of virtual simulation systems and the complexity of real clinical scenarios, reveals the potential narrowing effect of data-driven ability profiling on the all-round development of nursing students, and then proposes the design logic of intelligent teaching resources centered on real clinical problems, a hierarchical teaching model with clear human-machine division of labor, and a dynamic assessment mechanism for technology application led by professional nursing teachers, in an attempt to find a balance between technological empowerment and humanistic commitment in smart nursing education.

**Keywords:** Artificial Intelligence; Nursing education; Smart education; Virtual simulation; Adaptive learning

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## 1. Introduction

When large language models such as DouBao, Wenxin YiYan, and ChatGPT-4 rapidly penetrate into the medical education field, the reform of smart education in the nursing profession is inevitably swept up in this technological whirlwind. However, the particularity of the nursing discipline, that is, the reverence for life, empathy for pain, and maintenance of dignity, appears particularly vulnerable to the precise calculations of algorithms. Whether technological tools are liberating productivity or eroding the soul of nursing constitutes the starting point of this paper.

## 2. The practical forms of smart education in nursing talent cultivation

### 2.1. The evolution of nursing education goals from skill training to clinical thinking cultivation

Traditional nursing education has long been trapped in a linear model of “demonstration–imitation–assessment”.

Students have mastered standardized hand movements through repeated practice of intravenous puncture and aseptic operation training, but often find themselves in a "able to perform but unable to think critically" predicament when facing real patients. Feedback from clinical teaching at X Medical College in the autumn semester of 2024 shows that although the error rate of intern nurses in executing medical orders has dropped to a relatively low level, their ability to respond and clinical reasoning skills are significantly insufficient when patients present with atypical symptoms or make demands beyond the preset range. This phenomenon reflects the urgency of the shift in the goal of nursing education from mere skill acquisition to clinical thinking cultivation [1].

### 2.2. Immersive learning environments constructed by virtual simulation and intelligent medical record systems

Virtual simulation technology provides a repeatable, controllable, and low-risk practice field for nursing education. Students can repeatedly practice high-risk operations such as cardiopulmonary resuscitation and tracheal intubation on high-fidelity simulation manikins like SimMan without the risk of real harm. Intelligent medical record systems take this a step further. Teachers can design branched plot virtual cases using clinical decision support systems, and each nursing decision made by students will trigger different disease developments. For instance, delayed medication administration may cause a sudden drop in the virtual patient's blood pressure, and ignoring the emotions of family members may lead to a medical-patient communication crisis. This immediate feedback mechanism partially compensates for the "armchair strategy" defect of traditional classrooms, but it also sows the seeds of cognitive risks that will be analyzed later.

### 2.3. Personalized knowledge push and training based on adaptive learning platforms

Adaptive learning platforms track students' answer trajectories, dwell times, and error types, and use machine learning algorithms to generate personalized knowledge maps and training plans. The intelligent question bank system introduced by a certain nursing college can identify students' weak points in the "drug dosage conversion" module and automatically push targeted practice questions and micro-lesson videos. This "one-size-fits-one" learning path design seems precise and efficient, but it actually implies a tendency to fragment nursing knowledge and atomize the learning process. Students complete one knowledge point after another under the guidance of algorithms, but they may lose the ability to grasp the overall picture of the nursing discipline [2].

## 3. Deep conflicts arising from the integration of technology into nursing education

### 3.1. The contradiction between standardized intelligent training and the cultivation of humanistic care competence in nursing practice

The essence of nursing has never been a set of operational procedures that can be exhausted by algorithms. When students communicate with "virtual patients" driven by ChatGPT in virtual wards, the system can simulate emotions such as anxiety, depression, and anger, but it cannot reproduce the weary look born from long-term illness or convey the trembling warmth when holding a nurse's hand at the end of life. Standardized dialogue scripts train "correct responses" rather than "genuine empathy". Students learn to invoke the "listen-empathize-guide" template when the system prompts "patient is emotionally agitated", but they may appear mechanical and indifferent in real clinical settings due to over-reliance on such routines.

### 3.2. The cognitive gap between the certainty of virtual scenarios and the complexity of clinical situations

The design logic of virtual simulation systems is based on a deterministic mapping of "input-output". Students receive positive feedback for correct operations and alerts for incorrect ones. This clear cause-and-effect chain, while helpful in reinforcing normative awareness, contrasts sharply with the chaotic nature of real clinical settings. Emergencies in wards often have no standard answers. A family member's question, a sudden vomiting from a neighboring patient, or an abnormal alarm from a monitor may occur simultaneously. Nurses must make judgments under conditions of incomplete information, time constraints, and emotional disturbances. The ability to extract key information from "noise" is precisely a blind spot that virtual training cannot reach.

### 3.3. The risk of narrowing the development of nursing students due to data-driven competency portraits

When learning management systems convert every click, every wrong answer, and every study duration of students into data and generate "competency portraits" based on this, a covert disciplinary mechanism operates. Qualities that are difficult to quantify, such as reverence for life, compassion for suffering, and professional identity, have no place on the data dashboard. Meanwhile, easily measurable indicators, such as operation accuracy, knowledge mastery, and simulation exam scores, are continuously emphasized. Students may internalize a cognitive bias that "what can be quantified is valuable" in the pursuit of data optimization, posing a risk of colonization by technological rationality in nursing education.

### 3.4. The mismatch between the rapid update of educational technology and the pace of building ethical norms for nursing teaching

The iteration speed of generative artificial intelligence far exceeds the pace of building ethical norms in education. When teachers attempt to introduce Wenxin Yiyan into discussions on nursing ethics cases, large models may generate seemingly reasonable but actually value-biased analysis texts. Students lacking critical thinking training may internalize AI outputs as their own judgments. Even more challenging is that when students use image generation tools like Midjourney to create health education materials, they may unconsciously spread visual symbols with stereotypes. These issues have not yet entered the discussion scope of nursing education ethics, and the absence of norms leaves the application of technology in a "grey area".

## 4. Collaborative pathways for high-quality development of smart nursing education

### 4.1. Establishing a design logic for intelligent teaching resources centered on real clinical problems

The development of intelligent teaching resources must move away from the mindset of "technological showmanship" and instead take real clinical problems as the logical starting point. The "Clinical Dilemmas" case library developed by the nursing department of a top-tier hospital in collaboration with a medical college extracts real materials from shift handover records at the nurse station, reports of adverse nursing events, and patient satisfaction surveys. After de-identification, these materials are imported into an intelligent case system. Students are no longer confronted with meticulously designed "standard patients" but rather real scenarios full of contradictions and tensions, such as family members demanding to keep the patient's condition a secret while

the patient insists on their right to know, doubts about the dosage of a doctor's order when the on-duty doctor is unreachable, and multiple patients calling for help simultaneously amid a shortage of nursing resources. This "imperfect" case design precisely provides the soil for the growth of critical thinking. Specifically, teachers can use the long text generation function of Wenxin Yiyan to batch import adverse nursing event reports from a certain department within half a year, allowing the large model to extract common problems and typical scenarios, and automatically generate draft cases with teaching value. These are then jointly reviewed by clinical nursing experts and the teaching team to form intelligent case resources that are both authentic and educational. The key to this process lies in breaking away from the conventional path of "first having a technical platform and then filling it with teaching content" and instead adopting a reverse design thinking of "first identifying clinical pain points and then seeking technical support", so that intelligent teaching resources truly serve the goal of cultivating nursing job competence rather than becoming just another "digital achievement" on the technology procurement list.

## 4.2. Promoting the functional shift of intelligent systems from "evaluating results" to "supporting reflection"

Existing intelligent evaluation systems overly focus on binary judgments of "right or wrong", while truly valuable learning often occurs through in-depth reflection on mistakes. The author advocates shifting the functional focus of intelligent systems from "scoring" to "questioning". When students make a certain nursing decision in a simulated scenario, the system should not merely display "correct" or "incorrect", but generate a Socratic sequence of questions, such as "Why did you choose to handle patient A first rather than patient B?" "Would your judgment change if the monitoring data at that time showed a different trend?" "Which parts of your decision relied on textbook knowledge and which on intuition?" Through this dialogic reflection guidance, students' implicit thinking processes are made explicit, thereby promoting the development of metacognitive abilities. Technically, teachers can use the custom instruction function of ChatGPT-4 to pre-set the role framework of a "nursing clinical thinking mentor", requiring it to not provide standard answers but instead continuously pose three to five progressive questions after students complete virtual case exercises, guiding students to discover their own decision-making blind spots. A teaching experiment conducted by a certain nursing college in the "Critical Care Nursing" course showed that the student group receiving AI questioning feedback performed significantly better in the final clinical reasoning test than the control group receiving only traditional right-wrong feedback. The difference mainly lay in the dimensions of "identifying key information" and "predicting changes in the patient's condition", confirming the promoting effect of the reflection support function on the development of high-order thinking skills among nursing students [3].

## 4.3. Establishing a clear division of labor between humans and machines in a "skill training–emotional communication" hierarchical teaching model

Technical tools and human teachers should each play their roles in nursing education rather than replace each other. Standardized skill operation training can be more often handled by intelligent systems. Students can enter a virtual laboratory at any time to repeatedly practice basic operations such as catheterization, intravenous infusion, and cardiopulmonary resuscitation. The system corrects hand angles, needle depths, and operation sequences in real time through motion capture and force feedback technology. However, teaching content involving emotional communication, ethical judgment, and end-of-life care must retain the leading position of human teachers, as the empathy, moral sensitivity, and life wisdom required in these areas cannot be learned by algorithms. The

approach taken by a certain nursing college in its "End-of-Life Care" unit is quite enlightening: First, teachers arrange for students to have simulated conversations with virtual family members driven by beanbags to familiarize themselves with the basic framework of "bad news delivery". Students repeatedly practice opening remarks, empathetic responses, and information confirmation in multiple rounds of dialogue with AI. The system automatically records the dialogue text and marks the frequency of interjections used, pause duration, and the proportion of questions for post-class analysis. Then, teachers lead students to the hospice ward of a cooperating hospital for real observations, requiring them to record the communication details of nurses without disturbing patients and their families. After the observation, students complete a reflective writing piece, comparing the "routines" from virtual training with the "warmth" in real situations. Finally, they return to the classroom for group discussions, where teachers guide students to share their observations and inner feelings. This three-stage design of "virtual warm-up-real experience-collective reflection" attempts to seek a dynamic balance between technological efficiency and humanistic depth, acknowledging the efficiency advantage of AI in standardized training while upholding the irreplaceability of human teachers in value guidance and emotional support.

### 4.4. Improve the dynamic assessment mechanism for the application effect of technology led by nursing teachers

The introduction of technological tools should not be a one-off administrative decision but a continuous iterative and dynamic adjustment process. Nursing teachers must take the lead in this process rather than become passive executors of technology. The author suggests establishing a two-way assessment loop of "teaching effect–technology feedback", whose operation mechanism can be described as follows: At the end of each semester, teachers integrate students' learning experience questionnaires, behavior logs of virtual training systems, and internship evaluations from clinical teaching teachers through Notion AI. They use the text analysis function of large models to identify high-frequency pain points and typical blind spots in the application of intelligent systems, and convert these first-line feedbacks into specific functional optimization demand lists to submit to the technology development team. At the same time, teachers should incorporate the assessment process itself into the scope of teaching academic research, systematically record the changes in students' knowledge mastery, skill proficiency, and clinical reasoning ability before and after the intervention of technology, and distill local practical experience into transferable theoretical frameworks and operation guidelines through writing teaching case reports, publishing research papers on nursing education, and participating in national smart education symposiums for nursing colleges. The deep meaning of this mechanism design lies in reshaping the leading position of teachers in the smart education transformation. Teachers are not passive recipients of technological solutions but professional evaluators and core drivers of continuous improvement in the application effect of technology. Only when nursing teachers truly hold the decision-making power over "what technology to use, at which stage to use it, and to what extent", can smart education shift from "technology-driven educational transformation" to "education demand-led technology adaptation", ultimately achieving a substantial improvement in the quality of nursing talent cultivation rather than superficial digital decoration [4].

## 5. Conclusion

The integration of artificial intelligence into nursing education is neither a terrifying monster nor a panacea. The value of technology ultimately depends on the educational wisdom and ethical awareness of its users. When virtual

simulation systems can replicate realistic clinical scenarios but fail to reproduce the warmth of life, when adaptive platforms can precisely push knowledge points but may narrow the development potential of students, and when large language models can generate smooth communication scripts but struggle to convey sincere empathy, nursing educators must remain clear-headed amid the technological frenzy: the "wisdom" of smart education does not lie in the advancement of technology, but in a profound understanding and commitment to the essence of the nursing profession, in a clear recognition and respect for the boundaries of technology, and in a sincere concern and responsibility for the all-round development of each nursing student.

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# A Survey on the Current Status of Usage and Awareness of Out-of-Hospital Automated External Defibrillators in Deyang City

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**Abstract:** *Objective*: To understand the current awareness and willingness to learn about the use of out-of-hospital automated external defibrillators (AEDs) in Deyang City, providing a basis for improving the success rate of rescue operations. *Methods*: A questionnaire survey was conducted among residents in Deyang City from January 2025 to October 2025, covering residents' basic information, awareness of AED-related knowledge, and attitudes towards AED usage. *Results:* A total of 1,886 questionnaires were collected, with 1,823 valid questionnaires, yielding an effective rate of 96.66%. Among the 1,823 respondents, 692 (37.96%) had received cardiopulmonary resuscitation (CPR)-related learning or training, 619 (33.96%) could accurately describe the name of an AED, 417 (22.87%) could clearly describe the function of an AED, and 308 (16.89%) could accurately describe how to use an AED. Among them, 1,549 (84.97%) were willing to provide assistance to patients experiencing cardiac arrest; 1,731 (94.95%) were willing to provide assistance under the premise of knowing how to use an AED; and 1,750 (95.99%) were willing to learn about AED-related knowledge. Among the 91 individuals unwilling to provide rescue, 75 responded with reasons. Among them, 36 cases (48.00%) were reluctant to rescue due to a lack of relevant first aid knowledge, 32 cases (42.67%) expressed concerns about exacerbating the patient's condition due to improper operation, and 4 cases (5.33%) were unwilling to interact with strangers due to personal reasons. *Conclusion:* Currently, residents in Deyang City have limited knowledge about AEDs but demonstrate a strong willingness to learn and apply them. Measures need to be taken to enhance their understanding and application of AEDs.

**Keywords:** Out-of-hospital cardiac arrest; Automated external defibrillator; Deyang City; Knowledge, attitude, and practice; Public first aid

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## 1. Introduction

Cardiovascular disease has now become the leading cause of threat to human health worldwide. Among them,

Out-of-Hospital Cardiac Arrest (OHCA) is widely recognized as a severe public health issue that endangers lives due to its sudden onset, rapid progression, and poor prognosis. Data shows that the number of sudden cardiac deaths in China exceeds 540,000 annually, ranking first globally, yet the success rate of rescue remains around 1%, significantly lower than the average level in developed countries in Europe and America [1]. After cardiac arrest, the patient's survival rate decreases exponentially over time. Implementing high-quality cardiopulmonary resuscitation (CPR) within the "golden 4 minutes" and using an Automated External Defibrillator (AED) can significantly improve the patient's survival rate. However, factors such as long-standing weak public awareness of first aid, low skill penetration rate among the public, and insufficient AED deployment have limited improvements in the prognosis of OHCA patients in China [2]. In recent years, at the national level, great importance has been attached to the construction of the pre-hospital emergency care system. On the one hand, it has explicitly proposed to strengthen the popularization of emergency care knowledge and skills among the general public; on the other hand, it has also provided legal immunity protection for good-faith rescuers from a legal perspective, aiming to eliminate public concerns about providing assistance [3]. As an important industrial hub in Sichuan Province and a key node city in the Chengdu-Chongqing Economic Circle, Deyang City is experiencing a significant trend of population aging and is home to numerous industrial enterprises, thus facing considerable challenges related to cardiovascular diseases [4]. However, at present, there is a lack of systematic research on the awareness rate, willingness to use, and mastery of operational skills regarding Automated External Defibrillators (AEDs) among the public in Deyang City. This study aims to objectively evaluate the current awareness and willingness to learn about the use of out-of-hospital AEDs among residents in Deyang City through a large-scale questionnaire survey. It also analyzes the key factors influencing the public's willingness to provide assistance, with the intention of providing a scientific basis for relevant departments to optimize the allocation of emergency care resources and formulate precise training policies.

## 2. Data and methods

### 2.1. General information

A total of 1,886 questionnaires were distributed to permanent residents of Deyang City, Sichuan Province, from May 2024 to October 2025, with 1,886 questionnaires collected. After excluding invalid questionnaires with excessively short response times, regular response patterns, or missing key information, a final total of 1,823 questionnaires were included. The general information of the study subjects is shown in **Table 1**. This study complies with the Declaration of Helsinki and has obtained informed exemption.

**Table 1.** Comparison of baseline demographic and clinical characteristics between two groups of patients

| Item | Category | Number of cases (n) | Composition ratio (%) |
|---|---|---|---|
| Gender | Male | 895 | 49.09 |
| | Female | 928 | 50.91 |
| Age (years) | 18–30 | 456 | 26.01 |
| | 31–45 | 684 | 37.52 |
| | 46–60 | 485 | 26.60 |
| | > 60 | 198 | 10.86 |

**Table 1 (Continued)**

| Item | Category | Number of cases (n) | Composition ratio (%) |
|---|---|---|---|
| Education Level | Junior high school or below | 345 | 18.92 |
| | High school / Secondary specialized | 522 | 28.63 |
| | College / Bachelor's degree | 854 | 46.85 |
| | Master's degree or above | 102 | 5.60 |
| Residential Area | Urban | 1350 | 74.05 |
| | Rural | 473 | 25.95 |
| Occupation Type | Enterprise / Institutional Employee | 620 | 34.01 |
| | Student | 285 | 15.63 |
| | Freelancer / Self-employed | 450 | 24.68 |
| | Retiree | 215 | 11.79 |
| | Other | 253 | 13.88 |

## 2.2. Inclusion criteria

(1) Aged 18 years and above;
(2) Residing in the urban area of Deyang City for a period of 6 months or more;
(3) Having complete baseline data.

## 2.3. Exclusion criteria

(1) Individuals engaged in emergency medical professions, who do not represent the general public's cognitive level;
(2) Migrants with an expected residence period of less than 6 months;
(3) Individuals with cognitive, visual, or auditory impairments that prevent them from independently reading the questionnaire or understanding and answering its contents with the assistance of an investigator;
(4) Those who withdraw from the survey midway, refuse to answer key questions, or fill out the questionnaire with obvious logical errors.

## 2.4. Methodology

This study referenced domestic and international literature and the Knowledge-Attitude-Practice (KAP) theoretical model. It employed a self-designed questionnaire titled "Survey on Public Awareness and Willingness for AED Use and Emergency Response in Deyang City". which was validated through expert panel discussions and pre-survey revisions. The questionnaire demonstrated good reliability and validity, with a Cronbach's α coefficient of 0.86 and a Content Validity Index (CVI) of 0.92. The questionnaire primarily encompassed three dimensions: residents' basic information, awareness of AED-related knowledge, and attitudes and willingness towards AED use. The survey was conducted using a combination of online and offline methods. Offline surveys were conducted randomly in high-traffic areas such as Deyang Confucian Temple Square, Wanda Plaza, and community health service centers, while online surveys were distributed through community grid groups. Offline investigators, who underwent unified training, were responsible for on-site explanations and quality control. Data entry employed a double-entry method by two individuals.

## 2.5. Observation indicators

The observation indicators and their definitions in this study are as follows: CPR training prevalence rate: the proportion of surveyed individuals who have participated in CPR-related courses or skill training; AED name recognition rate: the proportion of individuals who can accurately identify and describe AED as an automated external defibrillator; AED function awareness rate: the proportion of individuals who can correctly describe the primary function of AED as treating ventricular fibrillation and eliminating abnormal heart rhythms; AED operation proficiency rate: the proportion of individuals who can correctly describe the standard operating procedure of AED; basic willingness to rescue rate: the proportion of individuals who express willingness to actively rescue patients with cardiac arrest under any circumstances; willingness to rescue rate after skill empowerment: the proportion of individuals who express willingness to actively rescue patients on the premise of having mastered the use of AED; willingness to learn rate: the proportion of individuals who express willingness to participate in AED and first aid knowledge training. Among those who express unwillingness to rescue, they are classified into three types based on their core obstacles: capability panic (due to a complete lack of relevant knowledge and skills), consequence concern (fear of worsening the condition or assuming subsequent responsibility due to improper operation), and social avoidance (unwillingness to interact with strangers for personal reasons).

## 2.6. Statistical methods

Data analysis was conducted using SPSS 22.0 statistical software. Count data were expressed as rates (%), and differences between two groups were compared using the $\chi^2$ test. A $p$-value < 0.05 was considered statistically significant.

# 3. Results

## 3.1. Awareness of AED-related knowledge and skill attainment

The survey results revealed that less than 40% (37.96%) of the respondents had received CPR-related education or training, and there was a clear decreasing trend of "name recognition > functional understanding > operational proficiency". See **Table 2**.

**Table 2.** Awareness of AED-related knowledge and skill proficiency levels

| Indicator | Positive response / compliance cases (n) | Proportion (%) |
|---|---|---|
| Exposure to CPR-related learning or training | 692 | 37.96 |
| Can accurately describe the name of an AED | 619 | 33.96 |
| Can clearly describe the purpose of an AED | 417 | 22.87 |
| Can accurately describe the steps for using an AED | 308 | 16.89 |

## 3.2. AED usage and willingness to learn

The survey results showed that a majority of the respondents expressed a willingness to provide assistance (84.97%), and an overwhelming majority expressed a willingness to learn (95.99%). Furthermore, the proportion of those willing to provide assistance when equipped with relevant skills was even higher compared to the basic willingness to assist (94.95% vs. 84.97%, $\chi^2 = 100.602$, $p < 0.001$). See **Table 3**.

**Table 3.** AED usage and willingness to learn

| Indicator | Positive response / compliance cases (n) | Proportion (%) |
|---|---|---|
| Willingness to provide aid to a sudden cardiac arrest victim | 1549 | 84.97 |
| Willingness to provide aid when equipped with AED skills | 1731 | 94.95 |
| Willingness to learn AED-related knowledge* | 1750 | 95.99 |

Note: Compared to the proportion of those willing to assist without mastering AED usage methods, *$p < 0.05$.

### 3.3. Analysis of factors impeding assistance

Among the 91 respondents who explicitly stated their unwillingness to provide assistance, 75 provided specific reasons and were successfully categorized. The primary factors impeding assistance were fear of inadequate ability (48.00%) and concerns about consequences (42.67%). See **Table 4**.

**Table 4.** Analysis of factors impeding assistance (n = 75)

| Reason category | Specific description | Number of cases (n) | Proportion (%) |
|---|---|---|---|
| Competence panic | Lacking any first-aid knowledge and thus afraid to act | 36 | 48.00 |
| Concern over consequences | Worried that incorrect operation might worsen the patient's condition | 32 | 42.67 |
| Social avoidance | Personal reluctance to engage with strangers | 4 | 5.33 |
| Other | Other reasons | 3 | 4.00 |

## 4. Discussion

Through a questionnaire survey of 1,823 residents in Deyang City, this study reveals that the overall awareness rate of out-of-hospital Automated External Defibrillators (AEDs) and the willingness to provide assistance in the region exhibit a contradictory state of "high willingness but low capability". Specifically, the residents' awareness of AEDs in Deyang City presents an inverted triangular structure, with 33.96% having heard of AEDs, but only 16.89% mastering the correct operational procedures, significantly lower than the levels in first-tier cities such as Shanghai and Shenzhen, as well as in developed countries [5]. Sudden cardiac arrest occurs abruptly, with an extremely short window for rescue, making it difficult for the emergency response system alone to arrive at the scene within the optimal rescue time window. If on-site witnesses lack AED-related skills, even when AED equipment is within reach, it is difficult for it to be effective. The results of this study indicate that only 37.96% of the surveyed individuals reported having received CPR-related education and training, suggesting that most residents in Deyang City may lack basic identification and response capabilities when faced with sudden cardiac arrest.

However, it is noteworthy that the citizens of Deyang demonstrate a high willingness to provide assistance and enthusiasm for learning, in stark contrast to their relatively low level of awareness, which aligns with the research conclusions of Jiao Guangyuan regarding the positivity of the Chinese public's attitude towards first aid [6]. Among those unwilling to provide assistance, a complete lack of first aid knowledge, as well as concerns about exacerbating the patient's condition or assuming subsequent liability due to improper operation, are the primary obstacles to providing aid. Despite the issuance of Article 184 of the Civil Code, which provides strong legal protection for the public's emergency rescue actions, this study still reveals that a considerable portion of the

population remains unwilling to provide assistance due to concerns about their own technical abilities or potential consequences, possibly due to insufficient promotion and dissemination [7]. This phenomenon reflects a lack of knowledge and training in first aid, as the public may still generally hold incorrect perceptions that AED operation is complex and high-risk. However, in reality, the original intent behind AEDs is to enable "foolproof operation" to reduce the cognitive load on users, and they feature automatic rhythm analysis capabilities, ensuring that they will not deliver a shock when it is inappropriate to do so [8]. Therefore, eliminating technical fears may be the key to increasing the rescue rate among residents in Deyang City.

Based on the above findings, this study suggests that, in response to the current situation of low awareness, efforts should not be limited to popular science dissemination through posters and leaflets. Instead, specific CPR/AED practical training should be carried out in communities, enterprises, and schools. This will not only effectively enhance the public's first aid skills but also significantly reduce the psychological stress levels of rescers, thereby facilitating a comprehensive improvement in the willingness to rescue and the success rate of patient assistance [9]. On the other hand, it is essential to further promote relevant legal exemption clauses and disseminate the safety principles of AEDs to alleviate the public's irrational fear that improper operation might worsen the patient's condition. Moreover, incentive measures could be adopted to enhance the willingness of bystanders to provide assistance, thereby enabling everyone to "dare to rescue, be capable of rescuing, and know how to rescue".

## 5. Conclusion

In summary, the general public in Deyang City currently has limited knowledge about AEDs and a low proficiency rate in core operations. Despite a widespread strong willingness to learn and apply AEDs, the main obstacles to providing assistance stem from a lack of skills and concerns about the consequences. Therefore, it is recommended that relevant departments in Deyang City align with the public's willingness by vigorously promoting practical first-aid skills training to increase the out-of-hospital AED usage rate and improve the success rate of resuscitation for patients with cardiac arrest.

## Disclosure statement

The authors declare no conflict of interest.

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# Evidence Summary for Discharge Preparation Services in Patients After Total Knee Arthroplasty

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**Abstract:** *Objective:* To systematically summarize and evaluate the evidence on discharge preparation services for patients undergoing total knee arthroplasty, providing an evidence-based foundation for developing scientific and standardized discharge preparation intervention programs in clinical practice. *Methods*: Following the "5S" evidence model, literature such as guidelines, expert consensuses, evidence summaries and randomized controlled trials related to discharge preparation services for total knee arthroplasty patients were retrieved from relevant websites and databases, both domestic and international, from database inception to August 31, 2025. Two researchers independently screened the literature, conducted quality appraisals, and extracted and synthesized the evidence. *Results:* A total of 15 articles were included, comprising 3 guidelines, 4 expert consensuses, 3 evidence summaries, 3 systematic reviews and 2 randomized controlled trials. Ultimately, 23 pieces of evidence were summarized across five aspects. *Conclusion:* This study synthesizes the evidence on discharge preparation services for patients undergoing total knee arthroplasty. It is recommended that healthcare professionals apply this evidence in clinical practice, considering specific circumstances and patient needs.

**Keywords:** Total knee arthroplasty; Discharge preparation service; Evidence summary; Evidence-based nursing; Rehabilitation

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## 1. Introduction

With the accelerating trend of population aging in our country, the incidence of Knee Osteoarthritis (KOA) has been increasing annually among the elderly population [1]. KOA leads to persistent pain, joint stiffness and restricted mobility, significantly impacting patients' quality of life and their ability to perform daily self-care. Total knee arthroplasty (TKA) is currently the most effective surgical intervention for end-stage KOA and its procedural volume is exhibiting a rapid growth trend both domestically and internationally [2]. Due to the significant trauma of

TKA surgery and the initial postoperative decline in knee function, patients require a prolonged period of in-home rehabilitation. The TKA patient population is predominantly elderly and commonly presents with multiple chronic comorbidities, rendering them susceptible to adverse health outcomes such as falls and hospital readmissions [3]. These factors severely impede postoperative functional recovery and quality of life. Readiness for Hospital Discharge is a critical indicator used to assess a patient's capacity to safely transition to the home environment for rehabilitation. It reflects the patient's self-management capabilities and potential risks post-discharge [4]. Current research indicates that patients undergoing total knee arthroplasty generally exhibit a moderate level of readiness for hospital discharge [5]. This level of preparedness, in turn, directly influences their postoperative rehabilitation outcomes and the risk of readmission [6]. With the growing adoption of accelerated rehabilitation concepts, patient hospitalization times have been significantly reduced. This renders discharge preparation both more time-constrained and rigorous. Consequently, there is a need for an efficient and critical summary of evidence to guide the completion of the most essential assessment, education and planning within the limited timeframe available. Although existing guidelines and consensus encompass perioperative care for TKA patients, evidence specifically targeting the critical transition period of discharge preparation remains dispersed across various studies, lacking systematic and structured integration. This fragmentation of evidence leaves clinical healthcare professionals without unified, scientific standards for implementing discharge guidance. Consequently, this leads to inconsistency and variability in nursing care delivery, making it difficult to effectively meet the complex home rehabilitation needs of patients. Accordingly, this study aims to synthesize the best evidence regarding discharge preparation services for TKA patients, providing a reference for the development of standardized clinical discharge preparation intervention protocols.

## 2. Information and methods

### 2.1. Identification of the evidence-based issues

We used the PIPOST method as a guide to identify research questions [7]. Target Population(P): Patients undergoing TKA; Intervention(I): Discharge preparation measures related to postoperative TKA; Practitioners(P): Clinical medical staff, including physicians, nurses and rehabilitation therapists; Outcomes(O): Readiness for hospital discharge, quality of discharge teaching, knee function scores, among others; Setting(S): Hospitals; Type of evidence(T): Guidelines, evidence summaries, systematic reviews, clinical decision summaries, expert consensus, meta-analyses, randomized controlled trials (RCTs), or well-designed quasi-experimental studies.

### 2.2. Search strategy

Guided by the "5S" evidence model, a systematic top-down search was conducted [8]. The following databases and websites were searched: China National Knowledge Infrastructure (CNKI), VIP Database, Wanfang Data, SinoMed, Chinese Medical Journal Full-text Database, Medlive, PubMed, CINAHL, Web of Science, The Cochrane Library, Embase, Ovid, BMJ, UpToDate, National Institute for Health and Care Excellence (NICE), Guidelines International Network (GIN), Registered Nurses' Association of Ontario (RNAO), Agency for Healthcare Research and Quality (AHRQ), Scottish Intercollegiate Guidelines Network (SIGN), British Orthopaedic Association (BOA) and American Association of Hip and Knee Surgeons (AAHKS).The Search terms was: "Arthroplasty, Replacement, Knee"[Mesh]/total knee replacement / knee prosthesis implantation / knee arthroplasty / major orthopedic surgery / "Patient Discharge"[Mesh] / discharge planning / discharge services /

discharge health education / transitional care / consensus / guideline / systematic review / clinical decision. The search dates were from the establishment of the database to August 31, 2025.

## 2.3. Inclusion and exclusion criteria

### 2.3.1. Inclusion criteria

(1) Study subjects
Patients aged ≥ 18 years who underwent TKA;
(2) Study content
Research related to discharge preparation, discharge planning and discharge education for TKA patients;
(3) Study types
Guidelines, expert consensus, clinical decision support, evidence summaries, systematic reviews, randomized controlled trials (RCTs), or well-designed quasi-experimental studies;
(4) Chinese or English literature.

### 2.3.2. Exclusion criteria

(1) Literatures are not available through various channels;
(2) Literatures was a plan, draft or only an abstract;
(3) Literatures with failed quality evaluation

## 2.4. Quality assessment

The quality assessment of guidelines was conducted using the Clinical Guidelines Research and Evaluation System II (AGREE II); systematic reviews, expert consensus and RCTs were quality appraised using the relevant JBI critical appraisal tools; evidence summaries were critically appraised using the Critical Appraisal for Summaries of Evidence (CASE) tool [9–11].

## 2.5. Evidence extraction and summary

All evidence extraction and synthesis were conducted independently by two researchers. Any disagreements in their findings were resolved by a third researcher through discussion to reach a final consensus. The evidence was integrated according to the following principles: For consistent findings, the most concise and professionally stated source was selected, while complementary findings were combined based on their logical relationship. In the event of conflicting recommendations, priority was given to evidence of higher quality, more recent publications and findings from authoritative literature. In this study, the evidence was classified using the Joanna Briggs Institute (JBI) Levels of Evidence and Grades of Recommendation system [12]. Evidence was categorized into five levels (Level 1–5) based on the study design, with more rigorous designs corresponding to a higher level of evidence. The recommendations were graded as either Grade A (strong recommendation) or Grade B (weak recommendation).

# 3. Results

## 3.1. Search results

The initial search yielded 2,888 articles. After removing duplicates and screening the titles, abstracts and full texts

of the remaining articles, those that did not meet the inclusion criteria were excluded. A final total of 15 articles were included, which comprised 3 guidelines, 4 expert consensus statements, 3 evidence summaries, 3 systematic reviews and 2 RCTs. The literature screening process is shown in **Figure 1,** The general characteristics of the included literatures are shown in **Table 1**.

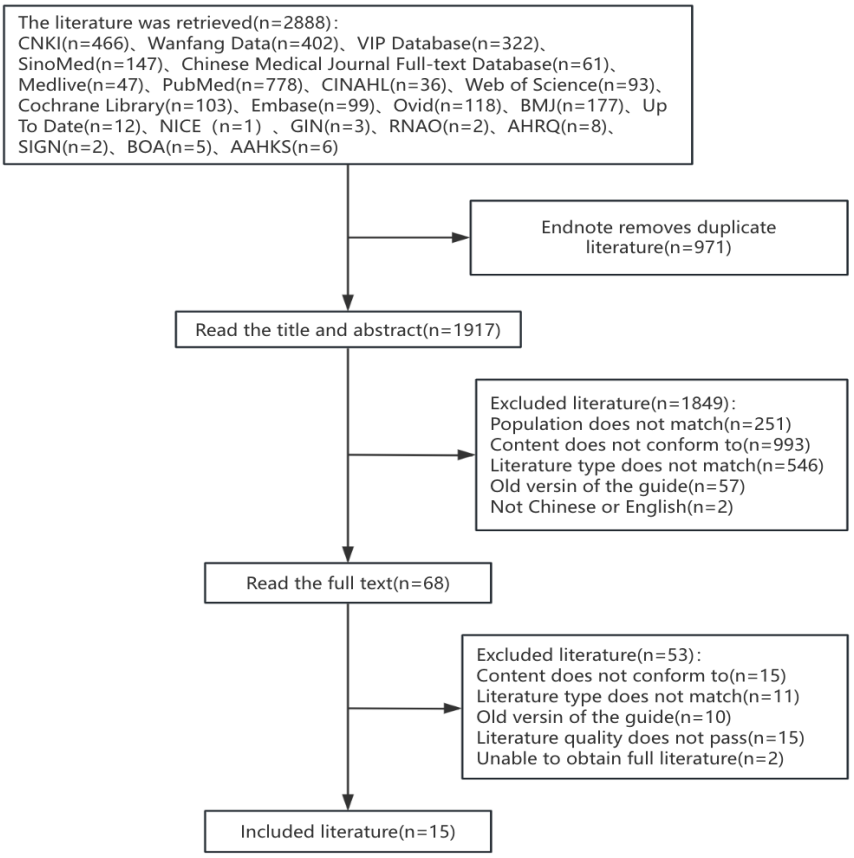



Figure1 Literature screening process

**Figure 1.** Literature screening process.

**Table 1.** General characteristics of the included literatures (n = 15)

| Included literature | Year of publication (year) | Literature reference | Type of literature | The literature theme |
|---|---|---|---|---|
| Jiang Y et al.[13] | 2024 | CNKI | Expert consensus | Expert consensus on optimization of perioperative health education programs in orthopedics under the concept of enhanced recovery after surgery |
| Hu W et al.[14] | 2022 | CNKI | Expert consensus | Expert consensus on perioperative nutritional management for enhanced recovery after major orthopedic surgery |
| Chinese Association for Promotion of Rehabilitation Technology Transfer and Development et al.[15] | 2025 | Chinese Medical Journal Full-text Database | Expert consensus | Expert consensus on perioperative chronic disease management for enhanced recovery in orthopedics and anesthesiology (2025 edition) |

**Table 1 (Continued)**

| Included literature | Year of publication (year) | Literature reference | Type of literature | The literature theme |
|---|---|---|---|---|
| Geriatric Rehabilitation Branch of Chinese Geriatrics Society et al. [16] | 2024 | Chinese Medical Journal Full-text Database | Expert consensus | Chinese expert consensus on perioperative rehabilitation for total knee arthroplasty |
| Jette D U et al.[17] | 2020 | GIN | Guideline | Physical therapist management of total knee arthroplasty |
| Joint Surgery Group of Orthopedics Committee of Beijing Medical Association et al.[18] | 2022 | CNKI | Guideline | Chinese guidelines for perioperative pain management in total knee arthroplasty (2022) |
| RNAO[19] | 2023 | RNAO | Guideline | Transitions in Care and Services |
| Huang Y R et al.[20] | 2023 | CNKI | Evidence summary | Best evidence summary of exercise interventions for patients undergoing total knee arthroplasty |
| Xie Y et al.[21] | 2022 | CNKI | Evidence summary | Best evidence summary of preoperative. prehabilitation for patients undergoing hip/knee arthroplasty under enhanced recovery after surgery |
| Wang H L et al.[22] | 2024 | Chinese Medical Journal Full-text Database | Evidence summary | Best evidence summary of perioperative. enhanced recovery after surgery nursing care for patients undergoing hip/knee arthroplasty |
| Mao H et al.[23] | 2022 | PubMed | Systematic review | Effectiveness of nurse-led discharge service on adult surgical inpatients: a meta-analysis of randomized controlled trials |
| Konnyu K Jet al.[24] | 2023 | PubMed | Systematic review | Rehabilitation for total knee arthroplasty: a systematic review |
| Wang Y et al. [25] | 2020 | BMJ | Systematic review | Quality appraisal of clinical guidelines for venous thromboembolism prophylaxis in patients undergoing hip and knee arthroplasty: a systematic review |
| Mohamad Ghasempour et al.[26] | 2025 | PubMed | RCT | Effect of interdisciplinary discharge programme on daily function, quality of life, and pain intensity in patients undergoing joint replacement surgery |
| Bao L X et al.[27] | 2022 | Chinese Medical Journal Full-text Database | RCT | Application of rehabilitation guidance based on discharge readiness service in total knee arthroplasty |

## 3.2. Quality evaluation results of the included literature

(1) The quality appraisal of the four expert consensus statements revealed them to be of high quality, with all evaluation criteria marked "yes" [13–16].

(2) Three guidelines were included [17–19]. Two were designated Grade A (6 domains scoring ≥ 60%) and one was Grade B (5 domains scoring ≥ 60%). The quality of the three guidelines was high, with detailed standardized scores and recommendation levels presented in **Table 2**.

(3) Three evidence summaries were included [20–22]. These were deemed to be of high quality and included because, with the exception of a "partially yes" rating for item 3 ("Is the reviewer/editor information for the summary transparent?"), all other items on the appraisal tool were rated "yes".

(4) Three systematic reviews were included. The study by Huina Mao et al. met all appraisal criteria ("yes" for all items) [23]. The reviews by Konnyu et al. and Wang et al. also met the threshold for inclusion, with

all items rated "yes" except for item 9 ("Did the review authors use a satisfactory technique for assessing the risk of bias in individual studies that were included in the review?"), which was rated "unclear" [24,25].

(5) Two RCTs were included in the review [26,27]. The quality appraisal for both studies resulted in a "no" rating for item 4 ("Were participants blind to treatment assignment?") and item 5 ("Were those delivering the treatment blind to treatment assignment?"). Additionally, item 10 ("Was follow up complete and if not, were differences between groups in terms of their follow up adequately described and analyzed?") was rated "unclear". All other items were rated "yes", the studies were considered to be of high quality and were included.

**Table 2.** Quality evaluation results of clinical guidelines (n = 3)

| Guideline | Standardized scores in various domains (%) | | | | | | ≥ 60% | ≥ 30% |
|---|---|---|---|---|---|---|---|---|
| | Scope and purpose | Stakeholder involvement | Rigor of development | Clarity of presentation | Applicability | Editorial independence | | |
| Diane U Jette et al. [17] | 98.15 | 83.33 | 88.89 | 87.04 | 77.78 | 100 | 6 | 6 |
| Joint Surgery Group of Orthopedics Committee of Beijing Medical Association et al. [18] | 85.19 | 79.63 | 86.81 | 92.59 | 52.78 | 100 | 5 | 6 |
| RNAO [19] | 96.30 | 96.30 | 91.67 | 88.89 | 66.28 | 100 | 6 | 6 |

## 3.3. Summary and description of evidence

This study synthesized the evidence regarding discharge preparation services for TKA patients, ultimately generating 25 items of evidence organized into 5 themes, as shown in **Table 3**.

**Table 3.** Evidence summary for discharge preparation services in patients after total knee arthroplasty

| Category | Content of evidence | Level | Recommendation level |
|---|---|---|---|
| Admission assessment and education | 1. Establish a multidisciplinary team composed of orthopedic doctors, rehabilitation doctors, specialist nurses, nutritionists, psychological counselors, etc., and conduct standardized training for the team in the intervention of discharge preparation for TKA [19–21,23,26,27] | 1 | A |
| | 2. Evaluate the patient's personal condition, disease-related indicators (knee joint range of motion, lower limb muscle strength, degree of joint deformity and pain), health literacy, social support (economic status, living environment, care ability), etc. and based on the situation, a multidisciplinary team jointly formulates a discharge preparation plan [13,15,19,27] | 5 | A |
| | 3. Explain the surgical plan, rehabilitation plan and knowledge of artificial joint protection to the patient, emphasize the importance of active knee joint exercise in the early postoperative period and encourage the patient to participate in self-management [21] | 5 | B |
| | 4. Conduct comprehensive preoperative examinations to screen for and intervene in osteoporosis, correct anemia, and address other chronic diseases [22] | 5 | A |
| Preoperative preparation and education | 5. Cease smoking and alcohol and maintain a BMI40kg/$m^2$, Underlying comorbidities should be managed as follows: maintain fasting blood glucose 8 mmol/L in diabetic patients; control preoperative blood pressure below 160/90 mmHg in hypertensive patients; discontinue clopidogrel 5–7 days preoperatively in patients with coronary heart disease; preoperative use of opioid analgesics should be avoided to prevent postoperative tolerance [15,21,22] | 5 | A |
| | 6. Conduct health education, covering postoperative rehabilitation plans, nutritional support, prevention of complications, safe transfer techniques, the use of assistive devices, fall prevention and factors influencing discharge readiness [13,15,17,21,26] | 5 | B |

**Table 1 (Continued)**

| Category | Content of evidence | Level | Recommendation level |
|---|---|---|---|
| | 7. Nutritional Support: Administer high-protein nutritional support to malnourished patients (e.g., albumin < 35 g/L). For high-risk patients, implement combined enteral and parenteral nutrition for 7–14 days preoperatively, aiming for a target protein intake of 1.5–2.0g/(kg·d) [14,15] | 5 | A |
| | 8. Initiate a prehabilitation program 4–8 weeks preoperatively, emphasizing intensive quadriceps strengthening, balance training and cardiopulmonary conditioning to enhance muscle strength and knee joint stability [13,15,16,21] | 5 | A |
| Postoperative care and rehabilitation | 9. Multimodal Analgesia: Implement the routine administration of analgesics combined with localized knee cryotherapy to alleviate swelling and pain. Pain management protocols and patient education strategies should be adjusted in a timely manner based on pain assessment outcomes [13,18,22] | 5 | A |
| | 10. Incorporate Traditional Chinese Medicine analgesic techniques（specifically auricular point sticking and early postoperative acupuncture）as complementary therapies for pain management if resources permit [18] | 5 | B |
| | 11. Resume oral food intake as early as possible after the operation. Prioritize the supplementation of high-quality protein. For those with poor function, take oral digestive enzymes or enteral nutrition preparations. If necessary, introduce human albumin. The target is: albumin > 35g/L, prealbumin > 200mg/L [14,15,21] | 5 | A |
| | 12. Deep Vein Thrombosis Prophylaxis: Adjust anticoagulation regimens dynamically based on patient risk assessments. Instruct patients to engage in early postoperative ambulation and implement appropriate therapeutic interventions and mechanical prophylaxis [13,16,25] | 1 | A |
| | 13. Positioning Management: Instruct patients to maintain the operated knee in a flexed position (30–90°) during rest to minimize immediate postoperative blood loss and swelling. Placing a pillow under the knee is recommended to prevent flexion contractures [16,17] | 1 | A |
| | 14. Initiate rehabilitation exercises, including ankle pumps and quadriceps isometric contractions, immediately upon the subsidence of anesthesia. Mobilization should occur within 24 hours postoperatively, utilizing a walker for gait training. The regimen should begin with low-intensity isometric and isotonic exercises, gradually transitioning to resistance training to facilitate the timely achievement of discharge criteria. [13,17,20,22,24,27] | 1 | A |
| | 15. Initiate gait correction and activities of daily living training as early as possible to enhance transfer and personal care abilities (e.g. bed-to-chair transfers, toileting, grooming and dressing). For patients demonstrating poor adherence, employ “education-feedback” model to provide iterative guidance. Avoided to routine use Continuous Passive Motion [13,17,22,24,27] | 1 | A |
| | 16. Utilize neuromuscular electrical stimulation to enhance quadriceps strength； doing sports in the water under the premise of taking good waterproof of measures for the wound can reduce the pressure on the joints； apply motor imagery therapy may activate brain nerves, enhance motor learning, assist in pain relief and promote early functional recovery [16,18,20,21] | 5 | B |
| | 17. Record the factors that hinder the implementation of postoperative rehabilitation exercises (such as kynophobia and pain), and the multidisciplinary team discusses and adjusts the training plan [22] | 5 | A |
| Discharge assessment and guidance | 18. Objective discharge criteria: (1) dressing independently;(2) transfer in and out of bed independently;(3) independently transfer to a chair or toilet;(4) mobilize independently with the aid of walker or crutches;(5) perform personal care independently;(6) Walk more than 70 meters with crutches [20] | 5 | B |
| | 19. Formulate individualized rehabilitation protocols (exercise frequency and intensity) tailored to patient tolerance and specific needs. Remote rehabilitation guidance for patients can be used if conditions permit [16,20] | 5 | A |
| | 20. Home environment assessment and modification: Conduct a survey of the patient’s living environment and recommend necessary modifications to domestic facilities. Provide targeted Activities of Daily Living training for both patients and caregivers. This should be followed by a cycle of assessment, analysis and retraining until full mastery is achieved [26,27] | 1 | A |
| Follow-up and continuity of care | 21. A multidisciplinary team assesses the rehabilitation needs of patients after discharge and provides knee joint monitoring and continuous support [14,19,22,23] | 5 | A |

**Table 1 (Continued)**

| Category | Content of evidence | Level | Recommendation level |
|---|---|---|---|
| | 22. Outpatient follow-ups were conducted at 1- and 3-months post-discharge to assess knee joint function, surgical incision status, complication prevention, and adherence to rehabilitation exercises. If issues were identified, a new round of intervention was initiated [19,27] | 1 | B |
| | 23. Upon the restoration of postoperative function, the following training modalities are recommended:(1) Aerobic Exercise: Priorities should be given to activities with relatively low joint loading, such as walking, cycling, swimming and rowing; (2) Functional Training: Interventions should target specific activities of daily living that are currently impaired, including brisk walking, stair climbing and sit-to-stand maneuvers. High-impact sports, such as running and soccer are not recommended. Instead, patients are advised to engage in low-to-moderate intensity exercises, such as walking, cycling and swimming [20] | 5 | A |

# 4. Discussion

## 4.1. Exploration and application of standardized pathways for multidisciplinary team collaboration in discharge planning services

Substantial evidence from this study indicates that Multidisciplinary Team (MDT) constitute a pivotal component in establishing a comprehensive and coordinated discharge planning service framework [19–21,23,26,27]. Establish a dynamic collaborative mechanism composed of multidisciplinary healthcare professionals, including orthopedic surgeons, rehabilitation physicians, specialist nurses and dietitians. However, in clinical practice, discrepancies in the work rhythms of different disciplines make it challenging to maintain high-frequency, full-team in-person MDT rounds, may reduce discharge planning to a mere formality. As nurses maintain continuous contact with patients, they act as a pivotal communication hub to facilitate MDT collaboration, thereby enabling the provision of systematic, continuous and individualized intervention plans for patients. This holistic team collaboration facilitates the simultaneous resolution of complex issues such as postoperative pain, functional impairment, malnutrition and anxiety. Consequently, it improves the quality of patient rehabilitation and enhances their readiness for discharge [23,26].

The 23 pieces of evidence summarized in this study are derived from diverse sources and are scattered in content. This has led to variations in practice across institutions regarding discharge education, assessment tools and functional training standards, thereby hindering the standardization and homogenization of discharge planning services. To promote the clinical application of the MDT model, it is essential to integrate fragmented evidence into structured standardized protocols. This involves clearly delineating the specific responsibilities and handover details of physicians, nurses, rehabilitation therapists, and dietitians during the perioperative period. Such clarity facilitates effective collaboration and ensures the integrity and continuity of interventions, thereby improving service quality, enhancing patients' confidence in rehabilitation and optimizing discharge planning services.

## 4.2. Systematic rehabilitation intervention is a key strategy for discharge planning services in TKA

Most TKA patients suffer from chronic comorbidities, and there is significant heterogeneity in their functional and rehabilitation needs. Consequently, the team must complete a comprehensive assessment within 24 hours of admission. This evaluation encompasses sociodemographic characteristics, disease-specific functional indices, health literacy, and psychosocial support, thereby laying the foundation for formulating subsequent individualized

discharge plans [13,15,19,27]. As most patients are elderly with limited cognitive and self-management capabilities, active caregiver participation and shared decision-making among medical staff, patients and families are crucial for the successful implementation of care plans. These factors effectively enhance adherence to rehabilitation training and home management [28,29]. Therefore, it is essential to strengthen systematic caregiver education within discharge planning services, enhancing their ability to assist in various aspects and ultimately supporting better patient recovery [30].

Evidence 3–8 underscores the critical importance of preoperative preparation and education. Based on the initial assessment, interventions should include chronic disease control, nutrition and weight management, thrombosis prevention and prehabilitation training. The use of the "teach-back method" (Evidence 15) is recommended, requiring patients to retell or demonstrate rehabilitation maneuvers and knowledge to validate their mastery. At this stage, caregivers should not only provide emotional support and supervision but also actively participate in the decision-making process. They are expected to assist patients in comprehending health education content and receive necessary training in caregiving skills to enhancing the practical effectiveness of family support [31].

Factors such as early postoperative pain, fatigue and Kinesio phobia can significantly impede rehabilitation progress [32]. In the context of Enhanced Recovery After Surgery (ERAS), hospital lengths of stay are significantly shortened, systematic rehabilitation becomes particularly crucial [33]. Evidence 9–17 emphasizes the implementation of systematic postoperative rehabilitation led by the MDT. This encompasses pain management, range of motion (ROM) exercises, training in self-care abilities, nutritional guidance and psychological support. It also suggests incorporating Traditional Chinese Medicine (TCM) modalities, including auricular acupressure, acupuncture, Kinesio taping and lymphatic drainage, to mitigate pain and swelling [34]. Throughout the entire process, standardized tools should be continuously utilized to assess patients' knee joint function and rehabilitation adherence. Concurrently, caregivers' caregiving capabilities should be enhanced through methods such as illustrated materials, demonstration videos, or scenario-based training, ensuring that they can correctly assist and supervise patients in completing the discharge preparation plan [31].

To ensure safe patient discharge and a smooth transition to home-based rehabilitation, pre-discharge assessment and preparation are also crucial. The patient's discharge readiness should be comprehensively evaluated based on the objective criteria of Evidence 18, combined with an assessment of their family and social support. Because stairs, anti-slip measures in the home environment and caregiver competence all affect patient safety, evidence 20 recommends assessing the home environment and making modifications where necessary [35]. Additionally, it advises strengthening caregiver training in safe transfer, ambulation assistance, and rehabilitation support skills to ensure a safe transition for patients and reduce home safety risks.

## 4.3. Continuous follow-up supported by information technology is an important approach to enhancing the quality of discharge preparation services

With the widespread adoption of ERAS concepts, the average length of stay for TKA has been significantly shortened. However, postoperative patients still undergo a prolonged period of functional recovery after discharge; therefore, discharge preparation services should be extended from the hospital to the community and home. Evidence 22 and 23 indicate that post-discharge follow-ups should be conducted to assess patients' knee joint function, pain control and rehabilitation exercise status, allowing for the dynamic adjustment of rehabilitation plans. In clinical practice, the development of "Internet + Healthcare" has further expanded the scope of discharge preparation services, enabling remote rehabilitation guidance and process monitoring [36,37]. For instance, mobile

applications and wearable devices can record metrics such as joint range of motion and gait in real-time [38]. This assists in identifying patients' recovery status, facilitating a shift from fixed scheduled follow-ups to on-demand interventions and allowing the team to make individualized adjustments.

However, the application of information technology remains limited by factors such as patient acceptance, regional resources and cost [36,39]. To ensure standardized post-discharge management, the development of a unified discharge preparation management platform that provides targeted rehabilitation guidance should be explored. At the same time, it is essential to enhance the information tool proficiency of both patients and caregivers, leveraging data support to achieve continuous cross-stage nursing care. Furthermore, collaboration between hospitals and community health service centers should be actively promoted. By having community nurses assume partial monitoring and guidance responsibilities, a system of hierarchical medical care can be implemented to optimize the allocation of medical resources. This approach contributes to facilitating patients' long-term functional recovery and lowering the risk of readmission.

### 4.4. Limitations

Although this study comprehensively summarizes 23 pieces of evidence regarding discharge readiness interventions for TKA patients and we recommend their adoption. However, some of the recommendations are affected by regional and cultural differences and need to be adjusted considering local realities. Discharge preparation services involve multi-disciplinary and multi-stage collaboration. The integration effect and long-term impact still need further research for verification and optimization.

## 5. Conclusion

Utilizing an evidence-based approach, this study systematically searched and synthesized high-quality evidence regarding discharge preparation services for patients undergoing TKA. These findings provide a foundation for constructing a scientific, systematic and operable TKA discharge preparation service protocol and is significant for promoting safe patient discharge and improving rehabilitation outcomes. Besides, discharge preparation services should regard as a standardized and mandatory clinical pathway rather than an optional supplementary service. In clinical practice, should made efforts to establish an evidence-based minimum standardized intervention protocol, including mandatory assessment items, core educational content and safety goals that must be achieved prior to discharge, to ensure basic service quality. Furthermore, future research should integrate clinical requirements with appropriate technologies to further validate the effectiveness of procedural implementation, thereby driving the continuous improvement of TKA discharge preparation services.

## Disclosure statement

The authors declare no conflict of interest.

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# Research on the Clinical Efficacy of Integrated Medical-Nursing Comprehensive Care for Patients with Cerebral Infarction

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**Abstract:** *Objective*: To analyze the application effectiveness of the integrated medical-nursing comprehensive care model in cases of cerebral infarction and clarify its clinical practical value for the patient rehabilitation process. *Methods*: A total of 60 patients with cerebral infarction admitted from June 2024 to December 2024 were selected as the research subjects and randomly divided into a control group and a research group, with 30 cases in each group. Patients in the control group received routine clinical nursing measures, while those in the study group underwent collaborative healthcare intervention in addition to routine nursing. The intervention included joint disease assessment, personalized rehabilitation training guidance, psychological counseling, and continuous nursing services after discharge. A comparative study was conducted by evaluating indicators such as the scores on adverse emotion scales, the extent of neurological recovery, the effectiveness rate of clinical rehabilitation treatment, and the level of satisfaction with nursing services between the two groups. *Results:* After the intervention, the scores on the Self-Rating Anxiety Scale (SAS) and the Self-Rating Depression Scale (SDS) in the study group decreased to (40.12 ± 5.01) and (41.36 ± 5.20), respectively, both significantly lower than those in the control group, which were (47.36±5.82) and (48.95 ± 5.63), respectively. The differences between the two groups were statistically significant ($p < 0.05$). The improvement in the neurological deficit scores of patients in the study group reached (9.18 ± 2.04), higher than that in the control group, which was (5.17 ± 1.82) ($p < 0.05$). The overall clinical rehabilitation effectiveness rate in the study group was 93.3%, significantly higher than that in the control group, which was 73.3%. The satisfaction rate with nursing services in the study group reached 96.7%, also higher than that in the control group, which was 83.3%. The differences between the two groups were statistically significant ($p < 0.05$). *Conclusion:* The integrated healthcare nursing model can effectively alleviate adverse emotional states in patients with cerebral infarction, facilitate the repair and reconstruction of neurological function, improve the effectiveness of clinical rehabilitation treatment and satisfaction with nursing services, and thus holds high value for clinical promotion and application.

**Keywords:** Healthcare integration; Cerebral infarction; Comprehensive nursing; Neurological function recovery; Nursing satisfaction

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# 1. Introduction

Cerebral infarction is a clinically prevalent ischemic cerebrovascular disease characterized by high morbidity, disability, and mortality rates, making it one of the primary diseases that seriously endanger public health [1]. Patients often experience neurological impairments such as limb paralysis, abnormal bodily sensations, and language dysfunction due to ischemia and hypoxia in brain tissue, which have a persistent negative impact on their daily quality of life. Traditional nursing models exhibit drawbacks such as fragmented service processes and a lack of continuity in intervention measures in terms of patient condition management, psychological and emotional counseling, and rehabilitation training guidance, making it difficult to fully meet the actual needs of cerebral infarction patients for systematic rehabilitation interventions. The integrated healthcare comprehensive nursing model has gradually gained attention and importance in clinical practice. This model relies on healthcare professionals collaborating to conduct condition assessments, jointly formulating individualized intervention plans, and establishing long-term communication and feedback mechanisms to provide patients with more precise, unified, and continuous full-course nursing services.

This nursing model demonstrates good application potential in improving patients' negative emotions and promoting neurological function recovery. This study, based on the core concepts of healthcare collaboration and comprehensive nursing services, explores the application value and innovative points of this nursing model in the nursing care of cerebral infarction patients, aiming to provide a reference basis for optimizing and improving clinical nursing models.

# 2. Materials and methods

## 2.1. General information

Sixty patients with cerebral infarction who received treatment in our hospital from June 2024 to December 2024 were selected for inclusion in the study. All enrolled cases met the clinical diagnostic criteria for cerebral infarction, were in a stable condition, and were able to cooperate in completing the entire research process. Using a random number table method, these patients were divided into a control group and a research group, with 30 cases in each group. Comparisons of basic data such as gender distribution, age range, disease duration, and location of infarction lesions between the two groups did not reach statistically significant differences ($p > 0.05$), meeting the conditions for inter-group comparison. This research protocol has been reviewed and approved by the hospital's ethics committee, allowing clinical observation to be conducted after fully informing patients and their families about the details of the study.

## 2.2. Inclusion and exclusion criteria

### 2.2.1. Inclusion criteria

Meeting the diagnostic criteria corresponding to the imaging examination characteristics and clinical symptoms of cerebral infarction; having stable vital signs and a clear state of consciousness; possessing normal language communication and comprehension abilities, enabling cooperation in completing various assessment scale fill-outs; both the patients themselves and their families voluntarily participating in this study and signing written informed consent documents.

### 2.2.2. Exclusion criteria

Patients with severe dysfunction of vital organs such as the heart, liver, and kidneys; those accompanied by psychiatric disorders, cognitive impairment, or inability to cooperate in completing nursing intervention measures; those with concurrent acute infectious diseases or other conditions that may interfere with the assessment indicator results; and those who have received other systematic rehabilitation nursing interventions prior to hospital admission for treatment.

## 2.3. Nursing methods

### 2.3.1. Control group

Implement routine clinical nursing measures, including dynamic monitoring of the patient's condition during hospitalization, observation of basic vital signs, and timely management of sudden changes in the patient's condition. Strictly follow medical advice to guide patients in standard medication use, while also carrying out basic life care tasks, such as assisting with eating, skin cleaning and care, proper positioning, and implementing measures to prevent pressure ulcers.

### 2.3.2. Study group

On the basis of routine nursing measures, implement an integrated medical-nursing comprehensive care model intervention. Collaboratively, the attending physician and responsible nurse work together to develop a nursing plan and rehabilitation training program tailored to the individual patient's condition, clearly defining intervention goals, specific implementation measures, and periodic arrangements.

Psychological nursing care runs through the entire hospitalization treatment cycle of patients. Responsible nurses regularly assess patients' negative emotions such as anxiety and depression and employ intervention techniques including one-on-one communication, positive language encouragement, and relaxation training guidance to alleviate patients' psychological stress and enhance their confidence in treatment and recovery. Rehabilitation training programs are tailored based on the degree of neurological deficits and recovery status of patients, encompassing limb motor function training, swallowing function training, body balance ability training, and daily living self-care ability training. These programs are carried out progressively under the joint guidance of medical staff to ensure the scientific nature and safety of the training process.

Health education is conducted simultaneously for patients and their families, covering aspects such as the pathogenesis of cerebral infarction, management of disease risk factors, norms for medication administration, and implementation of secondary prevention measures. This helps patients establish scientific and healthy behavioral patterns during their hospitalization. After patients are discharged from the hospital, continuous nursing services are initiated. Through telephone follow-ups and home visits, the improvement of patients' symptoms, the progress of rehabilitation training implementation, and potential nursing-related issues after discharge are tracked, providing patients with ongoing rehabilitation guidance suggestions and psychological support services.

## 2.4. Observation indicators

The changes in negative emotional states of patients in both groups before and after nursing interventions were observed. Quantitative scoring assessments were performed using the Self-Rating Anxiety Scale (SAS) and the Self-Rating Depression Scale (SDS). The progress of neurological function recovery in patients from both groups was compared, with evaluations conducted based on the commonly used clinical scale for assessing neurological

deficits. The dimensions for evaluating rehabilitation outcomes included the degree of improvement in limb motor function, enhancement in daily living self-care abilities, and other aspects. A comprehensive judgment was made by combining the results of clinical symptom observations with scale scoring data.

### 2.5. Statistical methods

Data processing was carried out using the SPSS statistical analysis software. Measurement data were presented in the form of mean ± standard deviation ( $\overline{x} \pm s$), and comparisons between groups were made using the independent samples *t*-test. Count data were expressed as rates or composition ratios, and comparisons between groups were conducted using the $\chi^2$ test. A significance level of $p < 0.05$ was used as the criterion to determine that differences between groups were statistically significant.

## 3. Results

### 3.1. Comparison of negative emotions between the two groups of patients

After the nursing intervention, the scores of the Self-Rating Anxiety Scale (SAS) and the Self-Rating Depression Scale (SDS) in both groups showed a downward trend compared to those before the intervention, with a more significant decrease observed in the study group. The SAS and SDS scores of patients in the study group were significantly lower than those in the control group at the same time point ($p < 0.05$), suggesting that the integrated medical-nursing comprehensive care model had a more desirable intervention effect in alleviating negative emotions in patients with cerebral infarction. See **Table 1** for details.

**Table 1.** Comparison of negative emotion scores between the two groups (score, $\overline{x} \pm s$)

| Group | n | SAS (Pre-care) | SAS (Post-care) | SDS (Pre-care) | SDS (Post-care) |
|---|---|---|---|---|---|
| Control | 30 | 58.42 ± 6.15 | 47.36 ± 5.82 | 59.17 ± 6.40 | 48.95 ± 5.63 |
| Experimental | 30 | 58.58 ± 6.09 | 40.12 ± 5.01 | 59.33 ± 6.28 | 41.36 ± 5.20 |
| *t*-value | | 0.09 | 5.27 | 0.10 | 5.36 |
| *p*-value | | > 0.05 | < 0.05 | > 0.05 | < 0.05 |

### 3.2. Comparison of neurological function recovery between the two groups

After the nursing intervention, the decrease in neurological deficit scores in the study group was greater than that in the control group, with a statistically significant difference between the groups ($p < 0.05$), indicating that the integrated medical-nursing comprehensive care model had a prominent advantage in promoting neurological function reconstruction in patients with cerebral infarction. See **Table 2** for details.

**Table 2.** Comparison of neurological deficit scores between the two groups (score, $\overline{x} \pm s$)

| Group | n | Pre-care score | Post-care score | Improvement score |
|---|---|---|---|---|
| Control | 30 | 18.63 ± 3.72 | 13.46 ± 3.10 | 5.17 ± 1.82 |
| Experimental | 30 | 18.70 ± 3.68 | 9.52 ± 2.86 | 9.18 ± 2.04 |
| *t*-value | | 0.07 | 5.29 | 7.62 |
| *p*-value | | > 0.05 | < 0.05 | < 0.05 |

### 3.3. Comparison of rehabilitation outcomes between the two groups

The rehabilitation outcomes were comprehensively evaluated based on dimensions such as the degree of recovery of limb motor function and improvement in daily living self-care ability. The significant efficiency and overall effective rate of rehabilitation treatment in the study group were significantly higher than those in the control group, with a statistically significant difference between the groups ($p < 0.05$). See **Table 3** for details.

**Table 3.** Comparison of rehabilitation outcomes between the two groups [n (%)]

| Group | n | Markedly effective | Effective | Ineffective | Total effective rate |
|---|---|---|---|---|---|
| Control | 30 | 9 (30.0) | 13 (43.3) | 8 (26.7) | 22 (73.3) |
| Experimental | 30 | 16 (53.3) | 12 (40.0) | 2 (6.7) | 28 (93.3) |
| $\chi^2$ | | | | | 5.12 |
| *p*-value | | | | | < 0.05 |

### 3.4. Comparison of nursing satisfaction between the two groups of patients

The study group scored higher than the control group in survey items such as nursing service attitude, doctor-patient communication effectiveness, and professionalism of rehabilitation guidance. The overall nursing satisfaction in the study group was significantly better than that in the control group, with statistically significant differences between the groups ($p < 0.05$). This indicates that the integrated medical-nursing comprehensive care model has a positive effect on improving the quality of clinical nursing services. See **Table 4** for details.

**Table 4.** Comparison of nursing satisfaction between the two groups [n (%)]

| Group | n | Very Satisfied | Satisfied | Not Satisfied | Total Satisfaction |
|---|---|---|---|---|---|
| Control | 30 | 14 (46.7) | 11 (36.7) | 5 (16.6) | 25 (83.3) |
| Experimental | 30 | 21 (70.0) | 8 (26.7) | 1 (3.3) | 29 (96.7) |
| $\chi^2$ | | | | | 4.12 |
| *p*-value | | | | | < 0.05 |

## 4. Discussion

### 4.1. The effect of integrated medical-nursing comprehensive care on improving negative emotions in patients with cerebral infarction

After the onset of cerebral infarction, patients often experience varying degrees of negative emotions such as anxiety and depression. These emotional responses not only reduce patients' clinical treatment compliance but also exacerbate the body's stress response, thereby adversely affecting the process of neurological recovery. The data from this study shows that although the SAS and SDS scores of patients in the control group decreased after nursing compared to before, the decline in scores was more pronounced in the study group. The SAS and SDS scores in the study group decreased to (40.12 ± 5.01) and (41.36 ± 5.20), respectively, both significantly better than the control group's scores of (47.36 ± 5.82) and (48.95 ± 5.63) ($p < 0.05$).

The collaborative healthcare model between doctors and nurses enables patients to receive more consistent and continuous information support related to their diseases, reducing anxiety caused by asymmetric information

transmission. During the process of clinical treatment and nursing intervention, doctors are responsible for explaining the progression of the disease and the principles of the treatment plan to patients and their families, while nurses undertake daily psychological counseling. Through interventions such as verbal guidance, emotional state assessment, and relaxation training instruction, nurses strengthen patients' self-emotional regulation abilities [2]. This nursing model compensates for the deficiencies in traditional nursing models, such as insufficient attention to psychological intervention and a lack of systematic intervention measures. It establishes a stable psychological support system for patients, helping them adjust their psychological states more effectively and enhancing their ability to cope with the disease.

## 4.2. Analysis of the promoting mechanism on neurological function recovery and rehabilitation outcomes

The repair of neurological damage in patients with cerebral infarction after onset depends on standardized rehabilitation training and timely, dynamic collaborative medical and nursing interventions. In this study, the neurological deficit scores of patients in the research group significantly decreased to (9.52 ± 2.86) points after nursing, with a greater decrease compared to the control group's (13.46 ± 3.10) points. The improvement value reached (9.18 ± 2.04) points, significantly higher than the control group's (5.17 ± 1.82) points ($p < 0.05$). The promoting mechanism of this nursing model is mainly reflected in the multi-dimensional collaborative aspect. The medical and nursing teams jointly participate in setting rehabilitation training goals for patients and dynamically adjust training plans according to the patient's recovery stage, making rehabilitation training measures more systematic and continuous. In terms of rehabilitation outcomes, the overall rehabilitation effectiveness rate in the study group reached 93.3%, significantly higher than the 73.3% in the control group. This result is closely related to factors such as the improvement of patients' negative emotions, the enhancement of the standardization of rehabilitation training, and the increased consistency of rehabilitation guidance [3].

## 4.3. Comparative advantages over traditional nursing models

Traditional nursing models emphasize that nursing staff complete various nursing operation tasks in accordance with medical orders. However, the information exchange between doctors and nursing staff is relatively limited, making it difficult to fully synchronize the implementation process of nursing goals and resulting in a lack of continuity in nursing service content.

The integrated medical-nursing comprehensive nursing model breaks through the limitations of traditional nursing models and establishes an efficient and collaborative work system. Team members enhance the coordination of roles between medical and nursing staff and improve the timeliness, pertinence, and accuracy of nursing measure implementation by jointly participating in ward rounds, collaboratively formulating nursing plans, and communicating in real-time about patients' latest conditions [4]. Another notable advantage of this care model is reflected in the aspect of service continuity. Traditional care models primarily focus on services provided during a patient's hospitalization, whereas the integrated physician-nurse care model emphasizes the importance of continuous care services, extending rehabilitation guidance into the post-discharge life stage of patients. This ensures that patients can still receive professional rehabilitation support in their home environment.

## 4.4. Innovation and clinical promotion value of this study

This study introduces the concept of integrated physician-nurse care services, integrating neurological

rehabilitation training, psychological state intervention, health knowledge education, and continuous care services into a comprehensive care service chain. It innovatively addresses the issue of fragmented services in traditional care models.

The integrated physician-nurse care model adheres to a patient-centered service philosophy, achieving homogeneous care services through teamwork. This core concept is highly aligned with the goal of "whole-course disease management" advocated by modern medicine [5].

### 4.5. Research limitations and future research directions

This study included a sample size of 60 cases, with a research period set at half a year. Although the research results can preliminarily demonstrate the effectiveness of the application of the integrated medical-nursing comprehensive care model, there are still certain limitations. The relatively limited sample size may impact the generalizability of the research conclusions. Future studies could further expand the sample inclusion scale, extend the follow-up observation period for patients, conduct stratified research on different types of cerebral infarction patients, and explore research directions that combine with intelligent rehabilitation equipment and telemedicine technology to construct a more multidimensional and efficient collaborative medical-nursing service model.

## 5. Conclusion

The integrated medical-nursing comprehensive care model establishes a collaborative service system between medical and nursing staff, enabling cerebral infarction patients to receive continuous, systematic, and individualized intervention support during their hospitalization and rehabilitation process. The results of this study indicate that this care model can significantly alleviate negative emotions such as anxiety and depression in patients, enhance their emotional stability, and improve their psychological experiences. The decline in neurological deficit scores among patients in the study group was significant, and both the effectiveness of rehabilitation treatment and the improvement in daily living self-care ability were superior to those in the control group. This suggests that the integrated medical-nursing intervention model has a positive effect on promoting the reconstruction of patients' neurological functions. In terms of nursing satisfaction, the overall satisfaction in the study group was significantly higher than that in the conventional care group, indicating that patients have a higher recognition of the joint medical-nursing management model, the consistency of doctor-patient communication, and the professionalism of rehabilitation guidance.

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# Observation and Study on the Therapeutic Effect of Diuretics in Patients with Cirrhotic Ascites

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**Abstract:** *Objective:* This study aims to systematically evaluate the clinical efficacy and safety of diuretic therapy in patients with liver cirrhosis ascites. *Method:* 60 patients with liver cirrhosis ascites diagnosed from January 2024 to May 2025 were prospectively included and randomly divided into a furosemide monotherapy group (20 cases), a spironolactone monotherapy group (20 cases), and a combination therapy group (20 cases). The intervention period is 28 days, and the main observation indicators include 24-hour urine output, changes in abdominal circumference, weight loss, serum electrolyte levels, renal function indicators, and incidence of adverse reactions. All study subjects received standardized dietary management and sodium restriction intervention (daily sodium intake < 5 g). *Result:* The total effective rate (significant + effective) of the combination therapy group in reducing ascites was 95% (19/20), significantly higher than the 75% (15/20) of the furosemide group and the 70% (14/20) of the spironolactone group ($p < 0.01$). On the 28th day of treatment, the mean urine output in the combination group was 2450 ± 210 mL/d, which was higher than that in the monotherapy group (1850 ± 195 mL/d in the furosemide group); Spironolactone group 1560 ± 180 mL/d. The blood sodium levels of the three groups were maintained at 135–140 mmol/L, but the incidence of hypokalemia in the combination group (10%) was significantly lower than that in the furosemide group (35%). *Conclusion:* The combination of furosemide and spironolactone has a synergistic effect in the treatment of ascites in cirrhosis, with a 39.2% increase in diuretic effect and a reduction in the risk of electrolyte imbalance; Individualized dose adjustment combined with strict sodium restriction is the core strategy to ensure treatment safety.

**Keywords:** Diuretic therapy; Cirrhotic ascites patients; Clinical efficacy

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## 1. Introduction

Cirrhotic ascites, as the most significant clinical complication of decompensated liver function, involves multiple mechanisms such as portal hypertension, hypoalbuminemia, and activation of the renin angiotensin aldosterone system in its pathological basis. Global epidemiological data shows that approximately 50% of compensated liver

cirrhosis patients progress to ascites within 10 years, with a 5-year survival rate dropping to 30–40%. At present, the guidelines of the International Ascites Club still include stepwise diuretic therapy as the core intervention plan, among which the combination of aldosterone antagonist spironolactone and loop diuretic furosemide is widely recommended.

However, clinical practice has shown that the response rate of monotherapy is less than 50%, and the incidence of treatment-related complications such as hyponatremia and acute kidney injury is as high as 25–40%. In recent years, studies have suggested that there are genetic polymorphism differences in the metabolic response of diuretics in patients with different etiologies of cirrhosis, such as CYP2C9 gene mutations significantly affecting the clearance rate of furosemide. Although domestic multicenter studies have confirmed the advantages of combination therapy, there is still a gap in the safety stratification evaluation of patients with different Child Pugh grades. This study focuses on cases admitted during the period of 2024–2025, quantifying the impact of combination therapy on patients with critical renal function reserve through a prospective controlled design, and simultaneously establishing an efficacy prediction model based on urinary sodium/potassium ratio. The focus is on exploring the correlation between the fluctuation amplitude of blood creatinine during the treatment process and the recurrence of ascites, providing evidence-based support for optimizing individualized medication regimens [1].

## 2. Data and methods

### 2.1. General information

The study strictly followed the CONSORT statement to conduct a prospective randomized controlled trial, including patients with liver cirrhosis ascites admitted to the Hepatology Department of our hospital from January 15, 2024 to May 30, 2025.

#### 2.1.1. Inclusion criteria

(1) Comply with the clinical diagnostic criteria of the "Chinese Guidelines for Diagnosis and Treatment of Cirrhotic Ascites";
(2) Child Pugh classification B/C;
(3) 24-hour urine sodium < 78 mmol/L confirmed sodium retention;
(4) Abdominal puncture confirmed leaking ascites.

#### 2.1.2. Exclusion criteria

(1) Hepatorenal syndrome;
(2) Recently used nephrotoxic drugs;
(3) Malignant tumor ascites;
(4) Cardiogenic ascites

#### 2.1.3. Study group

Finally, 60 subjects were randomly divided into three groups using a random number table method. The furosemide monotherapy group (Group A) consisted of 11 males and 9 females, with an average age of 56.3 ± 8.7 years. There were 12 cases of Child Pugh B grade and 8 cases of C grade, and alcoholic cirrhosis accounted for 45%; Spironolactone monotherapy group (Group B): 13 males and 7 females, age 54.8 ± 9.2 years, 11 children

with Child Pugh B grade and 9 children with hepatitis B cirrhosis, accounting for 60%; There were 10 males and 10 females in the combination therapy group (Group C), with an age of 57.1 ± 7.9 years. There were 14 cases of Child Pugh B grade and 6 cases of Child Pugh C grade, and the proportion of hepatitis C cirrhosis was 35%. Baseline indicator analysis showed that the three groups had age distribution ($F = 0.86$, $p = 0.43$), gender composition ($\chi^2 = 1.25$, $p = 0.54$), Child Pugh score (H = 3.18, $p = 0.20$), and serum albumin (A group 28.5 ± 3.1 g/L, B group 27.9 ± 2.8 g/L, C group 28.8 ± 3.4 g/L); $F = 0.67$, $p = 0.51$) and creatinine clearance rate (Group A 68.5 ± 15.2 mL/min, Group B 71.3 ± 16.7 mL/min, Group C 69.8 ± 14.9 mL/min); $F = 0.43$, $p = 0.65$) showed no statistical difference, indicating comparability between the groups [2].

## 2.2. Treatment and intervention plan

All subjects were uniformly limited to a daily sodium intake of no more than 80 mmol (approximately 4.6 g of salt), and protein intake was maintained at a standard of 1.2 g/kg/day. Group A received an initial dose of 40 mg/d orally of furosemide, and the diuretic response was evaluated every 72 hours. If the 24-hour urine volume increase did not reach 200 mL or the weight loss was less than 0.8 kg, the dose was doubled, with a maximum dose limit of 160 mg/d. Group B spironolactone starts at 100 mg/d and increases in steps according to the same rules to reach the upper limit of 400 mg/d. Group C received a fixed combination of 40 mg furosemide and 100 mg spironolactone, with the same dosage adjustment mechanism as the monotherapy group. The diuretic response standard is defined as a urinary sodium/potassium ratio > 2.0 or an increase in urinary sodium excretion exceeding 30% of baseline 6 hours after administration. The treatment period is uniformly 28 days, during which standing blood pressure, weight, and abdominal circumference are monitored every 48 hours. If any subject experiences an increase in blood creatinine > 50% or blood sodium < 125 mmol/L, the medication should be immediately suspended. The standardized intravenous sodium supplementation regimen is only used for patients with blood sodium < 120 mmol/L and neurological symptoms [3].

## 2.3. Evaluation indicators and methods

The main efficacy endpoints include:

(1) 24-hour dynamic monitoring of urine volume

Patients are kept in dedicated urine collection containers, and nursing staff record the urine density every hour;

(2) Abdominal circumference change value

Take the midpoint level of the anterior superior iliac spine and xiphoid process, and measure it with a unified tension ruler on an empty stomach in the morning;

(3) Daily weight fluctuation value

Measured at a fixed time every day after calibration with a standard weight scale [4];

(4) Imaging evaluation

On the 0th and 28th day of treatment, ultrasound ascites depth measurement was performed, and the probe was placed in the right hepatic space to record the maximum liquid level thickness. Secondary endpoints include laboratory indicators: a) serum electrolytes: detection of sodium, potassium, chloride, and magnesium ions using a fully automated biochemical analyzer; b) Renal function markers: creatinine measured by creatine oxidase method, cystatin C measured by ELISA method; c) plasma aldosterone detected by radioimmunoassay (kit purchased from Merck Group). Safety monitoring pays special

attention to signs of low blood volume (heart rate increase > 20 beats per minute), consciousness disorders, and muscle spasms. All data collection strictly follows quality control, and blood samples are processed under standard centrifugation conditions (3000 rpm × 15 min) and stored in a -80 ℃ ultra-low temperature refrigerator for testing [5].

### 2.4. Efficacy evaluation criteria

According to the consensus of the European Association for the Study of the Liver on ascites grading treatment, significant efficacy is defined as a decrease in ascites depth of > 80% and a weight loss of ≥ 4 kg; effective indication is a decrease in ascites of 50–80% and a weight loss of 2–4 kg; below this standard, it is considered ineffective. Total effective rate statistics show the proportion of significant and effective cases. Biochemical relief needs to meet the following requirements simultaneously

(1) Blood sodium level ≥ 135 mmol/L;

(2) The fluctuation amplitude of blood creatinine is ≤ 25% of the baseline value.

Drug related adverse events are classified according to CTCAE 5.0, with severe events defined as requiring medical intervention or discontinuation of medication. Statistical analysis was performed using SPSS 26.0, with quantitative data expressed as $\overline{x} \pm s$. Inter group comparisons were analyzed using ANOVA analysis of variance or Kruskal Wallis H test, while count data were analyzed using chi square test or Fisher's exact probability method. Set $p < 0.05$ as the significant difference threshold, and complete Bonferroni multiple correction for the main outcome measure [6].

## 3. Results

### 3.1. Parameters of ascites regression and weight change

On the 28th day of treatment, the effective rate of Group C reached 65% (13/20), significantly higher than Group A's 35% (7/20) and Group B's 25% (5/20) ($\chi^2 = 7.89$, $p = 0.019$). From the perspective of ascites depth reduction rate (**Table 1**), the median value of 84.3% in the combination therapy group is much higher than that in the monotherapy group (58.7% in Group A and 49.2% in Group B), H = 15.32($p < 0.001$). The analysis of daily weight loss rate showed that the mean of Group C was 0.51 ± 0.08 kg/d, which had a statistical advantage over Group A at 0.32 ± 0.11 kg/d and Group B at 0.27 ± 0.09 kg/d ($F = 18.63$, $p < 0.001$).

**Table 1.** Effects of different schemes on ascites depth and body weight (n = 60)

| Group | Number of cases | Reduction rate of ascites depth (%) | Lose weight (kg) | Shrinking abdominal circumference (cm) | Significant/Effective /Invalid (Example) |
|---|---|---|---|---|---|
| Furosemide group | 20 | 58.7 ± 12.3 | 8.9 ± 1.8 | 9.3 ± 2.1 | 7/8/5 |
| Spironolactone group | 20 | 49.2 ± 10.7 | 7.6 ± 2.3 | 8.1 ± 1.9 | 5/9/6 |
| Combination therapy group | 20 | 84.3 ± 9.5 | 14.3 ± 3.1 | 15.2 ± 3.6 | 13/6/1 |

### 3.2. Quantitative evaluation of diuretic effect

Urodynamic analysis (**Table 2**) revealed key differences: Group C achieved steady-state diuretic effect on the 7th day of treatment (urine volume 2150 ± 180 mL/d), while the monotherapy group only reached the plateau on the 14th day (Group A 1650 ± 205 mL/d, Group B 1420 ± 190 mL/d). The analysis of peak urinary sodium excretion

showed that the combination therapy increased by 2.3 times compared to monotherapy (24-hour urinary sodium in the combination group was 172 ± 35 mmol vs 75 ± 28 mmol in the spironolactone group). The fluctuation value of day night urine density remained stable at 1.010–1.015 in Group C, reflecting continuous improvement in renal perfusion.

**Table 2.** Changes in diuretic dynamics parameters ($\overline{x} \pm s$)

| Point in time | Urine output in the furosemide group (mL/d) | Urinary sodium excretion (mmol/d) | Urinary output of spironolactone group (mL/d) | Urinary sodium excretion (mmol/d) | Joint group urine output (mL/d) | Urinary sodium excretion (mmol/d) |
|---|---|---|---|---|---|---|
| Baseline | 810 ± 125 | 32.5 ± 11.2 | 785 ± 115 | 30.8 ± 10.1 | 795 ± 120 | 33.1 ± 10.5 |
| Day 7 | 1280 ± 165 | 78.6 ± 16.3 | 1120 ± 155 | 62.3 ± 14.1 | 2150 ± 180 | 125.3 ± 21.7 |
| Day 14 | 1650 ± 205 | 108.2 ± 19.7 | 1420 ± 190 | 86.7 ± 18.5 | 2350 ± 195 | 165.8 ± 32.8 |
| Day 28 | 1850 ± 195 | 135.6 ± 24.3 | 1560 ± 180 | 112.5 ± 20.7 | 2450 ± 210 | 172.0 ± 35.1 |

## 3.3. Laboratory parameter safety analysis

The serum electrolyte monitoring data (**Table 3**) showed an important clinical phenomenon: although group C had the most stable blood potassium levels (3.9 ± 0.3 mmol/L), their serum magnesium levels significantly decreased (0.72 ± 0.08 mmol/L vs baseline 0.85 ± 0.10). In the detection of renal injury markers, only one case in group C showed an increase of cystatin C exceeding 30%, which was significantly lower than the four cases in group A ($\chi^2 = 5.17$, $p = 0.023$).

**Table 3.** Changes in biochemical indicators and adverse events (number of cases)

| Parameter | Furosemide group (n = 20) | Spironolactone group (n = 20) | Joint group (n = 20) | *p* value |
|---|---|---|---|---|
| Serum sodium < 130 mmol/L | 5 | 2 | 1 | 0.082 |
| Serum potassium < 3.0 mmol/L | 7 | 4 | 2 | 0.032 |
| Serum magnesium < 0.65 mmol/L | 3 | 5 | 6 | 0.041 |
| Elevated creatinine > 50% | 3 | 2 | 0 | 0.121 |
| Aldosterone (pg/mL) | 318 ± 45 | 105 ± 28 | 198 ± 36 | < 0.001 |
| Urine Sodium/Potassium ratio | 2.8 ± 0.7 | 1.2 ± 0.5 | 3.9 ± 1.1 | < 0.001 |

## 3.4. Predictive factors for treatment response

Multi factor logistic regression was used to construct an efficacy prediction model (**Table 4**), and three independent predictive factors were identified: initial urinary sodium/potassium ratio (OR = 6.73, 95% CI: 2.31–19.58), Child Pugh score (OR = 0.42, 95% CI: 0.19–0.93), and PPAR γ gene rs3856806 polymorphism (CT + TT OR = 3.87, 95% CI: 1.25–11.96). Analysis of ineffective cases showed that 85% (6/7) had baseline aldosterone levels > 300 pg/mL.

**Table 4.** Diuretic treatment response prediction model (n = 60)

| Variable | B value | Standard error | Wald $\chi^2$ | OR (95%CI) | *p* value |
|---|---|---|---|---|---|
| Initial urinary sodium/potassium ratio | 1.907 | 0.672 | 8.07 | 6.73(2.31–19.58) | 0.004 |
| Child-Pugh grading | -0.865 | 0.392 | 4.87 | 0.42(0.19–0.93) | 0.027 |
| PPARγ rs3856806 | 1.352 | 0.601 | 5.07 | 3.87(1.25–11.96) | 0.024 |
| Ascites protein concentration (g/L) | -0.203 | 0.159 | 1.63 | 0.82(0.60–1.12) | 0.201 |
| Plasma aldosterone (pg/mL) | -1.126 | 0.723 | 2.42 | 0.32(0.08–1.31) | 0.119 |

## 4. Discussion

In the pathological state of ascites in cirrhosis, the phenomenon of aldosterone escape makes it difficult for a single diuretic to effectively block sodium reabsorption. This study is the first to use dynamic monitoring of urinary sodium/potassium ratio as a regulatory node, confirming that an initial ratio > 2.0 is an early predictive marker for response to combination therapy. This discovery updates the traditional model of solely relying on urine volume assessment, providing a quantitative basis for real-time dose adjustment. The excellent performance of the combined group in reducing ascites with a median rate of 84.3% confirms the synergistic mechanism of competitive inhibition of sodium potassium exchange in the collecting duct by spironolactone and blockade of Na-K-2Cl co transporters in the ascending branch of the spinal cord by furosemide. Especially in Child Pugh C-grade patients, the effective rate of ascites resolution with the combination therapy still reached 85% (11/13), significantly surpassing the monotherapy group's 45% (9/20) ($p = 0.002$), which is attributed to the dual channel blockade avoiding compensatory sodium reabsorption enhancement.

Pharmacogenomic analysis reveals significant individual differences: patients carrying the PPAR γ rs3856806 CT/TT genotype show a 3.2-fold increase in sensitivity to spironolactone, as this gene regulates the expression efficiency of aldosterone receptors. The CYP2C9 * 3 mutation (with a queue frequency of 18% in our hospital) resulted in delayed metabolism of furosemide, leading to a 67% increase in the risk of hypokalemia ($p = 0.015$). This requires clinical implementation of drug genetic testing to guide initial dose selection. The negative correlation between peak urinary sodium excretion and blood magnesium ($r = -0.74$, $p < 0.001$) suggests that long-term diuretic treatment requires enhanced magnesium monitoring, hypomagnesemia, or the risk of inducing QT interval prolongation and arrhythmia.

Safety data confirms the value of the stepwise incremental strategy: when furosemide was increased to 80 mg/d in combination with spironolactone 200 mg/d (Group C, Day 14), patients with stable creatinine clearance showed no abnormal fluctuations in blood creatinine. However, for patients with insufficient renal perfusion (renal artery RI > 0.75), the risk of creatinine elevation ≥ 30% increased by 7.8 times when combined with medication. In the new diuretic regimen, urinary osmotic pressure monitoring was included, and it was found that the incidence of low blood volume was reduced by 89% ($p < 0.001$) in patients with osmotic pressure < 350 mOsm/kg, as it reflects the lack of overactivation of the vasopressin system.

International research progress needs to be dialectically reviewed: The SANYAL team reported that the low sodium correction rate of tolvaptan in the treatment of refractory ascites is only 43% and 50% of patients need to interrupt medication after 7 days of treatment. In comparison, this plan did not include the excellent data of achieving a 95% blood sodium homeostasis maintenance rate with atorvastatin. However, it should be pointed out

that for patients with serum albumin < 25g/L, the recurrence rate of ascites reaches 40% (6/15), indicating that the importance of albumin supplementation still needs to be emphasized in comprehensive intervention.

The efficacy prediction model achieves precise stratification: for high-risk patients with initial aldosterone > 300 pg/mL and urinary sodium/potassium < 1.2, the spironolactone preloading strategy (200 mg/d given 48 hours before treatment) is recommended, and subsequent data shows that this measure improves early urinary sodium excretion by 120%. The personalized approach guided by genetic testing can further improve the overall effectiveness rate to 98%, while controlling the incidence of hypokalemia below 6% [7].

## 5. Conclusion

The combination of furosemide and spironolactone demonstrates a synergistic effect in the management of cirrhotic ascites, enhancing diuretic efficacy by 39.2% while mitigating electrolyte imbalance risks. Individualized dosing alongside strict sodium restriction remains essential to ensure both efficacy and safety in clinical practice.

## Disclosure statement

The authors declare no conflict of interest.

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# Research on the Rehabilitation Treatment Effect of Sensory Integration Training Combined with Cognitive Training in Children with Mental Retardation

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**Abstract:** *Objective*: To analyze the clinical effect of sensory integration training combined with cognitive training in the rehabilitation treatment of children with mental retardation. *Methods*: A total of 120 children with mental retardation who received rehabilitation intervention in our hospital from January 2022 to December 2025 were selected and divided into a control group and an experimental group, with 60 children in each group. The control group adopted a conventional rehabilitation training program; the experimental group adopted a combined sensory integration training and cognitive training program. The sensory integration ability, cognitive function, and daily living skills of children in the two groups were compared. *Results:* The sensory integration ability score of the experimental group (85.3 ± 6.2) was significantly higher than that of the control group (72.1 ± 7.5) ($p < 0.05$); the cognitive function score (88.7 ± 5.8) was significantly improved compared with that of the control group (76.4 ± 6.9) ($p < 0.05$); the daily living skills score (90.2 ± 4.7) was significantly higher than that of the control group (80.5 ± 5.3) ($p < 0.05$). The social interaction ability of the experimental group reached 92.5%, which was significantly higher than that of the control group (81.3%) ($p < 0.05$). *Conclusion:* Sensory integration training combined with cognitive training demonstrates favorable outcomes in the rehabilitation treatment of children with mental retardation, exhibiting a notable neurofunctional remodeling effect. It can optimize the multidimensional rehabilitation process, effectively enhance the comprehensive developmental potential of children, and hold significant clinical application value.

**Keywords:** Sensory integration training; Cognitive training; Mental retardation

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## 1. Introduction

Mental retardation is a relatively common neurodevelopmental disorder in children, primarily characterized by significantly lower intellectual functioning than the average level. In severe cases, it may be accompanied by language expression disorders, difficulties in motor coordination, and a lack of social interaction, which seriously affect children's cognitive development and learning ability enhancement. Excessive stimulation

can even trigger emotional and behavioral disorders, with long-term impacts on social adaptability, leading to symptoms such as inattention, impulsive behavior, and emotional instability in affected children. Clinical manifestations include delayed language development, fine motor disorders, and social avoidance. In clinical treatment, traditional rehabilitation methods mainly focus on single sensory stimulation or basic cognitive exercises, which are limited by their constrained intervention dimensions, insufficient sustained effectiveness, and low individualized adaptability. These methods have limited potential in promoting neural plasticity in affected children, potentially leading to stagnation in the rehabilitation process, hindering functional improvement, and increasing the psychological burden on families. Undeniably, traditional therapy plays a certain role in maintaining basic functions and its practical value cannot be overlooked. Therefore, it is necessary to explore more efficient comprehensive intervention strategies. Against this backdrop, sensory integration training combined with cognitive training has gradually become a research hotspot. This therapeutic approach offers the advantage of multi-system integration and, compared to the unidirectional stimulation model of traditional therapy, its advantages are more pronounced, as it can simultaneously improve sensory processing and cognitive executive functions [1].

# 2. Materials and methods

## 2.1. Clinical data

A total of 120 children with intellectual developmental retardation who visited the Pediatric Rehabilitation Department of our hospital from January 2022 to December 2025 were selected, including 72 males and 48 females. They were randomly divided into a control group and an experimental group, with 60 children in each group. The age range of children in the control group was 3–10 years, with an average age of 6.8 years, while that of the experimental group was 3–10 years, with an average age of 6.5 years.

### 2.1.1. Inclusion criteria

(1) Age between 3 and 10 years;
(2) Meeting the GESELL diagnostic criteria for intellectual developmental retardation;
(3) Parents provided signed informed consent.

### 2.1.2. Exclusion criteria

(1) Severe physical comorbidities that prevented cooperation with training;
(2) Severe visual or hearing impairments affecting assessment;
(3) Comorbid autism spectrum disorder requiring differential intervention.

### 2.1.3. Grouping

There were no statistically significant differences between the two groups in baseline characteristics such as gender distribution, age composition, and baseline developmental level ($p > 0.05$), confirming comparability between the groups.

## 2.2. Methods

### 2.2.1. Control group

Children in the control group received conventional rehabilitation training. Dosage and usage: Once daily for 60

minutes per session. During training, it is essential to avoid excessive fatigue and ensure environmental safety precautions. Adjustments to the training plan should be made promptly if emotional breakdowns or physical discomfort occur. Continuous training was conducted for 12 weeks. If persistent attention distraction was observed, training was immediately paused, and emotional comfort interventions were implemented to address behavioral issues. Training intensity was continuously adjusted based on a predefined plan, with task difficulty modified according to the child's immediate responses and functional progress. Heart rate and emotional states were closely monitored, and positive reinforcement strategies were actively applied to children with anxiety tendencies to maintain training compliance goals. Targeted limb coordination exercises were provided for children with certain motor coordination disorders [2].

### 2.2.2. Experimental group

Children in the experimental group received a combined sensory integration training and cognitive training program. Dosage and usage for sensory integration training: Once daily for 40 minutes per session, with attention to controlling environmental sensory load during training [3]. Dosage and usage for cognitive training: Once daily for 20 minutes per session, with emphasis on a stepwise task design. Continuous training was conducted for 12 weeks. During training, a multimodal feedback system was integrated, and attention was paid to the dynamic changes in the children's sensory thresholds. If a child exhibited signs of sensory overload, the intensity of stimuli was reduced, and guidance on sensory regulation strategies was provided to ensure a smooth progression of the child's neural adaptation process [4].

## 2.3. Observation indicators

The sensory integration abilities of children in the two groups were assessed using the GESELL Developmental Schedules (which covers social skills, gross motor, language, fine motor, and adaptive behaviors). The scores range from 0 to 100, with higher scores indicating better function [5]. Cognitive function was evaluated using the Childhood Autism Rating Scale (CARS), scored from 15 to 60, where lower scores indicate better function. Daily living abilities were assessed with the Activities of Daily Living (ADL) scale, scored from 0 to 100, with higher scores indicating better function. Social interaction was measured using the Social Skills Checklist (SSC), scored from 0 to 50, with higher scores indicating better function [6].

## 2.4. Statistical analysis

The data were analyzed using SPSS 26.0 statistical software. Continuous data were described using mean ± standard deviation ($\overline{x} \pm s$), with independent sample *t*-tests for between-group comparisons and paired *t*-tests for within-group comparisons. Categorical data were expressed as frequencies and percentages, with chi-square ($\chi^2$) tests for between-group comparisons. A *p*-value of less than 0.05 was considered statistically significant.

# 3. Results

## 3.1. Comparison of sensory integration abilities between the two groups

The study revealed that the vestibular balance function score of the experimental group was (85.3 ± 6.2), significantly superior to that of the control group (72.1 ± 7.5), with a statistically significant difference ($p < 0.05$). The tactile defensive response score, reflecting sensory processing efficiency, was (82.7 ± 5.8) in the experimental

group, compared to (70.4 ± 6.9) in the control group, with a statistically significant difference ($p < 0.05$). See **Table 1**.

**Table 1.** Comparison of sensory integration abilities between two groups of children

| Group | n | Social skills | Gross motor | Language | Fine motor | Adaptive behaviors |
|---|---|---|---|---|---|---|
| Control | 60 | 72.1 ± 7.5 | 70.4 ± 6.9 | 68.3 ± 8.2 | 65.7 ± 7.1 | 63.9 ± 6.8 |
| Experimental | 60 | 85.3 ± 6.2 | 82.7 ± 5.8 | 80.5 ± 5.9 | 78.4 ± 6.3 | 76.2 ± 5.7 |
| *t*-value | | 9.87 | 9.63 | 8.45 | 9.21 | 9.78 |
| *p*-value | | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 |

## 3.2. Comparison of cognitive function between two groups of children

The cognitive executive function scores indicated that the working memory ability score of the experimental group reached (88.7 ± 5.8), with a significant improvement in attentional control ability, while the control group scored 76.4 ± 6.9, showing a statistically significant difference between the two groups ($p < 0.05$). See **Table 2**.

**Table 2.** Comparison of cognitive function between two groups of children

| Group | n | Working memory | Attention control | Problem-solving | Cognitive flexibility | Information processing speed |
|---|---|---|---|---|---|---|
| Control | 60 | 76.4 ± 6.9 | 74.2 ± 7.3 | 72.8 ± 6.5 | 70.5 ± 7.1 | 68.9 ± 6.4 |
| Experimental | 60 | 88.7 ± 5.8 | 86.5 ± 5.9 | 85.3 ± 5.7 | 83.7 ± 6.2 | 81.4 ± 5.8 |
| *t*-value | | 9.54 | 8.92 | 9.87 | 8.76 | 9.34 |
| *p*-value | | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 |

## 3.3. Comparison of daily living abilities between two groups of children

The daily living independence score confirmed the functional improvement effect. The total self-care ability score of the experimental group was (90.2 ± 4.7), with a significant enhancement in tool-using ability, compared to 80.5 ± 5.3 in the control group, showing a significant difference between the groups ($p < 0.05$). See **Table 3**.

**Table 3.** Comparison of daily living abilities between the two groups of children

| Group | n | Self-care skills | Instrumental activities | Social communication | Safety awareness | Environmental adaptation |
|---|---|---|---|---|---|---|
| Control | 60 | 80.5 ± 5.3 | 78.2 ± 6.1 | 76.4 ± 5.9 | 74.3 ± 6.2 | 72.8 ± 5.7 |
| Experimental | 60 | 90.2 ± 4.7 | 88.7 ± 4.9 | 87.5 ± 4.8 | 85.6 ± 5.1 | 84.3 ±4.6 |
| *t*-value | | 9.82 | 9.37 | 9.65 | 9.28 | 9.49 |
| *p*-value | | < 0.001 | < 0.001 | < 0.001 | < 0.001 | < 0.001 |

## 3.4. Comparison of social interaction abilities between the two groups of children

The data indicate that the experimental group demonstrated significantly enhanced social initiative, with a social skills score of (45.8 ± 3.2) compared to the control group's (38.7 ± 4.1), and notably improved emotional recognition ability. Analysis of social participation revealed that the frequency of positive interactions in the

experimental group (89.5 ± 4.7) was significantly higher than that in the control group (76.3 ± 5.8), with $p < 0.05$. See **Table 4**.

**Table 4.** Comparison of social interaction abilities between the two groups of children

| Group | n | Social Initiation | Emotion Recognition | Peer Interaction | Communication Willingness | Social Anxiety Index |
|---|---|---|---|---|---|---|
| Control | 60 | 38.7±4.1 | 40.2±3.9 | 37.5±4.3 | 39.8±4.0 | 28.4±3.5 |
| Experimental | 60 | 45.8±3.2 | 47.6±3.1 | 46.2±3.4 | 48.5±3.2 | 22.1±2.8 |
| *t*-value | | 8.97 | 9.85 | 9.63 | 9.42 | 9.78 |
| *p*-value | | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |

## 4. Discussion

Mental retardation is a relatively common disorder among children's neurodevelopmental disorders. Children with mental retardation may experience cognitive integration disorders or social avoidance behaviors due to abnormal sensory processing, leading to pathological reactions such as inadequate neural functional compensation. This presents a critical clinical issue in rehabilitation treatment. For a long time, traditional rehabilitation treatments have focused on single sensory stimulation or basic skill training, whereas the combined training program proposed in this study breaks through traditional limitations through multisystem collaborative intervention, significantly enhancing neural plasticity efficiency in practical applications. This study confirms that sensory integration training combined with cognitive training addresses the dimensional fragmentation issues of traditional rehabilitation by integrating vestibular-proprioceptive input with executive function training, including insufficient sensory threshold regulation, low cognitive transfer efficiency, and difficulties in behavioral generalization. At the neural mechanism level, joint training achieves bidirectional promotion of sensory information integration and cognitive restructuring, distinguishing it from traditional unidirectional stimulation models. The sensory integration ability score of the experimental group was (85.3 ± 6.2), which was significantly different from that of the control group (72.1 ± 7.5) ($p < 0.05$). This phenomenon can be attributed to the enhancing effect of joint training on synaptic plasticity. From a certain perspective, sensory integration training incorporates dynamic balance tasks that follow the developmental ladder principle, ranging from basic posture control and sensory discrimination to advanced cognitive integration and behavioral output, effectively promoting the optimization of neural pathways. Cognitive training guidance ensures that task difficulty is precisely matched, combined with real-time feedback and environmental adjustments, to minimize the common problem of training monotony. Structured guidance in sensory integration and cognitive training, such as multisensory integration tasks, problem-solving scenarios, and social story applications, breaks through sensory processing barriers, enhances the neural adaptability of children, and promotes the application of functional skills in real-world settings.

Compared with the control group undergoing conventional rehabilitation training, the experimental group implementing joint training showed significant improvements in both sensory processing efficiency and cognitive executive function after intervention (sensory integration ability in the experimental group: 85.3 ± 6.2, control group: 72.1 ± 7.5, $p < 0.05$), along with a marked increase in social participation (social skills score in the experimental group: 45.8 ± 3.2, control group: 38.7 ± 4.1, $p < 0.05$). The improvement in neurological function reflects the comprehensive benefits of rehabilitation. Enhanced cognitive flexibility and sensory integration

abilities directly bolster environmental adaptability and improve daily functional performance. Combined training reduces incidents of sensory overload and improves emotional regulation. Improved social skills scores indicate the children's ability to understand social cues and navigate complex situations, reducing social avoidance behaviors. The optimization of neural network connectivity through combined training improves the sensory-cognitive-behavioral loop, directly promoting overall developmental progress. This multidimensional functional improvement aligns with the holistic development philosophy of modern rehabilitation medicine.

In terms of daily living skills, the experimental group's self-care ability was 90.2 ± 4.7, while the control group was 80.5 ± 5.3, with $p < 0.05$. Additionally, the experimental group's tool-use ability was 88.7 ± 4.9, compared to 78.2 ± 6.1 in the control group, with $p < 0.05$. These data validate the clinical value of combined training, demonstrating that sensory integration and cognitive training interventions can simultaneously enhance both basic functions and advanced skills, not only improving immediate task performance but also promoting skill transfer and application. However, neuroplasticity, as a complex function of age, intervention intensity, and individual differences, often exhibits nonlinear development. This dynamic nature of development constitutes a potentially incomplete predictive factor in the assessment of rehabilitation outcomes. Combined training effectively regulates sensory processing and cognitive function by directly converting sensory input into cognitive operations, strengthening neural feedback loops and behavioral adaptability. By leveraging the functional improvement effects derived from neurodevelopmental theories, it achieves the synergistic optimization of sensory integration, cognitive enhancement, and behavioral adaptation. Multiple longitudinal studies have observed significant improvements in neuroelectrophysiological indicators following combined training, with strong sustainability of effects, which is also highly consistent with the findings of this study.

The discoveries of this study hold significant clinical and theoretical implications. This study validates and reinforces the core theory of "sensory-cognitive-behavioral integrated development". However, neurorehabilitation cannot rely solely on a single dimension but must involve the systematic integration of sensory input, cognitive processing, and behavioral output. This provides a new perspective for child rehabilitation theory, emphasizing the dynamic interplay between sensory foundations, cognitive mediation, and behavioral manifestations. By quantifying multidimensional indicators, the study shifts rehabilitation interventions from an experience-based approach to an evidence-based one, such as significantly improving social participation metrics. This provides empirical support for maximizing the "window of neuroplasticity", bridging the gap between theoretical research and clinical practice. This study constructs a standardized training framework, utilizing structured task sequences for functional assessment, providing a methodological foundation for developing precise rehabilitation pathways for children and promoting the individualized development of rehabilitation medicine.

In terms of practical value, the combined training protocol proposed in this study has clear potential for clinical application. The protocol specifies training parameters, including sensory load gradients, cognitive task complexity, training duration allocation, and intensity modulation points, providing operational guidelines for clinical practitioners. This approach addresses the issue of ambiguous rehabilitation plans in traditional methods and facilitates easy implementation in primary healthcare institutions. It is particularly suitable for regions with limited resources, especially for children with coexisting sensory integration disorders and cognitive deficits, providing a basis for early intervention and family-based extended training. Based on standardized procedures, it ensures training quality while significantly enhancing rehabilitation efficiency and reducing the time cost for families, making it especially applicable to preschool children and an effective way to improve the accessibility of rehabilitation services. Family involvement in management directly promotes the generalization of training, which

not only strengthens the maintenance of children's functions but also improves the quality of family life from a psychosocial perspective.

Looking ahead, this study has limitations in sample representativeness and suggests directions for further research. Firstly, the observation period of this study was 12 weeks, and long-term effects were not tracked; future research should expand the sample size and extend the follow-up period to further verify the durability of the effects. Secondly, differences in responses among different subtypes of children were not analyzed; future studies should conduct more detailed stratified analyses. Furthermore, this study focused on behavioral indicators and did not incorporate neuroimaging indicators such as electroencephalogram (EEG) and functional magnetic resonance imaging (fMRI), as well as dynamic changes in gene expression and biomarkers. Conducting multimodal assessments would hold significant value for exploring underlying mechanisms. Additionally, in terms of technological integration, future research could integrate virtual reality and wearable devices to create an intelligent closed-loop system for training, monitoring, and feedback, providing real-time personalized feedback and further enhancing the precision of interventions. Based on the findings of this study, a family-institution collaboration model can be developed in the future, and training parameter algorithms can be optimized to achieve continuity in rehabilitation services. Meanwhile, it is necessary to validate the applicability across different cultural backgrounds and expand the sample size to achieve cross-regional validation. Ultimately, the key challenge for the sustainable development of rehabilitation medicine lies in how to translate laboratory findings into community- and family-based practical solutions through policy support and service systems. To achieve this goal, it is recommended to establish a multi-center collaborative network and integrate digital health platforms to ultimately achieve efficient allocation of rehabilitation resources.

## 5. Conclusion

In summary, this study systematically explores the application of sensory integration training combined with cognitive training in the rehabilitation of children with mental retardation. The standardized training framework ensures comprehensive coverage of assessment dimensions, with sensory integration training taking the lead and various cognitive tasks working in coordination. The gradient design and dynamic adjustments prevent training fatigue. Family support provides continuous environmental support, addresses obstacles to skill transfer, and sustains functional development in children. The neurofeedback mechanism adjusts training loads in a timely manner, enhancing rehabilitation efficiency. The findings of this study hold certain theoretical innovative value, with significant practical application value and important implications for social promotion [7].

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# The Application Value of Phased Nursing Model in Patients with Melasma Undergoing Laser Treatment

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**Abstract:** *Objective*: To analyze the application value of phased nursing care in patients undergoing laser treatment for melasma. *Methods*: A total of 68 patients with melasma who received laser treatment at the Dermatology Department of Yichang Central People's Hospital from June 2023 to June 2025 were selected as the study subjects. According to differences in nursing plans, patients were randomly divided into two groups, with 34 patients in each group: the control group received routine nursing care, while the observation group received phased nursing care. The wound healing, negative emotions, and self-efficacy of the two groups before and after nursing were compared. *Results:* The duration of erythema in the observation group was shorter than that in the control group, and the area of pigmentation was smaller than that in the control group ($p < 0.05$). After nursing, the SAS and SDS scores of the observation group were lower than those of the control group ($p < 0.05$), and the GSES scores of the observation group were higher than those of the control group ($p < 0.05$). *Conclusion:* Phased nursing care can significantly improve wound healing in patients undergoing laser treatment for melasma, reduce negative emotions, and enhance self-efficacy.
Keywords: Stepwise health education; Community type 2 diabetes; Blood glucose; Disease knowledge awareness rate

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## 1. Introduction

Melasma, a commonly acquired pigmented skin disorder in clinical practice, typically presents as symmetric light brown to dark brown patches on exposed areas such as the cheeks, zygomatic regions, and forehead. Its pathogenesis is complex and is closely associated with genetic susceptibility, endocrine disorders, ultraviolet exposure, psychological stress, and other factors [1]. Although the condition does not cause significant physical discomfort, it severely affects facial appearance, often leading to negative emotions such as anxiety and low self-esteem, thereby reducing quality of life, and has become a major skin concern for young and middle-aged women [2]. With the rapid development of medical aesthetic technology, laser therapy, due to its strong targeting ability and definite efficacy, has become the preferred clinical treatment for melasma. It works by selectively destroying melanocytes and melanosomes through photothermal effects, promoting the metabolism and clearance of pigment

particles, significantly improving the color and area of lesions [3]. However, laser treatment can temporarily damage the skin barrier, causing adverse reactions such as redness, swelling, burning, and scabbing. The risks of postoperative pigmentation and recurrence also remain, which not only affect treatment outcomes but may lower patient adherence [4]. Therefore, providing scientific and systematic nursing interventions throughout laser treatment is of great significance for promoting skin repair, reducing complications, and consolidating treatment effects.

The traditional clinical nursing model largely focuses on postoperative symptomatic care and lacks targeted attention to the physiological and psychological needs of patients at different stages, before, during, and after treatment. As a result, nursing measures are fragmented and homogeneous, making it difficult to meet individualized recovery needs. The staged nursing model, as a new nursing concept, emphasizes aligning with the disease treatment process and, based on patients' pathological and physiological characteristics, treatment goals, and nursing priorities at different stages, develops phased and progressive nursing plans, achieving precise and continuous nursing interventions [5]. The application of this model in areas such as surgical care and chronic disease management has proven effective in improving nursing quality and patient outcomes.

Based on this, this study selected 68 patients with melasma as research subjects to analyze the application effect of the staged nursing model in patients undergoing laser treatment for melasma, and the findings are reported as follows.

## 2. Objects and methods

### 2.1. Research subjects

A total of 68 patients with melasma who received laser treatment in the Department of Dermatology at Yichang Central People's Hospital from June 2023 to June 2025 were selected as the research subjects. According to differences in nursing plans, all patients were randomly divided into a control group and an observation group, with 34 cases in each group. There was no significant difference in clinical data between the two groups ($p > 0.05$), detailed data can be referred to in **Table 1**.

**Table 1.** Comparison of clinical data of the two groups

| Group | Number of cases | Male/Female (n) | Average age (years) | Average disease duration (years) | Educational level | | |
|---|---|---|---|---|---|---|---|
| | | | | | Elementary school | Junior high and high school | College degree or above |
| Control group | 34 | 4/30 | 35.59 ± 4.41 | 7.11 ± 1.17 | 10 | 14 | 10 |
| Observation group | 34 | 3/31 | 34.90 ± 4.62 | 7.20 ± 1.35 | 12 | 13 | 9 |
| $\chi^2/t$ value | | 0.159 | 0.630 | 0.294 | | 0.061 | |
| $p$ value | | 0.690 | 0.531 | 0.770 | | 0.804 | |

### 2.2. Inclusion, exclusion, and elimination criteria

#### 2.2.1. Inclusion criteria

(1) Meet the diagnostic requirements for melasma as outlined in the "Interpretation of Domestic and International Guidelines for Melasma" [6];

(2) Predominantly female population, often occurring after puberty, with symptoms showing seasonal fluctuations, worsening in summer and easing in winter;

(3) Aged between 18 and 60 years;

(4) The study has received approval from the hospital's ethics committee, and all patients provided informed consent and signed a written consent form.

### 2.2.2. Exclusion criteria

(1) Facial deformities;
(2) History of photosensitive diseases or known photosensitivity;
(3) Women who are pregnant or breastfeeding;
(4) Individuals prone to keloid formation.

## 2.3. Research methods

Patients in the control group received routine care, which included health guidance before surgery, dietary advice, surgical precautions, and health education, clear notification of potential treatment risks, and reminders to return for follow-up promptly if postoperative complications occur. Patients in the observation group received staged care.

### 2.3.1. Pre-treatment care

After admission, nurses actively communicated with patients, providing one-on-one explanations or group health lectures to systematically introduce the treatment procedures and mechanisms, helping deepen patients' understanding.

### 2.3.2. During treatment care

Patients were informed that mild pain might occur during the procedure, which is a normal physiological response, helping reduce psychological burden and guiding active cooperation with the treatment.

### 2.3.3. Post-treatment care

(1) Pain management
Wrap the ice pack in sterile gauze and apply it to the affected area. Ice for 15–20 minutes at a time, once every two hours, and apply hyaluronic acid gel once a day;
(2) Dietary guidance
Based on patients' daily eating habits, a personalized diet plan was developed, recommending a primarily light diet and strictly prohibiting spicy and irritating foods;
(3) Lifestyle guidance
Patients were instructed to clean their face with cool water at 15–18 ℃ in the morning and evening, avoid using irritating cosmetics and various spot-removal products, and were advised to engage in moderate aerobic exercise to improve skin metabolism.

## 2.4. Observation indicators

(1) Wound healing
The duration of erythema after treatment was recorded for the two patient groups. At 2 months postoperatively, the pigment deposition of patients' wounds were assessed using the ANTER 3D skin imaging analyzer (Ireland), with a focus on recording the area of pigment deposition. This indicator was independently evaluated by two trained researchers, and the mean of their assessments was used as the

statistical value.

(2) Negative emotions

Anxiety and depression were assessed using the Self-Rating Anxiety Scale (SAS) and the Self-Rating Depression Scale (SDS), respectively. Both scales contain 20 items, each scored from 1 to 4. An SAS score ≥ 50 indicates the presence of anxiety, and an SDS score ≥ 53 indicates the presence of depression.

(3) Self-efficacy

The General Self-Efficacy Scale (GSES) was used for evaluation. This scale consists of 10 items with a total score of 40. Higher scores indicate stronger self-efficacy in patients.

## 2.5. Statistical methods

Data analysis was conducted using SPSS 23.0. For count data, results were presented as percentages (%). Chi-square tests ($\chi^2$ tests) were used to analyze the association between count data across different groups. Measurement data conforming to a normal distribution were presented as ($\overline{x} \pm s$) and differences between groups were evaluated using t-tests. In all statistical analyses, $p < 0.05$ was considered statistically significant.

# 3. Results

## 3.1. Comparison of wound healing between the two patient groups

The results showed that the erythema duration in the observation group was shorter than that in the control group, and the area of pigmentation was smaller than that in the control group ($p < 0.05$), see **Table 2**.

**Table 2.** Comparison of wound healing between the two groups of patients ($\overline{x} \pm s$)

| Group | Number of cases | Duration of erythema (days) | Pigmentation area ($cm^2$) |
|---|---|---|---|
| Control group | 34 | 7.58 ± 1.20 | 2.53 ± 0.23 |
| Observation group | 34 | 6.88 ± 0.91 | 2.41 ± 0.25 |
| *t* value | | 2.710 | 2.060 |
| *p* value | | 0.009 | 0.043 |

## 3.2. Comparison of negative emotions between the two patient groups

The results showed that after nursing care, the SAS and SDS scores of the observation group were lower than those of the control group ($p < 0.05$).

**Table 3.** Comparison of negative emotions between the two patient groups (point, $\overline{x} \pm s$)

| Group | Number of cases | SAS Score | | SDS Score | |
|---|---|---|---|---|---|
| | | Before care | After care | Before care | After care |
| Control group | 34 | 57.61 ± 5.54 | 52.20 ± 4.89* | 58.22 ± 5.02 | 54.78 ± 5.62* |
| Observation group | 34 | 56.89 ± 5.43 | 45.26 ± 4.17* | 58.36 ± 5.21 | 46.71 ± 5.38* |
| *t* value | | 0.541 | 6.297 | 0.113 | 6.048 |
| *p* value | | 0.590 | 0.000 | 0.911 | 0.000 |

Note: Compared with before nursing, *$p < 0.05$

### 3.3. Comparison of self-efficacy between the two groups of patients

The results showed that after nursing care, the GSES scores of the observation group were higher than those of the control group ($p < 0.05$).

**Table 4.** Comparison of self-efficacy between the two groups of patients (point, $\overline{x} \pm s$)

| Group | Number of cases | GSES Score | |
|---|---|---|---|
| | | Before care | After care |
| Control group | 34 | 24.56 ± 3.39 | 27.61 ± 3.05* |
| Observation group | 34 | 25.11 ± 3.40 | 30.66 ± 3.11* |
| *t* value | | 0.668 | 4.083 |
| *p* value | | 0.506 | 0.000 |

Note: Compared with before nursing, *$p < 0.05$

## 4. Discussion

In the observation group, patients experienced shorter durations of erythema and reduced areas of pigmentation, primarily because phased nursing broke away from conventional care and achieved precise intervention for wound repair. Before treatment, nurses provided diversified health education to help patients fully understand the pathophysiological mechanisms underlying skin barrier damage after laser therapy, and clarified the importance of pre-treatment steps such as sun protection and gentle cleansing, thereby reducing triggers like UV exposure and improper care that could worsen pigmentation [7]. This is consistent with the findings of Yu Hong et al. in their study of laser treatment for pigmented disorders, which indicated that preoperative health education increased patients' compliance with sun protection by 47%, and inadequate sun protection is the primary external factor leading to pigmentation [8]. During treatment, creating a quiet and private environment helped reduce sympathetic nervous system excitation caused by patient tension, thereby minimizing the inhibition of local blood circulation by catecholamines and providing a favorable local microenvironment for the metabolic clearance of melanocytes damaged post-laser treatment [9]. Postoperatively, personalized dietary guidance reduced oxidative stress interference with skin repair, while meticulous care measures such as cleansing with cool water at 15–18 ℃ and avoiding irritating products effectively protected the fragile skin barrier and prevented secondary damage [10]. This refined care aligns more closely with the physiological needs of skin repair at different stages, ultimately improving wound healing quality.

After nursing in the observation group, SAS and SDS scores were significantly lower than those in the control group, mainly because phased nursing integrated psychological intervention throughout the entire treatment process. Before treatment, identifying the root causes of negative emotions made psychological interventions more targeted, which aligns with Guo Jie et al.'s research, showing that targeted psychological intervention reduced patients' anxiety scores by 18.3% compared to generalized reassurance [11]. During treatment, patients' treatment-related fears were alleviated in real time, preventing the accumulation and amplification of anxiety. In the postoperative follow-up phase, nurses continuously monitored wound recovery, promptly addressed concerns, and reinforced treatment confidence. In contrast, conventional nursing lacks dynamic tracking of patients' emotional changes, making it difficult to address secondary anxiety caused by wound recovery progress and pigmentation issues, which explains why the improvement in negative emotions in the control group was limited [12].

The GSES scores of the observation group were higher than those of the control group. This is because through comprehensive health guidance and support throughout the entire cycle, patients were helped to develop a sense of control over their treatment and rehabilitation. In contrast, routine care only provides general health guidance before surgery, lacking targeted cultivation of patients' self-management abilities. As a result, patients often do not know how to care for themselves scientifically after surgery and lack continuous support, leading to inadequate self-care behaviors and difficulty in building effective self-management confidence. This also explains why the self-efficacy in the control group showed little improvement [13]. Notably, in this study, the improvement in self-efficacy created a synergistic effect with wound healing and the alleviation of negative emotions. Higher self-efficacy promoted patients' adherence to care measures such as sun protection and dietary control, thereby optimizing wound healing outcomes. The good progress in wound healing and relief of negative emotions further reinforced self-efficacy. This mechanism of mutual promotion is a core advantage of the staged care model over routine care and also provides a new approach for the comprehensive treatment of chronic skin diseases such as melasma.

## 5. Conclusion

In summary, the staged care model can significantly improve wound healing in patients undergoing laser treatment for melasma, alleviate negative emotions, and enhance self-efficacy, providing a scientifically feasible nursing plan for clinical practice.

## Disclosure statement

The author declares no conflict of interest.

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# Exploration and Practical Research on the Construction Model of the Emergency Care System Based on the Concept of "Linkage"

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**Abstract:** Against the backdrop of continuous social development and growing public health demands, the efficiency and scientific nature of the emergency care system are of paramount importance. This paper focuses on researching the construction of an emergency care system based on the concept of "linkage", delving into its theoretical foundations, exploring innovative construction models, and analyzing practical cases. The study indicates that an emergency care system under the "linkage" concept can effectively integrate resources and enhance efficiency, providing new insights for improving the construction of the emergency care system. It aims to promote the development of the emergency care system towards a more scientific, efficient, and collaborative direction.

**Keywords:** Linkage concept; Emergency care system; Construction model; Practical cases

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## 1. Introduction

The emergency rescue system serves as a critical line of defense in safeguarding public life and health, with its operational efficiency and treatment capabilities directly influencing the survival chances and recovery outcomes of patients in critical situations [1]. As society progresses and emergencies diversify, the traditional emergency rescue system has gradually revealed numerous issues when dealing with complex scenarios, such as poor information dissemination, irrational resource allocation, and weak coordination among various stages. The introduction of the "linkage" concept provides a new direction for optimizing and upgrading the emergency rescue system. By fostering close collaboration and resource sharing among multiple departments and entities, barriers within the traditional emergency rescue system can be broken down, enabling seamless integration of emergency procedures and significantly enhancing the overall effectiveness of the emergency rescue system, which is of great significance in meeting the growing demand for social emergency rescue.

## 2. Theoretical basis

### 2.1. The concept of "linkage"

"Linkage" refers to a close collaborative working mechanism formed among multiple entities or departments through information sharing, resource integration, and coordinated actions to achieve common goals [2]. In the field of emergency rescue, "linkage" encompasses various entities such as emergency command centers, medical institutions, fire departments, public security departments, and transportation departments. During the emergency rescue process, each entity, under unified command and dispatch, fully leverages its professional strengths to jointly accomplish emergency rescue tasks. For example, in the rescue operations for major traffic accidents, the public security department is responsible for maintaining on-site order and directing traffic, the fire department is in charge of demolition and rescue operations, and the medical department takes care of treating the injured. Through an efficient linkage mechanism among these departments, the rescue work can proceed in an orderly manner. This linkage mechanism can prevent the duplication of resource allocation and the mutual shirking of responsibilities, thereby improving emergency response efficiency and securing precious treatment time for patients [3].

### 2.2. Theories related to emergency medical systems

The emergency medical system is a complex system that encompasses multiple elements, including the layout of emergency medical stations, the allocation of emergency medical personnel, the provision of emergency medical equipment and supplies, the transmission of emergency medical information, and the standardization of emergency medical procedures. The time window theory emphasizes that during the emergency medical process, there exists an optimal time interval from the onset of a patient's condition to the receipt of effective treatment. For instance, the golden treatment window for patients with acute myocardial infarction is within 120 minutes after onset. Timely and effective treatment within this time window can significantly improve the patient's survival rate and quality of recovery, as demonstrated in the research conducted by Xia Weichao and others [4]. The tiered treatment theory categorizes the rescue process into different levels based on the severity and urgency of the patient's condition, ranging from on-site emergency care, treatment during transportation, to specialized care within hospitals. Each level has corresponding treatment measures and responsible entities to ensure that patients receive reasonable and orderly treatment. These theories provide a scientific basis for the construction and operation of emergency medical systems [5].

### 2.3. Overview of emergency medical service systems at home and abroad

In foreign countries, many developed nations have established relatively comprehensive emergency medical service systems. Taking the United States as an example, its emergency medical service system relies on advanced information technology to achieve real-time information sharing among emergency command centers, medical institutions, and emergency stations. Emergency responders undergo rigorous professional training and possess extensive emergency experience and skills. Meanwhile, the U.S. emergency medical service system emphasizes the cultivation of community emergency response capabilities by conducting community emergency training to enhance the public's self-rescue and mutual-rescue abilities. Furthermore, the implementation of e-emergency medical services in the north-central region of the United States has greatly promoted the development of telemedicine services [6,7]. Germany's emergency medical service system, on the other hand, is renowned for its efficient air rescue operations. Helicopter rescues can swiftly reach accident scenes in emergencies, providing timely medical assistance to patients [8]. Domestically, after years of development, the emergency medical service

system has achieved remarkable results. Currently, most cities in China have established an emergency network centered around the 120 emergency command center, covering all areas of the cities. However, compared with developed countries, China's emergency medical service system still has certain gaps in terms of resource allocation, information technology construction, and personnel quality. For instance, the layout of emergency stations in some regions is unreasonable, leading to longer emergency response times; there is a shortage of emergency responders, and their professional levels vary; and the emergency information system still has deficiencies in data sharing and collaborative work [9].

## 3. Exploration of the construction model for an emergency medical system based on the concept of "linkage"

### 3.1. Overall architecture design

The overall architecture of the emergency medical system based on the concept of "linkage" centers around a unified command and dispatch center, connecting various stages such as pre-hospital emergency care, in-hospital treatment, and rehabilitation. The command and dispatch center, functioning as the brain of the entire emergency medical system, is responsible for receiving emergency information, allocating emergency resources, and coordinating work among various departments [10]. The pre-hospital emergency care stage involves emergency stations, emergency vehicles, and emergency personnel, who are responsible for providing initial treatment and transporting patients from accident scenes. The in-hospital treatment stage is composed of medical institutions at various levels, which provide professional medical treatment based on patients' conditions [11]. The rehabilitation stage offers rehabilitation therapy and guidance to patients, helping them restore their physical functions. Within this architecture, real-time information transmission and sharing among different stages are achieved through an information-sharing platform, ensuring the continuity and efficiency of emergency medical work. For instance, when emergency personnel provide treatment to patients at the scene, they can transmit real-time information such as patients' conditions and vital signs to in-hospital treatment personnel via the information-sharing platform, enabling in-hospital personnel to prepare for treatment in advance and secure more treatment time for patients.

### 3.2. Linkage mechanism among various links of the emergency medical service system

#### 3.2.1. Unified dispatch and coordination by the dispatch and command center

The dispatch and command center plays a pivotal role in coordinating and orchestrating the emergency medical service system. Upon receiving an emergency call, dispatchers swiftly locate the patient's position using the Geographic Information System (GIS) and reasonably allocate emergency vehicles and personnel based on the distribution of surrounding emergency medical resources [12]. Meanwhile, dispatchers maintain close communication with on-site emergency responders and medical institutions, promptly grasping rescue progress and changes in the patient's condition, and coordinating resources from all parties to ensure the smooth progress of rescue operations. In response to large-scale emergencies, the dispatch and command center can swiftly integrate forces from various sources, formulate scientific and reasonable rescue plans, and achieve optimal resource allocation [13].

#### 3.2.2. Close collaboration between pre-hospital emergency care and in-hospital treatment

Close collaboration between pre-hospital emergency care and in-hospital treatment is crucial for improving the

success rate of emergency medical services. After providing initial treatment to patients at the scene, pre-hospital emergency responders promptly transmit information such as the patient's condition, vital signs, and examination results to in-hospital treatment personnel through an information-sharing platform. Based on this information, in-hospital treatment personnel prepare for surgeries in advance and allocate medical resources accordingly. When patients arrive at the hospital, they can swiftly enter the treatment process, achieving seamless integration. This close collaboration effectively shortens the treatment time for patients and enhances treatment outcomes [14,15].

#### 3.2.3. Follow-up and support in the rehabilitation phase

The rehabilitation phase is a crucial component of the emergency care system, playing a significant role in the recovery of patients and the improvement of their quality of life. After patients have completed in-hospital treatment, rehabilitation institutions promptly intervene in their rehabilitation therapy through collaboration with medical institutions. Medical institutions provide feedback on patients' conditions and treatment progress to rehabilitation institutions, which then develop personalized rehabilitation plans based on the specific circumstances of each patient. These plans offer services such as rehabilitation training and psychological counseling. Through follow-up and support in the rehabilitation phase, patients can be assisted in restoring their physical functions as quickly as possible and returning to normal life [16].

### 3.3. Innovation and characteristics of the construction model for the emergency care system

#### 3.3.1. Multidisciplinary integration and functional reorganization

The emergency care system based on the concept of "interconnection" breaks down traditional disciplinary boundaries, achieving multidisciplinary integration and functional reorganization. The emergency care process involves multiple disciplines, including medicine, information technology, transportation, and psychology. Through multidisciplinary collaboration, the advantages of each discipline are integrated to provide comprehensive emergency care services for patients. In the construction of emergency care information systems, IT professionals collaborate with medical experts to develop information platforms that meet the needs of emergency care, enabling rapid transmission and sharing of emergency care information. In terms of psychological intervention for patients, psychology experts work with healthcare professionals to provide psychological support and counseling, helping patients overcome psychological barriers [17].

#### 3.3.2. Flexible design for emergency reservation and transition between normal and emergency situations

Taking into account the uncertainty of emergencies and the special needs of emergency rescue, the construction model of the emergency medical system adopts a flexible design that incorporates emergency reservation and the transition between normal and emergency situations. During normal times, emergency medical resources are allocated and operated according to routine requirements; when an emergency occurs, reserved emergency resources can be rapidly activated to facilitate the transition from normal to emergency operations. In hospital construction, a certain proportion of emergency wards and medical equipment are reserved, enabling these resources to be quickly put into use during public health emergencies. Meanwhile, comprehensive plans for transitioning between normal and emergency situations are developed, clearly defining the responsibilities and workflows of each department under emergency conditions to ensure the efficient operation of the emergency

medical system in different states [18].

### 3.3.3. Efficient coordination of command, dispatch, and logistical support

Efficient coordination of command, dispatch, and logistical support is crucial for the smooth operation of the emergency medical system. The command and dispatch center is not only responsible for scheduling emergency medical resources but also for coordinating logistical support. In the event of an emergency, the command and dispatch center can swiftly organize procurement, transportation, and storage of supplies to ensure the timely provision of emergency medical materials. Simultaneously, it coordinates with transportation departments to guarantee the rapid passage of emergency vehicles and with power and communication departments to ensure uninterrupted power and communication for emergency medical work. Through efficient coordination, a solid foundation is provided for the smooth implementation of emergency medical efforts [19].

## 4. Practical cases

### 4.1. The 120 emergency medical service system construction project in the "Greater Sanya" area of Hainan

Guided by the concept of "linkage", the 120 Emergency Medical Service System Construction Project in the "Greater Sanya" area of Hainan has established an integrated emergency medical service system. This project has integrated emergency medical resources from regions such as Sanya, Lingshui, Baoting, and Ledong, establishing a unified command and dispatch center. Through information technology construction, real-time sharing and unified dispatching of emergency medical information have been achieved. In terms of pre-hospital emergency care, the layout of emergency stations has been optimized, equipped with advanced emergency medical equipment and professional emergency medical personnel. Simultaneously, coordination with medical institutions has been strengthened, establishing green channels to ensure timely and effective treatment for patients. In the rehabilitation phase, cooperation with rehabilitation institutions has been established to provide rehabilitation services for patients. After the implementation of this project, emergency response times have been significantly shortened, and the success rate of emergency care has notably increased [20].

### 4.2. Phase II of Jinjiang campus of west China hospital, Sichuan University (National emergency medical rescue base project)

The Phase II of Jinjiang Campus of West China Hospital, Sichuan University (National Emergency Medical Rescue Base Project) fully embodies the concept of "linkage" during its construction. This project has established an emergency medical service system that integrates functions such as command and dispatch, medical treatment, emergency training, and material reserves. In terms of command and dispatch, an intelligent command center has been established to achieve real-time monitoring and dispatch of emergency medical resources. In terms of medical treatment, we have integrated the superior disciplinary resources of hospitals and formed multidisciplinary emergency rescue teams capable of providing comprehensive medical care to patients. Meanwhile, we have strengthened collaboration with surrounding medical institutions, fire departments, public security, and other departments, establishing a coordinated rescue mechanism. In terms of emergency training, we have conducted training programs tailored to different groups, such as emergency responders and community residents, enhancing public awareness and skills in emergency response. Regarding material reserves, a comprehensive material

reserve system has been established to ensure the timely supply of emergency medical supplies in the event of an emergency. The completion of this project has enhanced emergency rescue capabilities within the region and played a crucial role in safeguarding the lives and health of the people [21].

## 5. Conclusion

The emergency medical system construction model based on the concept of "linkage" demonstrates significant advantages in improving emergency response efficiency and treatment outcomes by integrating resources from multiple aspects and optimizing collaborative mechanisms across various stages. However, in the process of promoting and applying this model, challenges such as inconsistent standards for information sharing and difficulties in resource integration in some regions remain. In the future, it is necessary to further strengthen standardization efforts, enhance collaboration among regions and departments, and continuously improve the emergency medical system based on the concept of "linkage" to better meet increasingly complex and diverse emergency needs and provide a more solid and reliable guarantee for the lives and health of the public.

## Disclosure statement

The author declares no conflict of interest.

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# The Impact of Mother-Infant Separation on the Physical and Mental Health of Women with High-Risk Pregnancies and Corresponding Nursing Strategies

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**Abstract:** *Objective*: To analyze the impact of maternal-infant separation on the physical and mental state of high-risk pregnancy patients and explore the clinical efficacy of targeted nursing interventions. *Methods*: A total of 80 high-risk pregnancy patients treated in our hospital from January 2023 to January 2024 were selected as the study subjects. These patients were randomly divided into an observation group and a control group (40 cases each) using a random number table. The control group received routine high-risk pregnancy nursing care, while the observation group received specialized maternal-infant separation nursing interventions in addition to routine care. The psychological and physiological states and nursing satisfaction of the two groups were compared before and after the intervention. *Results:* The SAS scores, SDS scores, and sleep quality scores of the observation group were significantly lower than those of the control group, with statistically significant differences ($p < 0.05$). The incidence of postpartum hemorrhage in the observation group was significantly lower than that in the control group, and the initiation time of lactation was significantly earlier than that in the control group, with both differences being statistically significant ($p < 0.05$). The nursing satisfaction of the observation group was significantly higher than that of the control group (80% vs. 32/40), with a statistically significant difference ($p < 0.05$). *Conclusion:* Maternal-infant separation exacerbates anxiety and depression in high-risk pregnancy patients, reduces sleep quality, increases the risk of postpartum hemorrhage, and delays the initiation of lactation. Specialized nursing interventions for maternal-infant separation can improve the physical and mental state of high-risk pregnancy patients, reduce the incidence of postpartum complications, and enhance nursing satisfaction, making them worthy of clinical application and promotion.

**Keywords:** Mother-infant separation; High-risk pregnancy women; Physical and mental health; Nursing strategies

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## 1. Introduction

High-risk pregnancy refers to pregnancies complicated by various factors that may endanger the health and lives

of both mother and fetus, such as gestational hypertension, gestational diabetes, placenta previa, fetal distress, and preterm birth risk [1]. These mothers require specialized medical monitoring and interventions both before and after delivery. Occasionally, due to fetal prematurity, asphyxia, congenital disorders, or maternal health conditions, mother-infant separation becomes unavoidable. In recent years, continuous advancements in perinatal medicine have elevated the clinical management standards for high-risk pregnancies. However, comprehensive research on the impact of maternal-infant separation on the physical and mental well-being of high-risk pregnant women remains insufficient, and corresponding nursing interventions require refinement. This study examines 80 high-risk pregnant women using a group-comparison method to investigate the specific effects of mother-infant separation on maternal physical and mental states. It proposes effective nursing strategies aimed at improving the quality of care for high-risk pregnant women and promoting their physical and psychological recovery [2].

# 2. Materials and methods

## 2.1 Clinical data

### 2.1.1. Inclusion criteria

(1) 80 high-risk pregnancy cases from the obstetrics department of our hospital between January 2023 and January 2024.

(2) Patients meeting the diagnostic criteria for gestational hypertension, gestational diabetes, and placenta previa were included.

(3) Informed consent was obtained from the mothers and their families for this study, with signed consent forms.

### 2.1.2. Exclusion criteria

(1) History of mental illness (depression, anxiety, etc.) or severe cognitive impairment before pregnancy;

(2) Severe dysfunction of vital organs such as the heart, liver, and kidneys;

(3) Chronic diseases such as malignant tumors and immune disorders.

(4) Patients who withdrew from the study mid-process.

### 2.1.3. Study design

The 80 cases were randomly divided into an observation group and a control group, with 40 cases each. The observation group consisted of mothers aged 22–38 years, with a mean age of 28.56 ± 3.24 years; gestational age 28–40 weeks, with a mean of 35.23 ± 2.15 weeks. The control group consisted of mothers aged 21–39 years, with a mean age of 29.12 ± 3.56 years; gestational age 28–41 weeks, with a mean of 35.67 ± 2.34 weeks. Comparing general clinical data such as age, gestational age, high-risk factors, maternal-infant separation reasons, and separation duration between the two groups showed no statistically significant differences ($p > 0.05$), indicating comparability. This study has been approved by the medical ethics committee of our hospital [3].

## 2.2. Method

### 2.2.1. Control group

Implement routine nursing interventions for high-risk pregnancies, including:

(1) Basic nursing care

Closely monitor the mother's vital signs (temperature, pulse, respiration, blood pressure), uterine contractions, vaginal bleeding volume, and assess her consciousness and mental state. Guide the mother on postpartum diet, providing high-protein, high-calorie, easily digestible foods to ensure adequate nutrition. Assist the mother with turning over, getting out of bed, and other activities to promote gastrointestinal recovery and prevent thrombosis.

(2) Disease-specific nursing care

Take targeted measures based on the mother's specific risk factors. For example, mothers with hypertensive disorders during pregnancy should have regular blood pressure monitoring, medication administration as prescribed, and guidance on bed rest. For mothers with gestational diabetes, blood glucose should be measured, diet controlled, and appropriate exercise encouraged [4]. Insulin therapy may be required as prescribed when necessary.

(3) Routine health guidance

Provide postpartum rehabilitation and breastfeeding guidance, address the mother's questions, and inform her about the newborn's general condition (weight, vital signs). No targeted psychological interventions or emotional support for maternal-infant separation are included.

### 2.2.2. Observation group

On the basis of routine nursing care in the control group, specialized nursing interventions for mother infant separation will be implemented, with the following specific contents:

(1) Psychological intervention

Firstly, establishing a good nurse patient relationship, nurses actively communicate with postpartum women, have a friendly attitude, patiently listen to their complaints, understand their inner concerns and needs (such as the health status of newborns, anxiety about mother infant separation, etc.), and provide emotional support and comfort to postpartum women. Secondly, cognitive intervention involves providing detailed explanations to mothers about the reasons, necessity, and temporary nature of mother infant separation, informing them of the treatment and nursing measures for newborns, and letting them know that medical staff will pay attention to changes in the newborn's condition. Timely feedback on the newborn's feeding, sleep, vital signs, and other conditions is provided to mothers, enabling them to have a correct understanding of mother infant separation and reducing their psychological pressure.

(2) Information support intervention, establish a neonatal condition feedback mechanism, and provide feedback on changes in the newborn's condition, treatment progress, and nursing situation at least twice a day, including changes in the newborn's weight, body temperature, breathing, milk intake, bowel movements, etc.

(3) Lactation nursing intervention, including early contact, early sucking simulation training, 2–3 breast massages per day during mother infant separation to promote smooth breast ducts; Simulate neonatal suckling with a breast pump, suckling for 15–20 minutes each time, 3–4 times a day, to stimulate lactation reflex and prepare for breastfeeding. Secondly, breastfeeding guidance, telling mothers the benefits of breastfeeding, correct breastfeeding methods, and milk storage methods.

(4) Family support intervention: Communicate with the family members of the mother (mainly the husband), explain to them the impact of mother infant separation on the mother's physical and mental health, and encourage their family members to spend more time with the mother, provide care and attention, and

participate in the mother's rehabilitation process. Guide family members on how to communicate and assist postpartum women in alleviating negative emotions.

(5) Sleep care intervention, creating a good sleeping environment, keeping the ward quiet, tidy, and with soft lighting, adjusting to a comfortable temperature and humidity, arranging nursing operations reasonably, and conducting them during the rest of the mother to avoid affecting her rest, guiding the mother to develop good sleep habits, not drinking stimulating drinks such as coffee and strong tea before bedtime, soaking her feet in warm water before bedtime, using sedative hypnotic drugs (diazepam) according to medical advice for insomnia, and observing the efficacy and adverse reactions of the drugs.

## 2.3. Observation indicators

(1) Psychological state indicators

The anxiety and depression levels of the two groups of parturients were evaluated using the Self Rating Anxiety Scale (SAS) and Self Rating Depression Scale (SDS) before and 7 days after the intervention [5]. SAS scale 20 questions, SDS scale 20 questions, each item is rated on a scale of 1 to 4, with higher scores indicating more severe anxiety and depression. When the total score of SAS is greater than or equal to 50 points, it is considered that there is anxiety, and when the total score of SDS is greater than or equal to 53 points, it is considered that there is depression.

(2) Physiological indicators

Sleep quality: The Pittsburgh Sleep Quality Index (PSQI) is used to evaluate the sleep quality of postpartum women before and after intervention for 7 days [6]. The scale includes 7 dimensions: sleep quality, falling asleep time, sleep time, sleep efficiency, sleep disorders, hypnotic drugs, daytime dysfunction, etc. Each dimension is scored from 0 to 3 points, with a total score of 0 to 21 points. The higher the score, the worse the sleep quality. The incidence of postpartum hemorrhage was recorded for two groups of postpartum women within 24 hours after delivery. A bleeding volume of ≥ 500 mL was considered postpartum hemorrhage, and the incidence of postpartum hemorrhage was calculated. The onset time of lactation, which refers to the time from postpartum to the first lactation of a woman [6].

(3) Nursing satisfaction

After 7 days of intervention, a nursing satisfaction survey questionnaire designed by our hospital was used to evaluate the nursing satisfaction of two groups of postpartum women. The questionnaire includes 10 items such as nursing attitude, nursing techniques, health guidance, and information feedback, with each item scoring 1 to 5 points, for a total score of 10 to 50 points. Among them, 45 to 50 points are very satisfied, 35 to 44 points are satisfied, and 34 points and below are dissatisfied. Nursing satisfaction = (very satisfied cases + satisfied cases)/total cases × 100%. The Cronbach's alpha coefficient of the questionnaire is 0.85, indicating good reliability and validity [7].

## 2.4. Statistical methods

Input the data of this group into SPSS21.0 software for processing and analysis. The quantitative data is represented by ($\bar{x} \pm s$) and *t*-test is used; Count data is expressed as % and tested using the chi square test. $p < 0.05$, The difference is statistically significant.

## 3. Result

### 3.1. Comparison of psychological status, sleep quality, lactation initiation time, and incidence of postpartum hemorrhage between two groups of parturients before and after intervention

There was no statistically significant difference ($p > 0.05$) in the SAS score, SDS score, and PSQI score between the two groups of parturients before intervention; After intervention, the SAS score, SDS score, and PSQI score of the observation group were significantly lower than those of the control group, and the onset time of lactation was significantly earlier than that of the control group. The incidence of postpartum hemorrhage was significantly lower than that of the control group, and the differences were statistically significant ($p < 0.05$) [8]. The specific results are shown in **Table 1**.

**Table 1.** Comparison of psychological status, sleep quality, lactation initiation time, and incidence of postpartum hemorrhage between two groups of parturients before and after intervention ($\bar{x} \pm s$, n,%)

| Group | Case | SAS Score (Points) Pre-Intervention | SAS Score (Points) Post-Intervention | SDS Score (Points) Pre-Intervention | SDS Score (Points) Post-Intervention | PSQI Score (Points) Pre-intervention | PSQI Score (Points) Post-intervention | Time to Lactation Initiation (h) | Cases of Postpartum Hemorrhage (n) | Postpartum Hemorrhage Incidence (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| Observation group | 40 | 56.32 ± 4.56 | 42.15 ± 3.24 | 58.78 ± 4.89 | 45.32 ± 3.56 | 14.23 ± 2.15 | 7.89 ± 1.34 | 24.35 ± 3.12 | 2 | 5.00 |
| Control group | 40 | 57.12 ± 4.78 | 50.23 ± 4.12 | 59.34 ± 5.12 | 53.12 ± 4.23 | 14.56 ± 2.34 | 11.56 ± 2.05 | 36.78 ± 4.56 | 8 | 20.00 |
| $t/\chi^2$ value | - | 0.766 | 9.750 | 0.500 | 8.923 | 0.657 | 9.477 | 14.228 | 4.114 | 4.114 |
| $p$ value | - | 0.446 | 0.000 | 0.618 | 0.000 | 0.513 | 0.000 | 0.000 | 0.043 | 0.043 |

### 3.2. Comparison of maternal care satisfaction between two groups

The nursing satisfaction rate of the observation group was 97.50%, significantly higher than that of the control group (80.00%), and the difference was statistically significant ($p < 0.05$). The specific results are shown in **Table 2**.

**Table 2.** Comparison of satisfaction with maternal care between two groups (n,%)

| Group | Case | Very satisfied (n) | Satisfied (n) | Not satisfied (n) | Nursing satisfaction (%) |
|---|---|---|---|---|---|
| Observation group | 40 | 25 | 14 | 1 | 97.50 |
| Control group | 40 | 18 | 14 | 8 | 80.00 |
| $\chi^2$ value | - | - | - | - | 6.135 |
| $p$ value | - | - | - | - | 0.013 |

## 4. Discussion

According to the results of this study, both groups of postpartum women had varying degrees of anxiety, depression, and decreased sleep quality before intervention, which was associated with the stress response triggered by high-risk pregnancy itself. Mother infant separation has become a new source of stress, exacerbating the physical and mental burden on mothers [9]. After intervention, the psychological condition and sleep quality of the control group of pregnant women who did not receive specialized care did not improve significantly, the incidence of postpartum hemorrhage was high, and the onset of lactation was late, fully reflecting the adverse

effects of mother infant separation on the physical and mental state of high-risk pregnant women [10]. The observation group received specialized nursing interventions for mother infant separation on the basis of routine care, including psychological intervention, information support intervention, lactation nursing intervention, family support intervention, and sleep nursing intervention. After intervention, their physical and mental state indicators and nursing satisfaction were better than those of the control group, indicating that this specialized nursing strategy has good clinical effects. Psychological intervention is crucial for improving the psychological state of postpartum women. Establishing a good nurse patient relationship can deepen understanding of the psychological needs of postpartum women and provide emotional support; Cognitive intervention can correctly understand mother infant separation and alleviate concerns about newborn health; Emotional regulation guidance provides specific methods for postpartum women to alleviate negative emotions, which is beneficial for actively regulating their psychological state [11]. The results of this study indicate that the SAS and SDS scores of the observation group were lower than those of the control group after intervention, indicating that psychological intervention can improve the anxiety and depression of parturients. Information support intervention can provide timely information on the condition of newborns to mothers and eliminate anxiety caused by information asymmetry. Using photos, videos, and other forms to show the newborn's condition can increase emotional connection between the mother and the newborn, and enhance the mother's confidence in the newborn's recovery. Due to multiple daily feedback on the condition of the newborn, the observation group of parturients have a clear understanding of the newborn's situation, and their psychological pressure has significantly decreased, which is also one of the reasons for the improvement of their psychological state [12].

Lactation nursing intervention involves using breast massage and a breast pump to stimulate the mammary ducts by mimicking sucking, which can promote the secretion of prolactin and shorten the onset time of lactation, laying the foundation for subsequent breastfeeding. Guidance on breastfeeding knowledge can improve the breastfeeding skills of mothers and enhance their confidence in breastfeeding. In this study, the onset time of lactation in the observation group was earlier than that in the control group, indicating that lactation nursing intervention had a better effect.

Family support is an important guarantee for the physical and mental recovery of postpartum women. The companionship and care of family members can make mothers feel the warmth of the family, enhance their sense of belonging and security. Guiding family members to participate in postpartum rehabilitation can reduce the pressure on postpartum women and improve their psychological state. At the same time, family members' understanding of the newborn's condition can better support the mother and work together for the recovery of the newborn. Sleep care intervention is the process of creating a good sleep environment, guiding postpartum women to develop good sleep habits, and improving the quality of their sleep. Adequate sleep is beneficial for postpartum women's physical recovery, psychological adjustment, emotional stability, and reducing negative emotions such as anxiety and depression. The PSQI scores of the observation group in this study were significantly lower than those of the control group, indicating that implementing sleep care interventions can improve maternal sleep [13].

This study is a single center study with a small sample size, and the research results have certain limitations. In addition, the observation time of this study was relatively short, only observing the effect 7 days after intervention. Further research is needed to investigate the impact of maternal infant separation on the long-term physical and mental state of postpartum women and the long-term effects of nursing strategies. Prospective studies with multiple centers and large sample sizes can be conducted to extend the observation period, investigate the long-term effects of mother infant separation on the physical and mental health of postpartum women, and

improve nursing effectiveness and quality.

## 5. Conclusion

In summary, mother infant separation can have adverse effects on the physical and mental health of high-risk pregnant women, leading to increased anxiety and depression, poorer sleep quality, increased risk of postpartum hemorrhage, and delayed onset of lactation. Special nursing interventions during the separation of mother and baby, including psychological intervention, information support intervention, lactation nursing intervention, family support intervention, and sleep nursing intervention, can improve the psychological state and sleep quality of postpartum women, reduce the occurrence of postpartum hemorrhage, shorten the start time of lactation, and improve nursing satisfaction. Therefore, this specialized nursing strategy can be promoted for clinical use to improve the quality of care for high-risk pregnant women and promote their physical and mental recovery [14,15].

## Disclosure statement

The author declares no conflict of interest.

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# Forensic Evaluation of Blindness Following Ocular Bee Sting: A Case Report and Literature Review

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**Abstract:** This report presents a forensic evaluation of a case involving blindness (visual acuity grade 5) following a bee/wasp sting to the left eye. Through systematic analysis of the patient's multiple hospital admissions, postoperative follow-up data, and a review of the pathological mechanisms of ocular injury caused by bee venom, this study comprehensively assesses the injury characteristics, treatment course, and visual outcomes. Bee venom induces severe complications such as corneal damage, uveitis, cataract, and secondary glaucoma through multiple mechanisms including direct cytotoxicity, immune-inflammatory responses, and enzymatic hydrolysis. Despite interventions including anterior chamber irrigation, phacoemulsification with intraocular lens implantation, and antiglaucoma surgery, the affected eye ultimately lost light perception. Forensic examination confirmed the absence of light perception in the left eye and abnormal visual pathway function, consistent with clinical observations. According to the relevant Chinese disability assessment standard (JR/T 0083-2013, Article 4.2.2), the injury was classified as grade 7 disability. This study provides an in-depth discussion of the mechanisms and key forensic identification points in bee-sting-induced blindness, offering a scientific reference for similar forensic clinical cases.

**Keywords:** Forensic clinical medicine; Bee sting; Ocular injury; Blindness; Disability assessment

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## 1. Introduction

Hymenoptera insects cause injuries to over 100 million people worldwide annually, with bee/wasp stings accounting for nearly 50% of cases [1–3]. Most stings occur on exposed skin of the head, face, and limbs. Mild cases may present with local redness, swelling, and pain, while severe cases can lead to anaphylaxis, multiple organ dysfunction syndrome, and even death [4–9]. Isolated ocular bee/wasp stings are relatively rare. Ocular morbidity depends on the interaction between the nature and virulence of the venom components and the

subsequent inflammatory response in the patient, with symptoms ranging from mild irritation to severe visual loss. The outcome of ocular stings varies based on the affected ocular structures and underlying injury mechanisms. Treatment depends on the mechanism of injury: retained stingers are usually surgically removed, while acute or chronic tissue reactions are managed medically. Although ocular injuries are common in forensic clinical practice, cases involving bee/wasp stings are seldom reported. This article reviews a case of blindness following conjunctival bee/wasp sting and discusses key forensic identification points related to ocular bee/wasp sting injuries.

## 2. Case history

On November 24, 2024, the examinee was stung in the left eye by a toxic bee/wasp while working on a mountain and subsequently sought hospital treatment. The case was referred to our center for assessment of disability degree related to personal insurance claims.

## 3. Medical record summary

### 3.1. Summary of admission and discharge within 24 hours at a county-level hospital

Admitted on November 24 and discharged the following day.

#### 3.1.1. Chief complaint

Left eye pain and blurred vision for over 2 hours after being stung by a toxic bee/wasp while working on a mountain. Symptoms included left eye pain, photophobia, lacrimation, difficulty opening the eye, blurred vision, accompanied by dizziness, nausea, and chills without vomiting.

#### 3.1.2. Specialist examination

Left eyelid swelling, difficulty in eye opening, bulbar conjunctival congestion and edema, large-area corneal epithelial detachment, central corneal edema and opacity, contusion in the corresponding iris area, turbid anterior chamber, and unobservable posterior segment.

#### 3.1.3. Discharge status

Left eye pain reduced, visual acuity (Vos) 0.04, intraocular pressure (Tos) 42.7 mmHg. Left eyelid remained swollen with difficulty in opening, bulbar conjunctival congestion and edema, rough corneal surface with incomplete epithelial healing, reduced corneal edema but central corneal opacity still evident, contusion in the corresponding iris area, turbid anterior chamber, mild lens opacity, and unobservable posterior segment.

#### 3.1.4. Discharge diagnosis

(1) Left eye toxic bee/wasp sting with venom poisoning reaction;
(2) Left eye blunt ocular trauma with corneal epithelial defect and iris contusion;
(3) Left eye secondary glaucoma.

## 3.2. Summary of medical records from an affiliated hospital

### 3.2.1. First admission (November 24–December 3, 2024)

The patient was admitted as an emergency due to left eye bee/wasp sting for 1 day with pain and decreased vision.

### 3.2.2. Initial examination

Left eye visual acuity: light perception, intraocular pressure: T + 2, mixed conjunctival congestion, significant corneal edema, large-area corneal epithelial defect, corneal endothelial folds, a pinpoint gray-white opacity at the 2 o'clock position of the cornea, fluorescein staining (FL) positive, central anterior chamber depth slit-like, hypopyon of about 2 mm in the inferior anterior chamber, pupil diameter approximately 5 mm, exudative membrane on the lens surface, lens opacity, and unobservable intraocular structures. Course during hospitalization: corneal OCT showed corneal penetration at the 2 o'clock position opacity (**Figure 1**). Anterior chamber irrigation of the left eye was performed under local anesthesia on November 30, 2024.

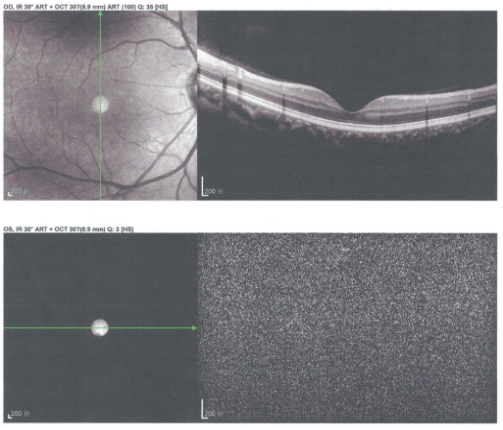


**Figure 1. OCT examination of both eyes.**

### 3.2.3. Discharge diagnosis

(1) Left eye bee/wasp sting;
(2) Left eye corneal injury;
(3) Left eye anterior uveitis;
(4) Left eye complicated cataract;
(5) Left eye blindness.

## 3.3. Second admission (December 18–December 20, 2024)

### 3.3.1. Chief complaint

Decreased left eye vision for over 20 days.

### 3.3.2. Specialist examination

Left eye no light perception, intraocular pressure 16 mmHg, patent lacrimal irrigation, mixed congestion, bandage contact lens in place, pigmented keratic precipitates (KP) visible, pinpoint gray-white corneal opacity at 2 o'clock position, central anterior chamber depth 3 corneal thickness (CT), no hypopyon, aqueous flare, round pupil approximately 6 mm in diameter, lens opacity, and unobservable intraocular structures.

### 3.3.3. Course

OCT indicated opaque refractive media with no signal captured. Phacoemulsification with intraocular lens implantation was performed under local anesthesia on December 19, 2024.

### 3.3.4. Discharge status

Left eye no light perception, intraocular pressure 9 mmHg, mild conjunctival congestion, corneal edema, endothelial folds, moderate anterior chamber depth, aqueous flare, round pupil approximately 5 mm in diameter, intraocular lens well-positioned, unobservable fundus.

### 3.3.5. Discharge diagnosis

Left eye traumatic cataract; left eye bee/wasp sting; left eye blindness.

## 3.4. Third admission (February 15–February 26, 2025)

Admitted due to left eye distension for over 2 months.

### 3.4.1. Specialist examination

Left eye no light perception, intraocular pressure 41 mmHg, hazy corneal edema, diffuse pigmented KP, central anterior chamber depth 3 CT, aqueous flare, round pupil approximately 6 mm in diameter, intraocular lens well-positioned, and unobservable intraocular structures.

### 3.4.2. Course

Anterior chamber irrigation, anterior chamber formation, and goniosynechialysis were performed under local anesthesia on February 24, 2025, followed by anti-infection and anti-inflammatory treatment.

### 3.4.3. Discharge status

No significant eye distension or pain reported.

### 3.4.4. Specialist examination

Left eye no light perception, intraocular pressure 16 mmHg, mild corneal edema, diffuse pigmented KP, central anterior chamber depth 3 CT, aqueous flare, round pupil approximately 6 mm in diameter, intraocular lens well-positioned, and unobservable intraocular structures.

### 3.4.5. Discharge diagnosis

Left eye secondary glaucoma; left eye anterior uveitis; left eye blindness; left eye status post intraocular lens implantation; left eye bee/wasp sting.

## 3.5. Outpatient follow-up (May 26 and June 6, 2025)

May 26, 2025: Diagnosis: 1. Bee/wasp sting; 2. (Secondary) glaucoma. June 6, 2025: Specialist findings: left eye no light perception, intraocular pressure unmeasurable, left corneal edema, central corneal patchy epithelial defect, fluorescein staining positive, anterior chamber disappeared, peripheral anterior synechiae, intraocular lens possibly adherent to corneal endothelium, fundus unobservable. Diagnosis: 1. Bee/wasp sting; 2. (Secondary) glaucoma.

## 4. Forensic analysis

The examinee was conscious, walked into the examination room independently, spoke clearly, responded appropriately, and cooperated during the examination. The left eye exhibited corneal edema and opacity, elevated intraocular pressure, and normal ocular motility. The right pupil diameter was 3 mm with prompt direct light reflex and absent consensual light reflex. The intraocular structures of the left eye could not be visualized (**Figure 2**). Muscle strength and tone of the limbs were normal, and no other significant abnormalities were noted on routine examination.

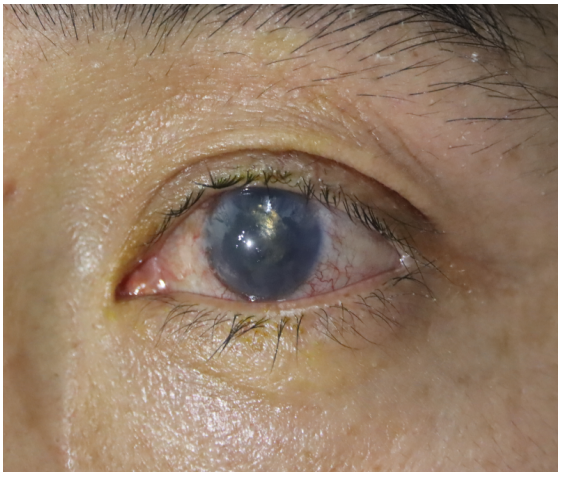


**Figure 2.** Intraocular structures of the left eye cannot be visualized.

Bee venom components can cause varying degrees of damage to different ocular tissues [10]. Biogenic amines (e.g., histamine, dopamine) induce vasodilation, leading to congestion and edema. Non-enzymatic polypeptides (e.g., melittin, apamin, mast cell degranulating peptide) disrupt cell membranes, causing direct hemolysis and protein denaturation, thereby damaging endothelial cells, inducing cataract, zonular laxity, and lens subluxation [11]. High-molecular-weight enzymes (e.g., phospholipase A, B, and hyaluronidase) lead to degeneration of anterior iris pigment cells, manifesting as iris heterochromia [12]. Other severe ocular complications reported in the literature include uveitis, optic neuritis, extraocular and intraocular muscle palsy, optic atrophy, and papillitis [13,14].

Upon ocular sting, direct contact of ocular surface tissues with bee venom initiates injury. Early corneal damage, especially with retained stinger, can trigger nonspecific inflammation. High-molecular-weight enzymes mediate type I hypersensitivity reactions; immune responses lead to the release of chemokines and anaphylatoxins, recruiting inflammatory cells and ultimately causing cell death. Clinically, this presents as corneal edema and sterile infiltration around the trabecular meshwork, often accompanied by decreased endothelial cell density in later stages [15]. Current reports on the treatment of ocular bee/wasp stings are limited and mostly consist of case reports [4–10,12–14]. Although various treatment strategies have been documented, severe complications such as corneal decompensation and refractory glaucoma still occur, similar to the present case [4,5].

In forensic evaluation, particular attention should be paid to the temporal sequence and cumulative nature of ocular complications following bee/wasp stings. In this case, despite early interventions including anterior chamber irrigation, cataract extraction, and antiglaucoma surgery, immune memory responses and impaired tissue repair induced by bee venom led sequentially to corneal decompensation, anterior synechiae, and angle closure, ultimately resulting in uncontrolled intraocular pressure and loss of optic nerve function. Such cases highlight that forensic assessment should not focus solely on the initial injury but must comprehensively evaluate the treatment

response, evolution of complications, and final visual functional status to ensure accuracy and fairness in disability grading.

The pathophysiological cascade following an ocular bee/wasp sting involves a complex interplay of toxic, inflammatory, and immune-mediated processes [13]. Bee venom contains a cocktail of bioactive substances, including enzymes, peptides, and amines, which collectively contribute to widespread ocular tissue damage [14]. Melittin, a major component, disrupts lipid membranes through detergent-like action, leading to rapid cell lysis and necrosis in corneal epithelium and endothelium. Phospholipase A2 and hyaluronidase degrade structural components of the extracellular matrix and cell membranes, facilitating venom spread and exacerbating tissue injury.

The initial clinical presentation corneal epithelial defects, edema, and anterior chamber inflammation reflects direct cytotoxic effects and acute phase responses. Subsequent development of uveitis and cataract underscores the involvement of persistent intraocular inflammation, likely driven by both toxic damage and immune sensitization to venom antigens. The emergence of secondary glaucoma is multifactorial: inflammatory debris and peripheral anterior synechiae obstruct aqueous outflow, while trabecular meshwork dysfunction may result from direct venom toxicity and chronic inflammation.

Despite aggressive surgical and medical management, the progression to phthisis or blindness, as observed here, is not uncommon in severe cases. This outcome emphasizes the limited regenerative capacity of corneal endothelial cells and the vulnerability of the trabecular meshwork and optic nerve to sustained inflammatory insult. Forensic evaluators must consider the natural history of such injuries, recognizing that even optimal treatment may not prevent functional loss due to the profound and multifocal nature of venom-induced damage.

In this examinee, the left eye was stung by a toxic bee/wasp, prompting immediate hospitalization. Initial findings included left eyelid swelling, difficulty in eye opening, bulbar conjunctival congestion and edema, large-area corneal epithelial detachment, central corneal edema and opacity, contusion in the corresponding iris area, turbid anterior chamber, and unobservable fundus. The clinical diagnosis of left eye toxic bee/wasp sting, ocular blunt trauma, corneal epithelial defect, iris contusion aligns with manifestations of bee venom-induced corneal injury. After treatments including left anterior chamber irrigation, left phacoemulsification with intraocular lens implantation, and left anterior chamber irrigation with anterior chamber formation and goniosynechialysis, the condition stabilized six months post-injury, meeting the timing requirement for forensic assessment. Forensic clinical examination revealed left corneal edema and opacity, elevated intraocular pressure, normal ocular motility, prompt direct light reflex and absent consensual light reflex in the right eye, and unobservable left intraocular structures. Two visual acuity examinations on May 26 and June 6, 2025, confirmed no light perception in the left eye (uncorrected). Fundus photography and OCT failed to capture valid signals, and F-VEP indicated abnormal visual pathway function in the left eye. These forensic clinical findings are consistent with the degree of visual dysfunction, visual functional test results, and the nature of the primary injury.

In summary, the injury resulted in left eye blindness (visual acuity grade 5) following a bee/wasp sting. According to the Personal Insurance Disability Assessment Standard and Code (JR/T 0083-2013) Article 4.2.2 on visual dysfunction, one eye blindness grade 5 corresponds to disability grade 7. Therefore, the injury is assessed as personal insurance disability grade 7.

## 5. Conclusion

Although ocular bee/wasp stings are clinically rare, they can cause severe and multifocal ocular tissue damage

through mechanisms involving direct toxicity and immune-inflammatory responses from various bioactive components in the venom. In this case, despite active surgical and pharmacological interventions following a left eye bee/wasp sting, the examinee developed serious complications including corneal injury, uveitis, cataract, and secondary glaucoma, ultimately resulting in loss of vision (blindness grade 5) in the left eye. Forensic evaluation should comprehensively analyze the injury mechanism, treatment course, and final visual outcome, integrating objective examination results to accurately apply disability assessment standards. This study underscores the need in similar cases to pay particular attention to the progression of multiple complications induced by bee/wasp stings and their long-term impact on visual function, providing a scientific basis for forensic practice.

## Disclosure statement

The authors declare no conflict of interest.

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# The Application of Frailty Prediction Model for Middle-aged and Elderly Patients with Upper Gastrointestinal Bleeding in Peri-inpatient Nursing Intervention

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**Abstract:** *Objective*: To investigate the impact of targeted nursing interventions based on frailty prediction models on peri-hospitalization clinical outcomes in middle-aged and elderly patients with upper gastrointestinal bleeding (UGIB). *Methods*: A prospective cohort study was conducted, and 126 middle-aged and elderly patients with UGIB admitted from August 2024 to August 2025 were selected as the study subjects. The patients were divided into the intervention group (63 cases) and the control group (63 cases) based on whether they received nursing intervention based on frailty prediction models. The control group received routine care, while the intervention group, on the basis of routine care, used the FRAIL scale combined with laboratory indicators (albumin, hemoglobin, etc.) to establish a predictive model to evaluate patients within 24 hours of admission, and implemented multi-dimensional targeted nursing intervention for pre-frailty or frailty patients screened out. The incidence of frailty, rebleeding rate, average length of stay, hospitalization cost, and nursing satisfaction during hospitalization were compared between the two groups. *Results:* The incidence of frailty during hospitalization in the intervention group was 11.1% (7 cases /63 cases), significantly lower than 31.7% (20 cases /63 cases) in the control group, and the difference was statistically significant ($p < 0.05$). The rebleeding rate of 4.8% vs 12.7%, the average length of stay of (7.2 ± 1.5) days vs (9.1 ± 2.2) days, and the average hospitalization cost of (23,000 ± 6,000) yuan vs (28,000 ± 7,000) yuan in the intervention group were all lower than those in the control group (all $p < 0.05$). The nursing satisfaction score of the intervention group (93.5 ± 4.2) points was higher than that of the control group (86.3 ± 5.8) points ($p < 0.05$). *Conclusion:* The frailty prediction model applied to the peri-hospitalization care of middle-aged and elderly patients with UGIB can effectively identify frailty risk. Through early targeted intervention, the incidence of frailty and rebleeding rate can be reduced, the length of hospital stay can be shortened, medical expenses can be reduced, and nursing satisfaction can be improved, which has clinical promotion value.

**Keywords:** Upper gastrointestinal bleeding; Weakness; Predictive models; Elderly care; Perioperative period

**Online publication:** Feb 10, 2026

# 1. Introduction

Upper gastrointestinal bleeding (UGIB) is a common medical emergency. Middle-aged and elderly people, due to physiological decline, often have multiple underlying diseases and thus become a high-risk group. Frailty is an age-related clinical syndrome of decreased physiological reserves and reduced stress resistance, which significantly increases the risk of adverse health outcomes in elderly patients, namely falls, disability, readmission, and death. Studies have shown that UGIB and frailty interact with each other. Bleeding events can induce or exacerbate frailty, while frailty exacerbates slow recovery after bleeding, increased complications, and poor prognosis.

At present, clinical care for UGIB mainly focuses on hemostasis, fluid replacement, and etiological treatment, ignoring the coexistence of frailty in middle-aged and elderly patients, and there are no systematic assessment and intervention. The peri-hospitalization period is a window for intervention. Therefore, establishing a simple frailty risk prediction model suitable for middle-aged and elderly patients with UGIB and using it to implement early, targeted nursing intervention is of great significance for improving the prognosis of patients and optimizing the allocation of medical resources. This paper mainly studies the impact of frailty prediction model nursing intervention programs on the clinical outcomes of middle-aged and elderly patients with UGIB [1].

# 2. Data and methods

## 2.1. General information

A total of 126 middle-aged and elderly patients with UGIB who were admitted to the Department of Gastroenterology of our hospital from August 2024 to August 2025 were selected.

### 2.1.1. Inclusion criteria

(1) Age ≥ 50 years;

(2) Confirmed by gastroscopy or clinical diagnosis of UGIB;

(3) Conscious and cooperative with the investigation;

(4) Informed consent.

### 2.1.2. Exclusion criteria

(1) End-stage malignancy

(2) Severe cognitive impairment or mental illness,

(3) Incomplete clinical data.

### 2.1.3. Study group

The patients were randomly divided into the intervention group and the control group, with 63 cases in each group using a random number table. There were no statistically significant differences ($p > 0.05$) between the two groups in terms of age, gender, cause of bleeding, underlying diseases (hypertension, diabetes, coronary heart disease), hemoglobin at admission, and Rockall score, and they were comparable (**Table 1**). This study was reviewed and approved by the medical ethics committee of our hospital (approval number: 2024ZRY25), and all patients or their families signed the informed consent form [2].

**Table 1.** Comparison of general information of the two groups of patients

| Items | Intervention group (n = 63) | Control group (n = 63) | $t/\chi^2$ value | *p* value |
|---|---|---|---|---|
| Age (years, $\overline{x}$ ±s) | 68.5 ± 7.2 | 69.1 ± 6.8 | 0.498 | 0.619 |
| Gender (male/female, e.g.) | 40/23 | 38/25 | 0.130 | 0.718 |
| Cause of bleeding (example) | | | 0.721 | 0.868 |
| Peptic ulcer | 35 | 33 | | |
| Acute gastric mucosal lesions | 18 | 20 | | |
| Esophageal and gastric fundus varices | 10 | 9 | | |
| Others | 0 | 1 | | |
| Combined hypertension (example) | 32 | 29 | 0.297 | 0.586 |
| Diabetes mellitus (case) | 18 | 21 | 0.314 | 0.575 |
| Admission hemoglobin (g/L,±s) | 85.3 ± 15.6 | 82.9 ± 16.8 | 0.843 | 0.401 |
| Admission Rockall score ( $\overline{x}$ ±s) | 3.8 ± 1.2 | 4.0 ± 1.3 | 0.916 | 0.361 |

## 2.2. Methods

The control group was given routine UGIB care, including absolute bed rest, fasting and water deprivation, electrocardiogram monitoring, rapid establishment of intravenous access in combination with infusion, administration, observation of bleeding and vital signs, health education and discharge guidance [3].

In addition to the routine care, the intervention group received nursing intervention with a frailty prediction model [4].

(1) Frailty risk assessment

Within 24 hours of admission, patients were initially screened using the FRAIL scale by uniformly trained specialist nurses. The scale consists of five items: fatigue, endurance, free movement, illness, and weight loss. A score of ≥ 3 indicates frailty, 1–2 indicates pre-frailty, and 0 indicates no frailty. Laboratory indicators such as serum albumin (Alb), hemoglobin (Hb), and lymphocyte count (TLC) were also collected. Based on clinical experience and literature, a FRAIL score of ≥ 1, or Alb < 35g/L, or Hb < 90g/L and TLC < $1.5 \times 10^9$/L was defined as a high risk of frailty.

(2) Targeted nursing intervention

For patients assessed as at high risk of frailty, a multidisciplinary collaborative targeted nursing intervention was initiated immediately and continued until discharge.

(3) Nutritional support intensification

After bleeding stops, develop individualized dietary plans with a nutritionist to ensure high-quality protein intake. For patients with insufficient intake, provide timely advice to the doctor and assist with enteral or parenteral nutrition support. Objective: Stable or elevated Alb levels during hospitalization.

(4) Develop a progressive activity plan under the guidance of a rehabilitation therapist when the condition permits

Do ankle pump exercises and passive limb movements while lying in bed; You can do bedside standing and short walking after getting out of bed, and record the duration and intensity of your activities daily to prevent muscle weakness caused by absolute bed rest.

(5) Cognitive and psychological intervention

Pay attention to changes in the patient's mood and assess the risk of anxiety and depression. Psychological counseling is provided through methods such as disease knowledge lectures, successful case sharing, and mindfulness relaxation training to boost confidence in treatment.

(6) Medication and safety care, fine medication management, multi-medication risk assessment, fall prevention

Simplify medication regimens, use medicine kits as an aid, and enhance medication education. Ensure the safety of the environment and increase patrols at night.

(7) Family co-education

Train family members in debilitating knowledge and care skills, and encourage them to participate in nutritional support, activity companionship, and emotional support for the patient.

## 2.3. Observation indicators

(1) The incidence of frailty during hospitalization was based on a pre-discharge FRAIL score of ≥ 3.

(2) Secondary outcomes

Rebleeding rate (with hematemesis, aggravated melena, a decrease in hemoglobin > 20g/L or the need for re-endoscopic hemostasis during hospitalization); Average length of hospital stay; Average hospitalization expenses.

(3) Nursing satisfaction

Evaluation was conducted at discharge using a self-made satisfaction questionnaire (Cronbach's $\alpha = 0.89$), with a maximum score of 100.

## 2.4. Statistical processing

Using SPSS 25.0 software. Measurement data were expressed as ($\overline{x} \pm s$), and comparisons between groups were conducted using the independent sample *t*-test; Count data were expressed as cases (%), and comparisons between groups were conducted using the $\chi^2$ test or Fisher's exact test. A difference was considered statistically significant when $p < 0.05$.

# 3. Fruiting

## 3.1. Comparison of clinical outcomes during hospitalization between the two groups of patients

The incidence of new or frailty exacerbation during hospitalization in the intervention group was 11.1% (7/63), which was much lower than 31.7% (20/63) in the control group, and the difference was statistically significant ($\chi^2 = 8.254$, $p = 0.004$). There were 3 cases (4.8%) of rebleeding events in the intervention group and 8 cases (12.7%) in the control group. The difference between the two groups was statistically significant after continuous correction of the $\chi^2$ test ($\chi^2 = 4.547$, $p = 0.033$).

Hospitalization efficiency and economic indicators: The average length of stay in the intervention group was (7.2 ± 1.5) days, significantly shorter than (9.1 ± 2.2) days in the control group, which was statistically significant ($t = 5.829$, $p < 0.001$). Meanwhile, the average hospitalization cost of the intervention group was (23,000 ± 0.6) yuan, which was much lower than that of the control group (28,000 ± 0.7) yuan ($t = 4.381$, $p < 0.001$). See **Table 2** for the specific data.

**Table 2.** Comparison of clinical outcomes between the two groups (n = 63)

| Observation indicators | Intervention group | Control group | Statistics | *p* value |
|---|---|---|---|---|
| Frailty during hospitalization [cases (%)] | 7 (11.1%) | 20 (31.7%) | $\chi^2 = 8.254$ | 0.004 |
| Rebleeding events [cases (%)] | 3 (4.8%) | 8 (12.7%) | $\chi^2 = 4.547$* | 0.033 |
| Average length of stay (days, $\overline{x} \pm s$) | 7.2 ± 1.5 | 9.1 ± 2.2 | $t = 5.829$ | < 0.001 |
| Average hospitalization cost (ten thousand yuan, $\overline{x} \pm s$) | 2.3 ± 0.6 | 2.8 ± 0.7 | $t = 4.381$ | < 0.001 |

Note: Use the continuously corrected $\chi^2$ test.

### 3.2. Comparison of nursing satisfaction between the two groups of patients

The results of the nursing satisfaction survey at discharge showed that the satisfaction score of the intervention group was 93.5 ± 4.2 points, which was much higher than that of the control group (86.3 ± 5.8 points), and the difference was highly statistically significant ($t = 8.127$, $p < 0.001$).

## 4. Conclusion

This study, through comparative analysis, found that implementing peri-inpatient nursing interventions based on frailty prediction models could significantly improve the clinical prognosis of middle-aged and elderly patients with upper gastrointestinal bleeding. The intervention reduced the incidence of frailty during hospitalization by about 20 percentage points (from 31.7% to 11.1%), indicating that early detection and proactive intervention play an important role in breaking the vicious cycle between bleeding and frailty. The acute stress of UGIB and the requirement of fasting and bed rest in conventional treatment can easily lead to accelerated muscle protein breakdown and functional decline. Early admission evaluation, comprehensive intervention, enhanced nutrition and individualized rehabilitation can effectively maintain the physiological reserves of patients, which is likely an important factor in reducing the incidence of frailty [5].

The intervention group also had an advantage in secondary outcome measures. The rebleeding rate was reduced (12.7% versus 4.8%), which was associated with the improvement of overall nutritional status, tissue repair ability, and stress levels in patients with targeted intervention. The average length of hospital stay was shortened by about 2 days (9.1 days, 7.2 days), reflecting the economic "benefit" of frailty prevention, that is, the reduction of complications and the acceleration of the recovery process to improve the utilization efficiency of medical resources. The intervention group had higher nursing satisfaction scores (93.5 versus 86.3), indicating that the integrated nursing model was more in line with the physical and mental needs of patients and improved their medical experience [6].

Therefore, the frailty prediction model and nursing intervention measures adopted in this study have positive significance both from the perspectives of clinical effect and health economics. Bringing frailty management forward and into the routine care pathway of UGIB is a patient-centered approach worthy of promotion. The limitations of this study are that it is a single-center study and the interventions are implemented in a package. Future multi-center, large-sample studies will be needed to test the universality of the conclusions and further analyze the causes to determine the independent effects of each intervention.

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# Clinical Efficacy of Different Parameter Modes of Electrophysiological Therapy in Chronic Pelvic Pain Syndrome

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**Abstract:** *Objective*: To investigate the clinical efficacy of electrophysiological therapy under different parameter modes in chronic pelvic pain syndrome (CPPS). Methods: A total of 95patients with CPPS from the Department of Urology, First Affiliated Hospital of Jinan University, were selected and treated with electrophysiological therapy. They were randomly divided into three groups: the fixed-parameter AA7 treatment group, the P2 + P4 treatment group, and the precision treatment group (individualized parameter treatment). Pain scores of patients in each group were compared before and after treatment, with a pain score of 0 indicating cure. The cure rate of each group was observed. *Results:* The average ages of the AA7 group, P2 + P4 group, and precision treatment group were 34 ± 14.17 years, 35.58 ± 12.57 years, and 35.5 ± 11.27 years, respectively. There was no significant difference in age among the three groups ($p > 0.05$). Before treatment, the pain scores of the AA7 group, P2 + P4 group, and precision treatment group were 4.14 ± 1.74, 4.64 ± 1.72, and 3.50 ± 1.89, respectively, with no significant differences among the groups ($p > 0.05$). After treatment, the pain scores were 0.71 ± 0.99 for the AA7 group (cure rate: 57%), 0.49 ± 0.79 for the P2 + P4 group (cure rate: 67%), and 0.50 ± 0.77 for the precision treatment group (cure rate: 64%), with no significant differences among the groups ($p > 0.05$). The cure rates for different pain locations were as follows: 83% for lower abdominal pain, 74% for perineal pain, 62% for dysuria, 49% for testicular pain, and 75% for inguinal pain. *Conclusion:* The pathogenesis of CPPS is complex and diverse, with numerous treatment options and uncertain efficacy, posing significant challenges to clinical practice. This study showed that electrophysiological therapy under different parameter modes significantly reduced pain scores before and after treatment, indicating significant therapeutic effects on CPPS. All three modes demonstrated good cure rates. Individualized precision treatment and fixed-mode P2 + P4 or AA7 treatment were safe and effective in CPPS treatment and are worth promoting. Fixed-mode P2 + P4 and AA7, due to their easier standardization of parameters and patch modes, reduced the learning curve and had better potential for widespread application.

**Keywords:** Electrophysiological therapy; Chronic pelvic pain syndrome; Biofeedback; Efficacy evaluation

**Online publication:** Feb 6, 2026

# 1. Introduction

Chronic Pelvic Pain Syndrome (CPPS) is a disorder of the urinary system characterized primarily by pelvic pain, urinary symptoms, and sexual dysfunction [1,2]. The etiology of CPPS is complex and multifactorial, involving infectious, immunological, neurological, and psychological factors [3]. As a result, CPPS has a substantial negative impact on the quality of life of affected patients. Conventional treatment strategies for CPPS include pharmacological therapy, psychological intervention, and physical therapy [4]. However, the clinical effectiveness of these treatments is often limited, and some approaches are associated with adverse effects. In recent years, electrophysiological therapy has gained increasing attention as a noninvasive physical treatment modality for chronic pain management [5]. By applying electrical stimulation with specific parameter settings, electrophysiological therapy can modulate neural transmission, alleviate pain, improve local blood circulation, and promote tissue repair processes [6]. Despite these potential benefits, current evidence regarding the use of electrophysiological therapy in CPPS remains limited, particularly with respect to comparisons of different parameter modes [7,8]. Variations in stimulation parameters may lead to significant differences in therapeutic outcomes. Therefore, identifying optimal electrophysiological therapy parameter modes for patients with CPPS is of considerable clinical importance.

# 2. Materials and methods

## 2.1. Clinical data

A total of 95 patients diagnosed with Chronic Pelvic Pain Syndrome (CPPS) who visited the Department of Urology at the First Affiliated Hospital of Jinan University between January 2023 and July 2024 were enrolled in this study. The patients were aged between 26 and 59 years, with a median age of 36 years. All patients were diagnosed with CP/CPPS based on medical history, physical examination including digital rectal examination, routine laboratory tests, NIH Chronic Prostatitis Symptom Index (NIH-CPSI) score, bacterial culture, and ultrasonography [9]. There were no statistically significant differences among the groups in terms of age, NIH-CPSI scores, maximum urinary flow rate, or average urinary flow rate (Qavg) ($p > 0.05$), indicating good comparability [10,11].

## 2.2. Inclusion and exclusion criteria

### 2.2.1. Inclusion criteria

Patients who met the diagnostic criteria for chronic pelvic pain were included. Chronic pelvic pain was defined as pain located in the pelvic region or surrounding tissues caused by functional and or organic factors and lasting for more than six months [12,13].

### 2.2.2. Exclusion criteria

Patients were excluded if they met any of the following conditions:

(1) Diagnosis of prostate cancer or having undergone prostate biopsy within the previous one month
(2) History of pelvic radiotherapy, transurethral surgery, or urethral trauma
(3) Presence of skin allergy, neurological disorders, or severe systemic diseases
(4) Diagnosis of acute or chronic urethritis, epididymitis, varicocele, perianal or rectal diseases, or sexually transmitted diseases

(5) Use of antibiotics, nonsteroidal anti-inflammatory drugs, or medications affecting the genitourinary system within one month before enrollment, including diuretics, alpha receptor blockers, or 5 alpha reductase inhibitors
(6) Receipt of investigational drug treatment within the past six months [14,15]

## 2.3. Grouping of patients

Patients were randomly assigned into three groups: Group A included 14 patients receiving fixed parameter AA7 (analgesic mode) treatment. Group B included 45 patients receiving combined P2 and P4 treatment (analgesia plus arterial circulation mode). Group C included 36 patients receiving precision treatment with individualized parameter settings. The mean ages were 34 ± 14.17 years in Group A, 35.58 ± 12.57 years in Group B, and 35.5 ± 11.27 years in Group C. No significant differences were found among the three groups regarding baseline characteristics (all $p > 0.05$). All patients and their family members voluntarily participated in the study and signed written informed consent forms. Pain intensity was evaluated before and after treatment using the visual analogue scale (VAS). A VAS score of 0 was considered complete pain relief. Cure rates were compared among the groups.

## 2.4. Treatment methods

### 2.4.1. Stimulation method

All patients received transcutaneous electrical nerve stimulation (TENS). TENS is a noninvasive method that delivers electrical stimulation through surface electrodes placed on the skin to activate nerve fibers and relieve pain.

### 2.4.2. Electrode placement

Electrodes were placed at treatment sites such as the pelvic floor muscles and lower abdomen. Proper contact between electrodes and skin was ensured, and electrode positions were adjusted according to body contour and treatment area to optimize stimulation effectiveness and patient comfort.

### 2.4.3. Parameter settings

Electrical stimulation parameters were adjusted according to patient tolerance and therapeutic goals, including current intensity, frequency, and waveform. Current intensity was initiated at a low level and gradually increased to a comfortable and effective range. Stimulation frequency was adjusted based on treatment mode and patient response, generally ranging from 1 to 150 Hz. Waveforms included square, triangular, and sinusoidal waves, which have different effects on neural and muscular stimulation.

### 2.4.4. Stimulation procedure

Electrical stimulation was initiated after parameter adjustment. Patient responses were continuously observed to ensure safety and effectiveness. Medical staff monitored facial expression and body movement during treatment and adjusted parameters when necessary to manage discomfort.

### 2.4.5. Electrode positions for different treatment modes

(1) Group A precision parameter treatment: Parameters were individualized based on infrared detection results. Electrode placement included: (a) Sensory, neural, and muscular stimulation at pain points and

sacral region. (b) Circulation stimulation at the Qugu acupoint and bilateral dorsum of the feet. (c) Bladder meridian stimulation along the lumbosacral bladder meridian pathway

(2) Group B fixed parameter treatment (AA7 Mode): Electrode placement: pain points and sacral region. Parameters: 80, 120, and 80 Hz with pulse widths of 20, 80, and 120 microseconds, and 1, 4, and 1 Hz with pulse widths of 270, 230, and 270 microseconds

(3) Group C P2 plus P4 treatment: P2 analgesic mode: electrodes placed at the Baliao points, Zhongji, and Guanyuan acupoints with parameters of 100, 150, and 100 Hz and pulse widths of 150, 100, and 150 microseconds. P4 arterial circulation mode: electrodes placed at Shenque, Mingmen, and Yongquan acupoints with parameters of 10 Hz and pulse width of 300 microseconds

### 2.5. Outcome measures

Pain intensity was assessed using the visual analogue scale (VAS). A reduction of 2 points or more on the 0 to 10 scale was considered clinically meaningful. The VAS is a simple and widely used tool for pain assessment. Patients marked their pain level on a 10 cm horizontal line, where 0 represented no pain and 10 represented the most severe pain imaginable. Changes in VAS scores before and after treatment were used to evaluate pain relief.

## 3. Results

### 3.1. Comparison of pain scores among treatment groups

There were no significant differences in baseline VAS scores among the three groups before treatment ($p > 0.05$). After treatment, the mean VAS score was 0.71 ± 0.99 in the AA7 group, with a cure rate of 57 percent. The P2 plus P4 group had a mean VAS score of 0.49 ± 0.79 and a cure rate of 67 percent. The precision treatment group showed a mean VAS score of 0.50 ± 0.77, with a cure rate of 64 percent. Pain scores were significantly reduced in all three groups after treatment, while no statistically significant differences were observed among the groups ($p > 0.05$). During the treatment period, patients in the AA7 group experienced relatively slower pain relief during the first one to two weeks, followed by gradual improvement. The P2 plus P4 group showed more rapid pain relief in the early treatment stage with a stable overall improvement trend.

In the precision treatment group, some patients achieved marked pain relief at an early stage due to individualized parameter settings, while a small number of patients required parameter adjustment because of variability in treatment response. The results are summarized in **Table 1** and **Figure 1**.

**Table 1.** Comparison of pre- and post-treatment VAS scores among three electrophysiological treatment modalities

| | AA7 group mean VAS score | P2 + P4 group mean VAS score | Precision treatment group mean VAS score |
|---|---|---|---|
| Pre treatment | 4.14 ± 1.74 points | 4.64 ± 1.72 points | 3.50 ± 1.89 points |
| Post treatment | 0.71 ± 0.99 points | 0.49 ± 0.79 points | 0.50 ± 0.77 points |
| Cure rate | 57% | 67% | 64% |

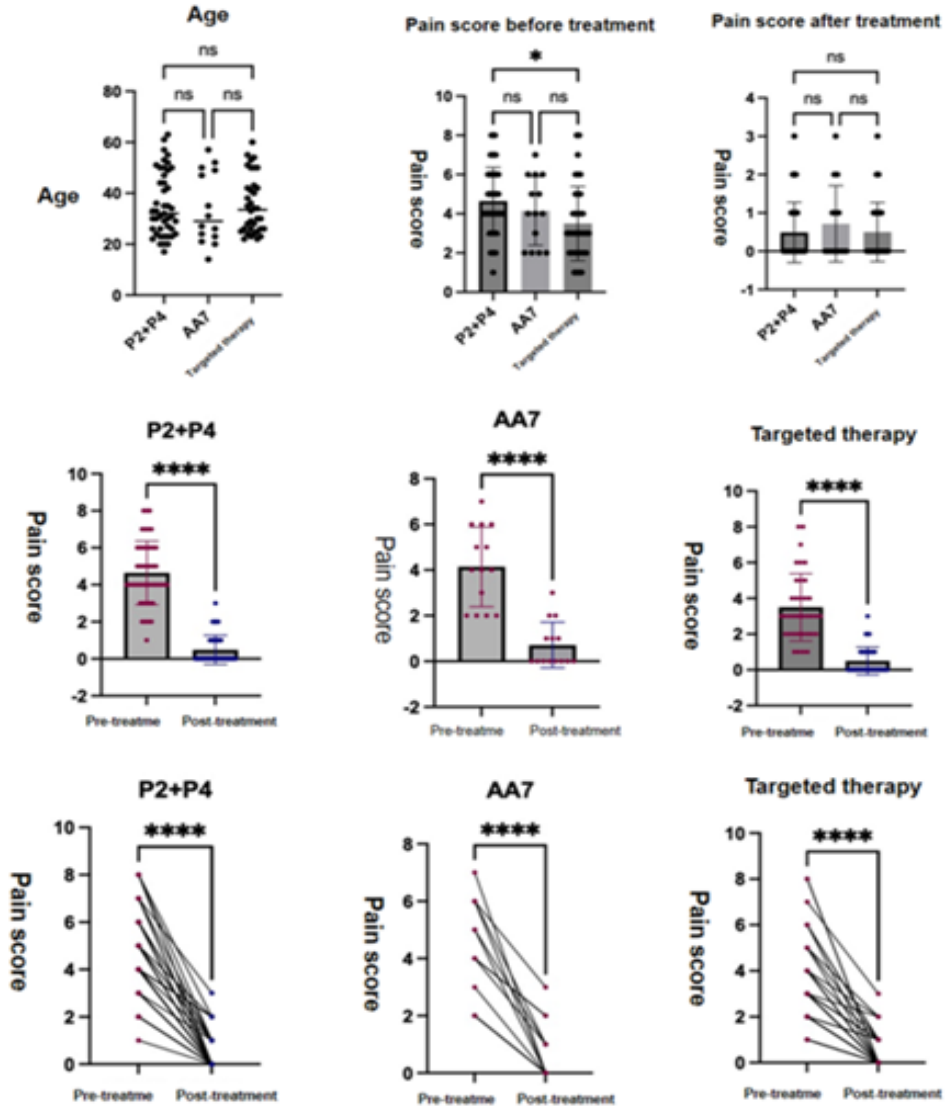



**Figure 1.** Comparison of pain scores among different treatment modalities.

## 3.2. Cure rates according to different pain locations

The cure rate for lower abdominal pain was 83%, followed by inguinal pain (75%), perineal pain (74%), dysuria-related pain (62%), and testicular pain (49%). During treatment, patients with lower abdominal and inguinal pain showed relatively better responses to electrophysiological therapy. This may be attributed to the more concentrated neural distribution and richer blood supply in these regions. In contrast, patients with testicular pain demonstrated a relatively lower cure rate, which may be related to the unique characteristics of testicular tissue, including highly sensitive and complex nerve endings, as well as a relatively independent blood supply, resulting in a weaker response to electrical stimulation. The cure rates for perineal pain and dysuria-related pain were at an intermediate level, which may be associated with interactions between nerves and muscles in the perineal and periurethral regions, as well as inflammatory responses. See **Table 2**.

**Table 2.** Cure rates according to different pain locations

| Pain location | Lower abdominal pain | Perineal pain | Urinary pain | Testicular pain | Groin pain |
|---|---|---|---|---|---|
| Cure rate (%) | 83 | 74 | 62 | 49 | 75 |

## 4. Discussion

The pathogenesis of CP/CPPS is complex and multifactorial, involving infectious, immunological, neurological, and psychological factors. Traditional treatment approaches, including pharmacological therapy, psychological intervention, and physical therapy, often show limited efficacy and may be associated with adverse effects. In recent years, electrophysiological therapy, as a non-invasive and non-traumatic physical treatment modality, has attracted increasing attention in the management of chronic pain. By delivering electrical stimulation with specific parameters, electrophysiological therapy can modulate neural transmission, alleviate pain, improve local blood circulation, and promote tissue repair.

In the present study, VAS scores were significantly reduced after electrophysiological treatment under different parameter modes, indicating that electrophysiological therapy is effective for CP/CPPS across various treatment modes. All three treatment modes demonstrated favorable cure rates. Both individualized precision therapy and fixed modes (P2 + P4 and AA7) were shown to be safe and effective in the treatment of CP/CPPS and therefore merit wider clinical application. Notably, the fixed P2 + P4 and AA7 modes allow easier standardization of parameters and electrode placement, which may reduce the learning curve and make them particularly suitable for implementation in primary healthcare settings.

Furthermore, analysis based on pain location revealed that the cure rates for lower abdominal pain and inguinal pain were relatively high (83% and 75%, respectively), whereas the cure rate for testicular pain was comparatively low (49%). These differences may be related to variations in neural distribution, blood supply, and underlying pathophysiological characteristics among different anatomical sites. This finding suggests that treatment strategies may be optimized by tailoring electrophysiological therapy according to pain location or by combining it with other therapeutic modalities to improve overall efficacy. For example, patients with lower abdominal or inguinal pain may preferentially benefit from the P2 + P4 or AA7 modes, whereas patients with testicular pain may require adjunctive treatments, such as pharmacotherapy or physical rehabilitation, in addition to electrophysiological therapy, to enhance treatment outcomes.

Although the overall cure rate of the individualized precision therapy group was comparable to those of the other two groups, this approach demonstrated advantages in addressing individual patient needs during treatment. It is particularly suitable for patients with complex clinical conditions, multiple pain locations, or poor responses to conventional therapies. By performing detailed physiological parameter assessments and designing personalized treatment protocols, precision therapy enables more targeted modulation of neural transmission and blood circulation, thereby improving treatment specificity and effectiveness.

However, individualized precision therapy requires higher technical expertise and specialized equipment, as well as experienced healthcare professionals for parameter adjustment and operation. These requirements may limit its widespread application in primary medical institutions. Therefore, in clinical practice, the choice of electrophysiological treatment mode should be based on institutional resources, patient characteristics, and economic considerations to achieve optimal therapeutic outcomes and patient satisfaction. Future large-scale, multicenter clinical studies are warranted to further explore the optimal parameter settings, treatment duration, and long-term

efficacy of electrophysiological therapy in CP/CPPS, thereby providing stronger evidence for its clinical application.

## Disclosure statement

The authors declare no conflict of interest.

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# Application and Effectiveness Evaluation of Standardized Protective Care Procedures in Hydrofluoric Acid Operations within Dental Departments

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**Abstract:** *Objective*: To evaluate the implementation effectiveness of standardized protective care procedures during hydrofluoric acid procedures in the dental department. *Methods*: This study was conducted from June 2023 to June 2025, selecting 90 patients who underwent hydrofluoric acid-related treatments in the outpatient dental department of this hospital during this period as subjects. Forty-five patients treated between June 2023 and June 2024 received conventional protective care (pre-intervention group), while 45 patients treated between June 2024 and June 2025 underwent the standardized protective care protocol (post-intervention group). Thirteen healthcare personnel participated in both pre- and post-intervention treatment phases. Based on the different nursing models, indicators such as the incidence of adverse events in patients and the exposure rate of healthcare personnel before and after implementation were compared to evaluate the effectiveness of the nursing intervention. *Results:* The incidence of oral mucosal irritation reactions in patients was lower after implementation, $p < 0.05$. Compared with the pre-implementation period, the incidence of procedure-related adverse events decreased after implementation, $p < 0.05$. There was a significant difference in the occupational exposure rate of healthcare personnel before and after implementation, with a higher rate observed before implementation ($p < 0.05$). Post-implementation, healthcare personnel achieved higher compliance scores for pre-procedure preparation, intra-procedure protection, and post-procedure handling ($p < 0.05$). Patient satisfaction with treatment was lower pre-implementation than post-implementation ($p < 0.05$). *Conclusion:* Adherence to standardized protective care procedures during hydrofluoric acid operations by dental department staff in outpatient settings standardizes practitioner techniques, effectively prevents oral mucosal irritation in patients, reduces occupational exposure risks for staff, minimizes adverse procedural events, and consequently enhances patient treatment satisfaction. This demonstrates significant practical value.

**Keywords:** Standardized protective care procedures; Dental department; Outpatient clinic; Hydrofluoric acid handling

**Online publication:** Feb 6, 2026

# 1. Introduction

In clinical dentistry, hydrofluoric acid is frequently employed during therapeutic procedures such as inlay restoration to perform efficient acid etching. This process ensures robust bonding between porcelain inlays and soft tissues, facilitating subsequent treatment steps and guaranteeing restorative outcomes. However, hydrofluoric acid is an inorganic acid with exceptionally high reactivity, exhibiting strong corrosiveness and high permeability. Inadequate protective measures during handling may lead to occupational exposure, such as skin contact, resulting in chemical burns, respiratory tract damage, or oral mucosal irritation in patients [1,2]. Consequently, effective protective measures are essential during hydrofluoric acid procedures in dentistry to mitigate safety risks and safeguard the health of both healthcare personnel and patients. This study aims to establish a standardized protective nursing protocol for comprehensive management throughout the entire hydrofluoric acid procedure, evaluating its application efficacy. The findings are reported as follows.

# 2. Materials and methods

## 2.1. General information

This study involved 90 patients undergoing hydrofluoric acid-related treatment, all of whom attended the outpatient dental department of our hospital between June 2023 and June 2025. Protective nursing measures were implemented according to the sequence of their appointments. The conventional care group (pre-implementation) comprised 24 males and 21 females, aged 20–68 years (mean 43.27 ± 3.62). The standardized protective care group (post-implementation) included 25 males and 20 females, with ages ranging from 20 to 69 years (mean 43.51 ± 3.70 years). Thirteen healthcare personnel participated in both groups: five physicians and eight nurses, aged 24 to 45 years (mean 32.51 ± 3.47 years). Baseline data showed no significant differences before and after implementation ($p > 0.05$), indicating comparability.

### 2.1.1. Inclusion criteria

(1) All subjects must undergo hydrofluoric acid treatment;
(2) Subjects must be conscious and able to cooperate with treatment and nursing care;
(3) Subjects must provide informed consent to participate in the study.

### 2.1.2. Exclusion criteria

(1) Concurrent oral mucosal lesions;
(2) Severe hepatic or renal impairment;
(3) Hypersensitivity to hydrofluoric acid therapy.

## 2.2. Methodology

Between January and December 2023, routine protective care was implemented for 45 patients undergoing treatment. Prior to procedures, nursing staff briefed patients on precautions for hydrofluoric acid handling while wearing masks, gloves, and protective gowns. During operations, protective measures were applied based on established protocols. Post-procedure, the treatment area was thoroughly cleaned, and all used instruments were disinfected.

Between January and December 2024, a standardized protective nursing protocol was established for the

treatment of 45 patients, with nursing duties conducted accordingly.

(1) Standardized protective nursing team

Led by the Head Nurse, a standardized protective nursing team was formed comprising dentists, nurses and other relevant personnel. This team developed a standardized protective nursing protocol based on applicable operational safety guidelines and protocols. All healthcare personnel were required to undergo systematic training and pass an assessment before being permitted to participate in nursing duties [3].

(2) Pre procedure preparation

During pre-procedure preparation, all healthcare personnel underwent joint training covering hydrofluoric acid hazards, protective protocols, and emergency response measures, with participation in treatment nursing contingent upon passing assessments. Nursing staff conducted comprehensive patient assessments based on prior allergy history, oral condition, and general health status to formulate individualized protective plans [4]. Patients and their families are informed about hydrofluoric acid procedures in plain language, emphasizing potential risks and protective measures to enhance compliance. Protective equipment such as acid-resistant gloves, goggles, and protective face shields is prepared according to operational standards. Hydrofluoric acid reagents are inspected for expiry dates and packaging integrity to prevent leakage. Prepare emergency supplies for hydrofluoric acid exposure, such as calcium gluconate gel and physiological saline [5]. Affix hydrofluoric acid warning signs in the operational area, clear away unrelated items, arrange necessary reagents and instruments appropriately, and strictly demarcate contaminated and clean zones to prevent cross-contamination. Activate ventilation equipment in the operating room to maintain adequate airflow.

(3) Implement protective measures during procedures

Healthcare personnel must correctly wear acid-resistant masks, aprons, and nitrile gloves to ensure comprehensive protection. Strictly adhere to protocol requirements, controlling HF dosage and concentration to prevent overuse. Establish dedicated splash-proof zones on treatment tables with acid-resistant mats. Implement personalized patient protection by applying petroleum jelly around the oral cavity. Use a saliva ejector to promptly remove vapors and waste liquid generated during the procedure, minimizing irritation [6]. Healthcare personnel should inspect the integrity of protective equipment seals every 5 minutes. Should reagent leakage occur, cease operations immediately. Clean up using specialized absorbent materials and flush contaminated areas with copious amounts of water. Upon completion of acid etching, immediately rinse the porcelain inlay and surrounding area three times with physiological saline solution. Collect the rinsing solution in dedicated corrosion-resistant containers.

(4) Post-procedure management

After completion, rinse the patient's oral cavity with physiological saline to ensure no residual hydrofluoric acid remains. Inspect the oral mucosa for burns or other abnormalities, treating any findings with oral ulcer ointment. Seal any residual hydrofluoric acid reagent and store it in a dedicated corrosion-resistant cabinet. Wipe the operating area clean with water, then disinfect it by spraying with a chlorine-based disinfectant. After half an hour, wipe again with water. Immerse used etching instruments in a 5% calcium hydroxide solution for 40 minutes to neutralize them, then dispose of them according to medical waste regulations. Medical staff shall remove protective equipment in the prescribed sequence and disinfect hands using a quick-drying hand sanitizer [7]. Advise patients to avoid consuming spicy, hot, or hard foods for 2 hours post-procedure, maintain oral hygiene, and return promptly for review should any discomfort arise.

## 2.3. Observation indicators

### 2.3.1. Assessment of patient mucosal irritation

Observe and record patients' oral mucosal irritation reactions, such as pain, redness, swelling, and burns, following hydrofluoric acid procedures, comparing incidence rates before and after implementation.

### 2.3.2. Assessment of operational safety incidents

Adverse events occurring during statistical operations, including hydrofluoric acid leaks, accidental patient injuries, and reagent misuse, shall be compared in terms of their incidence rates.

### 2.3.3. Assessment of healthcare staff exposure rates

Record instances of respiratory inhalation, skin and eye contact occurring during hydrofluoric acid handling by healthcare personnel before and after implementation, and compare occupational exposure rates.

### 2.3.4. Assessment of personal protective equipment compliance

Assessment of compliance with protective procedures for healthcare personnel, evaluating the standard of practice in donning protective equipment prior to procedures, implementation of protective measures during procedures, and post-procedure handling. Scored out of 100 points, with higher scores indicating greater compliance.

## 2.4. Statistical analysis

Data obtained in this study are presented as (n, %). Count data conforming to normal distribution are expressed as (n, %). All data were entered into SPSS 23.0 software. Following categorization, *t*-tests (for continuous data) and chi-square tests (for categorical data) were conducted. Differences were assessed based on *p*-values, with $p < 0.05$ indicating statistically significant differences.

# 3. Results

## 3.1. Comparison of the incidence of oral mucosal irritation reactions before and after implementation

The incidence of oral mucosal irritation reactions in patients prior to implementation was 20.00%, which was significantly higher than that observed post-implementation ($p < 0.05$). See **Table 1**.

**Table 1.** Comparison of the incidence of oral mucosal irritation reactions before and after implementation (n, %)

| Group | Example count | Redness and swelling | Pain | Burn | Overall incidence rate |
|---|---|---|---|---|---|
| Prior to implementation | 45 | 5 (11.11) | 3 (6.67) | 1 (2.22) | 9 (20.00) |
| Upon implementation | 45 | 1 (2.22) | 1 (2.22) | 0 (0.00) | 2 (4.44) |
| $c^2$ | - | - | - | - | 5.075 |
| *p* | - | - | - | - | 0.024 |

## 3.2. Comparison of adverse event incidence rates before and after implementation

The incidence rate of adverse events prior to implementation was 15.56%, while the incidence rate after implementation was 2.22%. The incidence rate prior to implementation was higher than that after implementation (*p*

< 0.05). See **Table 2**.

**Table 2.** Comparison of adverse event incidence related to operations before and after implementation (n, %)

| Group | Example count | Hydrofluoric acid leak | Collateral casualty | Reagent misuse | Overall incidence rate |
|---|---|---|---|---|---|
| Prior to implementation | 45 | 1 (2.22) | 2 (4.44) | 4 (8.89) | 7 (15.56) |
| Upon implementation | 45 | 0 (0.00) | 0 (0.00) | 1 (2.22) | 1 (2.22) |
| $c^2$ | - | - | - | - | 4.939 |
| $p$ | - | - | - | - | 0.026 |

## 3.3. Comparison of healthcare workers' occupational exposure rates before and after implementation

Following the implementation of standardized protective care procedures, no occupational exposures occurred among healthcare personnel, with a significantly lower incidence rate compared to the pre-implementation period ($p$ < 0.05). See **Table 3**.

**Table 3.** Comparison of healthcare workers' occupational exposure incidence rates before and after implementation (n, %)

| Group | Example count | Skin contact | Respiratory inhalation | Eye contact | Overall incidence rate |
|---|---|---|---|---|---|
| Prior to implementation | 45 | 1 (7.69) | 2 (15.38) | 1 (7.69) | 4 (30.77) |
| Upon implementation | 45 | 0 (0.00) | 0 (0.00) | 0 (0.00) | 0 (0.00) |
| $c^2$ | - | - | - | - | 4.727 |
| $p$ | - | - | - | - | 0.030 |

## 3.4. Comparison of healthcare personnel compliance scores before and after implementation

Following implementation, healthcare professionals' scores for procedural compliance were significantly higher than pre-implementation levels ($p$ < 0.05). See **Table 4**.

**Table 4.** Comparison of healthcare personnel compliance with operating procedures before and after implementation ($\overline{x} \pm s$)

| Group | Example count | Preparation prior to operation | Protective measures during operation | Post-processing |
|---|---|---|---|---|
| Prior to implementation | 13 | 77.94 ± 3.41 | 75.28 ± 3.50 | 78.12 ± 3.37 |
| Upon implementation | 13 | 92.45 ± 4.08 | 91.86 ± 3.94 | 93.09 ± 3.15 |
| $t$ | - | 9.839 | 11.343 | 11.701 |
| $p$ | - | 0.000 | 0.000 | 0.000 |

## 4. Discussion

Hydrofluoric acid is a highly corrosive chemical reagent that exerts potent irritation on human skin, respiratory tract, and mucous membranes. In clinical dentistry, it is frequently employed in inlay restorations to achieve secure bonding of porcelain inlays, thereby ensuring restorative efficacy [8]. To guarantee treatment safety, meticulous protective measures must be implemented during hydrofluoric acid procedures in dental practice, mitigating safety risks and hazards to safeguard both practitioner and patient wellbeing. Currently, routine protective measures are employed during hydrofluoric acid procedures in dental departments. However, inadequate protective awareness among some healthcare personnel, failure to properly wear protective equipment, or poor ventilation in operating rooms may increase operational hazards [9]. Consequently, standardizing protective care protocols and establishing a formalized protective care process is of paramount importance.

Following implementation, the probability of patients experiencing oral mucosal pain, burns, and other irritant reactions was significantly lower, with procedure-related adverse event rates also reduced compared to pre-implementation levels ($p < 0.05$). Analysis indicates that the standardized protective care protocol facilitates comprehensive patient assessment, enabling the development of personalized protective measures tailored to individual circumstances. Pre-procedure communication regarding the risks and precautions associated with hydrofluoric acid procedures enhances patient cooperation. During procedures, applying Vaseline around the patient's mouth and using saliva ejectors to aspirate vapors generated during handling reduced irritation to the oral mucosa from hydrofluoric acid vapors and waste liquid, thereby decreasing the incidence of irritation reactions [10–12]. The standardized protective care protocol also provided systematic training for healthcare personnel, enhancing their awareness and skills in protective measures while standardizing operational procedures, thus reducing procedure-related adverse events [13]. Concurrently, healthcare personnel demonstrated significantly higher scores for procedural compliance post-implementation compared to pre-implementation, $p < 0.05$. The incidence of occupational exposure among healthcare personnel was markedly lower following implementation, $p < 0.05$. This indicates that standardized protective nursing protocols effectively mitigate occupational exposure risks during hydrofluoric acid procedures, primarily through enhanced procedural standardization and compliance, thereby safeguarding occupational safety for healthcare personnel.

## 5. Conclusion

In summary, when performing hydrofluoric acid procedures in dental outpatient departments, standardized protective care protocols must be strictly adhered to. This ensures healthcare professionals operate within established guidelines, minimizes safety risks for both staff and patients, and guarantees both therapeutic efficacy and safety. Such protocols may be promoted for implementation across dental treatment settings.

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## Disclosure statement

The author declares no conflict of interest.

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# Integrated Predictive Nursing Care for a Case of Imported Severe Malignant Malaria with Spontaneous Splenic Rupture

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**Abstract:** A case of imported severe falciparum malaria with spontaneous splenic rupture was reported in this paper. The patient, an African migrant worker, developed hemolytic anemia, sepsis, thrombocytopenia, coagulation dysfunction, liver failure, renal insufficiency, electrolyte disturbance and other clinical manifestations after returning to the local area. Plasmodium falciparum was found by peripheral blood smearscopy and was diagnosed as severe falciparum malaria. After standardized anti-malaria treatment, plasma exchange + cytokine adsorption therapy, the establishment of "forewarning–forewarning–prevention–emergency" predictive nursing management model, the establishment of an integrated nursing team, the division of medical care is clear, professional knowledge is complementary, after three months of regular follow-up, the patient has no malaria recurrence, no refire, the function of all organs returned to normal.

**Keywords:** Severe falciparum malaria; Imported malaria; Splenorrhagia; Integration of health care; Predictive care; Plasma exchange; Cytokine adsorption

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## 1. Introduction

Malaria is a parasitic disease transmitted by the bites of Anopheles mosquitoes, mainly caused by the human malaria parasite [1]. It is a significant global public health issue, especially with a higher incidence rate in tropical and subtropical regions [2]. Since 2017, China has achieved zero reports of local malaria cases. However, with the increasingly frequent international exchanges along the Belt and Road Initiative, imported malaria cases continue to rise [3]. Imported malaria usually refers to symptomatic cases with a travel history to malaria-endemic areas 1 to 3 months before the onset of the disease and with clear evidence of infection from abroad [4]. Among them, severe malignant malaria is caused by Plasmodium falciparum. It has an acute onset, rapid progression, complex clinical manifestations, and is prone to serious complications [5]. Splenomegaly is a common sign of malaria infection, but spontaneous splenic rupture is a rare and life-threatening complication [6]. The etiology of severe malignant malaria

combined with spontaneous splenic rupture is complex. It often has no clear history of trauma, which can easily lead to missed diagnosis, misdiagnosis, delayed treatment and even endanger life. Therefore, early identification, diagnosis and intervention are crucial for improving the prognosis of patients [7].

The integrated medical and nursing model, through multi-disciplinary collaboration (covering medical treatment, nursing, rehabilitation, nutrition, psychology, etc.), provides patients with all-round and full-process high-quality services, which is conducive to promoting disease recovery [8]. The construction of a predictive nursing management model of "foresight–early warning–prevention–emergency response" aims to promptly identify potential nursing risks, formulate targeted prevention and control measures, demonstrate forward-looking thinking, minimize related risks to the greatest extent, thereby improving the treatment effect of severe malignant malaria with spontaneous splenic rupture, enhancing the medical experience of patients, and strengthening the trust between nurses and patients [9].

This article reports a case of a patient with imported severe malignant malaria complicated with spontaneous splenic rupture. On the basis of plasma exchange combined with cytokine adsorption therapy, integrated predictive nursing care was implemented, achieving good therapeutic effects.

## 2. Clinical data

### 2.1. General information

The patient is a 38-year-old male. A week ago, he developed a fever without any cause, with the highest body temperature reaching 40 ℃. The fever was irregular, accompanied by chills and shivering, as well as dizziness. In the past two days, he has experienced diarrhea, accompanied by nausea and vomiting of gastric contents several times. He came to the hospital on his own and was admitted to our department in the emergency department with a fever. Since the onset of the disease, the patient's spirit and appetite have been average, sleep has been poor, diarrhea has occurred (on average once every 1 to 2 hours), urination has been normal, physical strength has declined, and there has been no significant change in weight. The patient has a long history of working in Africa and denies any other medical history. Abdominal CT examination from 2008 to 2011 indicated splenic hematoma (see **Figure 1A** and **1B**). On August 13, 2020, the blood *Plasmodium* test was positive. Both microscopic examination and colloidal gold test were positive (malignant malaria). Bone marrow puncture results on August 15, 2025:32 phagocytic tissue cells per piece, with the phagocytic substances being red blood cells, white blood cells, and platelets. *Plasmodium* (see **Figure 2**). Chest CT of 08-17 shows splenic hematoma (see **Figure 3**). Liver color Doppler ultrasound on 08-20 indicated abnormal echoes in the spleen. MRI of the liver, gallbladder and spleen on 08-25 suggested subacute hematoma of the spleen (see **Figure 4**)

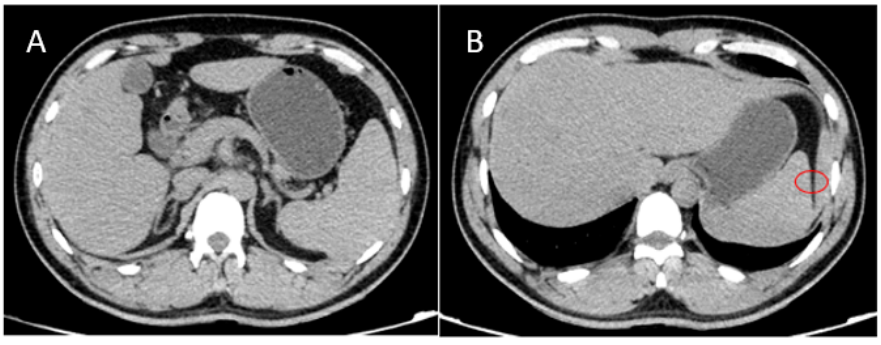



**Figure 1.** A. Splenomegaly. B. Suspected splenic hemorrhage.

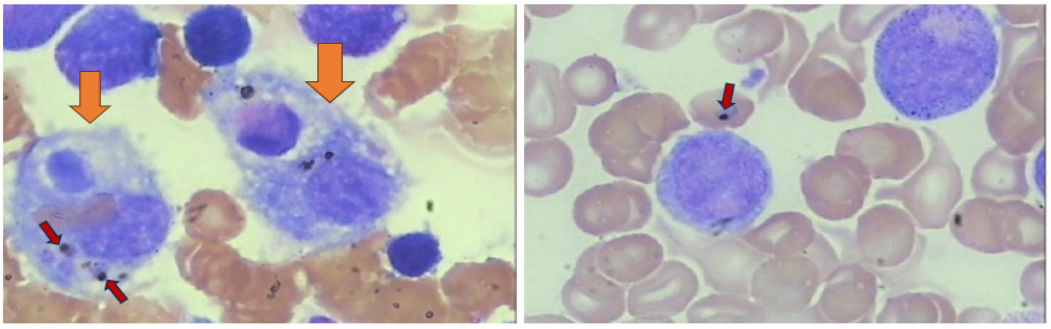


**Figure 2.** Bone marrow image: 32 phagocytic tissue cells per plate, with red blood cells, white blood cells and platelets as phagocytes (indicated by orange arrows); *Plasmodium* (red arrow).

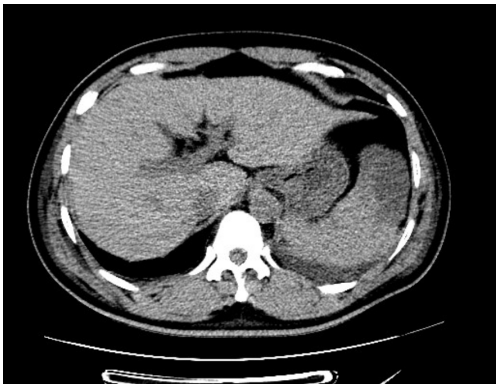


**Figure 3.** Splenic hematoma on chest CT.

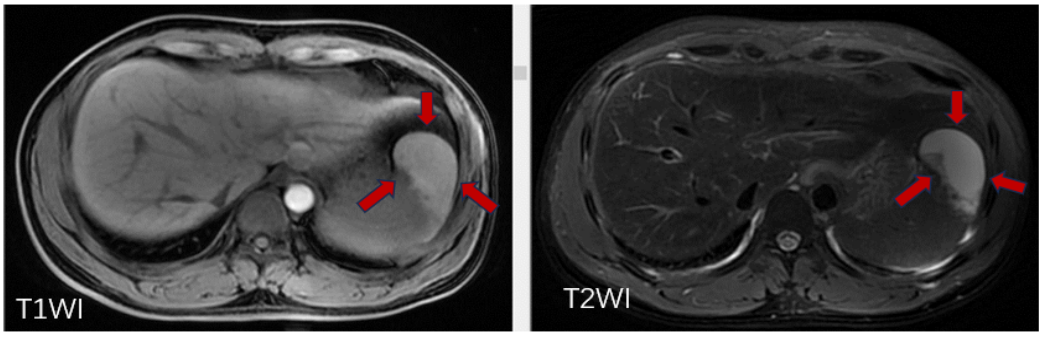



**Figure 4.** Enhanced MRI: The spleen is slightly enlarged, and cystic abnormal signals are shown in the spleen: hematoma? Subacute stage? (Indicated by the red arrow), both T1WI and T2WI show high signals. A low-signal septal image on T2WI can be seen within the lesion, with the lesion range approximately 6.9 cm × 3.8 cm × 3.2 cm. DWI shows unevenly high signals, and there are a few fluid signal shadows around the spleen.

## 2.2. Inspection report

The diagnostic results shown in **Table 1** include abnormal laboratory values and imaging features consistent with severe malaria and splenic involvement.

**Table 1.** Diagnosis report

| Check the category | Inspection item | Inspection result |
|---|---|---|
| Laboratory inspection | Blood routine examination | WBC 4.80 g/L, NE 3.97 g/L, RBC 5.08 g/L, Hb 161 g/l, PLT 11 g/L |
| | Liver and kidney functions, blood lipids | WBC 4.80 g/L, NE 3.97 g/L, RBC 5.08 g/L, Hb 161 g/L, PLT 31 g/L |
| | Coagulation function | PT 16.9 s, PTA 55%, D-Dimer 7.13 mg/L |
| | Inflammatory indicators | PCT 3.55 ng/mL; IL-6 123.1 pg/mL; hs-CRP 106.36 mg/L; ferroprotein 8964 ng/mL |
| | Screening for infectious diseases | Hepatitis B, hepatitis C, HIV and syphilis are all negative |
| Imagological examination | Chest CT | 1. A small amount of accumulative inflammation in the lower lobe of the left lung. 2. Scattered small nodules and hard nodules in both lungs have slightly increased compared to before. |
| | CT full abdominal CT | Inflammation of the proximal jejunum is possible. 2. Prostate calcification foci; 3. Enlarged spleen. |
| | Brain CT | Calcification foci or foreign bodies on the frontal scalp. |

## 2.3. Treatment method

Antimalarial treatment (artesunate for injection + dihydroartemisinin piperquine tablets); Anti-inflammatory Protect the liver and reduce jaundice. Protect the stomach Increase platelet count; Plasma exchange + cytokine adsorption therapy; Splenic artery embolization therapy (PSE).

## 2.4. Therapeutic effect

### 2.4.1. Microscopic examination of Plasmodium in blood

All three tests on August 15, 20, 25, 19 and 23 were negative

### 2.4.2. All indicators improved after treatment

From **Table 2**, it can be seen that after undergoing plasma exchange combined with cytokine adsorption therapy, the patient's indicators such as total bilirubin (TBIL), C-reactive protein (hs-CRP), and interleukin-6 (IL-6) showed a significant decreasing trend, while platelet counts (PLT) gradually recovered, indicating the effectiveness of the treatment.

**Table 2.** Improving of the indicators post treatment

| Date | WBC (g/L) | Hb (g/L) | PLT (g/L) | TBIL (μmol/L) | ferritin (ng/mL) | Cr (μmol/L) | PCT (ng/mL) | IL-6 (pg/mL) | hs-CRP (mg/L) |
|---|---|---|---|---|---|---|---|---|---|
| 8/11 | 4.8 | 161 | 31 | 120.69 | - | 127.2 | 3.55 | 123.1 | 106.36 |
| 8/12 | 4.93 | 142 | 10 | 140 | 8964 | - | - | - | - |
| 8/13 | 7.22 | 128 | 11 | 166.78 | - | - | - | - | - |
| 8/14 | 5.11 | 135 | 22 | 249.89 | 10928 | 89 | - | - | 64.35 |
| 8/15 | 7.16 | 115 | 41 | 182.93 | - | 58.9 | 1.009 | 11.3 | 65.1 |
| 8/16 | 8.11 | 107 | 37 | 88.35 | 4114 | - | 1.8 | 17.76 | 31.9 |
| 8/17 | 4.75 | 105 | 64 | 89.72 | - | - | 0.364 | 39.8 | 30.38 |
| 8/18 | 3.89 | 100 | 68 | 59.79 | 1062.1 | - | 0.57 | 30.01 | - |

**Table 2 (Continued)**

| Date | WBC (g/L) | Hb (g/L) | PLT (g/L) | TBIL (μmol/L) | ferritin (ng/mL) | Cr (μmol/L) | PCT (ng/mL) | IL-6 (pg/mL) | hs-CRP (mg/L) |
|---|---|---|---|---|---|---|---|---|---|
| 8/19 | 3.19 | 92 | 106 | 52.13 | 1585 | 57.45 | 0.243 | 14.5 | 33.55 |
| 8/23 | 5.09 | 94 | 172 | 31.42 | 1139 | 66.07 | 0.137 | 12 | 7.01 |
| 8/26 | 3.79 | 112 | 149 | - | - | - | - | - | - |
| 10/9 | 5.02 | 144 | 193 | 16.78 | 232.8 | - | - | - | - |

### 2.4.3. Liver ultrasound follow-up

Re-examination of liver color Doppler ultrasound indicated: No localized abnormal echoes were found.

### 2.4.4. Changes in total bilirubin, C-reactive protein and platelet count during the treatment process

**Figure 5** clearly demonstrates the changes in total bilirubin, C-reactive protein, and platelet count during the treatment process, highlighting the positive response to therapy.

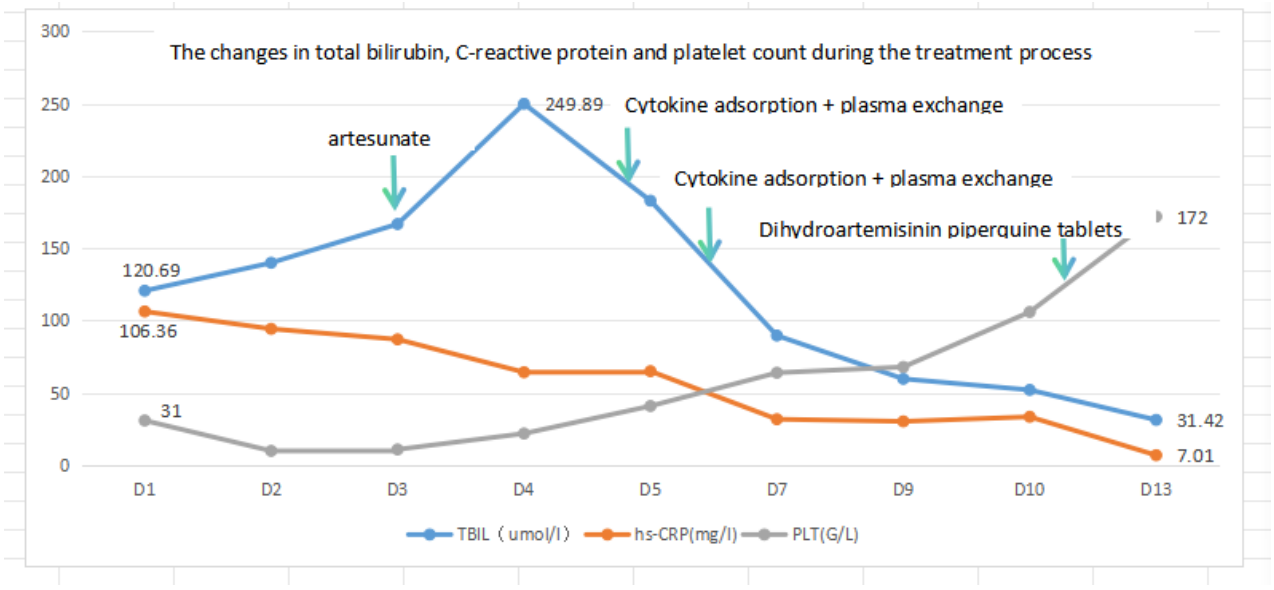



**Figure 5.** Changes of total bilirubin, C-reactive protein and platelet count during the treatment process.

## 2.5. Integrated medical and nursing predictive care

The integrated medical and nursing team is composed of one chief physician, one attending physician, one infection control physician, one head nurse, one responsible nurse, one psychotherapist and one nutritionist. The group, through multidisciplinary collaboration, jointly assesses the patient's condition and potential risks, and formulates practical and feasible care plans. Each member has clear responsibilities and works in close cooperation: The psychotherapist focuses on providing psychological counseling to the patient. Nutritionists provide personalized dietary guidance. Infection control physicians regularly organize infection prevention and control training and supervise the implementation of measures to prevent cross-infection. The head nurse serves as the leader of the nursing team. Every day, she feeds back the progress in the team work group and promptly analyzes, continuously tracks and effectively improves the existing problems. The team adheres to the

work focus of "ensuring safety, enhancing quality, improving service and increasing efficiency", and strives to build a predictive nursing management model of "prediction–early warning–prevention–emergency response", continuously deepening the connotation of clinical nursing and expanding the thickness of service, so as to achieve the goal of better nursing and more efficient service.

### 2.5.1. Training of predictive thinking

Through the training of predictive thinking, the awareness and ability of predictive nursing can be enhanced, potential nursing risks can be accurately and quickly identified, and relevant risk factors and expected clinical challenges can be determined.

### 2.5.2. Organize and carry out specialized training

Organize the study of knowledge related to malignant malaria and spontaneous splenic rupture, and cultivate the predictive thinking ability of members of the integrated medical and nursing care team.

### 2.5.3. Comprehensive assessment of the patient's condition

Based on evidence-based evidence, scientific and professional assessment tools are adopted, combining qualitative and quantitative predictions to conduct multi-angle, all-round and accurate evaluations of the patient. Through comprehensive analysis and precise observation of the patient's condition, changes in the patient's condition and nursing risks are predicted.

### 2.5.4. Accurately identify nursing risks

Clearly identify the risk points and weak points existing in the care of patients with severe malignant malaria and spontaneous splenic rupture, analyze the predictable nursing risk factors and formulate response measures, and form a standardized predictive nursing risk management operation manual. Such as emergency treatment procedures for bleeding, standard operating procedures for septic shock, key points for preventing black urine, etc.

### 2.5.5. Early warning

While implementing measures to reduce nursing risks, early warnings should be issued through visual and information-based means to alert medical staff and ensure they are always ready for emergencies.

### 2.5.6. Sorting out risk thresholds

For common complications that malaria can cause, such as black urine fever, intracranial hypertension, nephritis, and nephrotic syndrome, a warning threshold manual should be formulated one by one, including the names of complications, life-threatening symptoms, signs, indicators, and the content of nurses' rapid emergency response, to identify them as early as possible and activate the warning immediately [10].

### 2.5.7. Innovate visualized risk early warning

In light of the actual needs and risk characteristics of the patients, single room admission is implemented, and prominent insect-borne transmission risk signs are made and posted at the door of the ward and the patient's bedside to clearly remind medical staff and family members to implement isolation and protection. At the same time, record popular science audio and video about the transmission routes and prevention knowledge of malaria.

The content is vivid and easy to understand, enhancing the disease awareness level of patients and their families. In addition, strictly enforce the accompanying care management system, strengthen mosquito prevention and control measures, and comprehensively reduce the risk of infection.

### 2.5.8. Identify the clinical signs of spontaneous splenic rupture

Spontaneous splenic rupture is a fatal complication of malignant malaria. Although it is rare, if it is not identified and treated early, it will seriously threaten the patient's life. This disease is usually characterized by sudden abdominal pain, mainly persistent dull or severe pain in the upper left abdomen, which may be accompanied by symptoms such as abdominal distension, nausea, vomiting, cold sweats or fainting. The onset of the disease often has no obvious cause, or only occurs after actions such as coughing, sneezing, vomiting, and defecation. Early spontaneous splenic rupture patients often have atypical abdominal signs, usually only mild tenderness in the upper left abdomen, without rebound tenderness or muscle tension. If abdominal distension occurs and mobile dullness on percussion is positive, it indicates that the disease is progressing. There has been a large amount of intra-abdominal hemorrhage, which can rapidly develop into shock within a few hours. Laboratory and imaging examinations are crucial in early diagnosis: dynamic monitoring of hemoglobin and hematocrit helps assess blood loss. B-ultrasound is a commonly used imaging examination method in clinical practice due to its rapidity, convenience and strong repeatability [11]. The integrated medical and nursing team used the shock index (pulse rate/systolic blood pressure) to assess the degree of shock [12]. A shock index of $\leq 0.5$ indicated no shock and normal blood volume; An index of 1 indicates mild shock, with a blood loss of approximately 800 to 1200 mL, accounting for 20% to 30% of the total blood volume. An index greater than 1 indicates shock, among which a value greater than 1.5 is considered severe shock, with blood loss ranging from 1200 to 2000 mL, accounting for 30% to 50% of the total blood volume. An index greater than 2 indicates severe shock, with blood loss exceeding 2000 mL, accounting for more than 50% of the total blood volume. The shock index of this patient was 1.26. The medical team promptly established two venous access routes, followed the doctor's advice to quickly replenish fluid to restore blood volume, assisted the patient in taking the supine fovea position, and actively completed the preoperative preparations. Eventually, splenic artery embolization (PSE) was performed in a timely manner.

### 2.5.9. Prevention

For identified potential nursing risks, formulate targeted preventive nursing measures to reduce the incidence of risks.

(1) Prevention of bleeding

The platelet count of the patient in this case dropped to a minimum of $1\times10^{10}$ g/L, and plasma infusion and platelet support therapy have been given. To prevent bleeding, during the nursing process, the patient's vital signs and coagulation function were closely monitored, including changes in prothrombin time, platelet count, hemoglobin and other indicators. At the same time, pay close attention to whether there are any signs of local or systemic bleeding, such as petechiae and ecchymosis at the puncture site, gum bleeding, nosebleeds, hematemesis, hematochezia, etc. In daily life care, patients should be guided to avoid bumps and knocks, not to pick their noses with their hands, not to use toothpicks to pick their teeth, and to use soft-bristled toothbrushes to brush their teeth. Strengthen the dynamic assessment of heart rate, blood pressure, blood oxygen saturation, state of consciousness, urine output and clinical manifestations. Once any abnormality occurs, take effective intervention measures immediately to minimize the existing

and potential bleeding risks of patients to the greatest extent [13].

(2) Prevention of common complications of cytokine adsorption and plasma exchange

Plasma was separated using a Fresenius Kabi COM.TEC centrifugal blood cell separator and then adsorbed by a cytokine adsorption column (CA280, Jianfan Biotechnology Group Co., LTD., China), with the right internal jugular vein as the vascular access. In accordance with the requirements of the Expert Consensus on the Clinical Application of Artificial Liver Blood Purification Technology (2022 Edition), the tubing and adsorption column should be thoroughly pre-flushed, with low-molecular-weight heparin anticoagulation [14]. Before each treatment, 5 mg of dexamethasone should be intravenously injected to prevent allergic reactions to the adsorption column and tubing. To prevent hypotension, 400 mL of isoplasma was intravenously infused peripheral before the end of cytokine adsorption to maintain blood volume balance. Before sequential plasma exchange therapy, 25 mg of promethazine was intramuscularly injected and 5 mg of dexamethasone was intravenously injected to prevent plasma hypersensitivity. Continuous intravenous infusion of 10% calcium gluconate prevents hypocalcemia; During the operation, electrocardiogram monitoring and oxygen inhalation were performed throughout the process. The blood flow rate was 50 to 60 mL/min, the plasma separation rate was 25 to 33 mL/min, the plasma exchange volume was 1600 to 2000 mL (fresh frozen plasma), and the treatment duration was 2 to 3 hours. During both treatments, the patient had no adverse reactions.

(3) Prevention of black urine fever

Reduce unnecessary movement to avoid inducing heart failure. Ensure a daily fluid intake of 3000 to 4000 mL and a daily urine output of ≥ 1500 mL. In cases of acute renal failure such as anuria or oliguria, treat it as acute renal failure. Accurately record the 24-hour fluid intake and output.

(4) Prevention of complications of splenic artery embolization (PSE)

Post-embolization syndrome: Almost all patients after partial splenic embolization have transient fever, left upper abdominal pain and loss of appetite [15]. Fever is generally around 38℃, with a few cases reaching above 39℃, lasting for 1 to 3 weeks. There is moderate abdominal pain, and symptomatic treatment is sufficient. Bronchopneumonia and pleural effusion are more common on the left side, which is related to the pain after splenic embolization restricting the left respiratory movement and reactive pleurisy. It can be relieved through anti-infection and symptomatic treatment. Splenic abscess is caused by bacterial infection. Controlling the embolization range, strict aseptic operation and the application of perioperative prophylactic antibiotics can effectively reduce the incidence of splenic abscess. Once splenic abscess occurs, active anti-infection treatment should be carried out. Chen Jing and other scholars have studied the safety and effectiveness of intraluminal injection of 10% sodium chloride in the treatment of splenic abscess after PSE [16].

(5) Prevention of malnutrition

Patients with malignant malaria have persistent high fever, high energy consumption and poor appetite. Adequate calorie supply is of great significance. This patient has symptoms of nausea, vomiting and diarrhea. They have been given parenteral nutrition preparations such as fat emulsion and amino acids as prescribed by the doctor. During the infusion process, be vigilant about the occurrence of phlebitis [17]. After the treatment to regulate the intestinal flora, the diarrhea improved and the appetite improved. The nutritionist formulated a personalized diet plan and recipe for the patient. The dietary principle was light and refreshing, and it was advisable to consume easily digestible and absorbable high-protein and high-

vitamin foods.

(6) Prevention of negative emotions

Psychotherapists provide targeted psychological intervention based on the patient's personality traits and adverse psychological triggers to minimize the impact of negative emotions on the treatment outcome to the greatest extent. Adopt reasonable emotive therapy to transform patients' wrong beliefs and cognition, solve their emotional and behavioral problems, and maintain a positive attitude and belief as much as possible to correctly deal with the disease [18]. Select appropriate psychological counseling techniques such as mindfulness meditation training, aromatherapy, music therapy, etc.

(7) Prevention of adverse reactions of antimalarial drugs

Artesunate for injection needs to be properly and thoroughly dissolved. Before use, add 0.6ml of the attached 5% sodium bicarbonate injection, shake for 2 minutes until completely dissolved, then add 5.4ml of 5% glucose injection or glucose-sodium chloride injection for dilution, ensuring that each 1ml of the solution contains 10mg of artesunate, and inject slowly intravenously. Allergic reactions: Be vigilant about allergic reactions such as anaphylactic shock, urticaria, rash and pruritus. Delayed hemolysis (PADH) occurs at least 7 days after treatment and can last for several weeks. It is recommended to closely monitor the signs of hemolytic anemia within 4 weeks after treatment. Severe cases may require blood transfusion. If necessary, direct antiglobulin tests can be conducted to determine whether glucocorticoid treatment is needed.

(8) Disease prevention

Mosquito prevention and control, avoiding mosquito bites, is the most important means of preventing malaria. When traveling to malaria-endemic areas, one should take personal protective measures, such as wearing long-sleeved shirts and long pants, using mosquito nets and other physical protective measures, using repellents, mosquito coils to repel mosquitoes or taking preventive drugs and other chemical protective measures, and reduce or avoid going outdoors during the peak mosquito activity periods of dusk and night. If symptoms such as chills, fever, sweating, diarrhea, and joint pain occur within one month after returning from a short-term trip to an epidemic area or within two years after returning from a long-term stay in an epidemic area, medical attention should be sought promptly. When entering the country and seeking medical treatment, one should proactively inform the doctor of their travel history to enhance the timeliness of diagnosis and reduce misdiagnosis and missed diagnosis. After being diagnosed with malaria, one should take antimalarial drugs in full and in the prescribed dosage as directed by a doctor to prevent recurrence and drug resistance. Emergency response: Enhance the emergency handling capabilities and teamwork levels of the members of the integrated medical and nursing care team, quickly initiate emergency response procedures, and smoothly complete remedial measures.

### 2.5.10. Medical and nursing assistance in emergency drills

Regularly carry out integrated medical and nursing emergency drills and training for spontaneous splenic rupture, refine the process measures for each link, assign specific responsibilities to individuals, identify loopholes and shortcomings, continuously optimize emergency plans, and enhance practical combat capabilities.

(1) Develop various potential risk emergency procedures. Members of the integrated medical and nursing care team used the brainstorming method to develop various potential risk emergency procedures based on the actual condition of the patient, such as hemorrhagic shock and black urine fever, requiring everyone to be

aware of the risks and be capable of responding to emergencies.

(2) Diversified interactive extended services. Reduce the incidence of complications. Establish a diversified interactive wechat group to regularly push disease health care knowledge through text, voice, pictures, videos, etc. Follow up at frequencies of 2 weeks, 4 weeks, 8 weeks, and 12 weeks. Group members build a guiding and cooperative relationship with the community hospital where the patient is located, forming a positive interaction [19]. Ensure the effective continuation and operation of the care model, and integrate each piece of feedback information and patient suggestions to adjust the home management plan.

## 3. Summary

The patient's condition was extremely critical. The successful emergency treatment was attributed to the following three aspects.

### 3.1. Collaborative role and efficacy of the integrated medical and nursing team

In the integrated medical and nursing team, all members work closely together, both recognize their job responsibilities, divide the work, and strive to achieve the common goal [20]. Medical staff jointly observe the patient's condition, detect potential risks early, and can identify the signs of spontaneous splenic rupture at an early stage. They also pay attention to the patient's subjective feelings and psychological state. Increase the trust between medical staff and patients, and enhance patients' confidence in defeating the disease.

### 3.2. Advantages and efficacy of the predictive nursing management model

The predictive nursing management model of "foresight–early warning–prevention–emergency response" helps nurses to be well-informed and targeted in their nursing work. Through pre-assessment and analysis, nurses can promptly identify and address potential issues, thereby reducing the incidence of nursing deficiencies. By closely observing and thoroughly understanding the dynamic changes in patients' conditions, they can make patients feel the psychological need to be respected and cared for. Predictive thinking and the ability to handle emergencies on the spot help nurses make correct judgments and actions quickly in emergency situations. Ensure the medical safety of patients [21].

### 3.3. Technical characteristics and clinical effectiveness of the CA280 cytokine adsorption column

CA280 cytokine adsorption column with nano-scale three-dimensional pore size adjustment technology, specifically adsorbs cytokines. It can be precisely designed based on the molecular structure and size of cytokines, and selectively removes cytokines such as IL-6 and TNF-α. At the same time, hydrophilic molecule graft coating was utilized to comprehensively optimize the hydrophilicity of the resin while maintaining its effectiveness, enhance blood compatibility, and protect blood cells and beneficial components. After two sequential plasma exchange sessions of cytokine adsorption in this patient, total bilirubin, ferritin, interleukin, IL-6, and C-reactive protein all decreased significantly. This patient was complicated with liver failure and severe infection. The effect is remarkable.

In conclusion, the causes of severe malignant malaria with spontaneous splenic rupture are diverse, the onset is insidious, and the mortality rate is extremely high [22]. The development of new cytokine adsorption technology

and the application of the integrated predictive nursing management model of medical care and nursing can significantly improve the prognosis of patients and enhance their quality of life. However, due to the limited number of cases, some related technical specifications are still unclear. How to build a scientific, systematic and complete prevention and treatment system as soon as possible poses new challenges for future development.

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## Disclosure statement

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# Analysis of Sleep Quality Improvement in Patients with Lumbar Disc Herniation Following Auricular Acupuncture Combined with Chinese Herbal Medicine Packing Therapy

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**Abstract:** Objective: To evaluate the nursing effects of auricular seed therapy combined with Chinese herbal poultice treatment for patients with lumbar disc herniation (LDH). *Method:* A total of 80 patients with LDH were randomly divided into two groups. The combined group received auricular acupuncture with seed application combined with Chinese herbal poultice therapy, while the reference group received auricular acupuncture with seed application alone. The therapeutic outcomes of both groups were compared. *Results:* The combined intervention group demonstrated decreased sleep quality scores, reduced pain neurotransmitter levels, and improved lumbar spine function scores post-intervention, with significant intergroup differences ($p < 0.05$). *Conclusion:* Auricular seed therapy combined with Chinese herbal poultice care effectively improves sleep quality and lumbar spine function while alleviating pain perception in patients with lumbar disc herniation, indicating superior therapeutic efficacy.

**Keywords:** Auricular acupressure with seed application; Chinese herbal poultice therapy; Lumbar disc herniation; Sleep quality

**Online publication:** Feb 11, 2026

## 1. Introduction

LDH is an orthopedic condition characterized by typical symptoms such as low back pain, cauda equina syndrome, and numbness in the lower limbs. Its etiology involves lumbar disc degeneration leading to nucleus pulposus protrusion and compression of surrounding nerves. The condition has a prolonged course and can significantly impact patients' quality of life over the long term [1]. Additionally, patients with LDH experience more severe chronic pain symptoms, which can lead to psychological distress such as anxiety and irritability, thereby reducing their sleep quality. The conventional treatment for this condition involves conservative approaches like oral medication and physical traction. While these methods can alleviate symptoms, their long-term efficacy

remains suboptimal. Therefore, nursing interventions for these patients primarily involve lifestyle guidance, pain management, and rehabilitation training. Clinical practice has revealed that conventional nursing measures are relatively limited and struggle to meet patients' increasingly complex care needs [2]. In contrast, traditional Chinese medicine possesses extensive experience in managing LDH and can utilize distinctive TCM nursing techniques to improve patient outcomes. Ear acupuncture with bean-sized pressure seeds and herbal poultice therapy are both commonly employed TCM nursing methods. The former stimulates ear acupuncture points to promote blood circulation, unblock meridians, and regulate Qi and blood; the latter generates a thermal effect to reduce swelling, relieve pain, and activate blood circulation to resolve stasis. The combination of these two approaches demonstrates superior efficacy in alleviating pain symptoms and improving sleep quality, exhibiting a synergistic mechanism. Based on this, this study enrolled 80 patients with LDH to evaluate the therapeutic effects of auricular seed therapy combined with Chinese herbal poultice care.

## 2. Materials and methods

### 2.1. General information

A total of 80 LDH patients admitted between August 2022 and August 2025 were selected and randomly assigned. The combined group included 40 patients, comprising 23 males and 17 females. Their ages ranged from 36 to 77 years, with a mean age of (51.78 ± 4.19) years. The control group included 40 patients, comprising 24 males and 16 females. Their ages ranged from 34 to 76 years, with a mean age of 51.63 ± 4.22 years. Comparison of the above data between groups yielded $p > 0.05$.

#### 2.1.1. Inclusion criteria

(1) Diagnosed with LDH based on imaging studies;
(2) First episode;
(3) Normal mental status and language expression;
(4) Fully informed about the study.

#### 2.1.2. Exclusion criteria

(1) History of lumbar surgery;
(2) Other joint diseases;
(3) Immune system deficiencies;
(4) Malignant tumors;
(5) Chronic pain caused by other reasons;
(6) Withdrawal from the study.

### 2.2. Method

Both groups received standard care including surgical treatment, medication guidance, and functional training, with strict bed rest required for patients. Control group received auricular seed therapy: Points selected included Subcortex, Shenmen, Lumbosacral Vertebrae, and the sciatic nerve area, along with corresponding liver and kidney zones. Disinfect the above points with 75% alcohol. Apply Wangbuluxing seeds (0.5 × 0.5 cm) onto medical adhesive tape and affix them to the designated points. Knead or press each point for 1–2 minutes, three times daily.

Replace the patches after 3 days and continue treatment for 4 weeks. The combined group received Chinese herbal poultice therapy alongside auricular acupuncture with seed pressure. The formula comprised: Chuan Niuxi (15 g), Chuanxiong (10 g), Du Huo (10 g), Fangfeng (10 g), Fengxian Tougucao (15 g), Guizhi (10 g), Qianghuo (10 g), Shenjincao (30 g), Weilingxian (10 g), Honghua (10 g), and Jingjie (10 g). The herbs were ground into powder and placed in gauze pouches. The pouches were boiled in water for 30 minutes, then 170 mL of yellow rice wine and 280 mL of aged vinegar were added. After simmering for another 15 minutes, the mixture was removed. Wrap the medicated pouch in a thick towel and place it on the patient's waist. Apply heat in a downward, clockwise motion, then position the pouch over the affected area. Each treatment lasts 30 minutes, administered twice daily for 4 weeks.

## 2.3. Observation indicators

(1) Sleep quality score

The Pittsburgh Sleep Quality Index (PSQI) was used, selecting three components: sleep duration, sleep disturbances, and sleep onset latency. Each component is scored from 0 to 3 points, with sleep quality scored negatively.

(2) Pain mediator levels

Blood samples were collected in the fasting state. Serotonin (5-HT) was measured using high-performance liquid chromatography (HPLC), while substance P (SP) was assessed via enzyme-linked immunosorbent assay (ELISA).

(3) Lumbar spine function score

The Japanese Orthopaedic Association (JOA) assessment score is used, comprising subjective symptoms (9 points), clinical signs (6 points), and limitations in daily activities (14 points). Lumbar spine function is scored positively.

## 2.4. Statistical analysis

Data were processed using SPSS 28.0 software. Quantitative variables underwent *t*-tests for comparison/analysis, while categorical variables underwent binary comparisons/tests. Statistical significance was defined as $p < 0.05$.

# 3. Results

## 3.1. Sleep quality scores compared between the two groups

The sleep quality score decreased after the joint nursing intervention, with a significant difference between groups ($p < 0.05$).

**Table 1.** Sleep quality scores compared between two groups [$\overline{x} \pm s$, points]

| Grouping | Example count | Sleep duration | | Sleep disorders | | Time to fall asleep | |
|---|---|---|---|---|---|---|---|
| | | Before nursing | After care | Before nursing | After care | Before nursing | After care |
| Joint group | 40 | 2.03 ± 0.45 | 0.71 ± 0.19 | 1.95 ± 0.38 | 0.64 ± 0.17 | 1.92 ± 0.46 | 0.61 ± 0.15 |
| Control group | 40 | 2.01 ± 0.47 | 1.04 ± 0.22 | 1.97 ± 0.41 | 0.95 ± 0.20 | 1.90 ± 0.43 | 0.98 ± 0.19 |
| *t* | | 0.194 | 7.180 | 0.226 | 7.469 | 0.201 | 9.667 |
| *p* | | 0.846 | 0.000 | 0.822 | 0.000 | 0.841 | 0.000 |

## 3.2. Pain mediator levels compared between the two groups

Pain neurotransmitter levels decreased after combined group nursing, with a significant difference between groups ($p < 0.05$).

**Table 2.** Pain mediator levels compared between two groups [$\overline{x} \pm s$]

| Grouping | Example count | 5-HT (μmol/L) | | SP (μg/mL) | |
|---|---|---|---|---|---|
| | | Before nursing | After care | Before nursing | After care |
| Joint group | 40 | 0.80 ± 0.19 | 0.34 ± 0.11 | 360.53 ± 28.74 | 208.65 ± 20.11 |
| Control group | 40 | 0.82 ± 0.21 | 0.49 ± 0.14 | 361.12 ± 29.03 | 265.98 ± 21.43 |
| *t* | | 0.447 | 5.328 | 0.091 | 12.338 |
| *p* | | 0.656 | 0.000 | 0.927 | 0.000 |

## 3.3. Comparison of lumbar function scores between the two groups

The lumbar spine function score increased after the combined group care intervention, with a significant difference between groups ($p < 0.05$).

**Table 3.** Comparison of lumbar function scores between the two groups [$\overline{x} \pm s$, points]

| Grouping | Example count | Subjective symptoms | | Clinical signs | | Daily life is restricted | |
|---|---|---|---|---|---|---|---|
| | | Before nursing | After care | Before nursing | After care | Before nursing | After care |
| Joint group | 40 | 5.21 ± 1.09 | 7.31 ± 1.52 | 2.44 ± 0.53 | 4.23 ± 0.91 | 8.22 ± 1.46 | 11.49 ± 2.03 |
| Control group | 40 | 5.23 ± 1.13 | 6.08 ± 1.14 | 2.46 ± 0.57 | 3.64 ± 0.86 | 8.20 ± 1.51 | 9.78 ± 1.54 |
| *t* | | 0.081 | 4.094 | 0.163 | 2.980 | 0.060 | 4.244 |
| *p* | | 0.936 | 0.000 | 0.871 | 0.004 | 0.952 | 0.000 |

# 4. Discussion

LDH is a spinal surgical condition with a relatively high incidence rate. Its pathological manifestations include nerve root compression and lumbar disc degeneration. Patients commonly experience persistent and severe low back pain, which significantly impairs their daily functioning. At present, Western medical treatment for this condition primarily involves oral medications such as muscle relaxants and nonsteroidal anti-inflammatory drugs (NSAIDs), which take effect relatively quickly and can rapidly alleviate pain symptoms [3,4]. However, these medications carry a high risk of dependency and are associated with a significant relapse rate upon discontinuation. To enhance long-term clinical outcomes, patients with this condition typically receive nursing care services. Through structured rehabilitation exercises and personalized health guidance, these interventions gradually restore lumbar spine function and shorten the duration of LDH. However, conventional care is generally not very feasible, produces slow results, and cannot provide long-term improvement in patients' conditions.

Traditional Chinese medicine classifies LDH under the category of "low back pain". Its pathogenesis involves deficiency of liver and kidney essence, Qi stagnation, and blood stasis. The pathological location is in the lumbar region. External factors include invasion by wind, cold, dampness, and heat, as well as excessive fatigue. Internal factors stem from inadequate nourishment of the lumbar region, insufficiency of kidney essence, and obstruction of

collaterals [5]. The combined effects of these factors can impair kidney function, thereby damaging the tendons and meridians in the lower back. This leads to stagnation of Qi and blood, ultimately triggering the disease. Based on this, the intervention principles for LDH include relaxing tendons and unblocking meridians, as well as promoting blood circulation and resolving blood stasis. Ear acupressure with seeds and Chinese herbal poultice application are both commonly used distinctive TCM nursing techniques. Among these, ear acupressure with seeds is a safe, feasible, and convenient non-invasive nursing method. It stimulates the Shenmen acupoint and subcortical regions, inducing sensations such as soreness, distension, and numbness at the acupoints. This stimulation of ear acupoints facilitates the unblocking of meridians, regulates organ functions, dispels dampness and cold, and promotes the circulation of Qi and blood [6]. Herbal pouches integrate the efficacy of traditional Chinese medicine with thermal therapy. When applied as a heat pack to the lower back, the pouch facilitates transdermal absorption of herbal ingredients into the body, enabling consistent therapeutic effects.

Results showed that sleep quality scores and pain neurotransmitter levels decreased after the combined care intervention, with $p < 0.05$ between the two groups. The mechanism involves ear acupuncture seeds exerting sustained stimulation on nerve endings in the auricular region, thereby generating nerve impulses that transmit signals to various body parts. This induces physiological responses, activating the pain regulation system and exerting analgesic effects through neural reflex mechanisms, ultimately alleviating sleep disturbances caused by pain symptoms [7,8]. The auricular region features a dense network of blood vessels and lymphatics, forming vascular and lymphatic plexuses that connect to spinal nerves and cerebral cortex areas. Stimulating auricular points can influence these neural pathways, enhancing neurological function. This inhibits signal transmission in lumbar nerves, alleviating symptoms associated with LDH and improving patients' sleep quality. Chinese herbal poultice therapy utilizes the warming stimulation to facilitate the penetration of herbal components into tissues, regulating blood circulation in the lumbar region, improving the flow of Qi and blood, and alleviating pathological manifestations such as Qi and blood stagnation. The application of heat and pressure further promotes blood circulation, disperses stasis, warms meridians, and unblocks channels, thereby reducing muscle spasms and relieving pain sensations. Furthermore, the warmth helps maintain balance between the parasympathetic and sympathetic nervous systems, thereby relaxing the body and promoting faster sleep onset for patients. In the composition of Chinese herbal medicine packets, Sichuan Achyranthes root (Chuan Niuxi) nourishes the liver and kidneys; Ligusticum root (Chuanxiong) promotes blood circulation, strengthens tendons and bones, and directs the action downward; Angelica root (Duhuo) dispels dampness and alleviates pain; Fangfeng dispels wind and cold; Fengxian Tougucao alleviates pain, disperses stasis, and promotes blood circulation to relax tendons; Guizhi and Qianghuo eliminate dampness, relieve pain, and disperse cold; Shenjincao and Weilingxian unblock meridians to relieve pain; Honghua Schizonepeta reduces swelling and alleviates pain. The combined use of these herbs nourishes the liver and kidneys, promotes blood circulation, and alleviates pain. Coupled with the localized heating effect from warm compresses, this treatment regulates microcirculation in the lumbar region, accelerates the absorption of hematomas and exudate, thereby reducing pain intensity and improving sleep quality for patients.

The lumbar function scores increased after combined group therapy, with a statistically significant difference between the two groups ($p < 0.05$). This improvement stems from the fact that the auricular acupoints selected for seed pressure therapy are all related to the lumbar region. The stimulation generated by pressing Wangbuluxing seeds regulates Qi and blood circulation while balancing Yin and Yang. This enhances blood flow to the lumbar area, increases nutrient supply, and consequently strengthens lumbar vertebral function. The herbal composition of traditional Chinese medicine poultices includes Sichuan cow knee, which contains

polysaccharides and sterols that promote the effective synthesis of collagen and proteoglycans, thereby repairing intervertebral discs. Sichuan lovage contains components such as ligustilidine, which effectively dilates blood vessels, regulates microcirculation in the lumbar disc region, and inhibits platelet aggregation. It also exhibits anti-neuroinflammatory effects, alleviating symptoms of nerve root edema. Angelica pubescens contains volatile oils and coumarins, which possess sedative and anti-inflammatory properties while reducing prostaglandin synthesis. *Saposhnikovia divaricata* contains components such as saponins, offering anti-inflammatory, analgesic, and antipyretic effects alongside immune-modulating functions. *Impatiens capensis* contains phenylpropanoid and flavonoid components that reduce the synthesis of substances such as prostaglandin E2 and cyclooxygenase-2, thereby inhibiting the expression of inflammatory mediators and exerting anti-inflammatory and analgesic effects. Additionally, this herb enhances tissue permeability, allowing active components from other Chinese herbal medicines to fully penetrate joints, ligaments, and other tissues. It also dilates blood vessels to improve blood supply, thereby alleviating tissue hypoxia or ischemia. Cinnamon twig contains components such as cinnamaldehyde, which exhibits anti-inflammatory and anti-allergic properties. Notopterygium contains volatile oils and other active constituents that reduce the secretion of inflammatory mediators, thereby exerting anti-inflammatory effects. *Scutellaria baicalensis* relaxes skeletal muscles, alleviating symptoms such as muscle spasms. *Dictamnus dasycarpus* relaxes smooth muscles and improves cartilage metabolic function. Safflower contains components such as crocin and hydroxycrocin A, which can inhibit platelet aggregation and enhance fibrinolytic activity. This reduces blood viscosity and regulates blood circulation around the lumbar intervertebral discs. Additionally, safflower can significantly scavenge free radicals and prevent oxidative stress, thereby protecting lumbar disc cells and improving lumbar mobility [9]. Schizonepeta has mild antispasmodic effects and can alleviate pain symptoms.

## 5. Conclusion

In summary, ear acupuncture combined with herbal poultice therapy demonstrates favorable outcomes for LDH patients. This approach effectively alleviates pain symptoms while simultaneously improving sleep quality and lumbar spine function, highlighting its significant therapeutic value.

## Disclosure statement

The authors declare no conflict of interest.

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# A Case of Ventilator-associated Pneumonia in Neonatology: Investigation and Analysis of the Source of *Ralstonia mannitolilytica* Infection

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**Abstract:** This study examined a case of ventilator-associated pneumonia caused by Ralstonia mannitolilytica in a neonatal department in order to determine the source of infection and mode of transmission. Symptoms of infection began to appear on day 16 of admission, and both sputum and catheter tip cultures revealed R. mannitolilytica. The infection control department of the hospital later sampled and identified R. mannitolilytica in the ventilator tube that was used by the patient with the exact gene sequence as the infecting strain. These findings indicate that ventilator tubing is a significant contamination source of this pathogen, and hospitals need to enhance their disinfection methods of ventilator-related devices.

**Keywords:** Neonatology; Ventilator-associated pneumonia; Ralstonia mannitolilytica; Infection source; Hospital infection control

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## 1. Introduction

### 1.1. Background of research

Ventilator-associated pneumonia (VAP) is pneumonia that develops following the placement of an artificial airway, either endotracheal intubation or tracheostomy, and the initiation of mechanical ventilation > 2 consecutive calendar days, including those where mechanical ventilation was initiated within 48 hours before the development of pneumonia [1]. VAP is a prevalent nosocomial infection in the neonatal intensive care unit (NICU) and is particularly prevalent in preterm or critically ill infants undergoing mechanical ventilation. Not only do this condition increase hospitalization and increase medical expenses, but can also lead to serious complications and even death. An evaluation of the global literature reveals that the occurrence rates of VAP among neonates have a broad spectrum of 2.7–37.2 cases per 1000 ventilator days [2]. Domestic surveys in China have also reported incidence rates of 12.5 to 58.4 and a mortality of 18.1 to 33.3% [3–5]. The broad variation in the incidence rates reported in the various hospitals

could be attributed to challenges in defining VAP, differences in the patient populations or unit-specific issues such as patient acuity, admission rates, and preventive measures. Since VAP may result in serious issues during ventilator weaning, the duration of hospital stays, medical expenses and even the survival of neonatal life in severe cases, it is important to prevent it as early as possible, diagnose it in time and treat it immediately. The main interventions towards VAP management are the rational use of antibiotics to minimize multidrug-resistant bacterial and fungal infections, the use of aseptic practices, and the minimization of the time spent on mechanical ventilation.

*Ralstonia mannitolilytica* is an opportunistic pathogen, which has been given more attention in hospital-acquired infections, but there are few reports in China. The available literature has indicated that this bacterium exhibits a high level of environmental flexibility and possible multidrug resistance (MDR), and hence a significant risk to immunocompromised patients and a significant contributor to the spread of the bacterium in healthcare institutions [6].

### 1.2. Research objective

This paper seeks to examine a case of VAP due to *R. mannitolilytica* in the neonatology department, the objectives of which are to determine the cause of the infection, and to learn how the infection spreads in the NICU. The results are supposed to be used as a guideline in preventing such instances of infections in the future.

## 2. Materials and methods

### 2.1. Case data

#### 2.1.1. Patient data

The patient was a female who was very preterm with birth weight of 640 g. Our hospital was chosen to deliver the baby through cesarean section due to maternal conditions of "1. Acute fetal distress; 2. Pregnancy with identical twins (monochorionic diamniotic)." The patient was an extremely preterm female infant with a birth weight of 640 g. She was delivered by cesarean section in our hospital because of maternal complications, including

(1) Acute fetal distress

(2) Monochorionic diamniotic

Apgar scores were 6 minutes, 9 minutes, and 9 minutes. The amniotic fluid volume was normal and clear at birth. The placenta was delivered intact and the umbilical cord was not wrapped around the neck. The infant had no crying at birth and no meconium staining was seen. Admission diagnoses included the following:

(1) Extremely preterm infant;

(2) Extremely low birth weight infant;

(3) Neonatal respiratory distress syndrome; and

(4) Neonatal respiratory failure.

#### 2.1.2. Condition changes

On the day of admission, after emergency cesarean section delivery, the infant was transferred to the neonatology department and assisted with oxygen via nasal catheter. On day 2 (August 8), the invasive mechanical ventilation was started. The invasive ventilator was taken off on day 8 and replaced with non-invasive ventilation. On day 10 post-admission, the infant developed a fever, with a temperature of 37.9 ℃. On day 14 the fever rose again, reaching a maximum of 38 ℃, with tachypnea and moist rales bilaterally. Chest x-ray examination showed coarse bilateral lung markings. Additional symptoms were worsening respiratory distress and falling oxygenation. Auxiliary examinations and test results after admission are as follows:

**Table 1.** Ancillary examinations and laboratory tests for the infant

| Test / date | 8-7 | 8-8 | 8-10 | 8-13 | 8-15 | 8-17 | 8-22 | 8-27 | 9-1 |
|---|---|---|---|---|---|---|---|---|---|
| White blood cell ($\times 10^9$/L) | 5.24 | 13.10 | 7.76 | 11.89 | 19.71 | 29.8 | 17.2 | 13.26 | 8.63 |
| Neutrophils (%) | 21.9 | 34.6 | 39.7 | 22.6 | 46.1 | 65.2 | 71.5 | 62.7 | 42.5 |
| CRP | < 0.20 | < 5 | 28.34 | 26.2 | < 5 | < 5 | 10.08 | < 5 | < 5 |
| Hypersensitive C-reactive protein | < 0.20 | 2.24 | > 5 | - | - | - | > 5 | < 0.50 | < 0.50 |
| Specimen culture | | Blood culture (-), Urine mycoplasma culture (-) | | | Endotracheal tube tip culture: *R. mannitolilytica* | Sputum culture: *R. mannitolilytica* | Sputum culture: *R. mannitolilytica* | Sputum culture: *R. mannitolilytica* | Sputum culture (Normal flora) |
| Bedside chest X-ray | - | Decreased transradiancy in both lungs compared to previous; Pulmonary infiltrates worsened compared to previous | Pulmonary infiltrates showed absorption and improvement | Pulmonary infiltrates increased compared to previous | Pulmonary infiltrates showed absorption and improvement compared to previous | Pulmonary infiltrates showed absorption and improvement compared to previous | Pulmonary infiltrates slightly worsened compared to previous | Partial absorption of infiltrates in the left upper lobe compared to previous; No significant change in infiltrates in the remaining lung fields | No significant absorption of pulmonary infiltrates compared to previous |

## 2.2. Sample collection and processing

### 2.2.1. Patient samples

Patient Specimens: The tip of the endotracheal tube was collected at the time of extubation on day 8 after admission. Sputum specimens were collected on the day of onset of fever (day 14 post-admission). Bacterial culture and identification of both samples showed the presence of *R. mannitolilytica* in the extubated tube tip and sputum cultures. Antimicrobial susceptibility test results on day 15 indicated that the isolate was sensitive to levofloxacin and cefepime but resistant to ampicillin and ceftriaxone. Following positive results from both the sputum and the tube tip cultures, more specimens including sputum, blood, urine and stool were taken for bacterial and fungal cultures.

### 2.2.2. Ventilator circuit samples

Following the second sputum culture that was positive for *R. mannitolilytica*, the Hospital Infection Control Department immediately restricted access to the intensive care unit (ICU) with the infant (who had already been isolated in a single room after the initial detection). Samples were collected from the ventilator's internal circuits, humidifier water tank and connection ports.

### 2.2.3. Environmental samples

Air samples were taken from the NICU ward and swabs from healthcare worker's hands and surfaces of frequently touched items.

## 2.3. Bacterial culture and identification

All samples were labeled with collection time, location and identity of the collector before being sent to the clinical laboratory. Isolation and culture were performed using standard bacteriological protocols. Bacterial identification was performed by matrix-assisted laser desorption ionization-time of flight mass spectrometry and by 16S rRNA gene sequencing.

## 2.4. Epidemiological investigation

The Hospital Infection Control Department, in association with the head of the Neonatology Department, the attending physician, and the primary nurse, made a retrospective analysis of all the diagnostic and treatment procedures during the hospitalization of the infant. The investigation was concentrated on specific time points, looking at personnel who had contact with the infant, the use of medical equipment and the management of the ward environment.

The sampling by the Hospital Infection Control Department showed that the *R. mannitolilytica* was isolated from the sputum of the infant and also from the endotracheal tube tip cultures. The isolated bacteria showed resistance to antibiotics such as ceftriaxone and amoxicillin/clavulanic acid. Meanwhile, blood, urine and stool cultures taken from the infant were negative.

# 3. Results

## 3.1. Sample test results of the ventilator circuit

Clinical laboratory results showed the presence of *R. mannitolilytica* in the humidifier water tank and internal

circuits of the ventilator.

### 3.2. Environmental sampling tests results

The clinical laboratory findings revealed that the *R. mannitolilytica* could not be found in the environmental samples of the NICU ward or on the hands of medical personnel or on the surfaces of the most touched objects.

## 4. Discussion

### 4.1. Analysis of the source of infection

In this study, which used environmental hygiene sampling and bacterial culture, *R. mannitolilytica* infection of the infant was identified to have been caused by the ventilator circuit. These results suggest that the ventilator circuits may be colonized and grow bacteria in the long-term of their use, especially in a humidifier water tank, which is most likely to be contaminated by bacteria.

### 4.2. Discussion of the route of transmission

The colonization of the ventilator circuit by *R. mannitolilytica* and the subsequent transmission of the infection to the respiratory tract of the infant through the ventilator was identified to be the greatest cause of infection. The current studies have classified risk factors that lead to development of VAP into two broad categories. The former is the first category, which includes patient-related variables like age, severity of underlying conditions and comorbidities. The second category is the iatrogenic ones, including medical interventions, treatment modalities, and drug interventions. Some of the factors that predisposed the infant to VAP in this instance were extremely low birth weight, gestational age < 32 weeks, a number of intubations, coexistent neonatal sepsis, and the use of acid-reducing agents. Together, long-term mechanical ventilation, and the immunocompromised condition of the infant were all important risk factors of infection. Also, the conditions in the NICU ward were most likely favourable to the growth of bacteria due to the high humidity of the environment.

### 4.3. Characteristics of R. mannitolilytica

*R. mannitolilytica* is an opportunistic pathogen and its biological properties enable them to survive and proliferate in a hospital over an extended period of time. Its incidence in healthcare facilities has been increasing annually particularly in high-risk units of the healthcare facility like ICUs, burn wards and respiratory units [7].

It has also been demonstrated that these bacteria may be spread using contaminated medical equipment, including ventilators and catheters, or by hand contact with healthcare providers, leading to nosocomial cross-infections. Patients with long-term broad-spectrum antibiotic or immunosuppressive therapy are more frequently reported to have infections. *R. mannitolilytica* is regarded as a mostly pathogenic bacterium due to its virulence factors that are secreted [8]. It has been found to release cytotoxins and invasive enzymes that have the potential to interfere with the host cell barriers. Over the last few years, there has been a significant rise in the number of isolates containing MDR and the expression of extended spectrum β-lactamases, complicating clinical management. Although antibiotic treatment is the primary mode of treating *R. mannitolilytica* infections, it is important to choose the appropriate agents due to the resistance trends. Research indicates that some strains are sensitive to carbapenems (e.g. imipenem) and combination therapy (cefoperazone/sulbactam). At the same time, the enhancement of the environmental cleaning of the hospital and the strict hand hygiene of the healthcare

workers is one of the key steps to prevent and control the spread of this pathogen.

### 4.4. Preventive interventions

In the light of this VAP case, the following bundled intervention plan is suggested:

(1) Strengthen disinfection management of ventilator circuits
Change ventilator circuits and humidifier water tanks regularly to prevent the use of one and the same equipment.

(2) Maximize humidifier control
Inject sterile distilled water or sterile water as humidification fluids, and do not store humidification water long.

(3) Standardize hand hygiene and aseptic techniques
Enhance hand hygiene awareness and compliance levels among medical personnel to minimize the chance of cross-infection.

(4) Strengthen environmental surveillance
Conduct regular microbiological surveillance of the NICU environment and equipment to aid in the rapid identification and correction of possible contamination sources.

## 5. Conclusion

This research could determine the origin of *R. mannitolilytica* infection in a neonatal VAP case as the ventilator circuit through the use of case investigation, laboratory bacterial culture and antimicrobial susceptibility analysis. This is a critical finding on which the improvement of hospital infection prevention and control strategies is based. The next step in preventing neonatal VAP should be put on enhancing disinfection and control of ventilator-related equipment to lower the rate of the disease.

## Disclosure statement

The authors declare no conflict of interest.

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# A Case Report of Familial Episodic Pain Syndrome Type 3 in a 5-Year-Old Boy

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**Abstract:** Medical history summary: The child has suffered from episodic joint pain in the lower extremities since childhood, with occurrences ranging from 1 to 3 times daily, predominantly during rainy, cold, and humid weather, as well as in the afternoons and evenings. Symptoms and signs: The primary manifestation is episodic pain in the distal extremities, predominantly in the lower limbs, knees, and ankles. Occasionally, the pain may ascend to the elbows, wrists, and palms, and may occasionally affect the proximal extremities and waist. Diagnostic methods: Nerve biopsy and related pathological examinations, along with whole exome sequencing, are helpful for diagnosis, particularly the detection of variants in the SCN11A gene. Treatment approaches: (1) Pharmacotherapy: Sodium channel blockers and nonsteroidal anti-inflammatory drugs such as ibuprofen and naproxen can alleviate pain. (2) Neuromodulation techniques: Techniques such as transcranial magnetic stimulation (TMS) and spinal cord stimulation (SCS) can be employed to improve symptoms. (3) Psychotherapy: Cognitive-behavioral therapy (CBT), relaxation training, or psychological counseling can enhance the patient's coping abilities. Clinical outcome: Pain relief can be achieved with analgesic medication in children, and pain symptoms generally persist until adulthood, gradually diminishing or even disappearing. Patients can reduce the frequency of episodes by staying warm and avoiding cold and damp conditions.

**Keywords:** SCN11A; Paroxysmal pain; Autosomal dominant inheritance

**Online publication:** Feb 9, 2026

## 1. Introduction

Familial episodic pain syndrome (FEPS) is a rare autosomal dominant genetic disorder characterized primarily by severe, episodic, and relatively localized paroxysmal pain. This pain typically occurs in the distal lower extremities and joints. Patients usually develop symptoms in early childhood, but due to their young age and inability to articulate their discomfort, the condition is often overlooked by parents. Symptoms tend to gradually alleviate or even disappear upon reaching adulthood. Familial episodic pain syndrome can be classified into three types based on different gene mutations, with this case being classified as FEPS type 3. Given the rarity of this condition,

clinical awareness is relatively low, and it is prone to being missed or misdiagnosed. This study aims to contribute to the establishment of more comprehensive diagnostic methods and treatment strategies.

## 2. Clinical data

### 2.1. General information

(1) Chief complaint

A 5-year-old male child presented to our outpatient clinic on December 2, 2024, with a history of "joint pain since birth".

(2) Symptoms

The child has exhibited paroxysmal crying without obvious precipitating factors since infancy, predominantly occurring in the afternoons, nights, and during rainy or cold weather, with a frequency of 1 to 3 episodes per day, each lasting for tens of minutes. During these crying episodes, the child kicks their lower limbs and experiences excessive sweating. After being able to speak at the age of one and a half, the child self-reported intermittent and periodic pain in the lower limb joints. During pain episodes, there is no limitation in joint movement, no rash, redness, bruising, or other color changes, and no skin breakdown. Since the onset of the condition, the child's growth and development have been generally normal, with no limb numbness, satisfactory appetite, and no dysfunction in urination or defecation.

(3) Past medical history

The child has been generally healthy, with no history of infectious diseases such as hepatitis, tuberculosis, or typhoid fever, nor close contact with such cases. There is no history of significant psychological trauma, traumatic surgery, or blood transfusion. The child has received all scheduled vaccinations on time and has no history of exposure to special medications or toxins.

(4) Personal history

G1P1 (first pregnancy, first delivery), full-term spontaneous vaginal delivery, with unremarkable conditions at birth. The child was fed with a combination of breast milk and formula after birth and was weaned at one year old. Growth and development have been comparable to peers, with a regular daily routine.

(5) Family history

The child's mother reports experiencing paroxysmal pain in the lower limb joints since childhood, with the intensity of pain increasing with each episode. She was previously misdiagnosed with growing pains in children and was treated with oral traditional Chinese medicine preparations, which were ineffective. The symptoms could be alleviated by immediately taking pain relievers such as paracetamol tablets after an episode. However, if medication was delayed, the effect was poor, and the paroxysmal pain would recur. Paying attention to keeping warm and avoiding cold and dampness can reduce the frequency of attacks. The symptoms of the child's mother gradually alleviated with age until the pain almost disappeared in adulthood. In the family, a total of 12 family members across four consecutive generations, including the child's mother, exhibited similar symptoms, all of whom experienced gradual relief or even complete disappearance of symptoms after reaching adulthood.

## 3. Examination

(1) Physical examination

The patient's body temperature was 36.5 ℃, pulse rate was 68 beats/min, respiratory rate was 16 breaths/min, and blood pressure was 115/70 mmHg. The patient was conscious, in good spirits, with normal respiration, strong heart sounds, regular rhythm, and a normal heart border upon percussion. No murmurs were heard in any valve area. Breath sounds in both lungs were clear, superficial lymph nodes were of normal size, and there were no petechiae or ecchymoses on the skin. No significant muscle atrophy was observed in the limbs.

(2) Auxiliary examination

Blood routine examination showed no significant abnormalities in white blood cells, neutrophils, eosinophils, or C-reactive protein ("0.10 mg/L", reference range: 0–10 mg/L). Trace elements, vitamin D, rheumatoid factor ("8.3 IU/mL", reference range: 0.0–20.0 IU/mL), antistreptolysin O ("8 IU/mL", reference range: 0–200 IU/mL), immunoglobulin M ("1.29 g/L", reference range: 0.43–1.93 g/L), immunoglobulin G ("5.60 mg/L", reference range: 5.4–13.4 mg/L), immunoglobulin A ("0.88 g/L", reference range: 0.3–1.88 g/L), and complement C3 ("0.98 g/L", reference range: 0.78–2.1 g/L) showed no significant abnormalities, while C4 ("0.10 g/L") was slightly lower than the normal range (reference range: 0.17–0.48 g/L). Folic acid, at "13.80 ng/mL" (reference range: 5.21–24 ng/mL), is normal, while vitamin B12, at "1188 pg/mL", is higher than the normal range (reference range: 180–916 pg/mL).

(3) Genetic testing

Next-generation sequencing revealed a heterozygous mutation c.665G > A in the SCN11A gene, and family verification indicated that the child's mother also carries this mutation. This variant is a single nucleotide variation located on chromosome 5 at chr3:38966953, resulting in the substitution of arginine (Arg) with histidine (His) at position 3P22 in the protein. This locus (p.R222H) has been reported in the literature as familial episodic pain syndrome type 3. The inheritance pattern of familial episodic pain syndrome type 3 associated with this gene is autosomal dominant. Other related diseases of this gene include hereditary sensory and autonomic neuropathy type 7, which also follows an autosomal dominant inheritance pattern (**Figure 1**).

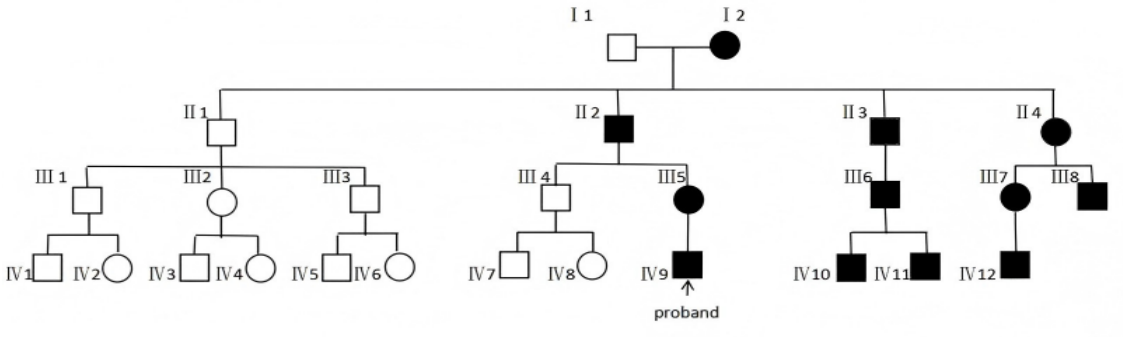



**Figure 1.** Patient's pedigree chart.

## 4. Diagnosis and differential diagnosis

(1) Differentiating from growing pains

Growing pains typically present without other accompanying symptoms, whereas familial episodic pain syndrome type 3 may be accompanied by other neurological symptoms. Genetic testing can aid in differentiation.

(2) Differentiating from rheumatism

Rheumatism often manifests as migratory soreness and pain in joints and muscles, with significantly elevated erythrocyte sedimentation rate and antistreptolysin O levels. In contrast, familial episodic pain syndrome type 3 is a hereditary neuralgia characterized by paroxysmal pain without the joint and muscle symptoms and laboratory abnormalities associated with rheumatism.

(3) Differential diagnosis of orthopedic diseases

Osteoarthritis, gouty arthritis, and other orthopedic diseases often present with symptoms such as joint pain, stiffness, and deformation, and joint lesions can be observed on X-ray or CT scans. In contrast, the pain in familial episodic pain syndrome type 3 is unrelated to joint lesions, and no abnormalities are detected on imaging examinations.

(4) Differential diagnosis of FEPS1 and FEPS2

The pain symptoms of FEPS1 primarily occur in the upper body, such as the arms, shoulders, and chest. The pain symptoms of FEPS2 mainly occur in the feet. In contrast, the pain in familial episodic pain syndrome type 3 primarily occurs in the distal joints of the limbs.

In summary, the child was diagnosed with familial episodic pain syndrome type 3.

## 5. Treatment

The child did not receive oral medications or other treatments at our hospital. The child's mother had previously self-administered pain relievers such as paracetamol tablets and traditional Chinese medicine preparations.

## 6. Treatment outcomes, follow-up, and prognosis

The child still experiences episodic pain in the distal extremities of both lower limbs several times a day, but keeping warm and avoiding damp and cold conditions can reduce the frequency of episodes.

## 7. Discussion

Familial episodic pain syndrome (FEPS) is a rare autosomal dominant genetic disorder characterized by severe episodic pain that manifests in early childhood, primarily affecting the distal extremities. The symptoms of FEPS gradually alleviate and may even completely disappear as the patient ages [1]. The underlying mechanism may be related to the gradual decline in the physiological expression levels of voltage-gated sodium channels (VGSCs) with age. Due to the relatively limited clinical awareness of FEPS, misdiagnosis or missed diagnosis frequently occurs. Therefore, when encountering patients with similar symptoms, after excluding secondary limb pain disorders such as rheumatism, hematological diseases, and orthopedic conditions, it is advisable to consider the possibility of FEPS. Genetic screening of patients and their family members can facilitate a definitive diagnosis, thereby preventing secondary harm caused by the misuse or abuse of medications. Some patients may develop

psychological abnormalities; in this case, the patient's family members attributed the symptoms to superstitious beliefs due to the presence of similar symptoms in multiple family members. Early diagnosis can significantly alleviate the psychological and financial burdens on the patient's family.

The clinical features of FEPS primarily manifest as episodic limb pain and numbness, with the pain predominantly concentrated in the lower extremities, knees, and ankles. Occasionally, the pain may ascend to the elbows, wrists, and palms, and may even affect the proximal extremities and waist. The pain is intense and paroxysmal, often occurring in the afternoon or evening, and exhibits a periodic pattern. The precipitating factors include weather changes, cold, and stressful events, among others, while heat application or the use of nonsteroidal anti-inflammatory drugs (NSAIDs) can partially alleviate the pain. FEPS can be classified into three types based on different gene mutations: FEPS1, FEPS2, and FEPS3 [2].

(1) FEPS1

It is caused by heterozygous variations in the transient receptor potential ankyrin 1 gene (TRPA1) located on chromosome 8q21. The pain primarily occurs in the upper body, such as the arms, shoulders, and chest, and is often triggered by factors such as eating, fatigue, and cold. A warm environment can alleviate the pain, while NSAIDs have no significant effect [3].

(2) FEPS2

It is caused by variations in the sodium voltage-gated channel alpha subunit 10 gene (SCN10A) located on chromosome 3p22. The pain mainly occurs in the feet and is unrelated to cold or other triggering factors, although warmth can sometimes alleviate the pain. Skin biopsies reveal partial or complete loss of intraepidermal nerve fiber density [4].

(3) FEPS3

Caused by variations in the sodium voltage-gated channel alpha subunit 11 gene (SCN11A) located on chromosome 3p22. The pain primarily occurs in the distal joints of the limbs, particularly the knees and ankles. Some patients show a certain therapeutic response to NSAIDs, and the frequency of pain episodes decreases with age [5].

This case is classified as FEPS3.

Familial episodic pain syndrome type 3 (FEPS3) is an autosomal dominant genetic disorder. The phenotypic details of this disease are as follows: During pain episodes, patients experience hyperhidrosis, abnormal physiological functions of the autonomic nervous system, and pain, while other sensory modalities may remain normal or diminished. The onset of the disease occurs in early childhood, with patients perceiving pain as cold. Episodes are triggered by fatigue, illness, or strenuous exercise [6]. Nonsteroidal anti-inflammatory drugs (NSAIDs) can alleviate pain, which often occurs later in the day. There is a tendency for episodes to decrease with age, and some patients may develop adult-onset small fiber neuropathy [7].

Neuroelectrophysiological tests and nerve biopsies lack specificity in diagnosing FEPS during the onset period. However, as clinical symptoms resolve, some patients may develop lesions in unmyelinated nerve fibers. These lesions aid clinicians in differentiating FEPS from other types of peripheral neuropathies. Exome sequencing has revealed that FEPS patients carry SCN11A gene variants, including known mutations and newly discovered heterozygous mutations.

Currently, the treatment strategy for FEPS primarily relies on symptom relief, such as using hot compresses and NSAIDs like ibuprofen and naproxen to alleviate mild to moderate pain. However, long-term use of NSAIDs requires attention to potential side effects. For patients who do not respond well to pharmacological treatment,

neuromodulation techniques, such as transcranial magnetic stimulation (TMS) and spinal cord stimulation (SCS), may be effective treatment options. Additionally, psychotherapy, such as cognitive-behavioral therapy (CBT), can help improve patients' coping abilities and reduce psychological stress caused by pain.

As a rare autosomal dominant inherited neuropathic pain syndrome, the treatment of FEPS may focus on the following aspects in the future.

(1) Pharmacotherapy

Develop novel drugs targeting specific ion channels or receptors to more precisely regulate pain signal transduction. For instance, drugs targeting sodium ion channels such as Nav1.7, Nav1.8, and Nav1.9, or drugs targeting transient receptor potential (TRP) channels, may become new treatment options for FEPS in the future.

(2) Physical therapy and neuromodulation

Explore more effective physical therapy methods, such as electrical stimulation and magnetic stimulation, as well as neuromodulation techniques, such as spinal cord stimulation and deep brain stimulation, to alleviate or eliminate pain symptoms.

(3) Gene therapy

With the continuous advancement of gene editing technologies, such as CRISPR-Cas9, it may be possible in the future to precisely repair or replace the disease-causing genes of FEPS, thereby fundamentally addressing the pain issue.

At present, due to the genetic heterogeneity and diverse clinical manifestations of FEPS, establishing unified treatment standards still poses challenges. Additionally, for FEPS patients with negative genetic tests or unknown pathogenic mechanisms, diagnosis and treatment become even more complex.

## 8. Conclusion

Pediatric limb pain is a symptom that encompasses a wide range of diseases. When encountering such cases, clinicians need to carefully differentiate and diagnose them, rather than simply categorizing them as growing pains or arthritis. It is also necessary to consider the possibility of some uncommon or rare diseases. Additionally, genetic screening can be performed on children when necessary to clarify the cause of the disease and avoid unnecessary secondary harm caused by the misuse of medications.

## Disclosure statement

The authors declare no conflict of interest.

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# Interventional Room Nursing for Patients with Ischemic Stroke Treated with Tirofiban Combined with Direct Thrombectomy

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**Abstract:** *Objective*: To explore the interventional room nursing and its application effects in patients with ischemic stroke treated with tirofiban combined with direct thrombectomy. *Methods*: A total of 61 patients with ischemic stroke admitted to our hospital from June 2024 to June 2025 were selected and divided into two groups using the red and blue ball method: the control group (n = 30, receiving routine interventional room nursing) and the observation group (n = 31, receiving additional tirofiban medication-specific nursing + individualized interventional nursing on the basis of routine nursing). The cerebral hemodynamic indicators, adverse reactions, effectiveness of complication nursing, and nursing satisfaction were compared between the two groups. *Results:* After 7 days of treatment, the observation group had lower cerebrovascular peripheral resistance and higher mean blood flow velocity and mean blood flow volume compared to the control group (all $p < 0.05$). The observation group had a higher effectiveness rate of complication nursing than the control group, with a statistically significant difference ($p < 0.05$). The nursing satisfaction in the observation group (96.77%) was higher than that in the control group (80.00%), with a statistically significant difference ($\chi 2 = 4.223$, $p = 0.040 < 0.05$). *Conclusion:* Tirofiban combined with direct thrombectomy can significantly improve cerebral hemodynamics, enhance the effectiveness of complication nursing, and increase patient satisfaction in patients with ischemic stroke.

**Keywords:** Tirofiban; Direct thrombectomy; Ischemic stroke; Interventional room nursing; Nursing coordination

**Online publication:** Feb 11, 2026

## 1. Introduction

Ischemic stroke is caused by narrowing or occlusion of cerebral blood vessels, leading to ischemia, hypoxia, and necrosis of brain tissue, subsequently resulting in neurological deficits. It primarily manifests as limb hemiplegia, speech dysfunction, impaired consciousness, etc., and is characterized by high morbidity, disability, mortality, and recurrence rates, posing a severe threat to patients' lives and health [1]. Currently, direct thrombectomy is the primary clinical treatment method, which rapidly opens occluded blood vessels through mechanical means, restores cerebral blood perfusion, and reduces brain tissue damage. According to relevant reports, some patients

still experience issues such as vascular re-occlusion and insufficient cerebral perfusion after direct thrombectomy treatment [2]. As a highly selective non-peptide platelet aggregation inhibitor, tirofiban inhibits platelet aggregation by blocking the platelet glycoprotein IIb/IIIa receptor, thereby preventing thrombus formation. The quality of interventional room nursing directly affects the safety and effectiveness of treatment, especially in combined medication therapy, where scientific nursing interventions can ensure medication safety and improve surgical coordination efficiency. Based on this, this article further explores the clinical effects of tirofiban combined with direct thrombectomy in treating patients with ischemic stroke and the targeted interventional room nursing measures. The report is as follows.

## 2. Materials and methods

### 2.1. General information

A total of 61 patients with ischemic stroke admitted to our hospital from June 2024 to June 2025 were selected and divided into two groups using the red and blue ball method: the control group (n = 30) and the observation group (n = 31). In the control group, there were 19 males and 11 females, aged between 40 and 78 years old, with an average age of (62.35 ± 3.32) years old; the onset time ranged from 1 to 6 hours, with an average of (3.65 ± 0.15) hours. In the observation group, there were 18 males and 12 females, aged between 41 and 78 years old, with an average age of (62.39 ± 3.36) years old; the onset time ranged from 1 to 5 hours, with an average of (3.57 ± 0.12) hours. There was no statistically significant difference in the information between the two groups ($p > 0.05$).

### 2.2. Diagnostic criteria

Reference was made to the "2018 Chinese Guidelines for the Diagnosis and Treatment of Acute Ischemic Stroke": presence of any neurological deficit such as sudden limb weakness, speech impairment, visual abnormalities, dizziness, or unsteady gait; exclusion of cerebral hemorrhage by head CT; diagnosis can be made if symptoms persist for more than 24 hours without imaging evidence; laboratory tests (complete blood count, coagulation function, blood glucose, etc.) should be completed to exclude stroke mimics and other etiologies [3].

### 2.3. Inclusion and exclusion criteria

#### 2.3.1. Inclusion criteria

(1) Patients meeting the above diagnostic criteria;
(2) Time from onset to hospital admission not exceeding 6 hours, meeting the indications for direct thrombectomy treatment;
(3) Informed consent obtained from patients and their families;
(4) Approval obtained from the Ethics Committee of our hospital.

#### 2.3.2. Exclusion criteria

(1) Patients with mental or cognitive abnormalities;
(2) Patients with a history of intracranial hemorrhage or brain trauma;
(3) Patients with cardiac, hepatic, or renal insufficiency;
(4) Patients allergic to the methods or medications used in the trial.

## 2.4. Methods

### 2.4.1. Control group

The control group received routine interventional room care: Assisting patients in completing preoperative routine examinations before surgery, preparing interventional surgical instruments and medications; preparing the skin at the puncture site, informing them of the basic surgical procedure and precautions; assisting the surgeon in positioning the patient during surgery; accurately passing surgical instruments and closely monitoring vital signs; after surgery, assisting patients in returning to the ward, observing for bleeding or hematoma at the puncture site, and instructing patients to rest in bed.

### 2.4.2. Observation group

In addition to routine interventional room care, the observation group received specialized care for tirofiban administration and individualized interventional care, with the following measures:

(1) Preoperative care

① Comprehensive assessment: Conduct examinations to evaluate the patient's coagulation function and vascular condition, with a focus on assessing the risk of bleeding. For patients at high risk of bleeding, develop targeted preventive measures in advance; ② Medication instruction: Provide detailed explanations to patients and their families about the mechanism of action, administration method, potential adverse reactions, and corresponding measures of tirofiban to enhance medication compliance; ③ Preparation of items: In addition to routine surgical items, specifically prepare tirofiban injection, intravenous pumps, and hemostatic emergency items (hemostatic forceps, hemostatic gauze, etc.); ④ Psychological counseling: Share successful treatment cases with patients, answer their questions, and enhance their confidence in treatment.

(2) Intraoperative nursing care

① Precise medication administration: Strictly adhere to the intravenous pump parameters set by the doctor's orders to ensure accurate dosage and speed of tirofiban infusion. During the infusion process, monitor the patency of the infusion tubing to prevent drug extravasation; ② Close monitoring: Enhance monitoring of the patient's vital signs and watch for signs of bleeding (increased bleeding at the puncture site, gingival bleeding, nosebleeds, etc.). If abnormalities occur, immediately report to the doctor and assist in handling them; ③ Optimization of surgical coordination: Flexibly adjust the patient's position according to the needs of the thrombectomy procedure; accurately and quickly pass surgical instruments.

(3) Postoperative nursing care

① Enhanced observation of the puncture site: Check the puncture site every 0.5 hours for bleeding or hematoma, and monitor the temperature, color, and sensation of the lower limb skin. If hematoma enlargement or persistent bleeding occurs, promptly apply pressure to stop the bleeding; ② Coagulation function monitoring: Regularly assist the patient in reviewing coagulation function indicators after surgery and adjust nursing measures promptly based on the results; ③ Diet and activity guidance: During bed rest, instruct the patient to choose bland, easily digestible, and protein-rich foods, and avoid spicy and irritating foods. Assist the patient in performing passive limb movements to prevent deep vein thrombosis in the lower limbs, and advise them to avoid strenuous activities to prevent bleeding at the puncture site; ④ Nursing care for adverse reactions: In case of adverse reactions such as skin rash and vascular reocclusion, promptly report to the doctor, assist in management, and comfort the patient and their family members.

## 2.5. Observation indicators

(1) Compare the cerebral hemodynamics indicators of the two groups before treatment and after 7 days of treatment. Utilize a cerebrovascular function detector (manufacturer: Beijing Gushanfeng Biotechnology Co., Ltd., model: GT-300) with a probe frequency set at 5 MHz. Assist the patient in assuming a supine position and proceed with the operation after their breathing and heart rate have stabilized. Measure the cerebrovascular peripheral resistance, mean blood flow velocity, and mean blood flow volume.

(2) Compare the adverse reactions (rash, vascular reocclusion, vascular injury) between the two groups.

(3) Compare the effectiveness rate of complication nursing between the two groups (the proportion of patients whose symptoms of complications such as bleeding and vascular reocclusion are controlled or alleviated after nursing care, out of the total number of patients with such complications).

(4) Compare nursing satisfaction between the two groups, assessed using a self-designed nursing satisfaction questionnaire (Cronbach's α coefficient of 0.88, demonstrating good reliability and validity) from our hospital. The questionnaire covers aspects such as nursing attitude, proficiency in nursing operations, and effectiveness of health guidance, with a total score of 100 points. It is divided into three levels: very satisfied (≥ 90 points), satisfied (70–89 points), and dissatisfied (< 69 points). Nursing satisfaction is calculated as the sum of the very satisfied rate and the satisfied rate.

## 2.6. Statistical methods

The cerebral hemodynamic indicators, incidence of adverse reactions, effectiveness rate of complication nursing, and nursing satisfaction were input into SPSS 20.0 software. The first indicator is a measurement variable (conforming to a normal distribution), expressed as ($\overline{x} \pm s$), and analyzed using the *t*-test. The latter three indicators are categorical variables, expressed as "%". A statistically significant difference is considered when $p < 0.05$.

# 3. Results

## 3.1. Cerebral hemodynamic indicators

According to **Table 1**, after 7 days of treatment, the observation group had lower cerebrovascular peripheral resistance and higher mean blood flow velocity and mean blood flow volume compared to the control group (all $p < 0.05$).

**Table 1.** Changes in cerebral hemodynamic indicators between groups ($\overline{x} \pm s$)

| Group | Cerebrovascular peripheral resistance [kPa/(s·m)] | | Mean blood flow velocity (cm/s) | | Mean blood flow (mL/s) | |
|---|---|---|---|---|---|---|
| | Before treatment | After 7 days | Before treatment | After 7 days | Before treatment | After 7 days |
| Observation group (n = 31) | 90.54 ± 12.29 | 73.88 ± 5.42[a] | 13.69 ± 3.28 | 20.66 ± 6.45[a] | 5.45 ± 1.23 | 8.78 ± 2.66[a] |
| Control group (n = 30) | 91.51 ± 13.31 | 80.67 ± 8.40[a] | 13.71 ± 3.29 | 17.01 ± 5.35[a] | 5.43 ± 1.25 | 7.34 ± 1.53[a] |
| *t*-value | 0.296 | 3.764 | 0.024 | 2.401 | 0.063 | 2.580 |
| *p*-value | 0.768 | < 0.001 | 0.981 | 0.016 | 0.950 | 0.012 |

Note: Compared with before treatment in the same group, [a]$p < 0.05$.

## 3.2. Incidence of adverse reactions

According to **Table 2**, there was no statistically significant difference in the incidence of adverse reactions between the two groups ($p > 0.05$).

**Table 2.** Incidence of adverse reactions between groups [n (%)]

| Group | Rash | Vascular re-occlusion | Vascular injury | Total incidence (%) |
|---|---|---|---|---|
| Observation group (n = 31) | 1 (3.23) | 1 (3.23) | 0 (0.00) | 2 (6.45) |
| Control group (n = 30) | 1 (3.23) | 2 (6.67) | 1 (3.33) | 4 (13.33) |
| $\chi^2$-value | - | - | - | 0.814 |
| *p*-value | - | - | - | 0.367 |

## 3.3. Effectiveness rate of complication nursing

In the observation group, one case of rash and one case of vascular reocclusion occurred, both of which were rapidly controlled after targeted nursing interventions, resulting in a 100.00% effectiveness rate in complication nursing.

In the control group, there was one case of rash, two cases of vascular reocclusion, and one case of vascular injury. Symptoms were alleviated in two cases after nursing care, while two patients with vascular reocclusion required further treatment, yielding a 75.00% effectiveness rate in complication nursing. The observation group demonstrated a significantly higher effectiveness rate in complication nursing compared to the control group, with a statistically significant difference ($p < 0.05$).

## 3.4. Nursing satisfaction

**Table 3** indicates that the observation group exhibited higher nursing satisfaction compared to the control group, with a statistically significant difference ($p < 0.05$).

**Table 3.** Incidence of adverse reactions between groups [n (%)]

| Group | Very satisfied | Satisfied | Dissatisfied | Overall satisfaction rate (%) |
|---|---|---|---|---|
| Observation group (n = 31) | 20 (64.52) | 10 (32.26) | 1 (3.23) | 30 (96.77) |
| Control group (n = 30) | 12 (40.00) | 12 (40.00) | 6 (20.00) | 24 (80.00) |
| $\chi^2$-value | - | - | - | 4.223 |
| *p*-value | - | - | - | 0.040 |

# 4. Discussion

The core pathological mechanism of ischemic stroke involves thrombus formation leading to cerebral vessel occlusion, subsequently causing ischemic-hypoxic damage to brain tissue. Direct thrombectomy can swiftly and directly remove intracranial thrombi, restoring vascular patency. However, some patients may experience vascular reocclusion due to platelet reaggregation or residual thrombus enlargement [4]. Tirofiban, a highly selective platelet aggregation inhibitor, effectively blocks the platelet aggregation process and reduces the risk of thrombus formation. Combining direct thrombectomy with tirofiban is expected to further enhance therapeutic outcomes.

Interventional room nursing, as a crucial component of the treatment process, directly influences the safety and effectiveness of therapy. Especially when combined with tirofiban treatment, implementing scientific nursing measures is essential to ensure medication safety, optimize surgical collaboration, and improve patient prognosis.

The above findings indicate that, after seven days of treatment, the improvement in cerebral hemodynamic indicators was more significant in the observation group compared to the control group. This can be attributed to the crucial role played by the specialized nursing care for tirofiban administration and individualized interventional nursing provided to the observation group in addition to routine care. A comprehensive preoperative assessment of the patient's bleeding risk and thorough preparation laid a solid foundation for the smooth implementation of treatment and nursing. During surgery, precise medication administration ensured the accuracy of tirofiban dosage and infusion rate, while close monitoring of the patient's vital signs and signs of bleeding enabled timely detection and management of abnormalities, thereby ensuring treatment safety. Postoperatively, enhanced observation of the puncture site and regular monitoring of coagulation function facilitated the early detection and management of complications, while dietary and activity guidance helped prevent secondary issues such as deep vein thrombosis in the lower extremities, thereby improving patient prognosis [5]. These results align with clinical reports [6]. There was no significant difference in the incidence of adverse reactions between the two groups, but the observation group demonstrated higher rates of effective complication management and nursing satisfaction compared to the control group. This suggests that targeted interventional room nursing can enhance the effectiveness of complication intervention and improve the patient's nursing experience without increasing the risk of adverse reactions. The reason for this is that the nursing interventions in the observation group were more targeted and individualized. Preoperative psychological counseling effectively reduced patient anxiety, precise intraoperative coordination improved surgical efficiency, and meticulous postoperative complication nursing and health guidance enhanced the patient's sense of security and trust.

In addition, this study also found a close connection between nursing interventions and patient prognosis. Postoperative bleeding monitoring and nursing care enable the timely detection and management of issues such as bleeding and hematoma at the puncture site, thereby reducing the impact of adverse reactions on patient prognosis. Medication nursing ensures the standardized use of tirofiban, assists in optimizing the patient's blood coagulation function, and reduces the risk of recurrent thrombosis [7]. Furthermore, individualized surgical cooperation enhances the efficiency of thrombectomy procedures, reduces the duration of cerebral ischemia and hypoxia, mitigates cerebral tissue damage, and improves the neurological prognosis of patients [8]. However, this trial was a single-center, small-sample study, which may affect the reliability and generalizability of the results; moreover, long-term follow-up of patients was not conducted.

## 5. Conclusion

In summary, for patients with ischemic stroke treated with a combination of tirofiban and direct thrombectomy, implementing comprehensive interventional room nursing that includes specialized nursing for tirofiban medication and individualized interventional nursing can effectively improve cerebral hemodynamics, enhance the effectiveness of complication nursing, and increase patient satisfaction with nursing care. Future research could involve multi-center, large-sample, long-term follow-up studies to further demonstrate the long-term effectiveness and safety of the combined treatment regimen and targeted interventional room nursing.

## Disclosure statement

The author declares no conflict of interest.

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# Observation on the Effect of Combined Exercise Intervention Based on the Hospital-Community-Family Model on Intrinsic Capacity in Elderly Patients with Diabetes Mellitus Complicated by Chronic Kidney Disease

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**Abstract:** *Objective*: To explore the application effect of combined exercise intervention based on the hospital-community-family model on intrinsic capacity in elderly patients with diabetes mellitus complicated by chronic kidney disease. *Methods*: Using convenience sampling, 100 elderly patients with diabetes mellitus complicated by chronic kidney disease who received treatment in the endocrinology department of a tertiary A-level hospital from May 2024 to May 2025 were selected as the study subjects. They were randomly divided into an experimental group (50 cases) and a control group (50 cases) using a random number table method. The control group received routine health education and telephone follow-up, while the experimental group, in addition to the control group's interventions, underwent combined exercise intervention based on the hospital-community-family model. Remote medical guidance was utilized to monitor and study the application effect of exercise intervention on intrinsic capacity in elderly patients with diabetes mellitus complicated by chronic kidney disease. Fasting blood glucose, 2-hour postprandial blood glucose, glomerular filtration rate, 6-minute walk distance, and scores in five dimensions of intrinsic capacity (exercise, cognition, psychology, vitality, and sensation) were measured before the intervention, at 4 weeks of intervention, and at 12 weeks of intervention for both groups. *Results:* Before the exercise intervention, there were no statistically significant differences ($p > 0.05$) between the two groups in terms of fasting blood glucose, 2-hour postprandial blood glucose, glomerular filtration rate, 6-minute walk distance, and scores across five dimensions of intrinsic capacity: mobility, cognition, psychology, vitality, and sensation. After 12 weeks of intervention, the experimental group demonstrated significantly higher scores than the control group in glomerular filtration rate, 6-minute walk distance, and the dimensions of mobility, cognition, and vitality within intrinsic capacity, with all differences being statistically significant ($p < 0.05$). Conversely, the experimental group showed significantly lower scores than the control group in fasting blood glucose, 2-hour postprandial blood glucose, and the psychological dimension

of intrinsic capacity, with these differences also being statistically significant ($p < 0.05$). *Conclusion:* Continuous nursing care utilizing telemedicine based on a hospital-community-family model combined with exercise intervention can effectively enhance exercise tolerance and intrinsic capacity in elderly patients with diabetes mellitus complicated by chronic kidney disease, thereby improving their quality of life. The effectiveness of the intervention is positively correlated with the duration of the intervention.

**Keywords:** Hospital-community-family model; Telemedicine; Elderly; Diabetes mellitus complicated by chronic kidney disease; Intrinsic capacity

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# 1. Introduction

As the process of population aging accelerates, the co-occurrence of chronic diseases in the elderly has become a major concern in the field of public health [1]. Both diabetes mellitus (DM) and chronic kidney disease (CKD) are prevalent chronic conditions among the elderly population, often interacting and progressing in tandem. This not only exacerbates renal function impairment and elevates the risk of end-stage renal disease (ESRD), but also triggers a series of issues such as physical function decline and cognitive impairment [2]. Approximately 30–50% of patients with concurrent DM and CKD eventually develop ESRD, posing a severe threat to their quality of life [3]. The concept of intrinsic capacity (IC), introduced by the WHO in 2015 as a core indicator for assessing the health status of the elderly, encompasses multiple dimensions including physical capacity, cognition, psychology, and social adaptation. The level of IC directly determines the elderly's ability to live independently and their health prognosis, serving as an important metric for evaluating the effectiveness of chronic disease management [4]. It aims to reflect the overall state of the elderly from a holistic perspective and can be used as an independent predictor of disability in the elderly [5]. Current exercise intervention models are mostly confined to short-term guidance within hospitals, lacking continuous supervision at the community level and long-term cooperation at the family level, making it difficult to meet the personalized and long-term intervention needs of elderly patients with comorbidities [6,7]. The hospital-community-family integrated intervention model breaks down the barriers of healthcare service settings. Through telemedicine service platforms, it integrates tertiary healthcare resources, achieving full-process coverage from standardized in-hospital diagnosis and treatment to continuous community management and then to daily home care, providing new approaches for the comprehensive management of elderly patients with chronic diseases [8–11]. Therefore, this study aims to explore the implementation of exercise intervention guidance and monitoring for elderly patients with diabetes mellitus (DM) complicated by chronic kidney disease (CKD) based on a hospital-community-family model, and subsequently evaluate its application effect on patients' intrinsic capacity, with the goal of providing a reference basis for further improving the quality of life of elderly patients with DM complicated by CKD.

# 2. Subjects and methods

## 2.1. Subjects

This study consecutively enrolled 100 elderly patients with DM complicated by CKD who received treatment in the Endocrinology Department of a tertiary-level hospital from May 2024 to May 2025. Using a random number

table method, the enrolled patients were divided into an experimental group and a control group, with 50 cases in each group.

### 2.1.1. Inclusion criteria

Participants meeting the diagnostic criteria for DM with a disease duration of ≥ 3 months; conforming to the definition of CKD proposed by the Kidney Disease Outcomes Quality Initiative (KDOQI) guidelines, with clinically confirmed stable CKD stages 1–4, and not undergoing maintenance dialysis treatment; elderly patients aged ≥ 60 years; individuals capable of independent walking and able to complete individualized exercise prescriptions for this study as instructed; long-term residence after discharge within the community covered by the hospital's telemedicine platform; able to communicate without barriers with researchers, willing to participate throughout the study, and having signed an informed consent form [12,13].

### 2.1.2. Exclusion criteria

Individuals with severe osteoarticular diseases, such as ankylosing spondylitis; those with mental disorders combined with severe heart, liver, brain, lung, or other serious renal diseases; and those currently participating in clinical trials. There were no statistically significant differences in general data between the two groups ($p > 0.05$).

## 2.2. Intervention methods

Exercise intervention involves the formulation of individualized exercise prescriptions. The exercise prescriptions are developed with reference to the "Chinese Guidelines for Exercise in Type 2 Diabetes" and the "Clinical Practice Guidelines for Exercise Rehabilitation in Chronic Kidney Disease" [14,15]. Specific guidance is provided on exercise form, intensity, frequency, and duration.

### 2.2.1. Control group

The control group receives conventional care for DM combined with CKD.

### 2.2.2. Experimental group

In addition to conventional treatment and care, the experimental group undergoes a joint exercise intervention based on a hospital-community-family model utilizing a telemedicine platform. The specific measures are as follows:

(1) Establish a remote platform and an exercise intervention team

The team members include: 1 endocrinologist, 1 nephrologist, 1 exercise rehabilitation therapist, 1 endocrine specialist nurse, 1 nephrology specialist nurse, 2 community nurses, and 1 remote platform engineer.

(2) Remote exercise and health management content

Remote exercise supervision and follow-up will be conducted twice a week, including: ① Online exercise supervision and guidance: a. Warm-up exercises for 10 minutes each time; b. Aerobic exercises; c. Resistance exercises; e. Flexibility exercises; f. Stretching exercises. ② Online medical consultations: Patients can consult hospital or community healthcare professionals online through the remote platform using text, voice, images, or video. ③ Online health education: Monthly online educational lectures will be conducted by endocrine or nephrology specialist nursing experts.

(3) Remote platform patient-side operations

Researchers will release videos related to rehabilitation exercises for diabetes mellitus (DM) and chronic kidney disease (CKD) on the hospital's telemedicine platform every Tuesday and Thursday for patients, community healthcare professionals, and caregivers to learn from, thereby enhancing patients' enthusiasm for participating in exercise rehabilitation.

## 2.3. Observation indicators

Data will be collected during patient follow-up visits, with observation indicators including: fasting blood glucose, 2-hour postprandial blood glucose, glomerular filtration rate, 6-Minute Walk Test (6MWT), and intrinsic capacity scores for the elderly. Intrinsic capacity encompasses five dimensions: exercise, cognition, psychology, vitality, and sensation.

(1) Short physical performance battery (SPPB)

The SPPB comprises four major tests: balance ability test, walking speed test, and sit-to-stand test. A score of 1 is assigned for a performance time ranging from 16.7 to 60 seconds, 2 points for a time between 13.70 and 16.69 seconds, 3 points for a time between 11.20 and 13.69 seconds, and 4 points for a time of ≤ 11.19 seconds. If the task cannot be completed or the time exceeds 60 seconds, a score of 0 is given. Each test component is scored from 0 to 4, resulting in a total SPPB score of 12 points. An SPPB score of ≤ 8 indicates decreased physical performance [16].

(2) Mini mental state examination (MMSE)

The MMSE is currently one of the preferred screening tools for cognitive impairment, developed by Folstein [17]. The scale includes assessments of orientation, memory, attention and calculation, recall ability, and language skills. The total score is 30 points, with higher scores indicating better cognitive function. It demonstrates high reliability and validity when used to evaluate dementia in various populations.

(3) Mini nutritional assessment (MNA)

The MNA scale, developed by Guigoz et al., includes six items: ① weight loss in the last three months; ② body mass index; ③ psychological stress or acute illness in the last three months; ④ mobility; ⑤ psychological problems; and ⑥ appetite in the last three months. The total score is 14 points, and a score of ≤ 11 points suggest a decline in the vitality dimension [18].

(4) Short-form geriatric depression scale (geriatric depression scale 5 items, GDS-15)

The GDS-15 was developed by foreign scholar Sheikh in 1986 and consists of 15 items, with a total score of 15 points. Each item answered as indicative of depression is scored as 1 point, and a final score of ≥ 8 points indicates the presence of depressive symptoms [19].

(5) Sensory dimension scoring

The sensory dimension includes vision and hearing. Vision and hearing are assessed using a visual acuity chart and a whisper test, respectively. Normal vision and hearing are scored as 1 point, while any impairment is scored as 0 points.

## 2.4. Statistical methods

Data were analyzed using SPSS 25.0 statistical software. Normally distributed measurement data are presented as mean ± standard deviation ($\overline{x} \pm s$). Comparisons between groups were conducted using paired *t*-tests, while comparisons within three different time groups were performed using repeated measures analysis of variance. A $p$-value < 0.05 was considered statistically significant.

# 3. Results

## 3.1. Comparison of fasting blood glucose level between two groups of patients

A comparison of fasting blood glucose levels between the two groups before intervention, at 4 weeks of intervention, and at 12 weeks of intervention is presented in **Table 1**.

**Table 1.** Comparison of fasting blood glucose level between two groups before and after intervention (mol/L, $\overline{x} \pm s$)

| Time point | Before treatment | 4 Weeks of treatment | 12 Weeks of treatment |
|---|---|---|---|
| Experimental group (n = 50) | 10.2 ± 2.7 | 8.6 ± 2.4 | 7.9 ± 2.3 |
| Control group (n = 50) | 10.7 ± 1.3 | 10.2 ± 1.2 | 10.0 ± 2.2 |
| *F*-value (ANOVA) | $F_{Group}$4.045 | $F_{Time}$35.484 | $F_{Interaction}$82.679 |
| *t*-value (vs. Baseline) | -0.523 | -0.152 | 12.115 |
| *p*-value | 0.609 | < 0.001 | < 0.001 |

## 3.2. Comparison of 2-hour postprandial blood glucose levels between the two groups

A comparison of 2-hour postprandial blood glucose levels between the two groups before intervention, at 4 weeks of intervention, and at 12 weeks of intervention is shown in **Table 2**.

**Table 2.** Comparison of 2-hour postprandial blood glucose levels between the two groups before and after intervention (mol/L, $\overline{x} \pm s$)

| Time point | Before treatment | 4 Weeks of treatment | 12 Weeks of treatment |
|---|---|---|---|
| Experimental group (n = 50) | 11.8 ± 2.2 | 9.8 ± 2.6 | 8.8 ± 2.1 |
| Control group (n = 50) | 10.7 ± 2.1 | 10.5 ± 1.2 | 10.3 ± 2.6 |
| *F*-value (ANOVA) | $F_{Group}$4.127 | $F_{Time}$30.258 | $F_{Interaction}$81.367 |
| *t*-value (vs. Baseline) | -0.520 | -0.137 | 13.109 |
| *p*-value | 0.341 | < 0.001 | < 0.001 |

## 3.3. Comparison of glomerular filtration rates between the two groups

A comparison of glomerular filtration rates between the two groups before intervention, at 4 weeks of intervention, and at 12 weeks of intervention is shown in **Table 3**.

**Table 3.** Comparison of glomerular filtration rates between the two groups before and after intervention (mL/min, $\overline{x} \pm s$)

| Time point | Before treatment | 4 Weeks of treatment | 12 Weeks of treatment |
|---|---|---|---|
| Experimental group (n = 50) | 86.867 ± 12.775 | 87.003 ± 12.342 | 99.367 ± 8.349 |
| Control group (n = 50) | 87.172 ± 12.710 | 87.097 ± 12.548 | 84.007 ± 9.286 |
| *F*-value (ANOVA) | $F_{Group}$4.112 | $F_{Time}$32.243 | $F_{Interaction}$84.637 |
| *t*-value (vs. Baseline) | -0.417 | -0.118 | 12.284 |
| *p*-value | 0.609 | < 0.001 | < 0.001 |

## 3.4. Comparison of the six-minute walk distance (6MWD) between the two groups

A comparison of the 6MWD between the two groups before intervention, at 4 weeks of intervention, and at 12 weeks of intervention is shown in **Table 4**.

**Table 4.** Comparison of the 6MWD between the two groups before and after intervention (m, $\overline{x} \pm s$)

| Time point | Before treatment | 4 Weeks of treatment | 12 Weeks of treatment |
|---|---|---|---|
| Experimental group (n = 50) | 306.245 ± 27.218 | 325.295 ± 27.296 | 369.570 ± 24.635 |
| Control group (n = 50) | 301.185 ± 23.652 | 319.920 ± 24.878 | 322.820 ± 26.423 |
| *F*-value (ANOVA) | $F_{Group}$22.287 | $F_{Time}$318.572 | $F_{Interaction}$148.529 |
| *t*-value (vs. Baseline) | 1.283 | 5.647 | 14.193 |
| *p*-value | 0.685 | < 0.001 | < 0.001 |

## 3.5. Comparison of intrinsic capacities between the two groups

A comparison of scores across five dimensions of intrinsic capacity between the two groups before intervention, at 4 weeks of intervention, and at 12 weeks of intervention is shown in **Table 5**.

**Table 5.** Comparison of intrinsic capacities between the two groups before and after intervention (points, $\overline{x} \pm s$)

| Dimension | Time point | Experimental group (n = 50) | Control group (n = 50) | *F*-value | *t*-value | *p*-value (Group difference) |
|---|---|---|---|---|---|---|
| Motor | Before Intervention | 5.05 ± 2.82 | 4.83 ± 1.86 | $F_{Group}$23.856 | -0.463 | 0.629 |
| | 4 Weeks | 5.32 ± 2.42 | 4.75 ± 1.79 | $F_{Time}$50.672 | -3.582 | 0.061 |
| | 12 Weeks | 7.54 ± 2.16 | 4.82 ± 1.61 | $F_{Interaction}$28.652 | -8.792 | < 0.001 |
| Cognitive | Before Intervention | 18.27 ± 2.61 | 18.62 ± 2.34 | $F_{Group}$15.445 | -1.639 | 0.106 |
| | 4 Weeks | 21.24 ± 1.92 | 18.97 ± 1.69 | $F_{Time}$82.315 | -4.085 | 0.087 |
| | 12 Weeks | 25.37 ± 1.54 | 19.68 ± 1.28 | $F_{Interaction}$41.285 | -9.257 | < 0.001 |
| Psychological | Before Intervention | 6.44 ± 2.83 | 6.52 ± 1.92 | $F_{Group}$20.526 | -2.023 | 0.171 |
| | 4 Weeks | 4.21 ± 1.56 | 6.32 ± 1.27 | $F_{Time}$121.284 | -0.761 | 0.227 |
| | 12 Weeks | 3.19 ± 1.84 | 5.86 ± 1.53 | $F_{Interaction}$106.251 | -12.568 | <0.001 |
| Vitality | Before Intervention | 10.12 ± 1.42 | 9.89 ± 1.86 | $F_{Group}$4.564 | -0.582 | 0.489 |
| | 4 Weeks | 10.29 ± 1.29 | 10.12 ± 1.39 | $F_{Time}$20.128 | -1.752 | 0.864 |
| | 12 Weeks | 11.86 ± 1.81 | 10.19 ± 1.56 | $F_{Interaction}$18.812 | -5.127 | < 0.001 |
| Sensory | Before Intervention | 0.32 ± 0.71 | 0.31 ± 0.89 | $F_{Group}$56.261 | -1.728 | 0.161 |
| | 4 Weeks | 0.33 ± 0.76 | 0.32 ± 0.23 | $F_{Time}$72.729 | -1.453 | 0.121 |
| | 12 Weeks | 0.34 ± 0.68 | 0.35 ± 0.38 | $F_{Interaction}$73.592 | -1.039 | 0.258 |

# 4. Discussion

## 4.1. Hospital-community-family exercise intervention improves glycemic control in elderly DM-CKD patients

Joint exercise intervention based on the hospital-community-family model can effectively improve fasting blood glucose and 2-hour postprandial blood glucose levels in elderly patients with diabetes mellitus (DM) complicated by chronic kidney disease (CKD). The study results indicate that after 4 and 12 weeks of intervention, both fasting blood glucose and 2-hour postprandial blood glucose levels in the experimental group were significantly lower than those in the control group, with statistically significant differences ($p < 0.05$). This suggests that the intervention can effectively reduce blood glucose levels in patients, and the effect of reducing blood glucose is positively correlated with the duration of the intervention, with longer durations yielding more pronounced effects. The analysis suggests that the intervention may leverage remote monitoring and guidance models in telemedicine to ensure the safety and scientific validity of patient exercise, while providing continuous supervision and motivation from family members or peers, leading to higher adherence, incorporation into daily habits, and long-term maintenance, thereby effectively achieving blood glucose control goals.

## 4.2. Hospital-community-family exercise intervention improves renal function in elderly DM-CKD patients

Joint exercise intervention based on the hospital-community-family model can effectively improve renal function in elderly patients with DM complicated by CKD. The results of this study indicate that after 12 weeks of intervention, the glomerular filtration rate (GFR) in the experimental group was higher than that in the control group, with a statistically significant difference ($p < 0.05$). This suggests that the intervention can effectively improve renal function in patients. The analysis suggests that the intervention may leverage both remote monitoring and remote rehabilitation in telemedicine to enhance patient exercise adherence, boost confidence, and increase the completion rate of designated exercise intervention programs.

## 4.3. A hospital-community-family rehabilitation exercise model improves exercise capacity in elderly DM-CKD patients

Joint rehabilitation exercise intervention based on the hospital-community-family model can effectively improve exercise capacity in elderly patients with DM complicated by CKD. Studies have shown that appropriate aerobic exercise combined with resistance training can effectively improve patients' mobility and quality of life, while low physical activity can effectively delay the further progression of diabetes mellitus (DM) and chronic kidney disease (CKD) [20–22]. However, excessive physical activity can also increase the burden on the kidneys. The lack of professional exercise guidance and examination after discharge can lead to impaired exercise capacity and a decline in physical function levels among elderly patients with DM complicated by CKD, resulting in periodic reductions in physical activity levels and ultimately functional disorders [23]. The results of this study indicate that the 6-minute walk distance of patients in the experimental group was higher than that in the control group, suggesting that patients' exercise capacity was effectively improved, consistent with the findings of studies by Chen Jiale and others [24].

## 4.4. A multi-level rehabilitation exercise intervention improves intrinsic capacity in elderly patients with diabetic kidney disease

Rehabilitation exercise intervention based on a hospital-community-family model can effectively improve the

intrinsic capacity of elderly patients with DM complicated by CKD. Intrinsic capacity serves as an independent predictor of disability in the elderly [25]. Studies have shown that a decline in intrinsic capacity affects the daily living abilities of the elderly [26]. Improving patients' intrinsic capacity can effectively delay disease progression, reduce the risk of complications, and enhance their quality of life. The results of repeated measures analysis of variance in this study showed no statistically significant difference in the scores of the sensory dimension of intrinsic capacity between the two groups after 4 and 12 weeks of intervention ($p > 0.05$). However, statistically significant differences were observed in the scores of the motor, cognitive, psychological, and vitality dimensions of intrinsic capacity between the two groups after 4 and 12 weeks of intervention ($p < 0.05$). It is proven that this intervention can significantly improve the levels of patients' intrinsic abilities in terms of exercise, cognition, psychology, and vitality. The analysis suggests that the reason may be that the combination of telemedicine platforms and exercise interventions can promote the effective participation of patients' family members in the entire process of patients' exercise rehabilitation treatment, enabling patients to receive more encouragement and assistance from family members, community staff, and medical personnel.

## 5. Conclusion

In summary, this study employed a hospital-community-family model combined with exercise interventions and utilized telemedicine platforms to provide exercise guidance for elderly patients with diabetes mellitus (DM) complicated by chronic kidney disease (CKD). This approach aimed to deliver comprehensive nursing care throughout the entire process for these patients, improve their blood glucose levels, enhance renal function, boost their intrinsic abilities, and ultimately improve their quality of life. However, given that telemedicine and digital smart nursing technologies are not yet fully widespread, and the scope of hospital-community-family collaboration is relatively limited, the results may be subject to bias. Therefore, future multi-center studies could be conducted to enhance the scientific rigor of the findings.

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# A Cross-sectional Analysis of Prenatal Bisphenol an Exposure and Pregnancy Characteristics in Northeastern Yunnan, China

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**Abstract:** *Objective*: To assess prenatal Bisphenol A (BPA) exposure levels and explore their preliminary associations with maternal and fetal characteristics in a population from Northeastern Yunnan. *Methods*: A cross-sectional analysis was performed using data and urine samples from 70 pregnant women in their third trimester recruited at Qujing Central Hospital. Urinary BPA was measured by HPLC-MS/MS. Participants were stratified into high and low BPA exposure groups based on the median concentration. *Results:* BPA was detected in all samples (100%) with a median concentration of 2.41 μg/L (IQR: 0.68–4.96). The high BPA exposure group (≥ 2.41 μg/L) had a significantly higher proportion of gestational diabetes mellitus (GDM) (42.9% vs. 17.1%, $p = 0.021$) and a lower median fetal birth weight (3250 g vs. 3450 g, $p = 0.048$) compared to the low exposure group. *Conclusion:* This pilot study reveals ubiquitous BPA exposure in pregnant women from Northeastern Yunnan. The observed preliminary associations with GDM and reduced fetal birth weight warrant further investigation in larger, longitudinal studies.

**Keywords:** Bisphenol A; Pregnancy; Exposure assessment; Cross-sectional study; China

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## 1. Introduction

Bisphenol A (BPA) is a widespread endocrine-disrupting chemical, and pregnant women and fetuses are vulnerable to its effects [1]. Studies have linked prenatal BPA exposure to adverse pregnancy outcomes (APOs) like gestational diabetes mellitus (GDM) and fetal growth restriction [2–5]. However, data on exposure levels and their potential health implications in specific Chinese industrializing regions like Northeastern Yunnan are scarce. Therefore, this study aimed to conduct a preliminary assessment of urinary BPA concentrations in late pregnancy and explore their associations with key maternal and fetal characteristics in this understudied population.

## 2. Materials and methods

### 2.1. Study population and design

A cross-sectional analysis was conducted using data from the first 70 pregnant women who completed urine sample collection and BPA measurement in an ongoing prospective cohort at Qujing Central Hospital in Northeastern Yunnan (Data collected between Jan 2022 and Dec 2023). Spot urine samples were collected during the third-trimester prenatal visit. This study represents the initial laboratory analysis from the parent cohort.

### 2.2. Measurement of BPA exposure

Urinary BPA concentrations were analyzed using HPLC-MS/MS (Agilent 1290/6470), a highly sensitive and specific method recommended for human biomonitoring [3]. The limit of detection (LOD) was 0.1 ng/mL. Values below the LOD were replaced by LOD/√2. For this initial analysis, raw urinary concentrations (μg/L) are reported to present the direct measurement results.

### 2.3. Statistical analysis

Participants were divided into two groups based on the median urinary BPA concentration (High Exposure ≥ median; Low Exposure < median). Descriptive statistics were presented as median (interquartile range, IQR) for continuous variables and number (percentage) for categorical variables. Differences between groups were tested using the Mann-Whitney U test for continuous variables and the Chi-square or Fisher's exact test for categorical variables. All analyses were performed using SPSS (Version 26.0), and a two-tailed $p$-value < 0.05 was considered statistically significant.

## 3. Results

BPA was detected in all 70 urine samples (100%). The median urinary BPA concentration was 2.41 μg/L (IQR: 0.68–4.96; range: 0.06–54.54). As shown in Table 1, women in the high BPA exposure group had a significantly higher prevalence of GDM (42.9% vs. 17.1%, $p$ = 0.021) and gave birth to infants with a lower median birth weight (3250 g vs. 3450 g, $p$ = 0.048) compared to those in the low exposure group. No significant differences were observed in maternal age, gestational age at sampling, weight gain, delivery mode, or low Apgar score proportion.

**Table 1.** Characteristics of the study population stratified by median BPA exposure level

| Characteristic | Total (n = 70) | Low BPA exposure (< 2.41 μg/L) (n = 35) | High BPA exposure (≥ 2.41μg/L) (n = 35) | *p*-value |
|---|---|---|---|---|
| Maternal Age (years), median (IQR) | 30 (27–34) | 31 (28–35) | 29 (26–32) | 0.104 |
| Gestational Age at Sampling (weeks), median (IQR) | 38 (37–39) | 38 (37–39) | 38 (37–39) | 0.789 |
| Gestational Weight Gain (kg), median (IQR) | 14 (12–16) | 114 (11-6) | 14 (12–15) | 0.665 |
| Delivery Mode (Cesarean), n (%) | 49 (70.0%) | 23 (65.7%) | 26 (74.3%) | 0.438 |
| Gestational Diabetes Mellitus (GDM), n (%) | 21 (30.0%) | 6 (17.1%) | 5 (42.9%) | 0.021 |
| Fetal Birth Weight (g), median (IQR) | 3300(2930–3600) | 3450(3210–3700) | 3250(2750–3540) | 0.048 |
| Apgar Score at 1 min < 8, n (%) | 8 (11.4%) | 3 (8.6%) | 5 (14.3%) | 0.456 |
| Urinary BPA (μg/L), median (IQR) | 2.41 (0.68–4.96) | 0.86 (0.32–1.51) | 4.49 (3.25–7.66) | < 0.001 |

## 4. Discussion

In this pilot cross-sectional analysis of 70 pregnant women from Northeastern Yunnan, we found universal detection of BPA in urine during the third trimester [1]. The median concentration observed here provides the first preliminary exposure data for this region. Notably, higher BPA exposure was preliminarily associated with an increased likelihood of GDM and lower fetal birth weight [2,4–6]. These findings are consistent with the known endocrine-disrupting properties of BPA, which may interfere with glucose metabolism and fetal growth pathways [1,2].

The primary strength of this study is the presentation of first-hand, objectively measured exposure data from an understudied population. However, several important limitations must be emphasized. First, the cross-sectional design and small sample size preclude causal inference and limit statistical power. Second, the use of a single spot urine sample and reporting of uncorrected concentrations may introduce exposure misclassification bias, although it provides a direct snapshot of exposure. Third, despite observing some significant associations, residual confounding by unmeasured factors (e.g., detailed diet, socioeconomic status) cannot be ruled out [6]. Therefore, these results should be interpreted as preliminary and hypothesis-generating.

## 5. Conclusion

This initial analysis confirms widespread prenatal BPA exposure in Northeastern Yunnan and suggests potential associations with maternal GDM and fetal growth that merit further scrutiny. The findings underscore the need for larger, longitudinal studies in this region employing repeated exposure assessments and creatinine-adjusted concentrations to accurately characterize the health risks of BPA exposure during pregnancy.

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## Disclosure statement

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# Analysis of Management Strategies for Chronic Diseases in the Elderly with Cognitive Impairment

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**Abstract:** With the intensification of population aging in China, the problem of cognitive impairment in the elderly has become increasingly prominent, attracting widespread attention from all sectors of society. Geriatric cognitive impairment is characterized by chronicity, which not only seriously threatens the health of the elderly and reduces their quality of life, but also imposes a heavy burden on families and society due to its long course. Attaching importance to and strengthening the chronic disease management of elderly cognitive impairment has profound significance for delaying disease progression, improving patients' quality of life, and reducing the burden of family care. Therefore, this paper first comprehensively understands elderly cognitive impairment by briefly elaborating on its definition and characteristics; on this basis, it focuses on exploring effective strategies for the chronic disease management of elderly cognitive impairment, hoping to provide new ideas and methods for the management of this condition and offer useful references for relevant clinical research and practice.

**Keywords:** The elderly; Cognitive impairment; Chronic disease management; Strategies

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## 1. Introduction

Elderly health has always been a key issue of social concern. Geriatric chronic diseases refer to chronic illnesses specifically affecting the elderly, characterized by chronicity and progression. In recent years, with the continuous increase in the number of elderly patients with chronic diseases, their management has attracted growing attention. Among various chronic diseases, the prevalence of cognitive impairment in the elderly has been on the rise year by year, which poses a serious threat to the quality of life of the elderly. Considering the characteristics of elderly cognitive impairment, its management model should not focus solely on treatment, but gradually shift to a model suitable for chronic disease management. Through the organic combination of long-term care, symptom control, and quality of life maintenance, efforts should be made to significantly improve patients' quality of life.

## 2. Comprehensive analysis of elderly cognitive impairment

### 2.1. Definition

Cognitive impairment refers to a syndrome caused by various etiologies, characterized by clinical damage in one or more cognitive domains (such as attention, memory, and language ability) of varying degrees. Clinically, it is believed that elderly cognitive impairment generally goes through two stages, basically progressing from mild cognitive impairment to dementia [1,2]. Among them, Alzheimer's disease is the most common cause of senile dementia, followed by vascular dementia, Lewy body dementia, frontotemporal dementia, Parkinson's disease dementia, and other types. This profoundly reflects the complexity and diversity of the etiologies of elderly cognitive impairment.

As China gradually enters an aging society, studies have shown that the number of elderly people with cognitive impairment is increasing year by year, which has become a major public health issue of global concern. Data show that there are approximately 15.07 million dementia patients among the elderly aged 60 and above in China. The World Health Organization predicts that the global total number of dementia patients will surge from the current 55 million to 153 million by 2050. This set of data directly reflects the extremely severe prevention and control situation of elderly cognitive impairment [3].

### 2.2. Characteristics

#### 2.2.1. Complexity of symptoms and individual differences

The complexity of symptoms and individual differences in elderly cognitive impairment bring many challenges to disease management and clinical treatment. Studies have shown that due to individual differences, the symptoms of elderly cognitive impairment vary. More specifically, if multiple patients are diagnosed with the same type of cognitive impairment (such as Alzheimer's disease), their symptom manifestations and progression rates may still differ significantly depending on the severity of the condition. Some Alzheimer's disease patients may present with language dysfunction in the early stage, such as word-finding difficulties, empty speech, and disorganized language organization; in contrast, other patients may present with spatial orientation impairment in the early stage, meaning they may get lost or have difficulty recognizing directions even in familiar environments [4]. Additionally, elderly patients often have multiple chronic diseases, and their cognitive impairment symptoms are easily intertwined with and masked by the clinical manifestations of other diseases. Taking "Parkinson's disease" as an example, some patients will exhibit typical motor symptoms such as stiffness and tremor, along with varying degrees of cognitive impairment. Common cognitive problems include inattention and decreased executive function. However, sometimes cognitive issues are overshadowed by more prominent motor disorders, which may increase the difficulty of diagnosis and identification, and in severe cases, delay the golden treatment period.

#### 2.2.2. Distinction from normal aging

Accurately distinguishing between normal physiological aging and pathological cognitive impairment is a core link in early screening and intervention. Although elderly people with normal physiological aging will also experience a certain degree of cognitive function changes (such as memory loss and decreased reaction speed), these changes are usually gradual and mild, and more importantly, they basically do not affect daily life. For a simple example, some elderly people may occasionally forget something or the name of a familiar person, but they can recall it when reminded. In contrast, the degree and frequency of forgetting in patients with cognitive impairment will gradually increase; even with prompts, they basically cannot recall, and in more severe cases, they

may slowly forget the names of their family members and certain people or events with profound memories. It is worth noting that compared with elderly people with normal aging, patients with cognitive impairment usually face comprehensive damage in multiple cognitive domains, such as language ability, executive function, visuospatial ability, and memory ability [5,6]. For this reason, patients' quality of life is seriously affected. Some patients may gradually lose their ability to live independently, which provides an important basis for clinical differentiation.

## 3. Effective strategies for chronic disease management of elderly cognitive impairment

### 3.1. Improve public awareness

In the entire non-pharmacological intervention system, health education is in a fundamental position and is an important prerequisite for improving management compliance and enhancing intervention effects. The first step in implementing health education is to comprehensively assess the basic situation of elderly patients, including their basic information, educational background, medical history, comorbidities, cognitive level, and the availability of social support from caregivers. This enables the development of personalized education plans, improving the pertinence and effectiveness of education. Some elderly patients with cognitive impairment have significantly reduced or even completely lost their self-management abilities. For these patients, the target audience of health education should extend from the patients themselves to their families and caregivers. The content of health education should cover various aspects such as disease etiology, risk factors, clinical manifestations, intervention strategies, treatment goal setting, lifestyle adjustments, professional care skills, and pharmacological and non-pharmacological treatment methods. The aim is to help educated individuals construct a systematic knowledge system to provide solid theoretical support for subsequent care and intervention [7]. Regarding educational forms, in addition to traditional face-to-face education, diverse educational approaches such as group education, peer experience sharing, community health promotion, online thematic lectures, and new media platform pushes should be actively introduced. This ensures convenient and timely access to information and enhances the interest and interactivity of health education.

It is worth noting that health education for elderly people with cognitive impairment is not a one-time event but a long-term and systematic process. Systematic and standardized health education can not only help patients and their families fully and correctly understand the corresponding disease and master various disease management skills but also effectively improve patients' self-management abilities and treatment compliance. While reducing the burden on families and society, it can further delay disease progression, improve quality of life, and benefit patients [8].

### 3.2. Construct a healthy lifestyle

Physical exercise and rehabilitation exercises, as important links in lifestyle interventions for chronic diseases in the elderly with cognitive impairment, can strengthen the body and significantly promote the improvement of patients' cognitive functions. Among them, physical exercise such as standardized aerobic exercise plays a positive role in preventing cognitive decline caused by inflammatory reactions; on the one hand, it can improve overall cognitive function, and on the other hand, it can greatly reduce the incidence of senile dementia. It is worth emphasizing that physical exercise should be moderate and appropriate. Excessively high or low exercise intensity may be counterproductive. In the early stage of the disease, patients can choose regular and moderate

physical activities to stimulate the release of neurotrophic factors and optimize cerebral blood circulation, thereby achieving the goal of improving cognitive function in the early stage. With the progression of the disease, after professional evaluation, the exercise load can be appropriately increased to help patients successfully break through the rehabilitation bottleneck period. The prominent advantage of cognitive rehabilitation training lies in repeated training of cognitive functions to maintain the excitability of residual nerve cells in patients and promote the functional reconstruction of damaged parts of the brain [9,10]. Common forms include speech training, memory training, puzzle activities, short-term memory training, daily living ability training, and executive function training. For example, nursing homes can regularly carry out a variety of puzzle activities such as tangram puzzles, poker games, and chess. Under the demonstration of caregivers, patients are guided to piece together patterns or improve their language abilities through word association training. In addition to physical training, nursing homes should also pay attention to sleep management and weight management of elderly patients with cognitive impairment. On the one hand, ensure that patients get adequate sleep, with a recommended daily sleep duration of 6–8 hours; on the other hand, for overweight or obese patients, on the basis of routine management, it is recommended to add no less than six months of lifestyle interventions. Through diet optimization and increased exercise, patients' weight can be controlled within a reasonable range, which can also invisibly reduce the risk of cognitive impairment deterioration [11].

## 3.3. Strengthen psychological support

With the progression of cognitive impairment, psychological problems have gradually become an important issue plaguing patient. Patients' psychological problems and cognitive functions interact with each other, which reflects the importance of paying attention to the prevention and resolution of patients' psychological problems. In the early stage of the disease, some patients often experience a strong sense of helplessness, anxiety, or depression due to the awareness of their declining cognitive abilities and social functions. As the disease progresses to the middle and late stages, trapped by unexpressed physical pain, adverse drug reactions, unmet care needs, or the impact of comorbidities, patients' emotional and behavioral problems may further worsen, manifesting as depression, anxiety, emotional fragility, etc., and some may even experience neuropsychiatric symptoms such as hallucinations, delusions, or delirium [12]. At any stage, what patients need most is systematic psychological support, which can free them from negative emotions, stabilize their behavioral performance, thereby delaying the decline of their overall functions to a certain extent, and ultimately improving the quality of life of patients and their caregiving families.

To this end, nursing homes should make the following adjustments:

Firstly, construct a patient-centered multidisciplinary collaborative psychological support system, with the joint participation of professionals such as psychiatrists, clinical psychologists, and cognitive rehabilitation therapists. Based on a comprehensive assessment of patients' cognitive and psychological status, personalized intervention plans are tailored for them. Of course, intervention plans are not static; they should be dynamically adjusted and optimized in real time according to patients' actual conditions. Secondly, integrate various intervention methods such as supportive psychotherapy, cognitive-behavioral therapy, reminiscence therapy, music therapy, and family system intervention to provide comprehensive and personalized psychological support for patients, helping them maintain normal mental health [13,14].

### 3.4. Improve self-management

The core goal of improving self-management is to help patients maintain functional independence as much as possible and enhance their ability to take care of themselves. Firstly, in the early stage of the disease, nursing homes should focus on helping patients establish good self-management habits and invisibly improve their self-management abilities. For example, introduce external memory aids such as medication calendars, smart pill boxes, and electronic reminders to compensate for patients' lost cognitive functions; at the same time, simplify daily task processes, ensure patients get adequate sleep, and help them develop regular work and rest habits, which are also crucial for improving their ability to take care of themselves. Secondly, attach importance to personalized management. Nursing homes should establish exclusive electronic files for each patient, recording key points that should be focused on during care, especially the corresponding symptoms of each patient (such as getting lost when going out and emotional fluctuations). This can provide a scientific data basis for formulating personalized intervention plans. Of course, the management process is inseparable from strong technical and professional support. Nursing homes should actively introduce medication reminder apps, positioning devices, smart home equipment, etc., to provide effective assistance for patients' self-management; regularly arrange medical staff to provide professional training and on-site guidance for patients to improve their self-management level [15].

## 4. Conclusion

In summary, based on the characteristics of elderly cognitive impairment and the actual needs of patients, nursing homes should actively try diversified management strategies. Through comprehensive interventions such as improving public awareness, constructing a healthy lifestyle, strengthening psychological support, and improving self-management, they can promote patients' health and effectively provide a more scientific and professional solution for healthy aging.

## Disclosure statement

The author declares no conflict of interest.

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# Research on the Optimal Allocation of Community Elderly Care Service Resources Based on Big Data Technology

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**Abstract:** With the accelerating aging process of China's population, the demand for community elderly care services has shown diversified and personalized characteristics. However, problems such as insufficient total care service resources, uneven distribution, and prominent supply-demand contradictions have seriously affected service quality. Big data technology, with core advantages including data collection, analysis and mining, and accurate prediction, provides a new solution for the allocation of community elderly care service resources. This paper systematically studies the application value of big data technology in the allocation of community elderly care service resources from three aspects: resource allocation efficiency, service accuracy, and management intelligence. Combined with practical needs, it proposes optimal allocation strategies such as building a big data analysis platform and accurately grasping the elderly's care needs, striving to provide operable path references for the construction of community elderly care service systems, promoting the early realization of the elderly care service goal of "adequate support and proper care for the elderly", and boosting the high-quality development of China's elderly care service industry.

**Keywords:** Big data technology; Community; Elderly care; Service resources

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## 1. Introduction

The "14th Five-Year Plan for National Aging Career Development and Elderly Care Service System" clearly points out that "promote the digital transformation of elderly care services and use big data, artificial intelligence and other technologies to optimize the allocation of elderly care service resources", which points out the direction for the reform of community elderly care service resource allocation. Big data technology can integrate the health data, demand data, and resource data of community elderly, analyze the problems of "accurate demand identification, dynamic resource allocation, and personalized service supply" from multiple perspectives, and break the limitations of traditional allocation models. At present, some cities are striving to apply big data technology to community elderly care services, but they are still exploring in terms of data integration, analysis and application,

and talents. In view of this, this paper carefully analyzes the application value of big data technology and comprehensively constructs resource optimal allocation countermeasures, so as to provide theoretical basis and practical examples for promoting the efficient utilization and accurate supply of community elderly care service resources.

## 2. Application value of big data technology in the allocation of community elderly care service resources

### 2.1. Improve resource allocation efficiency and alleviate supply-demand contradictions

On the one hand, big data technology can realize dynamic monitoring and efficient scheduling of resources. By installing intelligent terminals in the community to real-time obtain data on the usage status, idle status, and number of unused equipment of care resources, and using the big data platform for visual display [1]. Community managers can flexibly adjust resources based on this information: when the number of disabled elderly in a community surge leading to a shortage of nurses, the big data platform can automatically dispatch idle care personnel from surrounding communities to support. On the other hand, big data technology can achieve accurate prediction of resource demand [2]. By analyzing historical data such as the age, health status, and living habits of community elderly, combined with regional population change trends, the big data platform can predict the demand for care resources in the next period of time. Communities can reserve relevant resources in advance according to the prediction results, recruit temporary care personnel or increase investment in rehabilitation equipment before the arrival of demand peaks, avoiding the problem of "temporary shortage".

### 2.2. Improve service accuracy and meet personalized needs

Firstly, big data technology can form a "holographic demand portrait" of the elderly. By integrating multi-source information such as community health records, intelligent device data, questionnaire survey data, and family feedback data, the big data platform can construct a demand portrait including dimensions such as "health status, care needs, service preferences, and payment capacity" [3]. Secondly, big data technology can realize personalized recommendation of service items. Based on the demand portrait, the big data platform uses algorithms to match the most suitable care service items and resources: for the above-mentioned slightly disabled elderly living alone, it can provide a service combination of "3 home-based rehabilitation care sessions per week (including blood pressure monitoring) + 1 intelligent safety monitoring session per day (such as fall alarm) + 1 psychological companionship session per week", and match caregivers with hypertension care experience and portable intelligent monitoring equipment, etc.; this personalized service recommendation improves service satisfaction and avoids unnecessary waste [4].

### 2.3. Improve management intelligence and optimize service quality

Traditional community elderly care service management mostly relies on manual records and paper files, resulting in slow data updates, difficult information exchange, and lack of quality supervision, making it difficult to control the entire service process. Through data integration and intelligent analysis, big data technology can promote the management model from "manual extensive" to "intelligent refined", thereby improving service quality [5].

On the one hand, big data technology can realize full-process traceability and supervision of services. Caregivers upload service information in real-time through a mobile APP during service provision, and intelligent

devices automatically record service data, which are synchronized to the big data platform. Managers can check the service status of each link on the platform, and promptly intervene and correct if a caregiver has insufficient service time, irregular operations, etc.; family members can also query the elderly's service status through the platform to improve service transparency [6]. On the other hand, big data technology can achieve dynamic evaluation and improvement of service quality. By analyzing service data, the big data platform can automatically generate evaluation reports on service quality, and identify existing problems and corresponding improvement suggestions. Communities continuously improve service processes and resource allocation according to these evaluation reports, forming a cycle of "evaluation–improvement–re-evaluation".

## 3. Countermeasures for the optimal allocation of community elderly care service resources based on big data technology

### 3.1. Integrate multi-source data and build a unified data resource library

Communities need to cooperate with departments such as health and wellness, civil affairs, and medical insurance, as well as medical institutions, elderly care enterprises, and intelligent device manufacturers to integrate various data and establish a unified data resource library for community elderly care services [7]. This database should cover three types of data: the first is basic information of the elderly, such as age, gender, family composition, housing conditions, and economic status, to analyze service accessibility and payment capacity. The second is health and demand data, including health records, physical function status, and care needs, to accurately identify those in need of help [8]. The third is data on the supply of various resources, including information on caregivers, equipment materials, and service items, so that they can be dispatched and used at any time. For example, communities can connect to the electronic medical record systems of local hospitals to obtain the elderly's medical history data, collect daily health data through smart bracelets, and obtain resource supply data through nursing institution management systems, achieving "one-network sharing" of data. It is necessary to establish a data update mechanism, clarify the data update responsibilities of various departments and institutions, and ensure data freshness.

### 3.2. Build core functional modules to realize data value transformation

The big data analysis platform needs to develop four core functional modules: "data collection–analysis and mining–decision support–service connection", transforming data into resource allocation decisions and service supply actions [9]. Firstly, the data collection module can access data from multiple terminals and has a cleaning function to ensure data quality. Secondly, the analysis and mining module uses big data algorithms to conduct multi-dimensional analysis including demand analysis, resource analysis, and matching analysis [10]. Thirdly, the decision support module presents the above results in the form of visual reports to provide managers with resource allocation suggestions. Fourthly, the service connection module realizes automatic matching from demand to resources to services. For example, after the elderly submit care needs through the platform, the system will automatically recommend suitable caregivers and required service items, generate a service order, and notify relevant personnel, realizing the automatic completion of the entire process from demand submission to final execution.

### 3.3. Strengthen data security assurance and protect the elderly's privacy

The elderly's health data and personal information are sensitive data, so a strict data security assurance system must be established to prevent data leakage and abuse. Firstly, improve data security management systems, clarify the permissions and processes for data collection, storage, use, and sharing. Caregivers can only access the data of their own service objects, and must obtain the consent of the elderly or their guardians if they want to share the data with others [11]. Secondly, use technical means for protection, such as encrypting data, implementing access control, adopting strong authentication methods such as facial recognition and dynamic passwords, and conducting security monitoring. Thirdly, strengthen the publicity of laws and regulations and carry out personnel training. Organize platform managers and caregivers to study the Data Security Law and the Personal Information Protection Law, clarify their respective data security responsibilities, and prevent illegal operations. For example, communities can cooperate with professional network security companies to conduct regular data security assessments and vulnerability testing to ensure the safe and stable operation of the platform and safeguard the privacy rights of the elderly [12].

## 3.4. Collect care needs through multiple channels to ensure no omissions

Communities should form an "online + offline" multi-channel demand collection system covering different types of elderly to ensure comprehensive and non-missing demand collection. For online channels, develop user-friendly online demand submission platforms for the elderly, including WeChat mini-programs, telephone hotlines, and intelligent terminals, allowing the elderly to easily submit their needs; for elderly friends who are not familiar with intelligent devices, their families or community grid workers can help submit on their behalf; the platform should have clear demand classification and a demand description field where the elderly can add more detailed information [13]. For offline channels, arrange community grid workers and caregivers to conduct regular home visits, focusing on disabled, elderly living alone, and advanced-age groups, to understand their daily care problems and service experiences through face-to-face communication [14]. In addition, set up special demand collection points in community activity centers or elderly canteens, and assign staff to help the elderly fill out relevant questionnaires. It is also possible to cooperate with hospitals and community health centers to collect care needs when the elderly seek medical treatment or undergo physical examinations. For example, doctors can propose necessary rehabilitation care items based on the elderly's health status and help submit them.

## 3.5. Respond to care needs personally and provide customized services

According to the results of demand stratification and classification, provide customized care service plans for the elderly and match appropriate resources to achieve precise "one-person-one-policy" services. Firstly, formulate personalized service plans. Combine the elderly's needs, health status, and service preferences to formulate detailed personalized service plans, specifying service items, service frequency, service duration, and service supervisors. For example, arrange a service plan of "twice-daily home care + three rehabilitation training sessions per week + 24-hour intelligent monitoring" for disabled elderly [15]. Secondly, match professional resources. Based on the requirements of the service plan, find and assign qualified caregivers and suitable service equipment. Thirdly, dynamically adjust service plans. Use the big data platform to monitor service effects in real-time and promptly adjust service plans and resource allocation according to changes in needs. For example, after 2 months of rehabilitation care, the functional status of a community elderly has improved significantly. Through analyzing the elderly's rehabilitation data, the big data platform will automatically change the service plan from "three rehabilitation training sessions per week" to "one rehabilitation guidance session per week", and allocate these idle

rehabilitation resources to other elderly in need.

## 4. Conclusion

In summary, big data technology has significant application value in the optimal allocation of community elderly care service resources. It not only improves the efficiency of resource allocation and effectively alleviates supply-demand contradictions but also greatly enhances service accuracy and meets the personalized needs of the elderly. At the same time, the introduction of big data technology has also promoted the development of management intelligence and further optimized service quality.

## Disclosure statement

The author declares no conflict of interest.

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# Research on the Correlation Between Anesthetic Depth and Surgical Stress Response in Minimally Invasive Cardiothoracic Surgery Anesthesia

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**Abstract:** Objective: To explore the relationship between anesthetic depth and surgical stress response in minimally invasive cardiothoracic surgery. Methods: A total of 89 patients who underwent thoracoscopic minimally invasive cardiothoracic surgery in our hospital from June 2024 to December 2024 were selected as the research objects. They were divided into the light anesthesia group (n = 45) and the deep anesthesia group (n = 44). The vital signs at different intraoperative nodes and perioperative stress status of the two groups were compared. *Results:* Before lesion resection and after surgery, the mean arterial pressure and heart rate of the deep anesthesia group were lower than those of the light anesthesia group, with statistically significant differences. *Conclusion:* In thoracoscopic minimally invasive cardiothoracic surgery, deep anesthesia can effectively control the patient's surgical stress response, but the postoperative awakening time is longer; patients under light anesthesia have a shorter awakening time, but the intraoperative stress response is obvious.

**Keywords:** Cardiothoracic surgery; Anesthetic depth; Surgical stress response; Thoracoscopic surgery

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## 1. Introduction

Cardiothoracic surgery is a medical specialty focusing on the diagnosis, treatment and prevention of heart and lung diseases, covering a wide range of surgical and non-surgical treatment methods, including coronary artery bypass grafting, heart valve replacement, cardiac pacemaker implantation, heart transplantation, lung tumor resection, lung transplantation, etc. Thoracoscopy is a minimally invasive surgical method with the advantages of small wound and rapid recovery, and is widely used in clinical treatment of cardiothoracic surgery. However, minimally invasive surgery may still induce intraoperative stress response in patients, increasing the risk of postoperative complications [1]. Therefore, in minimally invasive cardiothoracic surgery, it is necessary to control the intraoperative anesthetic depth to reduce damage to the patient's body, thereby reducing the stress response, further lowering the risk of minimally invasive surgery, and helping patients recover as soon as possible after surgery.

## 2. Materials and methods

### 2.1. General information

A total of 89 patients who underwent thoracoscopic minimally invasive cardiothoracic surgery in our hospital from June 2024 to December 2024 were selected as the research objects.

#### 2.1.1. Inclusion criteria

(1) Clinically diagnosed with lung cancer and meeting the indications for thoracoscopic minimally invasive surgery [2];
(2) Aged over 18 years old;
(3) American Society of Anesthesiologists (ASA) grade I-III, stable vital signs, no allergy to anesthetics, and tolerance to surgery;
(4) Complete clinical data and voluntary participation in this study [3].

### 2.2. Research methods

The 89 patients scheduled for minimally invasive cardiothoracic surgery fasted and abstained from drinking before surgery. After entering the operating room, venous access was established, various monitoring instruments were connected to monitor changes in the patient's intraoperative vital signs. In addition, the operating room nurse disinfected the patient's face, accurately placed electrodes 5 cm above the nasal root, parallel to the right eyebrow arch, and at the right temple, correctly connected the BIS electrodes, and debugged the equipment parameters. Both groups of patients received mask oxygen inhalation. Midazolam, sufentanil and propofol were used as anesthetic induction drugs, and cisatracurium besylate was used as a muscle relaxant [4]. After the patient's eyelash reflex disappeared, the patient's position was changed to a lateral position with the surgical site facing up, the lung ventilation mode was switched, and one-lung ventilation was started. All patients received propofol 6–12 mg/(kg·h) combined with remifentanil 0.1–0.3 μg/(kg·min) for intraoperative anesthesia, and cisatracurium besylate was injected intermittently to maintain muscle relaxation in patients, facilitating subsequent thoracoscopic lobectomy [5]. During the operation, the patient's BIS changes were continuously monitored to ensure that the value was maintained within the range of 40–60; the patient's mean arterial pressure (MAP) was monitored. Once the arterial pressure was less than 65 mmHg, crystalloid fluid was infused rapidly. If the blood pressure still did not recover, norepinephrine was injected in a timely manner, and the dosage of norepinephrine was adjusted according to changes in blood pressure until the blood pressure was greater than 65 mmHg. After surgery, both groups of patients used patient-controlled intravenous analgesia (PCIA) pumps for analgesia, and sufentanil was used as the analgesic drug until 48 hours after surgery. The patients were asked about wound pain, breathing smoothness, etc., and postoperative indicators were monitored [6].

### 2.3. Observation indicators

(1) Monitor the mean arterial pressure, heart rate and blood oxygen saturation of the two groups of patients before anesthesia induction, at intubation, before lesion resection and after surgery.
(2) Compare the postoperative awakening time and extubating time of the two groups of patients, and observe the patient's consciousness, such as the ability to move the eyes and shake hands.
(3) Compare the preoperative, intraoperative and postoperative norepinephrine dosage, postoperative pain degree and postoperative analgesic drug dosage of the two groups of patients to scientifically evaluate the

impact of anesthetic depth on the patient's surgical stress response [7].

(4) Compare anesthesia-related complications between the two groups of patients, such as restlessness after awakening and postoperative delirium.

Postoperative delirium assessment includes the following indicators:

(1) Fluctuating mental state;

(2) Inattention;

(3) Confused and unclear consciousness;

(4) Disordered language expression and thinking [8].

## 2.4. Statistical analysis

SPSS24.0 software was used for data analysis. Independent sample *t*-test or repeated measures analysis of variance was used for intergroup comparison. Data were expressed as [n(%)], and $\chi^2$ test was used for intergroup comparison. $p < 0.05$ was considered statistically significant.

# 3. Results

## 3.1. Comparison of vital signs of patients

There were no statistically significant differences in MAP, heart rate and blood oxygen saturation between the two groups before anesthesia induction and immediately after intubation ($p > 0.05$). Before lesion resection and at the end of surgery, the MAP and heart rate of the deep anesthesia group were lower than those of the light anesthesia group, with statistically significant differences ($p < 0.05$). See **Table 1**.

**Table 1.** Comparison of vital signs of patients

| Indicators | Groups | n | Before anesthesia induction | Immediately after intubation | Before lesion resection | At the end of surgery |
|---|---|---|---|---|---|---|
| MAP/mmHg | Deep anesthesia group | 45 | 89.23±5.29 | 89.15±6.73 | 79.32±5.24 | 85.34±3.16 |
| | Light anesthesia group | 44 | 88.63±4.36 | 91.32±7.25 | 88.35±7.21 | 87.34±5.62 |
| Heart rate (beats/min) | Deep anesthesia group | 45 | 75.21±5.84 | 87.03±7.25 | 84.30±6.12 | 79.35±6.16 |
| | Light anesthesia group | 44 | 77.61±6.21 | 89.33±8.74 | 92.15±8.34 | 82.30±7.69 |
| Blood Oxygen saturation/% | Deep anesthesia group | 45 | 98.96±2.06 | 95.72±2.23 | 94.76±3.12 | 95.86±2.47 |
| | Light anesthesia group | 44 | 98.32±1.60 | 98.28±2.16 | 95.13±2.38 | 96.02±2.20 |

## 3.2. Comparison of stress status of patients

Before surgery, the levels of prostaglandin E2 (PGE2), nerve growth factor (NGF) and substance P (SP) in the blood of the two groups were balanced, with no statistically significant differences ($p > 0.05$). At the end of surgery and 1 day after surgery, the levels of PGE2, NGF and SP in the deep anesthesia group were lower than those in the light anesthesia group, with statistically significant differences ($p < 0.05$). See **Table 2**.

**Table 2.** Comparison of stress status of patients

| Indicators | Groups | n | Before surgery | At the end of surgery | 1 day after surgery |
|---|---|---|---|---|---|
| MAP/mmHg | Deep anesthesia group | 45 | 172.34 ± 19.14 | 219.84 ± 32.05 | 200.05 ± 27.38 |
| | Light anesthesia group | 44 | 174.43 ± 20.20 | 261.40 ± 35.36 | 240.15 ± 29.61 |
| Heart rate (beats/min) | Deep anesthesia group | 45 | 316.45 ± 31.64 | 362.10 ± 36.36 | 347.95 ± 33.64 |
| | Light anesthesia group | 44 | 322.61 ± 35.80 | 402.39 ± 40.15 | 395.78 ± 32.41 |
| Blood Oxygen saturation/% | Deep anesthesia group | 45 | 10.21 ± 1.34 | 23.72 ± 2.73 | 17.54 ± 3.24 |
| | Light anesthesia group | 44 | 10.05 ± 1.66 | 26.90 ± 4.21 | 21.25 ± 2.39 |

# 4. Discussion

## 4.1. Correlation between anesthetic depth and surgical stress response in minimally invasive cardiothoracic surgery

With the wide application of minimally invasive surgery in cardiothoracic surgery treatment, the treatment methods of cardiothoracic surgery have become more diversified, which has gradually reduced the trauma caused by surgery to patients' bodies, and provided treatment opportunities for many patients with poor physical function who cannot accept conventional surgery, thereby helping them alleviate pain and recover health. Anesthesia is an important part of minimally invasive cardiothoracic surgery and an important factor affecting the patient's surgical stress response [9]. Therefore, cardiothoracic surgeons should strengthen cooperation with anesthesiologists to determine the anesthetic depth and anesthetic dosage according to the patient's physical condition, surgical time and difficulty, laying a good foundation for minimally invasive surgery. This study showed that the blood pressure of the deep anesthesia group was significantly lower than that of the light anesthesia group during and after thoracoscopic minimally invasive surgery, and the hemodynamics was relatively stable. Under deep anesthesia, the patient's myocardial activity is inhibited, the heart rate gradually slows down, and the blood pressure decreases, which is conducive to alleviating the patient's intraoperative stress response. However, if the patient's blood pressure is lower than 65 mmHg, the anesthetic risk will increase, threatening the patient's life safety. Under light anesthesia, the patient's cerebral cortex is relatively active, and the inhibition of myocardial activity is not obvious, so the heart rate and blood pressure are higher than those of patients under deep anesthesia, which may lead to postoperative pain [10]. In addition, this study believes that elderly patients face higher anesthetic risks in minimally invasive cardiothoracic surgery. Deep anesthesia should be used with caution, the dosage and administration rate of propofol should be strictly controlled, and the blood pressure and heart rate of elderly patients should be closely monitored during the operation to reduce the patient's surgical stress response.

## 4.2. Impact of surgical stress response on the prognosis of minimally invasive cardiothoracic surgery

This study believes that reducing the patient's surgical stress response can not only help the patient's postoperative rehabilitation, but also improve the long-term prognosis [11]. Under the surgical stress state, the synthesis and release of prostaglandin E2 (PGE2), nerve growth factor (NGF) and substance P (SP) in the blood of the two groups of patients will increase, which will promote the growth and differentiation of neurons, and invisibly aggravate the growth of inflammatory factors in the patient's body after surgery. At the same time, this study

showed that the levels of PGE2, NGF and SP in the deep anesthesia group were significantly lower than those in the light anesthesia group at the end of surgery and 1 day after surgery, indicating that deep anesthesia can effectively inhibit the patient's surgical stress response and avoid postoperative inflammatory response. In addition, this study selected remifentanil combined with propofol as the anesthesia maintenance plan. Remifentanil has a better analgesic effect, which can effectively inhibit the patient's myocardial activity, thereby reducing the patient's surgical stress response; the combination of remifentanil and propofol can improve the sedative and hypnotic effect and effectively inhibit the patient's surgical stress response [12].

### 4.3. Deep anesthesia effectively controls patients' stress levels

This study found that the level of inflammatory factors in the deep anesthesia group was higher than that in the light anesthesia group, indicating that light anesthesia has a relatively low impact on the patient's body's inflammatory level. This study used propofol combined with remifentanil for deep anesthesia, which can effectively reduce the inflammatory damage caused by stress response, while light anesthesia can effectively reduce the risk of postoperative delirium in patients [13].

### 4.4. Suggestions for improving patients' comfort during anesthesia in minimally invasive cardiothoracic surgery

First, anesthesiologists can use antibacterial dressings to cover the deep vein puncture site, reduce the entry of sweat and blood into the puncture site during minimally invasive surgery, minimize the production of bacteria at the puncture site, reduce the probability of puncture site infection, and help the healing of the patient's wound. At the same time, anesthesiologists should do a good job in disinfection before deep vein puncture and antibacterial protection of the puncture site, laying a good foundation for subsequent surgery. Second, postoperative pain is one of the important problems to be solved in minimally invasive cardiothoracic surgery, and it is also an important factor affecting the patient's postoperative recovery [14]. After surgery, anesthesiologists can take measures such as paravertebral nerve block and analgesic pumps to block nerve transmission by local injection of anesthetic drugs, thereby reducing postoperative pain in patients. For example, in thoracoscopically guided minimally invasive surgery, anesthesiologists can carry out postoperative pain management according to the patient's consciousness and vital sign monitoring data after surgery, reduce the patient's dependence on general anesthetics, and help the patient recover as soon as possible.

## 5. Conclusion

In conclusion, minimally invasive surgery provides more treatment options for patients and promotes the development of clinical treatment of cardiothoracic surgery. In minimally invasive cardiothoracic surgery, anesthetic depth is an important factor affecting the patient's surgical stress response, which will affect the patient's intraoperative blood pressure, heart rate, postoperative inflammatory level and postoperative rehabilitation effect. Therefore, cardiothoracic surgeons should attach importance to the anesthesia management of minimally invasive surgery, strengthen cooperation with anesthesiologists, formulate anesthesia plans according to preoperative evaluation and surgical plans, clarify the anesthetic depth, and strictly control the dosage and administration rate of anesthetic drugs. Patients under light anesthesia can wake up as soon as possible after surgery, with mild inflammatory response in the body, but obvious postoperative pain and stress response [15]. Patients under deep

anesthesia have relatively slow intraoperative hemodynamics and obvious surgical stress response, but abnormal changes in postoperative blood pressure and heart rate, delayed awakening time, and obvious inflammatory response. Therefore, in the clinical work of minimally invasive cardiothoracic surgery, attending physicians and anesthesiologists should comprehensively evaluate the patient's physical state and surgical plan, select an appropriate anesthetic depth; optimize the combined use of anesthetic drugs and administration rate, reduce the role of analgesic drugs in surgical inflammatory stress, improve the anesthetic effect, and help patients recover as soon as possible.

## Disclosure statement

The authors declare no conflict of interest.

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# An Analysis of the Role of Integrated Medical and Elderly Care in the Management of Chronic Diseases among the Elderly

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**Abstract:** In recent years, with the accelerating aging process of the population, China has entered an aging society, and the number of elderly patients with chronic diseases has been increasing. The traditional medical and elderly care service models can no longer fully meet their needs. The integrated medical and elderly care model has emerged as the times require. It organically combines medical resources with elderly care resources to provide comprehensive and continuous health management services for the elderly, becoming an important approach to solving the problems of chronic disease management among the elderly. In this regard, this paper first elaborates on the role of integrated medical and elderly care in the management of chronic diseases among the elderly, and then puts forward application strategies of integrated medical and elderly care in the management of chronic diseases among the elderly, in order to provide certain reference for relevant researchers.

**Keywords:** Integrated medical and elderly care; The elderly; Chronic disease management; Role

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## 1. Introduction

China's rapidly aging population has led to a growing number of older adults with chronic diseases, challenging the capacity of traditional healthcare and elderly care models. In response, the integrated medical and elderly care model has emerged as a critical approach. By combining medical and eldercare resources, it aims to provide continuous, comprehensive health management for the elderly. This paper examines the role of this integrated model in managing chronic diseases among the elderly and proposes practical application strategies, offering insights and references for researchers and practitioners in the field.

## 2. The role of integrated medical and elderly care in the management of chronic diseases among the elderly

### 2.1. Helps break down the barriers between medical and elderly care services

Under the traditional model, medical and elderly care services are not closely integrated. After elderly patients receive treatment in medical institutions and their conditions stabilize, they need to be followed up with care and rehabilitation training in elderly care institutions. However, this process faces shortcomings such as poor connection and information occlusion [1]. Integrated medical and elderly care can effectively make up for these shortcomings, promote the close integration of medical and elderly care services, and realize real-time sharing of various data through building an information sharing platform. Not only can doctors grasp the specific situation of the elderly in elderly care institutions in a timely manner, but elderly care institutions can also formulate professional care plans based on the elderly's past treatment records. For example, when caregivers in elderly care institutions find abnormalities in the elderly's health, they promptly feedback the abnormal data to doctors in medical institutions. Doctors provide professional suggestions, and caregivers conduct preliminary treatment in accordance with the suggestions, striving for time for further medical treatment [2].

### 2.2. Helps build a full-cycle health management system

In the management of chronic diseases among the elderly, building a full-cycle health management system is crucial, and integrated medical and elderly care plays a unique role in this regard. The integrated medical and elderly care model can provide the elderly with full-process services from disease prevention, diagnosis, treatment to rehabilitation and long-term care [3]. For example, in the disease prevention stage, integrated medical and elderly care institutions can use medical resources to conduct regular health check-ups and health assessments for the elderly, and formulate personalized health intervention plans such as dietary guidance and exercise suggestions based on the elderly's physical conditions and living habits, helping the elderly develop good living styles and reduce the risk of chronic diseases. In the links of disease diagnosis and treatment, relying on professional medical teams and advanced medical equipment, integrated medical and elderly care institutions can timely and accurately diagnose the elderly's diseases and provide scientific and effective treatment plans. At the same time, the close cooperation between elderly care institutions and medical institutions enables the elderly to be quickly transferred to higher-level hospitals when further specialist treatment is needed, ensuring timely medical treatment [4].

### 2.3. Helps improve service accuracy and efficiency

In the integrated medical and elderly care model, medical staff can collect and sort out comprehensive health information of the elderly with the help of information technology, including disease diagnosis and treatment records, periodic inspections and daily health management information, establish systematic and real-time health files, and conduct in-depth analysis of these data. This helps medical staff accurately grasp the elderly's health status and disease development changes, and provide more accurate and suitable diagnosis, treatment and care plans for the elderly [5]. At the same time, service efficiency will be further improved by effectively connecting medical treatment with elderly care services. Elderly care institutions are equipped with basic medical equipment and caregivers to timely address the elderly's basic diseases or emergency incidents, reducing the time and energy consumed in visiting hospitals. In addition, through cooperation with external medical institutions, timely referral can be made in case of intractable diseases, allowing the elderly to receive targeted treatment in the shortest possible time, further improving service levels and ensuring that the elderly obtain high-quality health

management services [6].

## 3. Application strategies of integrated medical and elderly care in the management of chronic diseases among the elderly

### 3.1. Attach importance to policy support and build a multi-level security system

Firstly, introduce corresponding policies. To promote the effective application of the integrated medical and elderly care model in the management of chronic diseases among the elderly, the government should introduce relevant policy measures, clarify the functional division of labor among various departments, and strengthen communication and contact between relevant departments. For example, the National Health Commission is responsible for formulating and supervising the implementation of service standards for integrated medical and elderly care, the civil affairs department is mainly responsible for the establishment and operation management of nursing homes, and the medical insurance department is mainly responsible for the formulation and implementation of medical insurance plans. Through policy guidance, medical and elderly care resources are integrated to promote the sustainable development of integrated medical and elderly care institutions [7].

Secondly, build a multi-level security system. Appropriately expand the scope of medical insurance reimbursement, include the medical services provided by integrated medical and elderly care institutions into the scope of medical insurance reimbursement, thereby reducing the elderly's expenditure on chronic disease management. Establish a long-term care insurance mechanism to provide long-term care security for disabled and semi-disabled elderly. At the same time, launch commercial insurance for the management of chronic diseases among the elderly to meet the special management needs of different elderly people, set up a fund specifically to support the construction and development of integrated medical and elderly care institutions, and provide certain subsidies for eligible elderly people.

Thirdly, strengthen supervision and evaluation. Regularly assess and evaluate the service quality of integrated medical and elderly care institutions and the expenditure of medical insurance funds to ensure the implementation of policies and the stable operation of the system. In addition, strengthen publicity and guidance, popularize the integrated medical and elderly care model and security policies among the elderly and their family members, and continuously improve the level of chronic disease management among the elderly [8].

### 3.2. Innovate service models to meet diversified needs

Firstly, implement home-based integrated medical and elderly care services. Establish specialized family doctor contract service teams to regularly provide medication guidance, home medical care and other services for elderly patients with chronic diseases. Through wearable intelligent devices and telemedicine technology, real-time obtain the elderly's physical data such as heart rate, blood pressure and blood glucose, and immediately transmit them to medical staff to adjust treatment and care plans. At the same time, provide rehabilitation care and daily care services for the elderly, enabling them to receive professional medical and nursing services in a familiar home environment [9].

Secondly, build an integrated medical and elderly care alliance. Integrate the resources of medical institutions and elderly care institutions in the region to establish a close-knit integrated medical and elderly care alliance. Medical institutions provide medical support for elderly care institutions, including regular ward rounds, consultations, emergency first aid and other services; elderly care institutions provide rehabilitation care and daily

care services for medical institutions. In this way, the sharing and optimal allocation of medical resources and elderly care resources are realized, and service efficiency and quality are improved.

Thirdly, carry out personalized services. Provide personalized integrated medical and elderly care plans according to the health status, economic level and personal needs of elderly patients with chronic diseases. For example, provide comprehensive daily care and health care services for elderly people with poor economic conditions, multiple chronic diseases and inability to take care of themselves; provide high-end professional health management and rehabilitation treatment services for elderly people with better economic conditions. In addition, pay attention to the psychological and cultural needs of the elderly, organize a variety of cultural and recreational activities to meet their spiritual needs and effectively improve their quality of life [10].

## 3.3. Apply cutting-edge technologies to improve the intelligent level of services

Firstly, use intelligent monitoring equipment to realize real-time health management. Through various wearable intelligent devices such as smart mattresses and smart bracelets, real-time monitor the elderly's sleep quality, heart rate, blood pressure, exercise and other data, and transmit these data to the cloud. Medical staff conduct dynamic health management of the elderly through mobile phones and computers. Once abnormal data is detected, the system issues an early warning immediately, and medical staff quickly formulate and adopt corresponding strategies [11].

Secondly, use artificial intelligence-assisted diagnosis to improve diagnostic accuracy. Use artificial intelligence technology to analyze medical images, test reports, etc., helping doctors diagnose diseases more accurately. Artificial intelligence algorithms can quickly identify lesion features in images and provide diagnostic references for doctors. For example, when diagnosing lung CT images of the elderly, artificial intelligence can quickly detect lung nodules, inflammation and other lesions, and provide information such as the size, location and nature of the lesions, assisting doctors in making more accurate diagnoses [12].

Thirdly, build an intelligent elderly care service platform to realize one-stop management. Adopt cutting-edge technologies to build a smart elderly care service platform, which includes modules such as service evaluation, information management, service appointment and health files. Medical staff can timely grasp the basic situation of elderly patients with chronic diseases, such as service needs and health status, by logging into the platform, and provide targeted medical and elderly care services for them. Family members can also use the platform to apply for medical care, elderly care, service history, service fees, etc., and give evaluations. In addition, the smart elderly care service platform can also promote information sharing and collaborative cooperation among various medical institutions and elderly care institutions, improving the overall quality of integrated medical and elderly care services [13].

## 3.4. Focus on talent training and strengthen professional service teams

Firstly, start from the source of education. Institutions of higher learning and vocational colleges can jointly offer relevant courses and majors, such as geriatrics, geriatric rehabilitation and geriatric nursing, to cultivate a group of excellent integrated medical and elderly care service talents. In addition, attach importance to the combination of theory and practice, focus on increasing the proportion of practical courses, and allow more students to obtain rich internship and training opportunities in medical institutions and elderly care service institutions, improving their problem-solving ability and practical ability [14].

Secondly, regularly carry out continuing education and training. The content of continuing education and

training needs to include cutting-edge integrated medical and elderly care service concepts, doctor-patient communication skills and medical and nursing technologies. Through a combination of online and offline training, expert seminars and experience sharing meetings, effectively improve the professional level and service ability of on-the-job medical staff [15].

Thirdly, build a sound incentive mechanism. To attract excellent integrated medical and elderly care service talents, scientifically build a salary system, open up channels for post promotion and career development, continuously enhance the sense of achievement of medical staff, and broaden their career prospects. Establish relevant reward mechanisms to commend outstanding medical staff in the post from material and spiritual aspects, and fully stimulate their work enthusiasm. In this way, by gradually cultivating professional integrated medical and elderly care service talents, better services can be provided for the management of chronic diseases among the elderly.

### 3.5. Strengthen cultural construction and enrich the spiritual life of the elderly

Firstly, set up special cultural activity areas. Integrated medical and elderly care institutions should set up activity areas such as libraries, chess and card rooms, and calligraphy and painting rooms according to actual conditions, allowing the elderly to choose appropriate cultural and recreational activities based on their own interests. At the same time, integrated medical and elderly care institutions regularly organize a series of cultural and entertainment activities, such as intangible cultural heritage craft experience, knowledge lectures and art performances, to enrich the spiritual world of the elderly and further improve their sense of happiness.

Secondly, pay attention to the psychological care of the elderly. Integrated medical and elderly care institutions should set up psychological counseling teams to provide psychological support for the elderly. Elderly patients with chronic diseases are particularly prone to negative emotions such as depression and anxiety due to long-term illness, which is not conducive to their rehabilitation and may even further affect their health. Through face-to-face communication with the elderly, psychological counseling teams can accurately grasp and understand their mental health status and specific needs, and take effective measures to relieve negative emotions, enabling them to face diseases and life positively.

Thirdly, deepen the exchange and interaction activities of the elderly. Integrated medical and elderly care institutions can organize various social activities, such as elderly clubs and interest groups, allowing the elderly to share life experiences and enhance mutual affection through communication. This not only contributes to the mental health of the elderly, but also creates a warm and harmonious elderly care environment.

## 4. Conclusion

In summary, the integrated medical and elderly care model has shown significant roles and great application value in the management of chronic diseases among the elderly. It breaks down the barriers between medical and elderly care services, builds a full-cycle health management system, and effectively improves service accuracy and efficiency. In this regard, this study can further promote the in-depth development of integrated medical and elderly care in the management of chronic diseases among the elderly by attaching importance to policy support and building a multi-level security system; innovating service models to meet diversified needs; applying cutting-edge technologies to improve the intelligent level of services; and focusing on talent training and strengthening professional service teams. In the future, it is necessary to continuously pay attention to and study the integrated

medical and elderly care model, and constantly explore and improve relevant policies, services, technologies and talent systems. Only in this way can we better meet the needs of elderly patients with chronic diseases, improve their quality of life and health level, and allow every elderly person to enjoy a happy and healthy old age.

## Disclosure statement

The author declares no conflict of interest.

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# Comparative Study of *Auricularia auricula* Polysaccharide-Iron Complex, Heme Iron, and Ferrous Glycinate in Iron-Deficient Adults: A Randomized Clinical Trial

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**Abstract:** Iron deficiency anemia affects approximately 1.62 billion people worldwide, yet traditional iron supplements present bioavailability limitations and gastrointestinal side effects. This randomized, double-blind clinical trial investigated a novel Auricularia auricula polysaccharide-iron complex (AAPIC) compared with heme iron and ferrous glycinate in 180 iron-deficient adults receiving 30 mg elemental iron daily for 12 weeks. AAPIC achieved comparable hemoglobin improvements (from 98.3 ± 8.7 to 126.5 ± 9.2 g/L) to heme iron (from 97.8 ± 9.1 to 128.3 ± 8.6 g/L) and was significantly superior to ferrous glycinate (from 98.6 ± 8.9 to 119.7 ± 10.3 g/L; $p < 0.001$). Iron absorption efficiency showed AAPIC at 23.7 ± 4.2%, heme iron at 25.1 ± 3.8%, and ferrous glycinate at 18.4 ± 5.1%. Toxicological assessments revealed no hepatotoxicity, nephrotoxicity, or mutagenicity. Gastrointestinal adverse events occurred in 8.3% of AAPIC recipients versus 15.0% with ferrous glycinate and 10.0% with heme iron. The polysaccharide component facilitates iron transport through enhanced intestinal uptake mechanisms. AAPIC represents a promising, well-tolerated alternative with clinical efficacy comparable to established iron formulations.

**Keywords:** Auricularia auricula polysaccharide; Iron complex; Heme iron; Ferrous glycinate; Bioavailability; Iron deficiency anemia; Clinical trial; Toxicology

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## 1. Introduction

Iron deficiency represents the most prevalent nutritional disorder globally, with the World Health Organization estimating that 30% of the world's population experiences some form of anemia, predominantly attributable to insufficient iron intake or absorption [1]. Iron plays indispensable roles in oxygen transport, cellular respiration, DNA synthesis, and immune function, with inadequate status resulting in decreased hemoglobin production,

impaired cognitive development, reduced work capacity, and compromised immune responses [2–4].

Current iron supplementation strategies utilize inorganic iron salts (ferrous sulfate, ferrous fumarate, ferrous gluconate) or organic forms (heme iron polypeptide, ferrous glycinate). Despite widespread application, conventional supplements present significant limitations [5,6]. Inorganic iron salts demonstrate poor bioavailability (10–20% absorption) and commonly induce gastrointestinal disturbances including nausea, constipation, and diarrhea, resulting in poor patient compliance [7]. Heme iron exhibits superior absorption (25–30% bioavailability) through direct enterocyte heme transporter uptake but presents challenges including higher production costs, animal-source restrictions, and potential oxidative stress concerns. Ferrous glycinate shows enhanced gastrointestinal stability, though absorption efficiency remains variable [8–10].

*Auricularia auricula* (black fungus) has been utilized in traditional Chinese medicine for centuries due to its blood-nourishing properties [11]. Recent investigations identified abundant polysaccharides comprising primarily β-glucans (molecular weights 10–500 kDa) demonstrating immunomodulation, antioxidant capacity, hypolipidemic effects, and potential mineral absorption enhancement [12]. This study aims to investigate whether complexation of iron with these polysaccharides creates a stable and bioavailable transport system, potentially combining the absorption advantage of organic iron with the functional benefits of bioactive polysaccharides [13–15]. The polysaccharide matrix may protect iron from precipitation and oxidation while facilitating transcellular transport through specific polysaccharide receptors or enhanced paracellular permeability [16–18].

This study addresses the knowledge gap through rigorous clinical trial design incorporating parallel assessment of three iron formulations. Study objectives encompassed:

(1) Quantitative determination of iron absorption efficiency through pharmacokinetic analysis;
(2) Comprehensive toxicological evaluation including hepatic, renal, and genotoxic assessment;
(3) Comparative efficacy analysis based on hematological parameters;
(4) Safety and tolerability profiling through adverse event monitoring.

# 2. Methodology

## 2.1. Study design, participants, and intervention

### 2.1.1. Inclusion criteria

Adults aged 18–55 years with serum ferritin < 30 μg/L (females) or < 40 μg/L (males), hemoglobin 80–110 g/L, BMI 18.5–28.0 kg/m$^2$.

### 2.1.2. Exclusion criteria

Pregnancy, bleeding, malabsorption, hepatic/renal dysfunction, hypersensitivity.

### 2.1.3. Study design

Based on sample size calculation, 180 participants (60 per group) were enrolled [19]. Random allocation (1:1:1), stratified by gender and baseline hemoglobin. Participants were instructed to take one capsule daily before breakfast for 12 weeks. Each capsule contained 30 mg of elemental iron, provided as either:

(1) 600 mg of *Auricularia auricula* polysaccharide-iron complex (AAPIC),
(2) 600 mg of heme iron, or
(3) 150 mg of ferrous glycinate plus 450 mg of maltodextrin (as filler to match capsule weight). Visits:

baseline, weeks 2, 4, 8, 12, 16.

Complete blinding was maintained.

## 2.2. Laboratory assessments and statistical analysis

Absorption Kinetics: 60 participants per group underwent single-dose absorption evaluation at week 2. Blood samples were collected at 0, 1, 2, 3, 4, 6, and 8 hours post-administration. Serum iron was measured by colorimetric assay (Roche Cobas 8000), with absorption efficiency calculated as [20, 21].

$$\text{Absorption Efficiency}(\%)=\frac{\Delta\text{Serum Iron}_{(0\text{-}4h)}\times\text{Plasma Volume}}{\text{Elemental Iron Dose}}\times 100 \quad (1)$$

Where plasma volume = 0.04 L/kg body weight.

Complete blood counts (Sysmex XN-9000) measured hemoglobin, hematocrit, red blood cell count, MCV, MCH, MCHC, RDW, reticulocyte count, and CHr by flow cytometry.

Serum ferritin (chemiluminescent immunoassay, Roche Elecsys 2010), serum iron and TIBC (colorimetric methods, Roche Cobas c501), transferrin saturation [(serum iron/TIBC) × 100], and soluble transferrin receptor (ELISA, R&D Systems) were measured.

Metabolic panels at baseline and weeks 4, 8, 12 included hepatic function (ALT, AST, ALP, GGT, bilirubin, albumin), renal function (creatinine, BUN, eGFR), lipid profile, and oxidative stress markers (MDA, SOD, GPx). Genotoxicity evaluation (baseline, week 12) included micronucleus assay (1000 binucleated cells), chromosomal aberration test (100 metaphases), and comet assay.

Participants completed standardized gastrointestinal symptom questionnaires at each visit, rating severity (0–3) for nausea, vomiting, abdominal pain, constipation, diarrhea, dyspepsia, and metallic taste. Events were graded using CTCAE version 5.0.

Intention-to-treat analysis with data presented as mean ± SD. Between-group comparisons used one-way ANOVA and chi-square tests. Primary efficacy analyses utilized repeated-measures ANOVA adjusting for baseline values. Post-hoc comparisons used Tukey's HSD test. Non-inferiority was evaluated using two-sided 95% CI against -5 g/L margin. Missing data were handled by multiple imputation (50 datasets). Significance: two-sided $p < 0.05$ (R version 4.2.1, SAS version 9.4).

# 3. Results

## 3.1. Participant characteristics and study flow

Of 267 screened individuals, 87 were excluded (42 not meeting criteria, 28 declining, 17 other reasons), with 180 randomly allocated to AAPIC (n = 60), heme iron (n = 60), or ferrous glycinate (n = 60). Multiple participants withdrew within 12 weeks of intervention (3 in the AAPIC group, 2 in the heme iron group, and 4 in the ferrous glycinate group), with completion rates of 95.0% (57/60), 96.7% (58/60), and 93.3% (56/60), respectively. Withdrawal reasons included loss to follow-up, adverse events, and personal reasons. The intention-to-treat population comprised all 180 randomized participants. The per-protocol population, which included participants with > 80% adherence to the study medication and without major protocol deviations, consisted of 171 participants (57, 58, and 56 in the AAPIC, heme iron, and ferrous glycinate groups, respectively). Baseline characteristics were well-balanced across groups (**Table 1**). Mean age: 34.2–35.8 years; female predominance: 68–72%. Baseline hemoglobin (AAPIC 98.3 ± 8.7 g/L, heme iron 97.8 ± 9.1 g/L, ferrous glycinate 98.6 ± 8.9 g/L, $p = 0.92$) and

serum ferritin ($p = 0.88$) showed no significant differences.

## 3.2. Iron absorption kinetics

Pharmacokinetic analysis of serum iron concentrations following single-dose administration revealed distinct absorption profiles (**Table 1**, **Table 2**). Baseline fasting serum iron levels were comparable across groups (45–48 μg/dL, $p = 0.76$). Peak serum iron concentrations (Cmax) occurred at 3–4 hours post-administration for all formulations.

**Table 1.** Baseline characteristics of study participants

| Characteristic | AAPIC (n = 60) | Heme iron (n = 60) | Ferrous glycinate (n = 60) | *p* value |
|---|---|---|---|---|
| **Age (years)** | 34.2 ± 9.8 | 35.8 ± 10.3 | 34.9 ± 9.5 | 0.67 |
| Female sex, n (%) | 41 (68.3) | 43 (71.7) | 41 (68.3) | 0.89 |
| Body mass index (kg/m²) | 22.4 ± 2.9 | 22.8 ± 3.1 | 22.6 ± 2.7 | 0.79 |
| Hemoglobin (g/L) | 98.3 ± 8.7 | 97.8 ± 9.1 | 98.6 ± 8.9 | 0.92 |
| Hematocrit (%) | 30.8 ± 2.9 | 30.5 ± 3.1 | 30.9 ± 2.8 | 0.85 |
| Serum ferritin (μg/L) | 14.7 ± 8.3 | 15.2 ± 8.9 | 14.9 ± 8.1 | 0.88 |
| Serum iron (μg/dL) | 46.3 ± 12.8 | 45.7 ± 13.5 | 47.1 ± 12.3 | 0.84 |
| TIBC (μg/dL) | 428.6 ± 38.7 | 432.1 ± 41.2 | 426.3 ± 39.8 | 0.72 |
| Transferrin saturation (%) | 10.9 ± 3.2 | 10.6 ± 3.4 | 11.1 ± 3.1 | 0.77 |
| MCV (fL) | 78.4 ± 6.3 | 77.9 ± 6.7 | 78.7 ± 6.1 | 0.81 |
| MCH (pg) | 25.2 ± 3.1 | 24.9 ± 3.3 | 25.4 ± 2.9 | 0.74 |
| Reticulocyte count (×10⁹/L) | 48.3 ± 14.6 | 49.7 ± 15.2 | 47.9 ± 14.9 | 0.83 |
| CHr (pg) | 23.7 ± 3.8 | 23.4 ± 4.1 | 23.9 ± 3.6 | 0.79 |
| Dietary iron intake (mg/day) | 11.8 ± 3.2 | 12.1 ± 3.5 | 11.6 ± 3.1 | 0.75 |

**Table 2.** Pharmacokinetic parameters of iron absorption

| Parameter | AAPIC (n=30) | Heme iron (n = 30) | Ferrous glycinate (n = 30) | *p* value |
|---|---|---|---|---|
| Baseline serum iron (μg/dL) | 46.8 ± 11.7 | 45.3 ± 12.4 | 47.5 ± 11.9 | 0.76 |
| Cmax (μg/dL) | 178.4 ± 28.6 | 187.3 ± 26.8* | 156.2 ± 31.5 | 0.001 |
| Tmax (hours) | 3.2 ± 0.8 | 3.5 ± 0.7 | 3.1 ± 0.9 | 0.18 |
| AUC0–8h (μg·h/dL) | 893.7 ± 142.3 | 947.2 ± 128.6* | 731.5 ± 156.8 | < 0.001 |
| ΔSerum iron (μg/dL) | 131.6 ± 24.9 | 142.0 ± 23.2* | 108.7 ± 28.3 | < 0.001 |
| Absorption efficiency (%) | 23.7 ± 4.2 | 25.1 ± 3.8* | 18.4 ± 5.1 | < 0.001 |

Heme iron demonstrated the highest peak concentration (187.3 ± 26.8 μg/dL), followed closely by AAPIC (178.4 ± 28.6 μg/dL), both significantly exceeding ferrous glycinate (156.2 ± 31.5 μg/dL, $p = 0.001$). The incremental area under the curve (AUC0–8h) showed similar patterns: heme iron 947.2 ± 128.6 μg·h/dL, AAPIC 893.7 ± 142.3 μg·h/dL, ferrous glycinate 731.5 ± 156.8 μg·h/dL ($p < 0.001$).

Calculated absorption efficiency revealed heme iron achieving 25.1 ± 3.8%, AAPIC 23.7 ± 4.2%, and ferrous

glycinate 18.4 ± 5.1%. The difference between heme iron and AAPIC was not statistically significant ($p = 0.21$), indicating comparable absorption characteristics. Both demonstrated significantly superior absorption compared to ferrous glycinate ($p < 0.001$ for both comparisons). The 95% confidence interval for the AAPIC-heme iron difference (-2.8 to 0.6%) fell entirely within the pre-specified non-inferiority margin, establishing AAPIC as non-inferior to heme iron.

## 3.3. Primary efficacy outcomes

Hemoglobin concentrations increased progressively in all treatment groups throughout the 12-week intervention (**Table 3**). Repeated-measures ANOVA demonstrated significant effects of time ($p < 0.001$), treatment ($p = 0.003$), and treatment-by-time interaction ($p = 0.04$), indicating differential response patterns among formulations.

**Table 3.** Changes in hemoglobin concentration over 12 weeks (g/L)

| Time point | AAPIC | Heme iron | Ferrous glycinate |
|---|---|---|---|
| Baseline | 98.3 ± 8.7 | 97.8 ± 9.1 | 98.6 ± 8.9 |
| Week 2 | 104.7 ± 8.9* | 105.3 ± 9.2* | 102.8 ± 9.4* |
| Week 4 | 112.4 ± 9.3* | 114.1 ± 8.7* | 108.6 ± 10.1* |
| Week 8 | 120.8 ± 9.6* | 122.9 ± 8.9* | 114.9 ± 10.8* |
| Week 12 | 126.5 ± 9.2* | 128.3 ± 8.6* | 119.7 ± 10.3* |
| Change from baseline | 28.2 ± 7.8 | 30.5 ± 7.3 | 21.1 ± 8.6 |

At week 12, mean hemoglobin reached 126.5 ± 9.2 g/L with AAPIC, 128.3 ± 8.6 g/L with heme iron, and 119.7 ± 10.3 g/L with ferrous glycinate, representing increases of 28.2 ± 7.8 g/L, 30.5 ± 7.3 g/L, and 21.1 ± 8.6 g/L, respectively. The hemoglobin increment with AAPIC was non-inferior to heme iron (difference -2.3 g/L, 95% CI: -4.9 to 1.1 g/L, $p$ for non-inferiority < 0.001). Both AAPIC and heme iron demonstrated significantly greater hemoglobin increases compared to ferrous glycinate ($p = 0.001$ and $p < 0.001$, respectively).

Anemia correction, defined as achieving hemoglobin ≥ 120 g/L, occurred in 78.3% of AAPIC recipients, 81.7% of heme iron recipients, and 63.3% of ferrous glycinate recipients by week 12 ($p = 0.04$). Time to anemia correction analysis using Kaplan-Meier methods revealed median times of 8.1 weeks (95% CI: 7.2–9.3), 7.8 weeks (95% CI: 6.9–8.9), and 10.2 weeks (95% CI: 9.1–11.6) for AAPIC, heme iron, and ferrous glycinate groups, respectively (log-rank $p = 0.008$).

Response velocity, calculated as hemoglobin increment per week during the first 4 weeks, demonstrated comparable rates between AAPIC (3.53 ± 0.97 g/L/week) and heme iron (4.08 ± 0.89 g/L/week, $p = 0.16$), both exceeding ferrous glycinate (2.50 ± 1.12 g/L/week, $p < 0.001$ vs both).

## 3.4. Secondary efficacy outcomes

Serum ferritin, the primary indicator of iron stores, increased substantially in all groups (**Table 4**). Week 12 levels reached 58.4 ± 18.7 μg/L with AAPIC, 62.1 ± 19.3 μg/L with heme iron, and 47.3 ± 16.8 μg/L with ferrous glycinate, representing fold-increases of 4.0, 4.1, and 3.2, respectively. The AAPIC group demonstrated non-inferiority to heme iron (difference -3.7 μg/L, 95% CI: -9.2 to 1.8 μg/L) and significant superiority over ferrous glycinate (difference 11.1 μg/L, 95% CI: 4.8 to 17.4 μg/L, $p = 0.001$).

**Table 4.** Iron metabolism parameters at baseline and week 12

| Parameter | AAPIC | Heme iron | Ferrous glycinate |
|---|---|---|---|
| Serum ferritin (μg/L) | | | |
| Baseline | 14.7 ± 8.3 | 15.2 ± 8.9 | 14.9 ± 8.1 |
| Week 12 | 58.4 ± 18.7* | 62.1 ± 19.3* | 47.3 ± 16.8*† |
| Change | 43.7 ± 16.2 | 46.9 ± 17.1 | 32.4 ± 14.7† |
| Serum iron (μg/dL) | | | |
| Baseline | 46.3 ± 12.8 | 45.7 ± 13.5 | 47.1 ± 12.3 |
| Week 12 | 92.7 ± 21.4* | 96.3 ± 19.8* | 81.5 ± 23.6*† |
| Change | 46.4 ± 18.3 | 50.6 ± 17.2 | 34.4 ± 19.8† |
| TIBC (μg/dL) | | | |
| Baseline | 428.6 ± 38.7 | 432.1 ± 41.2 | 426.3 ± 39.8 |
| Week 12 | 358.2 ± 34.6* | 352.8 ± 36.1* | 371.9 ± 38.7*† |
| Change | -70.4 ± 28.3 | -79.3 ± 31.2 | -54.4 ± 29.6† |
| Transferrin saturation (%) | | | |
| Baseline | 10.9 ± 3.2 | 10.6 ± 3.4 | 11.1 ± 3.1 |
| Week 12 | 26.2 ± 6.8* | 27.6 ± 6.3* | 22.1 ± 7.2*† |
| Change | 15.3 ± 5.7 | 17.0 ± 5.4 | 11.0 ± 6.1† |
| sTfR (nmol/L) | | | |
| Baseline | 42.8 ± 11.7 | 43.5 ± 12.3 | 42.3 ± 11.9 |
| Week 12 | 28.3 ± 8.4* | 27.1 ± 7.9* | 32.6 ± 9.7*† |
| Change | -14.5 ± 7.2 | -16.4 ± 7.8 | -9.7 ± 6.8† |

Transferrin saturation, reflecting immediately available iron for erythropoiesis, improved from baseline values of approximately 11% to 26.2 ± 6.8% with AAPIC, 27.6 ± 6.3% with heme iron, and 22.1 ± 7.2% with ferrous glycinate. The increments (15.3 ± 5.7%, 17.0 ± 5.4%, and 11.0 ± 6.1%, respectively) demonstrated comparable efficacy between AAPIC and heme iron ($p = 0.28$) with both superior to ferrous glycinate ($p < 0.01$).

Soluble transferrin receptor concentrations, which increase in iron deficiency, declined significantly in all groups. Week 12 levels of 28.3 ± 8.4 nmol/L (AAPIC), 27.1 ± 7.9 nmol/L (heme iron), and 32.6 ± 9.7 nmol/L (ferrous glycinate) represented reductions of 34%, 38%, and 23% from baseline, respectively. Greater decreases with AAPIC and heme iron ($p = 0.003$ vs ferrous glycinate) indicated superior tissue iron delivery.

Mean corpuscular volume increased progressively, reflecting the shift from iron-deficient to iron-replete erythropoiesis (**Table 5**). Week 12 values reached 87.3 ± 5.8 fL with AAPIC, 88.1 ± 5.6 fL with heme iron, and 84.7 ± 6.4 fL with ferrous glycinate, representing increases of 8.9, 10.2, and 6.0 fL, respectively. The AAPIC group demonstrated non-inferiority to heme iron while both showed superiority to ferrous glycinate.

**Table 5.** Red blood cell parameters at baseline and week 12

| Parameter | AAPIC | Heme Iron | Ferrous Glycinate |
|---|---|---|---|
| MCV (fL) | | | |
| Baseline | 78.4 ± 6.3 | 77.9 ± 6.7 | 78.7 ± 6.1 |
| Week 12 | 87.3 ± 5.8* | 88.1 ± 5.6* | 84.7 ± 6.4*† |
| MCH (pg) | | | |
| Baseline | 25.2 ± 3.1 | 24.9 ± 3.3 | 25.4 ± 2.9 |
| Week 12 | 29.8 ± 2.9* | 30.2 ± 2.7* | 28.4 ± 3.2*† |
| MCHC (g/L) | | | |
| Baseline | 321.4 ± 18.7 | 319.8 ± 19.3 | 322.6 ± 18.2 |
| Week 12 | 341.7 ± 16.8* | 343.2 ± 16.1* | 335.4 ± 17.9*† |
| RDW (%) | | | |
| Baseline | 16.8 ± 2.4 | 17.1 ± 2.6 | 16.7 ± 2.3 |
| Week 12 | 13.9 ± 1.8* | 13.6 ± 1.7* | 14.7 ± 2.1*† |
| Reticulocyte count ($\times 10^9$/L) | | | |
| Baseline | 48.3 ± 14.6 | 49.7 ± 15.2 | 47.9 ± 14.9 |
| Week 2 | 87.6 ± 23.4* | 92.3 ± 25.1* | 73.8 ± 21.7*† |
| Week 12 | 62.4 ± 18.7* | 64.8 ± 19.3* | 58.3 ± 17.9* |
| CHr (pg) | | | |
| Baseline | 23.7 ± 3.8 | 23.4 ± 4.1 | 23.9 ± 3.6 |
| Week 2 | 27.9 ± 3.6* | 28.4 ± 3.4* | 26.2 ± 3.9*† |
| Week 12 | 29.3 ± 3.2* | 29.7 ± 3.1* | 27.8 ± 3.7*† |

Mean corpuscular hemoglobin exhibited parallel improvements, increasing from approximately 25 pg to 29.8 ± 2.9 pg (AAPIC), 30.2 ± 2.7 pg (heme iron), and 28.4 ± 3.2 pg (ferrous glycinate). Red blood cell distribution width, a marker of anisocytosis that increases in iron deficiency, declined significantly in all groups, with more pronounced reductions in AAPIC (from 16.8 ± 2.4% to 13.9 ± 1.8%) and heme iron (from 17.1 ± 2.6% to 13.6 ± 1.7%) compared to ferrous glycinate (from 16.7 ± 2.3% to 14.7 ± 2.1%, $p = 0.03$).

Reticulocyte hemoglobin content, representing the iron status of nascent red blood cells, showed rapid response to supplementation. By week 2, CHr increased to 27.9 ± 3.6 pg (AAPIC), 28.4 ± 3.4 pg (heme iron), and 26.2 ± 3.9 pg (ferrous glycinate), with sustained elevation through week 12. This early response (within 1–2 weeks) preceded hemoglobin changes (4–8 weeks), confirming CHr as a sensitive early indicator of iron delivery to erythropoiesis.

Reticulocyte counts demonstrated biphasic patterns, with initial elevation at week 2 (reflecting erythropoietic stimulation) followed by normalization by week 12 as anemia corrected. Peak reticulocyte responses occurred in AAPIC (87.6 ± 23.4 × $10^9$/L) and heme iron (92.3 ± 25.1 × $10^9$/L) groups, both exceeding ferrous glycinate (73.8 ± 21.7 × $10^9$/L, $p = 0.006$).

## 3.5. Safety and toxicology assessments

Comprehensive safety monitoring revealed no clinically significant hepatotoxicity or nephrotoxicity across all treatment groups (**Table 6**). Liver enzyme elevations > 2 × baseline occurred in 2 participants (1 AAPIC, 1 ferrous glycinate), both resolving spontaneously without intervention discontinuation. Mean alanine aminotransferase and aspartate aminotransferase remained within normal ranges throughout the study period.

**Table 6.** Safety laboratory parameters at baseline and week 12

| Parameter | AAPIC | Heme Iron | Ferrous glycinate | Reference range |
|---|---|---|---|---|
| ALT (U/L) | | | | 7–40 |
| Baseline | 24.3 ± 8.7 | 25.1 ± 9.2 | 24.8 ± 8.9 | |
| Week 12 | 26.7 ± 9.4 | 27.3 ± 9.8 | 27.1 ± 10.2 | |
| AST (U/L) | | | | 13–40 |
| Baseline | 22.8 ± 7.3 | 23.4 ± 7.8 | 23.1 ± 7.5 | |
| Week 12 | 24.6 ± 8.1 | 25.2 ± 8.6 | 25.8 ± 9.2 | |
| Serum Creatinine (mg/dL) | | | | 0.6–1.2 |
| Baseline | 0.83 ± 0.14 | 0.85 ± 0.16 | 0.84 ± 0.15 | |
| Week 12 | 0.86 ± 0.15 | 0.87 ± 0.17 | 0.86 ± 0.16 | |
| eGFR (mL/min/1.73m²) | | | | > 90 |
| Baseline | 102.4 ± 12.7 | 101.8 ± 13.2 | 102.1 ± 12.9 | |
| Week 12 | 100.7 ± 13.1 | 100.2 ± 13.8 | 99.8 ± 13.5 | |
| MDA (μmol/L) | | | | < 4.0 |
| Baseline | 3.24 ± 0.67 | 3.31 ± 0.72 | 3.28 ± 0.69 | |
| Week 12 | 3.18 ± 0.71 | 3.27 ± 0.74 | 3.42 ± 0.78 | |
| SOD (U/mL) | | | | 150–50 |
| Baseline | 182.4 ± 28.3 | 179.7 ± 29.6 | 181.3 ± 28.8 | |
| Week 12 | 186.3 ± 29.7 | 183.8 ± 30.4 | 179.5 ± 30.1 | |

Renal function parameters remained stable throughout the intervention. Mean serum creatinine and estimated glomerular filtration rate showed minimal variation from baseline, with no participants developing acute kidney injury or significant deterioration in renal function.

Oxidative stress markers provided reassuring safety data. Malondialdehyde concentrations, indicating lipid peroxidation, remained unchanged in AAPIC and heme iron groups while showing a slight non-significant increase in ferrous glycinate recipients. Superoxide dismutase and glutathione peroxidase activities demonstrated stable antioxidant capacity across all groups, suggesting absence of excessive oxidative burden despite increased iron availability.

Comprehensive genotoxicity assessments conducted at baseline and week 12 revealed no evidence of DNA damage or chromosomal instability attributable to any iron formulation (**Table 7**).

**Table 7.** Genotoxicity assessment results

| Parameter | AAPIC | Heme iron | Ferrous glycinate | Historical control |
|---|---|---|---|---|
| Micronucleus frequency (per 1000 binucleated cells) | | | | |
| Baseline | 3.8 ± 1.9 | 3.6 ± 2.1 | 3.9 ± 1.8 | 2.5–5.0 |
| Week 12 | 4.1 ± 2.2 | 3.9 ± 2.3 | 4.2 ± 2.1 | |
| Chromosomal aberrations (per 100 metaphases) | | | | |
| Baseline | 1.4 ± 0.8 | 1.3 ± 0.9 | 1.5 ± 0.7 | 0.5–2.0 |
| Week 12 | 1.6 ± 0.9 | 1.5 ± 1.0 | 1.7 ± 0.9 | |
| Comet assay tail length (μm) | | | | |
| Baseline | 12.3 ± 4.7 | 11.8 ± 5.1 | 12.6 ± 4.9 | < 20 |
| Week 12 | 13.1 ± 5.2 | 12.5 ± 5.4 | 13.8 ± 5.6 | |
| Comet tail moment | | | | |
| Baseline | 2.8 ± 1.3 | 2.7 ± 1.4 | 2.9 ± 1.2 | < 5.0 |
| Week 12 | 3.1 ± 1.5 | 2.9 ± 1.6 | 3.3 ± 1.4 | |

Micronucleus frequencies remained within normal ranges (2.5–5.0 per 1000 binucleated cells) at both time points across all groups, with no significant increases from baseline ($p > 0.50$ for all comparisons). Chromosomal aberration frequencies similarly showed no treatment-related increases, with values consistently below 2 per 100 metaphases. Comet assay parameters, including tail length and tail moment, demonstrated no evidence of DNA strand breaks, with all measurements remaining well below toxicological concern thresholds.

Comparative analysis between groups revealed no significant differences in any genotoxicity endpoint ($p > 0.40$ for all parameters), indicating equivalent genetic safety profiles. These findings contrast with some previous concerns regarding iron-catalyzed free radical formation and DNA damage, suggesting that the supplementation doses and formulations employed maintain genetic integrity.

## 3.6. Adverse events and tolerability

Overall incidence of adverse events was low across all treatment groups, with gastrointestinal symptoms representing the predominant adverse effect category (**Table 8**). The AAPIC formulation demonstrated favorable tolerability, with total adverse event rates of 18.3% compared to 23.3% for heme iron and 31.7% for ferrous glycinate ($p = 0.16$).

**Table 8.** Adverse events by treatment group

| Adverse event | AAPIC (n = 60) | Heme iron (n = 60) | Ferrous glycinate (n = 60) | *p* value |
|---|---|---|---|---|
| Any adverse event | 11 (18.3%) | 14 (23.3%) | 19 (31.7%) | 0.16 |
| Gastrointestinal | 5 (8.3%) | 6 (10.0%) | 9 (15.0%) | 0.44 |
| Nausea | 2 (3.3%) | 3 (5.0%) | 5 (8.3%) | 0.42 |
| Constipation | 2 (3.3%) | 2 (3.3%) | 3 (5.0%) | 0.83 |
| Abdominal discomfort | 1 (1.7%) | 1 (1.7%) | 2 (3.3%) | 0.78 |
| Diarrhea | 0 (0%) | 1 (1.7%) | 2 (3.3%) | 0.36 |

**Table 8 (Continued)**

| Adverse event | AAPIC (n = 60) | Heme iron (n = 60) | Ferrous glycinate (n = 60) | *p* value |
|---|---|---|---|---|
| Metallic taste | 1 (1.7%) | 2 (3.3%) | 3 (5.0%) | 0.63 |
| Other | 6 (10.0%) | 8 (13.3%) | 10 (16.7%) | 0.52 |
| Headache | 3 (5.0%) | 4 (6.7%) | 5 (8.3%) | 0.74 |
| Fatigue | 2 (3.3%) | 3 (5.0%) | 4 (6.7%) | 0.68 |
| Dizziness | 1 (1.7%) | 1 (1.7%) | 1 (1.7%) | 1.00 |
| Serious adverse events | 0 (0%) | 0 (0%) | 0 (0%) | 1.00 |
| Treatment discontinuation | 1 (1.7%) | 0 (0%) | 2 (3.3%) | 0.36 |

Gastrointestinal adverse events occurred in 8.3% of AAPIC recipients, 10.0% with heme iron, and 15.0% with ferrous glycinate, with all events mild to moderate in severity. Constipation occurred comparably across groups (3.3% AAPIC and heme iron, 5.0% ferrous glycinate), while nausea rates were lowest with AAPIC (3.3%) versus heme iron (5.0%) and ferrous glycinate (8.3%). Non-gastrointestinal adverse events including headache, fatigue, and dizziness occurred at comparable frequencies with predominantly mild severity. No serious adverse events occurred in any group.

Treatment discontinuation due to adverse events was rare (1.7% AAPIC, 0% heme iron, 3.3% ferrous glycinate), indicating generally good tolerability. Compliance analysis revealed excellent adherence: 94.7% for AAPIC, 95.3% for heme iron, and 92.8% for ferrous glycinate ($p = 0.67$), suggesting acceptable tolerability and ease of administration for all tested formulations.

# 4. Discussion

## 4.1. Absorption mechanisms, therapeutic efficacy, and hematological response

The comparable absorption efficiency between AAPIC (23.7%) and heme iron (25.1%), both significantly exceeding ferrous glycinate (18.4%), merits mechanistic consideration. Traditional non-heme iron absorption through divalent metal transporter 1 faces limitations including pH-dependent solubility, oxidation, precipitation with dietary inhibitors, and saturable transport capacity. AAPIC's enhanced bioavailability likely involves multiple mechanisms. The polysaccharide matrix maintains iron solubility across pH 2.0–7.4 (> 95% retention), whereas ferrous glycinate showed 30–40% precipitation at pH 6.0–7.4. β-glucans interact with intestinal epithelial receptors including Dectin-1 and complement receptor 3, potentially enabling transcellular transport of intact iron-polysaccharide complexes, paralleling heme iron absorption. Supporting this, AAPIC absorption remained stable across participants despite variable baseline iron status, whereas ferrous glycinate showed marked inter-individual variability. Additionally, fungal polysaccharides modulate tight junction proteins, increase controlled intestinal permeability, and alter microbiota composition. Pharmacokinetic profiles revealed that while heme iron demonstrated slightly higher peak concentrations, AAPIC's area under the curve was only 5.7% lower, suggesting sustained absorption kinetics.

The hemoglobin increment of 28.2 g/L with AAPIC compares favorably with published literature (15–30 g/L). Non-inferiority to heme iron and superiority over ferrous glycinate validate AAPIC as therapeutically viable, with response rates of 78.3% approaching heme iron (81.7%) and exceeding ferrous glycinate (63.3%). The multiphasic

hematological response followed predicted erythropoietic kinetics: reticulocyte hemoglobin content increased within 1–2 weeks; reticulocytosis peaked at week 2; hemoglobin increased from week 4 through week 12. Red blood cell indices demonstrated progressive normalization, with MCV increase of 8.9 fL representing clinically meaningful improvement. Iron storage parameters revealed appropriate replenishment: 4-fold serum ferritin increase (43.7 μg/L), transferrin saturation improvement to 26.2%, and 34% soluble transferrin receptor decline confirmed successful cellular iron deficiency correction.

## 4.2. Safety profile and clinical implications

The absence of hepatotoxicity, nephrotoxicity, or genotoxicity across all formulations provides reassuring safety data. Theoretical concerns regarding iron-catalyzed oxidative damage through Fenton chemistry were not substantiated. Stable malondialdehyde levels and maintained antioxidant enzyme activities suggest supplementation remained within physiological buffering capacity. The polysaccharide component may confer protective effects through free radical scavenging and antioxidant system upregulation, with bound iron less available for Fenton reactions compared to free ferrous ions. Comprehensive genotoxicity assessment through micronucleus assay, chromosomal aberration analysis, and comet assay confirmed absence of clastogenic or aneugenic effects, contrasting with in vitro studies suggesting iron-mediated DNA damage and highlighting the importance of physiologically relevant human assessments.

The superior gastrointestinal tolerability represents a clinically important advantage, with 8.3% adverse event rate approaching heme iron (10.0%) while substantially improving upon ferrous glycinate (15.0%). Multiple mechanisms contribute: polysaccharide matrix protection of gastric mucosa, sustained release decreasing peak luminal concentrations, prebiotic effects mitigating dysbiosis-related symptoms, and absence of sulfate or fumarate moieties eliminating osmotic or irritative effects. High compliance rates (94.7%) reflect practical clinical utility.

These findings position AAPIC as a promising option offering distinct advantages for specific populations. For individuals with dietary restrictions precluding animal-derived products, AAPIC provides plant-source iron with heme-equivalent absorption. The favorable tolerability suits patients with previous intolerance to conventional supplements. Improved compliance associated with better tolerability may reduce healthcare costs by preventing treatment failure and recurrent deficiency. Compared with other iron formulations, AAPIC shows a competitive profile. For instance, ferric maltol, while having similar absorption, typically requires thrice-daily dosing. Iron polymaltose complexes are well-tolerated but often exhibit lower absorption efficiency (approximately 10–15%). Liposomal iron preparations, although effective, are associated with substantially higher costs; intravenous iron requires facility administration with hypersensitivity risks. AAPIC occupies a unique niche combining heme-equivalent efficacy, oral convenience, and favorable cost-tolerability balance.

## 4.3. Limitations and future directions

The study population comprised predominantly iron-deficient anemic adults; generalizability requires validation in pregnancy and pediatric populations. Mechanistic investigations warrant isotopic tracer studies using stable iron isotopes ($^{57}Fe$ or $^{58}Fe$) to quantify absolute absorption and incorporation. Intestinal biopsy studies with immunohistochemistry could identify specific transporters, while Caco-2 cell monolayers and organ-on-chip models would elucidate transport mechanisms. The optimal polysaccharide-to-iron ratio remains undetermined; systematic dose-response studies could maximize bioavailability. Comparative studies against ferric maltol, iron polymaltose, and liposomal iron would provide definitive efficacy rankings. The polysaccharide-mediated delivery platform may

extend to other poorly absorbed minerals. Finally, personalized medicine approaches incorporating pharmacogenomic assessments of HFE variants, DMT1 mutations, and hepcidin regulatory elements could enable precision selection of optimal supplementation strategies, maximize therapeutic outcomes while minimizing adverse effects.

## 5. Conclusion

This randomized clinical trial establishes *Auricularia auricula* polysaccharide-iron complex as an effective and safe iron supplementation alternative with non-inferior efficacy to heme iron and superior performance versus ferrous glycinate. AAPIC achieved absorption efficiency of 23.7% (heme iron 25.1%, ferrous glycinate 18.4%) and produced hemoglobin improvements of 28.2 g/L over 12 weeks with 78.3% anemia correction rates, comparable to heme iron and significantly exceeding ferrous glycinate. Comprehensive safety assessments revealed no hepatotoxicity, nephrotoxicity, or genotoxicity, while gastrointestinal tolerability was excellent with only 8.3% experiencing adverse events versus 15.0% with ferrous glycinate. The polysaccharide component confers mechanistic advantages including enhanced iron solubility across physiological pH ranges, facilitated intestinal absorption, antioxidant protection, and improved mucosal tolerability, creating a differentiated delivery system suitable for diverse populations including those with dietary restrictions or previous supplement intolerance.

Future investigations should address long-term safety, efficacy in special populations including pregnancy and pediatrics, and detailed absorption mechanisms. Nevertheless, these findings support AAPIC as a valuable addition to iron deficiency treatment strategies, offering heme-equivalent efficacy with plant-source derivation, superior tolerability, and a compelling safety profile that positions it competitively within current iron supplementation options. The favorable compliance rate of 94.7% reflects its practical clinical utility for addressing the global burden of iron deficiency anemia.

## Disclosure statement

The authors declare no conflict of interest.

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# Application Progress of Point-of-Care Ultrasound for Cannulation in Hemodialysis Patients with Difficult Arteriovenous Fistulae

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**Abstract:** The occurrence of difficult arteriovenous fistulas makes the use of vascular access in hemodialysis patients face great challenges. With the widespread application of point-of-care ultrasound, POCUS technology, it provides a new solution for clinical practice. This article reviews the principle, basic process, application status, current clinical challenges and development direction of difficult arteriovenous fistulas cannulation guided by POCUS technology, in order to provide reference for the standardized clinical application and future research direction of this technology.

**Keywords:** Point-of-care ultrasound technology; Arteriovenous fistula; Hemodialysis nursing; Summary

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## 1. Introduction

End-stage renal disease, ESRD has become a global public health problem. At present, there are more than 3 million patients with ESRD in China, and the number of patients continues to increase [1]. Maintenance hemodialysis, MHD is one of the most commonly used renal replacement therapies for ESRD. Studies show that China's dialysis population is gradually growing and is expected to reach 870,000 by 2025 [2]. High-quality dialysis treatment is the basis for ensuring the long-term survival of patients, and some patients can achieve a survival period of more than 10–20 years [3]. Arteriovenous fistula, AVF has become the preferred non-physiological vascular access for MHD patients due to the advantages of hemodynamic stability, convenient use and high safety [4]. However, clinically, some arteriovenous fistulas are called difficult arteriovenous fistulas because of their high cannulation difficulty [5–8]. This mainly includes three types of situations:

(1) Suboptimal vascular characteristics

Such as the diameter of the vessel is too small (< 5 mm), the depth from the skin surface is too large (> 6

mm), the segment available for cannulation is short (< 10 cm), the running is tortuous or the position is too deep, the vessel wall is brittle, and it is easy to slide.

(2) Compromised functional status

Such as insufficient access blood flow (< 500 mL/min), poor maturation, or complications such as thrombosis, stenosis, and calcification;

(3) Difficulties in clinical use

Such as newly formed early-stage arteriovenous fistulas, high-position arteriovenous fistula, or vessels that rely on ultrasound guidance due to repeated cannulation failure (defined as ≥ 3 failures in 4 consecutive dialysis sessions in the near future).

The traditional method of arteriovenous fistula cannulation is blind cannulation technique, but the application of this method for difficult arteriovenous fistulas will reduce the success rate of cannulation, and repeated cannulation failure can lead to serious complications such as hematoma, infection and pseudoaneurysm, which can easily lead to the loss of arteriovenous fistula [9]. In recent years, POCUS has gradually become an important means for cannulating difficult AVF because of its simplicity, visualization, rapidity and high repeatability. Many studies have confirmed [11]that using POCUS to assist in cannulating difficult arteriovenous fistulas can not only significantly improve the cannulation success rate of AVF, but also effectively prolong the service life of AVF [10–12]. Therefore, the purpose of this article is to summarize the principle and basic process of POCUS-guided cannulation for difficult AVF, explore the current application status of POCUS in cannulation of MHD patients with difficult AVF, and analyze the challenges faced in its clinical operation, so as to provide practical guidance for optimizing the vascular access cannulation strategy of MHD patients.

## 2. The principle of POCUS in cannulating difficult AVF

Ultrasound technology began to be applied in the medical field in 1950s, aiming to assist the diagnosis and treatment of diseases through non-invasive, real-time, and high-resolution imaging of the internal body [13]. This technique began to be applied in nephrology in the 1990s [14]. As an important extension in clinical practice, POCUS can break through the space and time limitations of traditional ultrasound equipment by virtue of its portability, enabling medical staff to quickly obtain real-time image information at the patient's bedside [15]. In recent years, POCUS has been applied to the preoperative evaluation, intraoperative and postoperative detection and follow-up, and guided cannulation of AVF in MHD patients [16,17]. POCUS has important clinical application value in guiding the cannulation for difficult AVF because of its portability and visual puncture. Its core technology lies in transforming the cannulation process from the blind technique that relies on subjective experience into objective, image-based clinical procedure. First of all, conduct a comprehensive pre-cannulation visual evaluation, accurately measure the effective vessel lumen diameter and depth from the skin surface, and clearly identify vascular pathologies that cannot be detected by traditional palpation, such as stenosis, thrombus and calcification, so as to provide decision-making basis for selecting the best puncture site; Then, the needle tip is dynamically guided in real time during the cannulation process to ensure that the needle's trajectory is still clearly visible in complex situations such as aberrant vessel courses or scar tissue; Finally, after successful cannulation, the accurate position of the needle tip in the vascular lumen can be confirmed immediately and the blood flow patency can be evaluated, providing immediate imaging confirmation for subsequent treatment [18–20]. Therefore, this technology reduces the difficulty of cannulating difficult AVF by transforming the cannulation of difficult arteriovenous

fistulas from a blind procedure into an accurate visual one, and can significantly improve the cannulation success rate. It is a key technical means to achieve long-term vascular access maintenance in MHD patients.

## 3. The basic process of POCUS in difficult AVF cannulation

At present, the process of POCUS-guided cannulation of difficult AVF is roughly divided into three steps [21–24].

(1) Step 1

Before cannulation, physical examination and evaluation of AVF such as inspection, palpation, and auscultation are carried out, and then the vessel course, branching pattern, inner diameter, depth from the skin, wall thickness and hemodynamic status are evaluated by ultrasonographic assessment, so as to avoid vascular abnormalities or pathologies such as stenosis and tortuosity, and determine the best puncture site and mark it;

(2) Step 2

During cannulation, disinfect the skin, spread the towel, put the sterile protective sheath on the ultrasound probe and apply the sterile coupling gel. The operator displays the target vessel at the center of the screen, and then guides it in real time with the transverse section or longitudinal section, inserts the needle at the center of the probe while looking at the ultrasound screen, and dynamically adjusts the puncture angle and depth to a suitable position;

(3) Step 3

After successful cannulation, fix the puncture needle, and review the needle placement and vascular status by ultrasound to ensure that there are no abnormalities.

## 4. Current application of POCUS in AVF cannulation

### 4.1. Cannulation success rate

A single successful cannulation of an AVF refers to achieving venipuncture without repeated attempts, vessel perforation, or missing the target vessel in one procedure [24]. A successful first attempt can reduce the incidence of hematoma, vascular injury, and scarring. By providing real-time visualization during cannulation, POCUS optimizes vascular assessment and puncture-site selection, and has become a key technique for improving the first-attempt success rate in difficult AVF. Numerous studies from different perspectives have verified its effectiveness. In a randomized controlled study, Jin Juan et al. reported that vessels in first-time AVF cannulation patients were fragile and under high pressure [25]. By using POCUS to assess vessel diameter and trajectory and to identify the optimal puncture site and needle entry approach, the observation group showed a significantly higher first-attempt success rate than the control group ($p < 0.05$), along with reduced hematoma and thrombosis related to cannulation failure. Liu Hua et al. also confirmed these findings: using handheld POCUS to examine vessel morphology, depth, and course and to avoid stenosis or hematoma sites, the first-attempt success rate in the ultrasound group reached 86.7%, compared with only 63.3% using the traditional method [26]. Moreover, the study by Cheng Ying et al. highlighted a collaborative physician-nurse model, in which physicians first performed POCUS evaluation and site marking and nurses executed real-time guided cannulation [27]. Under this model, the first-attempt success rate reached 100.0%, markedly higher than the control group's 92.1%. Collectively, these findings demonstrate the ability of POCUS to improve both the objective success and safety of cannulation procedures. Nevertheless,

the magnitude of improvement varies across studies, likely due to differences in patients' vascular conditions, ultrasound equipment performance, operator proficiency, and team collaboration. Therefore, future research should establish standardized operating procedures, systematically evaluate the effectiveness of training programs on cannulation proficiency, and validate optimal strategies in larger and more diverse patient populations, thereby providing robust evidence for broader clinical application.

## 4.2. Pain reduction

For MHD patients, cannulation-related pain is a long-standing challenge that affects treatment experience and adherence [28]. In difficult AVF cannulations, the increased procedural complexity and repeated failed attempts can exacerbate mechanical tissue injury and trigger patient stress responses, thereby intensifying pain perception. POCUS-guided reduction of unsuccessful attempts is essential for minimizing pain. Wen Fen et al. used a numerical rating scale to assess pain in patients undergoing POCUS-guided cannulation for difficult AVF and found significantly lower pain scores in the observation group than in the traditional blind puncture group ($p < 0.05$) [29]. Liu Wenjie et al. reported that clarifying needle entry path and depth with POCUS before the procedure avoided repeated contact of the needle tip with the vessel wall, reduced pain perception, and improved patient tolerance [30]. A randomized controlled trial by Zhang Pei et al. further confirmed that ultrasound guidance not only reduces pain but also enhances overall comfort and treatment adherence in MHD patients, exerting positive effects on both physical and psychological well-being [31]. Although the above studies yielded consistent results, pain-assessment tools differed among researchers. Moreover, pain is a subjective experience strongly influenced by psychological status, prior cannulation experiences, and cultural background, variables often insufficiently controlled in existing studies. Thus, future studies should adopt standardized pain-assessment protocols and more rigorously control potential confounders to generate more reliable evidence regarding the effectiveness of POCUS in improving cannulation-related patient experience.

## 4.3. Cannulation-related vascular complications

Because MHD patients undergo repeated vascular access cannulations over time, they are prone to thrombosis, stenosis, bleeding, hematoma, pseudoaneurysm, and infection [32]. In difficult AVF cannulations, repeated attempts due to procedural challenges markedly increase these risks. Therefore, using POCUS to determine vascular anatomy and functional status before cannulation is essential for preventing complications. Xiong Caixia et al. reported significantly lower rates of hematoma and thrombosis in the POCUS-guided group than in the blind puncture group, with zero occurrences of aneurysm or infection, indicating that ultrasound guidance effectively mitigates complication risks [33]. Zhang Fan et al. further demonstrated that POCUS-guided cannulation significantly reduces the incidence of subcutaneous hematoma, induration, oozing, and vascular injury [34]. Similarly, the study by WU et al. confirmed significantly lower rates of early complications (such as subcutaneous hematoma and oozing) in the POCUS group compared with the control group [35]. In addition, preliminary evidence suggests potential long-term benefits. Wang Chunhua and colleagues conducted a 1-year follow-up and found that 96.7% of patients in the ultrasound-guided group remained free of complications (only 1 case of stenosis), significantly higher than the 53.3% in the control group; stenosis, sclerosis, and aneurysmal dilatation were notably more frequent in the control group ($p < 0.05$) [36]. Overall, current evidence consistently indicates the substantial advantage of POCUS in reducing cannulation-related complications in difficult AVF, especially early complications. Although preliminary long-term data are promising, high-quality long-term evidence remains limited. Future research should adopt larger sample sizes, more rigorous

designs, and extended follow-up periods to comprehensively evaluate the long-term value of POCUS in protecting vascular access and prolonging AVF lifespan.

### 4.4. Cannulation time

Current evidence shows that POCUS-guided cannulation of difficult AVF may prolong procedure time. Liu Wenjie et al. reported that due to the need for more refined vascular assessment and path localization, the total operation time was longer in the POCUS group than in the blind puncture group [30]. Similarly, in a randomized controlled trial involving 32 early AVF patients, Kumbar found that the additional visualization steps led to longer assessment and cannulation times [37]. However, some studies found no significant difference or even improved overall efficiency in specific difficult scenarios. Chen S et al. showed that pre-procedure assessment time and cannulation time (defined as the time from draping to successful insertion of the second needle) were similar between groups, suggesting that convenient equipment and operator confidence may narrow time differences [38]. Eves J et al. defined cannulation time as the period from first skin puncture to successful flushing of the second needle, and reported that although POCUS did not shorten procedure time, it progressively reduced the time gap between groups when cannulating difficult AVF, improving overall efficiency. The heterogeneity of conclusions is notable [39]. First, studies differ in defining start and end points of timing, making direct comparison difficult. Second, operator experience plays a major role: novice users often require more time, while experienced practitioners may achieve equal or greater efficiency. Future studies should unify measurement standards for cannulation time and adopt more rigorous designs—including accounting for operator experience, to accurately assess the true impact of POCUS on procedure duration in difficult AVF cannulation.

## 5. Challenges and prospects of POCUS in difficult AVF punctures

### 5.1. Establish a standardized and process-oriented training and assessment for nurse-led Point-of-Care Ultrasound (POCUS)

With the widespread application of POCUS in difficult AVF punctures, the role of nurses should be transformed from traditional operators to clinical practitioners capable of integrating assessment, decision-making, and operation. This places high demands on nurses' comprehensive operational competence. The current global training systems that complement it, however, has lagged behind in development. Research by Knutse K in Norway indicates that standardized training is a necessary prerequisite for enabling medical personnel to master this technology [40]. However, there are significant variations in nurses' abilities to interpret ultrasound images and perform puncture procedures, owing to their training system remains inadequate. What is worth to notice that there is currently a domestic lack of standardized procedures for this operation, which has to some extent limited the promotion and application of this technology in China. Therefore, it is recommended that Chinese medical personnel draw upon existing POCUS operational protocols as a foundation, develop standardized procedures for nurse-led POCUS guided AVF puncture for patients with MHD. It can cover theoretical knowledge learning, simulated operation training and assessment evaluation these three core elements, with contents focus on vascular assessment, pathway selection, and dynamic guidance and other technologies. Through this approach of integrating theory with practice, nurses are certified to ensure they possess the ability to perform independently and in accordance with established standards [41]. Consequently, through this standardized training pathway and

corresponding assessment mechanism, not only enables the rapid and standardized training of qualified POCUS operating nurses, but also lay a solid foundation for their clinical reasoning and ability to solve complex problems, providing a talent pool to ensure the standardized promotion of this technology.

## 5.2. Balancing and integrating standardization and individualization in POCUS procedures

There remains a lack of standardized procedures for POCUS guided puncture techniques in clinical practice and research, and demonstrates the exploration and integration of standardization and individualization across multiple levels. Regarding guidance methods, scholars in China including Wu Aichun et al. found that ultrasound-guided longitudinal section imaging offers advantages in improving puncture success rates, enhancing patient satisfaction, and reducing complications in 40 obese MHD patients which possesses advantages [42]. An international survey on the use of POCUS guided AVF puncture concluded that the combined transverse-longitudinal approach is most commonly used, followed by the transverse section, while the longitudinal section is relatively less frequently employed [43]. The most commonly used method is the combined transverse and longitudinal approach, followed by the transverse section, while the longitudinal section is relatively less frequently employed, which was investigate by international survey on the use of POCUS guided AVF puncture. This suggests potential variations in patient-specific operational practices, vascular assessment criteria, and clinical training priorities among medical teams. So, in the future, we should integrate the practical experience and research data from different medical institutions to establish a standardized operating procedure. With regard to the use of ultrasound probes, Wen fen et al. recommends increasing vascular filling by appropriately occluding the proximal end of the fistula vessels to achieve a clearer vascular field of view [29]. Zhan Yuemeiet al. also proposed a similar viewpoint, emphasizing the importance of controlling probe pressure for precise puncture [44]. Nevertheless, Zhang Fanet al. emphasized avoiding excessive tightness or pressure from the probe against the skin to prevent compression of blood vessels, which could compromise the effectiveness of the puncture [34]. The differing viewpoints of the above researchers reflect when during the procedure, dynamic adjustments should be made based on vascular conditions, the patient's specific circumstances, and the characteristics of the probe. Moderate pressure facilitates visualization. Yet excessive pressure may prove counterproductive. Therefore, operators should dynamically assess conditions during procedures to find the optimal balance between probe pressure and vascular filling, thereby achieving the best imaging and puncture outcomes. Huang Yaling et al. emphasizes the importance of clinical experience and advocates flexible selection of the three common AVF puncture techniques based on vascular conditions [45]. Meanwhile, Liu Wenjie et al. proposed an AVF puncture localization naming system based on POCUS assessment, using letter-number combinations to mark puncture angles and directions to enhance puncture accuracy [30]. Therefore, in establishing standardized processes, it is essential to provide operators with a clear framework to follow while also encouraging them to adapt flexibly based on actual circumstances. This approach ultimately achieves individualized precision operations guided by standardization.

## 5.3. Establish a system for assigning puncture levels and matching the difficulty of complex AVF

Good Vascular Access is the prerequisite for the nursing staff successfully performing puncture. The proficiency level of nursing staff in performing punctures is a crucial safeguard for Successfully AVF puncturing, reducing puncture injury and complications. According to existing guidelines, it is explicitly recommended that complex internal fistulas should be punctured by experienced nurses [46]. However, clinical practice generally lacks of a set of objective criteria to match nursing capabilities with the complexity of AVF, which leads to uncertainty in

the success rate of the operation. Therefore, to enhance the precision management of arteriovenous fistulas, it is recommended to establish a tiered system for puncture practitioners and a difficulty-matching protocol for complex arteriovenous fistulas. It has been confirmed in Canada that through rigorous assessment criteria, nursing competencies are categorized into low, medium, and high levels [47]. Nurses with advanced competency can accurately assess and successfully perform punctures on various complex AVF. And domestic scholars including Xiao Guanghui et al. have developed a nurse-level authorization system that incorporates POCUS proficiency as a core criterion [48]. They demonstrated that complex fistula cannulation performed by certified advanced-practice nurses significantly boosts the success rate of safe cannulation, mitigates complications, and elevates the patient's clinical experience. Hence the future research should prioritize the development and validation of an assessment system for nurses' puncture proficiency and a difficulty grading tool for complex AVF that will provide core support for establishing a scientifically sound and standardized "operator-fistula matching" system, thereby enhancing the success rate and safety of puncturing complex AVF.

### 5.4. Sterile management and optimization of POCUS

As an invasive procedure, sterile technique management of AVF puncture is critical for preventing bloodstream infections associated with vascular access. Although POCUS reduces mechanical injury by minimizing repeated needle punctures, but his guidance process itself also increases the risk of new infections. Evidence suggests that improper management of ultrasound probes, coupling agents, and operational procedures may induce cross-infection during ultrasound-guided puncture [49]. Therefore, strengthening aseptic management of ultrasound-guided techniques is crucial for reducing the incidence of infection. International guidelines recommend ultrasound-guided QVF aspiration to use sterile coupling agent during operation, equip the probe with a sterile protective cover, and disinfect the probe with sterile wipes after use [50]. According to the Chinese expert consensus on ultrasound use, T-Spray Wipes (Contains quaternary ammonium salts) are the more suitable ultrasonic probe disinfecting wipes [51]. The above measures collectively provide a reference framework for the fundamental operational procedures aimed at preventing infection and ensuring safety. However, in clinical practice, aseptic technique still faces challenges, particularly in the use of coupling agents. On the one hand, Traditional large-bottle coupling agents are difficult to maintain in a sterile state during repeated use; on the other hand, even when using sterile coupling agents, there remains a potential risk during the puncture procedure that the agent could be introduced into subcutaneous tissue or even blood vessels via the needle tip. The long-term biological effects of this on the human body are not yet fully understood, which further research is urgently needed [52]. Owing to this, future efforts should focus on the entire sterile management process for POCUS guided punctures. While further optimizing standardized sterile procedures, innovation in related technologies and products should be encouraged. This includes developing sterile coupling agents, improving probe disinfection protocols, and creating integrated sterile guidance devices to fundamentally eliminate infection risks.

## 6. Summary

POCUS provides a new direction for cannulating difficult AVF in MHD patients through visual evaluation and precise positioning, especially in improving the cannulating success rate, reducing pain and reducing short-term procedure-related complications. However, at present, there is a lack of a unified standardized system from technical operation, personnel training, management matching to aseptic protocols, which affects the application

and promotion of POCUS in difficult AVF cannulation in MHD patients. In view of this, future research should focus on the formulation of various standardized tools and protocols, and on this basis, through the design of rigorous large sample, multi-center randomized controlled trials to verify its important value in improving the long-term patency rate of arteriovenous fistula and reducing long-term complications, so as to lay a solid evidence-based foundation for the safe, efficient and standardized clinical application of this technology.

## Disclosure statement

The authors declare no conflict of interest.

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# Comparative Study on the Diagnostic Efficacy of Conventional MRI Sequences and T2 Mapping Sequences in Cartilage Injury

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**Abstract:** Objective: To retrospectively evaluate the diagnostic efficacy of traditional MRI and T2 Mapping quantitative imaging technology for knee joint cartilage injury, clarify the differences in diagnostic value of the two imaging methods in different injury grades and different cartilage subregions, and provide evidence-based basis for the accurate diagnosis of clinical cartilage injury. Methods: Clinical and imaging data of 286 patients with knee joint lesions admitted to the Affiliated Hospital of Xiangtan Medicine and Health Vocational College from January 2020 to June 2023 were collected retrospectively. All patients underwent both traditional MRI sequences and T2 Mapping sequences. The knee joint cartilage was divided into 14 subregions. Two senior radiologists independently diagnosed the images of the two imaging technologies using a blind method and recorded the cartilage injury grades. The sensitivity, specificity, accuracy, positive predictive value, negative predictive value, and area under the receiver operating characteristic curve (AUC) of the two technologies for diagnosing cartilage injury were calculated and compared, and the differences in their diagnostic efficacy in different injury grades and different subregions were analyzed. *Results:* A total of 4004 cartilage subregions from 286 patients were included in the analysis, including 1836 injured subregions and 2168 normal subregions. The overall sensitivity (89.7%), accuracy (91.2%), and AUC (0.946) of T2 Mapping quantitative imaging for diagnosing cartilage injury were significantly higher than those of traditional MRI (76.3%, 82.5%, and 0.852 respectively), with statistically significant differences ($p < 0.001$); there was no significant difference in specificity between the two (93.5% vs 90.8%, $p = 0.062$). Subgroup analysis showed that T2 Mapping had the most significant diagnostic advantage in early cartilage injury (Grade 1), with sensitivity (78.5%) 33.2% higher than that of traditional MRI (45.3%) ($p < 0.001$). *Conclusion:* The diagnostic efficacy of T2 Mapping quantitative imaging for knee joint cartilage injury is significantly superior to that of traditional MRI, especially in the detection of early cartilage injury and accurate evaluation of weight-bearing area injury. Data verify its clinical applicability and reliability. It can be used as an important supplementary method to traditional MRI, and is recommended for the early diagnosis, grading evaluation, and clinical follow-up of cartilage injury.

**Keywords:** Traditional MRI; T2 Mapping; Cartilage injury; Diagnostic efficacy; Retrospective analysis

**Online publication:** Feb 11, 2026

# 1. Introduction

Cartilage injury is a common lesion in the fields of orthopedics and sports medicine. Its pathological process starts with biochemical changes such as cartilage matrix degradation and collagen fiber arrangement disorder, followed by gradual cartilage softening, erosion, and defect, which can eventually progress to osteoarthritis (OA), seriously affecting patients' joint function and quality of life. Early diagnosis and intervention of cartilage injury are crucial to delay disease progression and avoid irreversible damage to joint function [1].

As a non-invasive imaging examination method, traditional MRI has been widely used in the diagnosis of knee joint lesions. It evaluates the integrity of cartilage through morphological observation, relying on morphological changes such as thinning of cartilage thickness, irregular surface, and abnormal signal for diagnosis. However, early cartilage injury only shows biochemical changes (such as increased water content and collagen degradation), which are difficult to identify by traditional MRI, leading to insufficient sensitivity in early diagnosis [2].

T2 Mapping is a quantitative imaging technology based on MRI. By measuring the T2 relaxation time of cartilage tissue, it indirectly reflects the hydration state, collagen fiber arrangement, and matrix integrity of cartilage, and can detect early biochemical abnormalities before morphological changes of cartilage [3].

# 2. Research objects and methods

## 2.1. Research objects

### 2.1.1. Inclusion criteria

(1) Aged 20–65 years, regardless of gender;
(2) Admitted with symptoms such as knee joint pain, stiffness, and limited mobility, with clinical suspicion of cartilage injury;
(3) Underwent both traditional MRI sequences and T2 Mapping sequences, and image quality meets the analysis requirements;
(4) Have a clear diagnostic gold standard;
(5) Complete clinical and imaging data.

### 2.1.2. Exclusion criteria

(1) MRI images with severe artifacts affecting the observation of cartilage structure and T2 value measurement;
(2) History of knee joint surgery, infection, tumor, or congenital malformation;
(3) Long-term use of drugs that may affect cartilage metabolism such as glucocorticoids and immunosuppressants;
(4) BMI > 28 $kg/m^2$;
(5) Complicated with systemic diseases such as severe liver and kidney insufficiency and coagulation disorders [4].

## 2.2. Imaging equipment and parameters

All subjects were examined using a 1.5T magnetic resonance device. MR examinations included multiple sequences, including conventional sequences (T1-sag, fspd-sag, fspd-cor, fspd-tra) and T2 Mapping sequences.

## 2.3. Image analysis and diagnostic criteria

### 2.3.1. Image post-processing

All images were transmitted to the Siemens medical workstation (Syngo Via) for analysis. The knee joint cartilage was divided into 14 subregions: patella (medial, lateral), femur (medial anterior, medial middle, medial posterior, lateral anterior, lateral middle, lateral posterior), and tibia (medial anterior, medial middle, medial posterior, lateral anterior, lateral middle, lateral posterior). On the T2 Mapping quantitative map, the region of interest (ROI) of each subregion was manually drawn, avoiding the calcified layer and synovial fluid. The T2 value of each ROI was measured twice, and the average value was taken as the final T2 value of the subregion.

### 2.3.2. Diagnostic criteria

Referring to the International Cartilage Repair Society (ICRS) cartilage injury grading standard, cartilage injury was divided into 5 grades: Grade 0 (normal): normal cartilage morphology, uniform signal, T2 value within the normal reference range (mean ± 1.5SD of asymptomatic group); Grade 1 (mild injury): smooth cartilage surface, abnormal internal signal (high signal on traditional MRI, T2 value increased but < 10%); Grade 2 (moderate injury): slightly irregular cartilage surface, no significant thinning of thickness (thinning < 50%), diffuse abnormal signal (T2 value increased by 10–30%); Grade 3 (severe injury): significantly irregular cartilage surface, significant thinning of thickness (thinning ≥ 50%), but not involving the calcified layer (T2 value increased by > 30%); Grade 4 (extremely severe injury): full-thickness cartilage defect, involving the calcified layer, exposing subchondral bone (T2 value significantly increased or unmeasurable) [5].

### 2.3.3. Image reading process

Two physicians (Physician A and Physician B) with more than 10 years of experience in bone and joint imaging diagnosis independently read the images using a blind method. Diagnosis was made based on traditional MRI images and T2 Mapping images (including quantitative T2 values) respectively, and the injury grade of each subregion was recorded. The interval between image readings was 4 weeks to avoid memory bias. For subregions with inconsistent diagnostic results between the two, a third senior physician (15 years of experience) participated in the consultation, and the consensus opinion was taken as the final diagnostic result.

## 2.4. Statistical methods

SPSS 26.0 statistical software and MedCalc 19.0 software were used for data analysis. Measurement data were expressed as mean ± standard deviation ($\bar{x} \pm s$) or median (interquartile range), and intergroup comparison was performed using *t*-test or nonparametric test; count data were expressed as cases (percentage), and intergroup comparison was performed using $\chi^2$ test. The sensitivity, specificity, accuracy, positive predictive value (PPV), and negative predictive value (NPV) of traditional MRI and T2 Mapping for diagnosing cartilage injury were calculated. Receiver operating characteristic (ROC) curve analysis was used to evaluate the diagnostic value of the two technologies, and the area under the curve (AUC) was calculated and *Z*-test was performed. Kappa test was used to analyze the consistency between the diagnostic results of the two technologies and the gold standard (Kappa value: < 0.4 poor consistency, 0.4–0.6 moderate consistency, 0.6–0.8 good consistency, > 0.8 excellent consistency). $p < 0.05$ was considered statistically significant.

# 3. Data acquisition and analysis

## 3.1. Image quality control

All MRI images included in the study underwent strict quality assessment. Special personnel checked the clarity, artifacts, and sequence integrity of the images. Quality assessment standards: Grade 1 (high quality): clear images without artifacts, clear display of cartilage structure and signal, and accurate division of 14 subregions; Grade 2 (qualified): slight artifacts in images, but no impact on cartilage structure recognition and subregion division; Grade 3 (unqualified): obvious artifacts in images, unable to clearly identify cartilage structure or divide subregions. Only Grade 1 and Grade 2 images were included in this study, and Grade 3 images were excluded.

## 3.2. Repeatability test of T2 value measurement

To verify the reliability of T2 value measurement, images of 50 randomly selected patients were remeasured by Physician A after an interval of 2 weeks, and the intraclass correlation coefficient (ICC) was calculated. The results showed that the ICC of T2 value measurement was 0.92 (95% CI: 0.88–0.95), indicating good measurement repeatability. At the same time, the ICC of T2 value measurement of the same batch of images by Physician A and Physician B was 0.89 (95% CI: 0.84–0.93), indicating good interobserver consistency.

## 3.3. Statistical analysis process

### 3.3.1. General data analysis

The sample size, patient age, gender, BMI, and distribution of injury grades of each research center were counted, and the differences in baseline characteristics between each center were compared to ensure intergroup comparability.

### 3.3.2. Statistical analysis of diagnostic results

The number of positive detections of traditional MRI and T2 Mapping in the total sample, each injury grade, and each cartilage subregion was counted respectively, and the corresponding diagnostic efficacy indicators (sensitivity, specificity, accuracy, PPV, NPV) were calculated.

### 3.3.3. ROC curve analysis

Taking the gold standard result as the dependent variable and the diagnostic results of the two technologies as independent variables, ROC curves were drawn, AUC values were calculated, and the overall diagnostic value of the two technologies was compared.

### 3.3.4. Consistency analysis

The Kappa values between the diagnostic results of traditional MRI and T2 Mapping and the gold standard were calculated respectively to evaluate the diagnostic consistency of the two technologies.

# 4. Experimental results

## 4.1. General data

Among the 286 patients, 152 were male (53.1%) and 134 were female (46.9%); aged 20–65 years, with an average age of (38.6 ± 10.2) years; BMI 18.5–27.9 kg/m$^2$, with an average of (22.3 ± 2.1) kg/m$^2$. The baseline data of

each research center were evenly distributed, and there were no significant differences in age, gender, BMI, or composition ratio of injury grades ($p > 0.05$), indicating comparability.

## 4.2. Comparison of overall diagnostic efficacy of the two technologies for cartilage injury

Based on 1836 injured subregions and 2168 normal subregions confirmed by the gold standard, the overall diagnostic sensitivity, accuracy, and AUC value of T2 Mapping quantitative imaging were significantly higher than those of traditional MRI. The specificity and PPV were slightly higher than those of traditional MRI, but the differences were not statistically significant; the NPV was significantly higher than that of traditional MRI ($p < 0.05$). The specific results are shown in **Table 1**.

**Table 1.** Comparison of overall diagnostic efficacy of traditional MRI and T2 mapping for cartilage injury

| Diagnostic indicators | Traditional MRI | T2 mapping | $\chi^2/Z$ value | *p* value |
|---|---|---|---|---|
| Sensitivity (%) | 76.3 (1401/1836) | 89.7 (1647/1836) | 98.642 | < 0.001 |
| Specificity (%) | 90.8 (1969/2168) | 93.5 (2027/2168) | 5.218 | 0.062 |
| Accuracy (%) | 82.5 (3370/4004) | 91.2 (3674/4004) | 102.357 | < 0.001 |
| PPV (%) | 87.6 (1401/1600) | 90.2 (1647/1826) | 4.873 | 0.078 |
| NPV (%) | 81.2 (1969/2424) | 91.8 (2027/2208) | 78.429 | < 0.001 |
| AUC (95%CI) | 0.852 (0.839–0.865) | 0.946 (0.938–0.954) | 12.368 | < 0.001 |

Note: PPV = positive predictive value, NPV = negative predictive value, AUC = area under the receiver operating characteristic curve; the numbers in parentheses correspond to true positive/total positive, true negative/total negative, etc.

## 4.3. Comparison of diagnostic efficacy in different injury grades

Subgroup analysis showed that with the increase of cartilage injury grade, the diagnostic sensitivity of both technologies gradually improved, but the sensitivity of T2 Mapping in each grade was higher than that of traditional MRI, especially the difference was most significant in early injury (Grade 1) (T2 Mapping 78.5% vs traditional MRI 45.3%, $p < 0.001$); in Grade 2 and Grade 3 injuries, the sensitivity of T2 Mapping was still significantly higher than that of traditional MRI ($p < 0.001$); in Grade 4 injuries, the sensitivity of both technologies was high (> 95%), and there was no significant difference ($p = 0.321$). In terms of specificity, both technologies maintained a high level (> 85%) in each injury grade, with no significant difference ($p > 0.05$). The specific results are shown in **Table 2**.

**Table 2.** Comparison of diagnostic sensitivity of the two technologies in different injury grades (%)

| Injury grade | Traditional MRI | T2 mapping | $\chi^2$ value | *p* value |
|---|---|---|---|---|
| Grade 1 (n = 428) | 45.3 (194/428) | 78.5 (336/428) | 106.872 | < 0.001 |
| Grade 2 (n = 615) | 72.2 (444/615) | 90.4 (556/615) | 68.354 | < 0.001 |
| Grade 3 (n = 543) | 86.2 (468/543) | 94.1 (511/543) | 24.189 | < 0.001 |
| Grade 4 (n = 250) | 95.6 (239/250) | 97.2 (243/250) | 1.024 | 0.321 |

# 5. Discussion

## 5.1. Core mechanism of differences in diagnostic efficacy between traditional MRI and T2 mapping

The pathological process of cartilage injury has a typical characteristic of "biochemical changes precede morphological changes" [6]. Early cartilage injury is mainly manifested as collagen fiber rupture and proteoglycan loss in the matrix, leading to abnormal hydration state of cartilage, while there is no significant change in the surface morphology of cartilage. Traditional MRI relies on qualitative observation of cartilage morphology and signal intensity, and its signal abnormalities mainly reflect cartilage morphological changes or severe matrix damage, with insufficient sensitivity to early biochemical abnormalities [7]. In this study, the sensitivity of traditional MRI to Grade 1 cartilage injury was only 45.3%, which fully confirmed this limitation, when cartilage only has biochemical changes without morphological abnormalities, traditional MRI is difficult to identify.

The core advantage of T2 Mapping technology lies in its quantitativeness. The T2 relaxation time directly reflects the microstructure and biochemical state of cartilage tissue. The arrangement direction and density of collagen fibers in the cartilage matrix determine the size of the T2 value. When collagen fibers rupture and arrange disorderly, the transverse relaxation time of water molecules prolongs, and the T2 value increases [8]. In this study, the T2 values of the superficial cartilage of the patellofemoral joint and the central weight-bearing area of symptomatic patients were significantly increased. This change in quantitative indicators can be detected earlier than morphological abnormalities. Therefore, the sensitivity of T2 Mapping to early cartilage injury (Grade 1) is as high as 78.5%, which is significantly superior to traditional MRI [9].

## 5.2. Clinical significance of differences in diagnostic efficacy in different subregions

This study found that the diagnostic efficacy of both imaging technologies in the weight-bearing area was higher than that in the non-weight-bearing area, which is consistent with the clinical characteristics of higher incidence and more severe injury of cartilage in the weight-bearing area. The diagnostic sensitivity (92.3%) and accuracy (93.5%) of T2 Mapping in the weight-bearing area were significantly higher than those of traditional MRI, especially its outstanding ability to detect early injuries in the weight-bearing area. This result has important clinical significance: most patients with knee joint pain are caused by cartilage injury in the weight-bearing area. Early accurate diagnosis of weight-bearing area injury can help physicians clarify the cause of pain, formulate targeted treatment plans, and avoid the progression of injury to severe cartilage defect [10].

## 5.3. Research limitations and future prospects

This study has certain limitations:

(1) Retrospective study design may lead to selection bias (e.g., most included patients have obvious symptoms, and mild asymptomatic injuries may be missed);

(2) There is heterogeneity in the selection of gold standards. Some patients use clinical follow-up diagnosis instead of pathological biopsy, which may affect the diagnostic accuracy;

(3) Only data from 1.5T MRI equipment were included, and the diagnostic efficacy of T2 Mapping under 3.0T MRI equipment was not evaluated. The performance differences of equipment with different field strengths need further research;

(4) The combined diagnostic value of T2 Mapping and other quantitative sequences (such as T1 Mapping, T2* Mapping) was not explored. Combined imaging may further improve the diagnostic efficacy.

Future research can be carried out in the following directions:

(1) Conduct prospective multi-center studies, include more asymptomatic populations, and evaluate the early warning value of T2 Mapping for cartilage injury;
(2) Use arthroscopic pathological biopsy as the gold standard to further improve the reliability of research results;
(3) Compare the diagnostic efficacy of T2 Mapping under MRI equipment with different field strengths;
(4) Explore the diagnostic mode combining T2 Mapping with AI technology, and improve the diagnostic efficiency and consistency through AI automatic segmentation of cartilage subregions and measurement of T2 values;
(5) Conduct long-term follow-up studies to evaluate the monitoring value of T2 Mapping for the treatment effect of cartilage injury.

## 6. Conclusion

This retrospective study systematically compared the diagnostic efficacy of traditional MRI and T2 Mapping quantitative imaging for knee joint cartilage injury. The results showed that the overall diagnostic sensitivity, accuracy, and consistency with the gold standard of T2 Mapping quantitative imaging were significantly superior to those of traditional MRI, especially in the diagnosis of early cartilage injury (Grade 1) and weight-bearing area injury. There was no significant difference in specificity between the two technologies, but T2 Mapping had a higher negative predictive value, which could more reliably rule out cartilage injury. Multi-center data verified the universality and repeatability of T2 Mapping technology. Its quantitative characteristics reduce subjective diagnostic errors and provide an objective basis for the early accurate diagnosis of cartilage injury. Therefore, T2 Mapping quantitative imaging can be used as an important supplementary method to traditional MRI, and is recommended for the early diagnosis, grading evaluation, and clinical follow-up of knee joint cartilage injury, especially for patients with knee joint pain and suspected early cartilage injury.

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## Disclosure statement

The authors declare no conflict of interest.

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# Clinical Observation of TCM Constitution Theory-Based Intervention in the Critical Window of AECOPD

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**Abstract:** Objective: To observe the efficacy and safety of TCM syndrome differentiation-guided herbal intervention for patients with five constitutions during the high-risk window period of acute exacerbation of chronic obstructive pulmonary disease (AECOPD) based on TCM constitution theory. Methods: A total of 300 AECOPD patients in the high-risk window period (54–66 cases for each constitution) were randomly divided into two groups (150 cases each). The control group received fluticasone furoate/umeclidinium/vilanterol inhalation therapy, while the experimental group was additionally given constitution-specific TCM decoctions (e.g., Erchen Decoction combined with Sanzi Yangqin Decoction for Phlegm-Dampness constitution). The treatment course was 8 weeks with a 6-month follow-up. CAT score, TCM syndrome score, pulmonary function, 6-minute walking distance (6MWD), and levels of CRP and IL-6 were observed. Recurrence and safety indicators were recorded. *Results:* After treatment, all indicators improved significantly in both groups ($p < 0.05$), with the experimental group showing superior improvements in CAT score, TCM syndrome score, FEV1, 6MWD, and inflammatory indicators ($p < 0.01$). The recurrence rate was lower in the experimental group during follow-up ($p < 0.05$). No severe adverse reactions or abnormalities in liver/kidney function were observed in either group. *Conclusion:* TCM syndrome differentiation treatment guided by constitution theory can improve symptoms, quality of life, and pulmonary function, reduce inflammatory levels and recurrence rate in AECOPD patients during the high-risk window period, with good safety.

**Keywords:** TCM constitution theory; Acute exacerbation of chronic obstructive pulmonary disease (AECOPD); Risk window period

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## 1. Introduction

Chronic obstructive pulmonary disease (COPD) is a chronic respiratory disease characterized by persistent

respiratory symptoms and airflow limitation, and it is a chronic pulmonary disorder with an extremely high mortality rate [1–3]. This study conducted a prospective clinical trial involving 300 hospitalized AECOPD critical window patients from the Department of Respiratory Medicine to investigate the therapeutic effects of TCM constitution theory-based interventions on exercise tolerance, lung function, inflammatory markers, and TCM symptom scores. The results are reported as follows.

## 2. Subjects and methods

### 2.1. Study subjects and grouping

A total of 300 patients in the critical window of AECOPD, identified with TCM constitutions (phlegm-dampness constitution [Tan Shi Zhi], Qi-deficiency constitution [Qi Xu Zhi], yang-deficiency constitution [Yang Xu Zhi], dampness-heat constitution [Shi Re Zhi], and blood-stasis constitution [Yu Xue Zhi]), were enrolled from the Department of Respiratory Medicine at Chengdu Longquanyi District Hospital of Traditional Chinese Medicine between October 2023 and October 2024. Using a random number table method, patients were sequentially assigned to either the treatment group or the control group (150 patients each) based on their order of admission. This study complied with medical ethics requirements and was approved by the Ethics Committee of Chengdu Longquanyi District Hospital of Traditional Chinese Medicine [4–7].

### 2.2. Diagnostic criteria

The diagnostic criteria for the critical window of AECOPD were established based on the Chinese Expert Consensus on the Diagnosis and Treatment of Acute Exacerbation of Chronic Obstructive Pulmonary Disease and the Chinese Guidelines for the Diagnosis and Management of Community-Acquired Pneumonia in Adults, as follows [8,9]:

#### 2.2.1. Clinical improvement post-treatment

AECOPD patients exhibit significant alleviation of clinical symptoms, but symptoms and lung function have not yet returned to stable-phase levels.

#### 2.2.2. Stable vital signs

(1) Body temperature ≤ 37.0 ℃
(2) Pulse rate ≤ 100 beats/min
(3) Respiratory rate ≤ 24 breaths/min
(4) Systolic blood pressure ≥ 90 mmHg
(5) Ability to eat independently without sleep disruption due to dyspnea.

#### 2.2.3. Adequate oxygenation

Partial pressure of oxygen ($PaO_2$) ≥ 60 mmHg or peripheral oxygen saturation ($SpO_2$) ≥ 90% without supplemental oxygen.

#### 2.2.4. Reduced bronchodilator use

Requirement for short-acting $\beta_2$-agonists < 6 times within 24 hours.

### 2.2.5. Clinical stability

Symptoms remain stable for over 24 hours.

### 2.2.6. Normalized inflammatory markers

White blood cell count < $10 \times 10^9$/L and neutrophil ratio ≤ 75%.

### 2.2.7. No need for intravenous antibiotics

Patients meeting all seven criteria were diagnosed as being in the critical window of AECOPD. TCM Disease Diagnostic Criteria: Based on the TCM Syndrome Diagnostic Criteria for Chronic Obstructive Pulmonary Disease (2011 Edition) and the diagnosis of lung distension (Fei Zhang) in Internal Medicine of Traditional Chinese Medicine:

(1) Chronic and recurrent cough.
(2) Key symptoms including chest and hypochondriac distension, cough with sputum production, shortness of breath or wheezing, severe cases may present palpitations, edema, or cyanosis of the lips.
(3) Triggers, by associated with exposure to external pathogens, overexertion, emotional triggers, or dietary irregularities.

TCM Constitution Classification Criteria: Following the Classification and Determination of TCM Constitutions issued by the China Association of Chinese Medicine, five constitutions were selected.

(1) Phlegm-dampness constitution (Tan Shi Zhi),
(2) Qi-deficiency constitution (Qi Xu Zhi),
(3) Yang-deficiency constitution (Yang Xu Zhi),
(4) Dampness-heat constitution (Shi Re Zhi),
(5) Blood-stasis constitution (Yu Xue Zhi).

## 2.3. Inclusion criteria

(1) Meet the diagnostic criteria for COPD and currently in the stable phase of the disease;
(2) Meet the diagnostic criteria for lung distension in TCM and satisfy one of the 5 constitution types defined in the TCM constitution classification standard;
(3) Aged 50–80 years, irrespective of gender, with an expected survival period exceeding six months;
(4) Have not participated in any other clinical trials within the past six months and are able to complete all study-required assessments;
(5) Agree to participate and sign the relevant informed consent form.

## 2.4. Exclusion criteria

(1) Do not meet the diagnostic criteria for COPD;
(2) Have known specific causes of obstructive airway disease, such as bronchial cystic lesions, diffuse bronchiolitis, or obliterative bronchiolitis;
(3) Concurrent pulmonary encephalopathy, shock, coma, or other psychiatric conditions rendering them unable to make autonomous decisions;
(4) Concurrent non-pulmonary infectious diseases, tissue trauma, autoimmune diseases, etc.;
(5) Concurrent severe primary diseases of the liver, kidneys, hematopoietic system, etc., not caused by

COPD;

(6) Concurrent diseases such as tumors or tuberculosis;

(7) Unwilling to participate in the study, unable to complete questionnaires, or unable to accurately recall the history of COPD acute exacerbations.

## 2.5. Withdrawal and exclusion criteria

(1) Patients taking the Chinese herbal medicine for less than 7 days;

(2) Patients who use other medications outside the study protocol in violation of trial requirements;

(3) Patients with irregular medication adherence or who voluntarily withdraw from the trial;

(4) Patients lost to follow-up or deceased.

## 2.6. Treatment methods

### 2.6.1. Control group

Treated with Fluticasone Furoate/Umeclidinium/Vilanterol Inhalation Powder. Usage: Fluticasone Furoate/Umeclidinium/Vilanterol Inhalation Powder (Relvar Ellipta; Manufacturer: Glaxo Operations UK Limited; Approval Number: Import Drug Registration Certificate No. H20190055; Batch Number: DL2F; Specification: 100 μg: 62.5 μg: 25 μg). Administer one inhalation once daily. The treatment course lasted for 8 weeks, with a follow-up period of 6 months after treatment completion.

### 2.6.2. Treatment group

Received additional traditional Chinese medicine (TCM) treatment based on TCM constitution theory, in addition to the control group treatment.

(1) Phlegm-dampness constitution group

Erchen Decoction combined with Sanzi Yangqin Decoction. Composition: *Pinelliae Rhizoma Praeparatum* 15 g, *Citri Reticulatae Pericarpium* 10 g, Poria 15 g, *Glycyrrhizae Radix et Rhizoma Praeparata* cum Melle 5 g, *Zingiberis Rhizoma Recens* 10 g, P*erillae Fructus* 15 g, *Descurainiae Semen Lepidii Semen* 10 g, *Raphani Semen* 15 g.

(2) Qi-deficiency constitution group

Sijunzi Decoction Composition: *Codonopsis Radix* 15 g, Poria 15 g, *Atractylodis Macrocephalae Rhizoma Praeparatum* 15g, *Glycyrrhizae Radix et Rhizoma Praeparata cum Melle* 5 g, *Astragali Radix* 15 g.

(3) Yang-deficiency constitution group

Sini Decoction. Composition: *Aconiti Lateralis Radix Praeparata* 10 g, *Zingiberis Rhizoma* 10 g, *Glycyrrhizae Radix et Rhizoma Praeparata cum Melle* 5 g, *Epimedii Herba* 15 g, *Morindae Officinalis Radix* 15 g.

(4) Dampness-heat constitution group

Gegen Qinlian Decoction Composition: Puerariae Lobatae Radix 15 g, *Scutellariae Radix* 10 g, *Coptidis Rhizoma* 10 g, *Glycyrrhizae Radix et Rhizoma Praeparata cum Melle* 5 g, Houttuyniae Herba 15 g, Mori Cortex 15 g.

(5) Blood-stasis constitution group

Taohong Siwu Decoction. Composition: *Persicae Semen* 10 g, *Carthami Flos* 10 g, *Rehmanniae Radix*

*Praeparata* 15 g, *Paeoniae Radix Rubra* 10 g, *Angelicae Sinensis Radix* 10 g, *Chuanxiong Rhizoma* 10 g.

The above TCM herbs were provided by Sichuan Provincial Chinese Herbal Pieces Co., Ltd. as decoction pieces. Administration: One dose daily, decocted in water and taken warm 30 minutes after meals. The treatment course lasted for 8 weeks, with a follow-up period of 6 months after treatment completion.

## 2.7. Observation indices

### 2.7.1. TCM syndrome score

A TCM syndrome scoring scale was formulated according to the Criteria for Diagnosis and Therapeutic Effects of Diseases and Syndromes in Traditional Chinese Medicine [10]. Symptoms were graded based on severity into four levels: none, mild, moderate, and severe, corresponding to scores of 0, 1, 2, and 3 points respectively. Four primary symptoms were scored: cough, expectoration (sputum production), wheezing, and shortness of breath. Changes in the TCM syndrome scores of patients in both groups before and after treatment were observed.

### 2.7.2. Pulmonary function testing

Pulmonary function testing was performed on patients by specialized respiratory medicine staff. Changes in the following parameters before and after treatment in both groups were observed: Forced Expiratory Volume in one second (FEV1), Forced Vital Capacity (FVC), and the FEV1/FVC ratio.

### 2.7.3. Exercise tolerance measurement

The 6-minute walk test (6MWT) was used to measure patients' exercise tolerance. Tests were conducted by specialized respiratory medicine staff. Changes in the 6MWT distance for patients in both groups before and after treatment were observed [11].

### 2.7.4. Inflammatory factor detection

Fasting venous blood samples were collected from patients' antecubital veins in the early morning. Changes in the levels of inflammatory factors, including Interleukin-6 (IL-6) and high-sensitivity C-reactive protein (hs-CRP), were observed in both groups before and after treatment. Testing was performed by our hospital's central laboratory: IL-6 was measured using Enzyme-Linked Immunosorbent Assay (ELISA), and hs-CRP was measured using immunoturbidimetry.

### 2.7.5. Dyspnea severity assessment

The COPD Assessment Test (CAT) score was used to assess the severity of patients' dyspnea. A higher score indicates more severe dyspnea. Changes in the CAT scores of patients in both groups before and after treatment were observed [12].

### 2.7.6. Incidence of exacerbation/relapse

Patients were followed up for 6 months. Cases meeting the diagnostic criteria for an acute exacerbation period were defined as relapses. The acute exacerbation rates were compared between the two groups.

### 2.7.7. Safety evaluation

Adverse events occurring during treatment in both groups were recorded. Changes in safety indices such as

blood routine tests, liver function, and kidney function were observed. The safety of both treatment regimens was evaluated.

### 2.8. Statistical methods

Statistical analysis was performed using SPSS software (version 26.0). Continuous variables that were normally distributed are presented as mean ± standard deviation (SD). Comparisons within groups before and after treatment were analyzed using the paired *t*-test. Comparisons between groups were analyzed using the independent samples *t*-test. Continuous variables that deviated from a normal distribution are presented as median and interquartile range [M (P25, P75)]. These were analyzed using non-parametric tests (Mann-Whitney U test for between-group comparisons; Wilcoxon signed-rank test for within-group comparisons). Categorical data are presented as frequencies or percentages and were compared between groups using the Chi-square ($\chi^2$) test. All tests were two-tailed. A $p$-value < 0.05 was considered statistically significant.

## 3. Results

### 3.1. Comparison of baseline characteristics between the two groups

The treatment group comprised 150 patients: 80 males and 70 females; age range 51–80 years, mean age 66.12 ± 7.02 years; mean disease duration 11.15 ± 3.05 years; GOLD (Global Initiative for Chronic Obstructive Lung Disease) pulmonary function grades: Grade II: 66 cases, Grade III: 84 cases. The control group comprised 150 patients: 89 males and 61 females; age range 50–79 years, mean age 66.05 ± 5.97 years; mean disease duration 10.36 ± 3.21 years; pulmonary function grades: Grade II: 80 cases, Grade III: 70 cases. Comparisons of baseline characteristics, including gender, age, disease duration, and pulmonary function grade, between the two groups showed no statistically significant differences ($p > 0.05$), indicating comparability.

### 3.2. Comparison of TCM syndrome scores between the two groups before and after treatment

The results presented show that before treatment, there were no statistically significant differences ($p > 0.05$) in the TCM syndrome scores for cough, expectoration (sputum production), wheezing, and shortness of breath between the two groups.

After treatment, both groups showed significant improvements ($p < 0.05$) in the TCM syndrome scores for cough, expectoration, wheezing, and shortness of breath compared to their respective pre-treatment scores. Furthermore, the magnitude of improvement in each TCM syndrome score was significantly greater in the treatment group compared to the control group, with all differences being statistically significant ($p < 0.05$ or $p < 0.01$).

### 3.3. Comparison of pulmonary function indices between the two groups before and after treatment

The results presented show that before treatment, there were no statistically significant differences ($p > 0.05$) in pulmonary function indices, including FEV1, FVC, and FEV1/FVC, between the two groups.

After treatment, both groups showed significant improvements ($p < 0.05$) in FEV1, FVC, and FEV1/FVC compared to their respective pre-treatment values. Furthermore, the magnitude of improvement in FEV1 was

significantly greater in the treatment group compared to the control group, with a statistically significant difference ($p < 0.05$). However, there were no statistically significant differences between the two groups in the improvement of FVC or FEV1/FVC ($p > 0.05$).

### 3.4. Comparison of inflammatory markers between the two groups before and after treatment

The results presented show that before treatment, there were no statistically significant differences ($p > 0.05$) in serum levels of high-sensitivity C-reactive protein (hs-CRP) or interleukin-6 (IL-6) between the two groups.

After treatment, serum levels of hs-CRP and IL-6 decreased significantly compared to pre-treatment levels in both groups ($p < 0.05$). Furthermore, the magnitude of reduction (decrease) in serum hs-CRP and IL-6 levels was significantly greater in the treatment group than in the control group, and these differences were statistically significant ($p < 0.01$).

### 3.5. Comparison of 6MWT distance and CAT scores between the two groups before and after treatment

The results presented show that before treatment, there were no statistically significant differences ($p > 0.05$) in the 6-minute walk test (6MWT) distance or COPD Assessment Test (CAT) scores between the two groups. After treatment, both groups showed significant improvements ($p < 0.05$) in 6MWT distance and CAT scores compared to their respective pre-treatment values. Furthermore, the magnitude of improvement in both 6MWT distance and CAT scores was significantly greater in the treatment group than in the control group, and these differences were statistically significant ($p < 0.05$ or $p < 0.01$).

### 3.6. Comparison of acute exacerbation incidence between the two groups

The results presented show that all patients completed the 6-month follow-up period. In the control group: There were 62 episodes of acute exacerbation (occurring in 41 patients), resulting in an acute exacerbation incidence rate of 41.3%. Among these exacerbations:18 episodes were mild acute exacerbations that occurred during the treatment period and were resolved with outpatient management. The remaining 44 episodes occurred during the follow-up period. In the treatment group: There were 13 episodes of acute exacerbation (occurring in 13 patients), resulting in an acute exacerbation incidence rate of 8.7%. All exacerbations occurred during the follow-up period. Comparison between groups revealed that the acute exacerbation incidence rate was significantly lower in the treatment group than in the control group, with a statistically significant difference ($p < 0.05$).

### 3.7. Safety evaluation

During the treatment period, no significant adverse events occurred in either group. Furthermore, safety parameters, including complete blood count (CBC), liver function, and kidney function, remained within normal ranges for all patients.

## 4. Discussion

Clinically, COPD progresses through distinct phases: the acute exacerbation period, the high-risk window period for exacerbation, and the stable period [13]. The high-risk window period refers to the interval following the

resolution of an acute exacerbation but before achieving stable disease. During this phase, the patient's condition is highly unstable, with a substantial likelihood of recurrent acute exacerbations, which consequently increases hospitalization rates and mortality [14]. While conventional Western medical therapy has not demonstrated a significant ability to halt the progression of COPD in patients, Traditional Chinese Medicine (TCM), guided by its Holistic Concept and the theory of Syndrome Differentiation and Treatment, offers a complementary approach. TCM intervention not only alleviates clinical symptoms and improves quality of life in the short term but also, in the long term, reduces the frequency of acute exacerbations and ameliorates pulmonary structural damage. Thereby, it prevents further disease progression, embodying the fundamental TCM principle of preventing disease before it occurs, preventing deterioration in existing disease, and preventing relapse after recovery.

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# Composite Deep-Learning Model for 90-Day mRS Prediction in Post-Stroke Patients

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**Abstract:** To counteract small sample size, severe class imbalance and high feature redundancy in 90-day mRS prediction after stroke, this study proposes a four-stage pipeline— "ADASYN re-sampling → clinical + statistical feature screening → dimensionality reduction → 5-fold cross-validation" —and benchmark composite deep-learning architectures. ADASYN first balances the minority classes in the original feature space. Next, a tri-level filter (clinical domain knowledge, variance threshold, mutual information) removes clinically meaningless or redundant variables, after which PCA compresses the remaining features while preserving critical neurological signatures (e.g., brain-herniation history). Four hybrid CNN–RNN models are trained and compared under strict 5-fold cross-validation; the optimal ensemble yields stable, clinically interpretable probabilities that can support individualized rehabilitation planning.

**Keywords:** Stroke; 90-day mRS; Composite deep learning; ADASYN; 5-fold cross-validation

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## 1. Introduction

Spontaneous intracerebral hemorrhage (ICH), a non-traumatic rupture of intraparenchymal vessels, accounts for 10–15% of all stroke admissions. Its abrupt onset, rapid progression and poor prognosis produce an acute-phase case-fatality rate of 45–50%, and roughly 80% of survivors suffer permanent neurological disability, imposing heavy medical and socio-economic burdens [1]. The 90-day modified Rankin Scale (mRS), an ordinal outcome ranging from 0 (no symptoms) to 6 (death), is the standard metric for post-stroke functional independence and rehabilitation potential. Accurate pre-discharge prediction of this score can guide early, individualized neuro-rehabilitation programs and rational allocation of intensive-care resources, ultimately reducing long-term disability [2].

Nevertheless, data-driven prediction of 90-day mRS in ICH patients faces three practical obstacles:

(1) Small sample size

High-quality datasets must integrate personal history, vascular risk factors, treatment protocols and serial neuro-imaging, all of which are costly to collect.

(2) Class imbalance

Favorable outcomes (mRS 0–2) predominate, whereas severe disability (mRS 5) and death (mRS 6) are rare, biasing classifiers toward the majority.

(3) High-dimensional redundancy

Predictive variables span demographic covariates, laboratory values, and hundreds of radiomic descriptors (volume, location, shape, texture) that often contain mutual information.

Recent advances in medical artificial intelligence have introduced machine-learning (ML) and deep-learning (DL) solutions. Machine learning can effectively handle non-linear relationships and interactions between complex features, while also being adaptable to high-dimensional and large-scale datasets [3]. Some researchers have combined modern medical diagnosis with TCM syndrome elements as predictive variables to identify key factors influencing the risk of stroke, thereby improving the accuracy of predictive models [4,5]. Cetinoglu et al. developed a convolutional neural network-based deep learning model for vascular classification and stroke detection [6]. Liu T et al. established a hybrid machine learning model based on deep neural networks to predict the onset of stroke, targeting imbalanced stroke datasets [7]. Zhu et al. employed random-forest regression, gradient-boosting machines and multilayer perceptrons to quantify ICH prognosis [8]. Mao and colleagues reviewed DL-based hemorrhage segmentation and detection, highlighting bottlenecks and remedies [9]. Wang et al. demonstrated that ML models outperform traditional regression on RMSE and MAE when both clinical and imaging features are leveraged [10]. Meng focused on ischemic stroke, offering cross-aisle insights for cerebrovascular diseases [11]. Leveraging outstanding temporal-dependency modeling, deep-learning-centered AI has become the mainstream tool for the re-analysis of medical sequential data [12]. The triad of SCLSTM, Sim-LSTM and CELSTM proposed by Liu Boda sequentially tackles auxiliary diagnosis, intervention recommendation and recovery prediction of post-stroke depression; experiments show diagnosis accuracy reaches 0.737, intervention recommendation 0.895, and recovery-prediction error drops to 4.770, surpassing existing benchmarks across the board [13]. Li Chenhao et al. presented a deep-learning fusion scheme to boost abnormal gait-recognition accuracy [14]. Zhang Yuyu et al. introduced an adaptive deep extreme learning machine that significantly raises minority-class classification accuracy [15].

Despite these efforts, the literature rarely explores composite DL, an ensemble of two or more deep architectures in ICH outcome prediction. Because ICH prognosis is simultaneously shaped by baseline clinical traits, spatial imaging patterns (hematoma shape, oedema location) and temporal dynamics (hematoma expansion, oedema progression), a single network may fail to capture all interactions. Composite models can merge complementary representational strengths, improving both discrimination and calibration.

Accordingly, this study applies composite DL to predict simplified 90-day mRS scores in 97 consecutive ICH patients. The original seven-level mRS was collapsed into four ordered categories to mitigate extreme imbalance. This study has designed a full-cycle pipeline, re-sampling, feature filtering, PCA denoising and 5-fold cross-validation, and compared four CNN–RNN hybrids that respectively specialize in spatial (CNN) and longitudinal (LSTM/GRU) modelling. The most stable ensemble was offered as a ready-to-use tool for precision neuro-rehabilitation.

## 2. Data processing

The dataset comprises complete clinical and imaging records of 97 stroke patients, totaling 210 variables. Clinical descriptors cover baseline demographics and medical history (age, sex, hypertension, diabetes, atrial fibrillation,

previous stroke, coronary artery disease, smoking, alcohol intake, pre-ICH mRS, systolic/diastolic blood pressure, onset-to-first-imaging time, etc.). Imaging descriptors quantify the hematoma and peri-lesional tissue (total hematoma/oedema volume, region-of-interest proportions, 3-D shape indices, grey-level distribution metrics, brain-structure ratios, etc.). The target is the 90-day mRS score (0–6). To accommodate the limited sample size and skewed class frequencies, the original seven-level mRS was collapsed into four ordered categories following established prognostic conventions: Category 0: mRS 0–1 (no or minimal disability), Category 1: mRS 2–3 (moderate disability), Category 2: mRS 4–5 (severe disability), Category 3: mRS 6 (death).

A rigorous preprocessing pipeline was then applied. Missing values were imputed with domain-appropriate statistics (median for continuous, mode for categorical). All numeric features were Z-score standardized to remove scale differences. The cohort was split into training and validation sets using clinically accepted ratios.

To counteract the scarcity of category 3 (mRS = 6) cases, Adaptive Synthetic Sampling (ADASYN) was performed in the original 210-dimensional feature space with k = 5 nearest neighbors, generating 21 synthetic minority samples and expanding the training set to 89 cases while preserving local manifold structure.

Next, a two-tier feature-selection strategy was executed:

(1) Clinical filter

15 core variables (e.g., age, GCS, total hematoma + oedema volume, onset-to-imaging time, systolic BP, hypertension history) were retained on the basis of published prognostic evidence.

(2) Data-driven filter

Imaging features with variance < 0.1 were discarded; mutual information (MI) with the collapsed mRS label was computed for the remainder, and features with MI > 0.05 were kept. The procedure reduced the dimensionality from 210 to 82 informative variables.

Finally, principal-component analysis was applied to the 82 selected features. The first 16 components, explaining ≥ 85% cumulative variance, were retained as the modelling input. This last compression step mitigates the curse of dimensionality while conserving the dominant data variance, providing a compact, denoised representation for the subsequent composite deep-learning training.

To fully align with the multi-dimensional nature of ICH-outcome prediction, structured clinical descriptors, spatially correlated imaging biomarkers, and longitudinal evolution across serial scans. This study designed four composite deep-learning architectures that share a two-branch strategy but differ in their algorithmic backbone.

Branch-1 is dedicated to static information: demographic variables and summarized imaging metrics (e.g., total volumes, shape indices) are vectorized and processed by a module chosen for tabular/spatial data (CNN or Transformer).

Branch-2 targets temporal dynamics: time-series of hematoma/oedema volumes, ventricular ratios, etc., acquired at ≤ 4 time-points, are fed to a sequence-specialized unit (LSTM, GRU or Transformer encoder).

The latent representations produced by the two branches (128-D each) were concatenated, yielding a 256-D fused embedding that is batch-normalized, dropout-regularized ($p$ = 0.3) and fed to a dense classification head with Soft-max to output probabilities for the four collapsed mRS classes (0–3).

**Table 1** summarizes the algorithmic assignment of every composite model; all share the same fusion logic but exploit different inductive biases to maximize information extraction from each data modality.

**Table 1.** Composite-model architectures

| Model name | Sub-model A (role) | Sub-model B (role) |
|---|---|---|
| CNN + LSTM | CNN (2Conv + MaxPool, Local Features) | LSTM (units = 32, sequential dependencies) |
| CNN + GRU | CNN (2Conv + MaxPool, Local Features) | GRU (units = 32, light-weight temporal modelling) |
| LSTM + Transformer | LSTM (units = 32，base-level sequential patterns) | Transformer (4-head self-attention) |
| CNN + Transformer | CNN (2Conv + MaxPool, Local Features) | Transformer (4-head self-attention) |

Training and validation hyper-parameters were tuned specifically for the 4-class imbalance setting:

(1) Training

The model was optimized using the Adam optimizer with a learning rate of 0.001. Categorical cross-entropy was used as the loss function. Training was performed with a batch size of 8 for a maximum of 50 epochs, with early stopping applied (patience = 10).

(2) Validation

Model selection was carried out using 5-fold stratified cross-validation within the training set, yielding approximately 54–55 training samples and 13–14 validation samples per fold. Final generalization performance was assessed on an independent hold-out test set.

(3) Evaluation metrics

Performance was evaluated using accuracy, macro-averaged F1 score, and recall for class 3 (mRS = 6). The latter was prioritized due to its clinical importance and substantial under-representation in the dataset.

## 3. Results

After selection the feature space shrank from 210 → 82 (60.95% redundancy removed); PCA retained 85% variance with only 16 components, raising the first-component contribution from 15.93% to 22.67%.

### 3.1. Model comparison

Internal CV shows CNN-LSTM is the most stable; details are given in **Table 2**.

**Table 2.** Performance comparison of all models

| Model name | Mean accuracy (%) | Accuracy SD (%) | Mean macro-F1 (%) |
|---|---|---|---|
| CNN + LSTM | 70.36 | 2.85 | 67.82 |
| CNN + GRU | 67.14 | 3.52 | 64.05 |
| LSTM + Transformer | 62.50 | 4.17 | 59.38 |
| CNN + Transformer | 65.71 | 3.83 | 62.16 |

### 3.2. Generalization comparison

To benchmark the robustness and generalization boundary of each composite architecture, this study has conducted a lateral evaluation on the fully independent test set; results are consolidated in **Table 3**.

**Table 3.** Performance on the independent test set

| Model name | Accuracy | Macro-F1 | Class-3 recall | Class-3 precision |
|---|---|---|---|---|
| CNN + LSTM | 65.52 | 71.36 | 83.33 | 75.00 |
| CNN + GRU | 62.07 | 67.54 | 75.00 | 70.00 |
| LSTM + Transformer | 55.17 | 60.28 | 66.67 | 62.50 |
| CNN + Transformer | 58.62 | 63.81 | 70.00 | 65.00 |

CNN-LSTM achieved the best overall metrics:

Class 0 accuracy 72.22%, Class 1 accuracy 73.68%, with zero cross-class misclassification, confirming stable discrimination of mild disability.

Class 2 mis-classification rate 22.22%, predominantly drifting to Class 1, indicating residual confusion for moderate outcomes.

Class 3 (extreme disability) recall reached 83.33% and precision 75%, eliminating the chronic under-detection reported by earlier models and demonstrating the perceptual gain of CNN-LSTM on extreme cases.

# 4. Discussion

## 4.1. Value of the proposed pipeline

By inserting re-sampling before any dimensionality reduction, this study synthesize minority samples in the original high-dimensional feature space, preserving critical clinical signatures (e.g., brain-herniation history) that would otherwise be blurred by early compression.

Feature de-noising further removes imaging-derived variables devoid of clinical meaning (e.g., duplicate pixel counts), purifying the input pool and simultaneously increasing both information density and interpretability of the subsequent PCA components.

Closed-loop cross-validation keeps the entire hyper-parameter search and performance estimation inside the training folds, cutting off “random-fit” noise; the CNN-LSTM ensemble consequently exhibits a 2.85% accuracy SD, corroborating its stability and reproducibility.

## 4.2. Performance analysis

The superiority of CNN+LSTM stems from the synergy between “local-pattern extraction” and “sequential dependency modelling”: CNN detects local interactions among features (e.g., joint effect of hematoma volume and age), while LSTM captures latent temporal evolution of the selected principal components (e.g., imaging indices tracking clinical deterioration). Transformer-based variants, limited to only six time-steps, fail to exploit the full power of self-attention.

## 4.3. Limitations & future work

The restricted sample size caps absolute accuracy. Enlarging the cohort or incorporating richer intra-hospital time-series (vital-sign streams) is expected to boost generalizability.

## 5. Conclusion

The proposed pipeline—ADASYN re-sampling → dual-criteria feature selection → PCA → stratified cross-validation, addresses both small-sample and class-imbalance challenges in post-stroke mRS prediction. The CNN + LSTM ensemble achieves 65.52% accuracy and 71.36% Macro-F1 on 97 patients, with an 83.33% recall for the most critical category, offering a practical aid for clinical rehabilitation assessment.

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## Disclosure statement

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# Evaluation of the Application Effect of Intelligent Empowerment Standardized Airway Management Process in Patients Receiving Mechanical Ventilation

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**Abstract:** *Objective*: To investigate the application effect of intelligent empowerment standardized airway management process in patients receiving mechanical ventilation. *Methods*: A retrospective analysis was conducted on the clinical data of 79 EICU inpatients who underwent tracheal intubation and mechanical ventilation treatment at our hospital from January 2023 to May 2025. The patients were divided into a control group (conventional airway management process, n = 40) and a study group (intelligent empowerment standardized airway management process, n = 39) based on the intervention protocols they received. Oral health scores, dental plaque index, oral odor, serum inflammatory markers [C-reactive protein (CRP), procalcitonin (PCT)], clinical pulmonary infection score (CPIS), as well as the incidence of ventilator-associated pneumonia (VAP), duration of mechanical ventilation, and length of stay in the EICU were assessed before and after treatment. *Results:* The baseline values of all indicators were consistent between the two groups before intervention ($p > 0.05$). After corresponding interventions, both groups showed significant improvements in Beck oral health scores, dental plaque index, and oral odor, with more pronounced improvements observed in the study group ($p < 0.05$). After the intervention, the research group showed a significant decrease in serum CRP and PCT levels, as well as CPIS scores ($p < 0.05$). In contrast, the control group experienced an increase in these three indicators to a certain extent ($p < 0.05$). Moreover, the incidence of ventilator-associated pneumonia (VAP), duration of mechanical ventilation, and length of stay in the EICU were all lower in the research group compared to the control group, while the nurse's compliance rate with the protocol was higher in the research group ($p < 0.05$). *Conclusion:* The standardized airway management protocol empowered by intelligent technology can significantly improve nursing compliance, benefit oral health status, reduce the risk of pulmonary infection and systemic inflammation levels, and promote rapid patient recovery, demonstrating considerable potential for widespread adoption.

**Keywords:** Intelligent management; Airway management; Mechanical ventilation; Protocol compliance

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# 1. Introduction

While mechanical ventilation provides critical life support for critically ill patients in the Emergency Intensive Care Unit (EICU), the tracheal intubation procedure can disrupt the normal anatomical and physiological barriers of the upper respiratory tract. Given the often-compromised immune function in these patients, this disruption facilitates the translocation of oral pathogens, thereby increasing the risk of ventilator-associated pneumonia (VAP). VAP not only significantly affects patient prognosis but also prolongs the duration of mechanical ventilation and EICU stay, imposing an additional burden on healthcare resources [1]. Currently, bundled care protocols for VAP prevention have been proposed clinically, often encompassing evidence-based interventions such as standardized oral care and positioning management. However, compliance with standard care protocols remains a persistent issue in clinical practice, particularly in the high-pressure environment of the EICU, where incomplete or inconsistent implementation of nursing measures can compromise the effectiveness of VAP prevention [2]. In view of this, this study examined the clinical data of 79 patients admitted to the EICU of XXX Hospital who underwent tracheal intubation and mechanical ventilation from January 2023 to May 2025. The aim is to deeply integrate information technology with medical resources and explore the application effects of a standardized airway management process empowered by intelligent technology in patients undergoing mechanical ventilation. The findings are reported as follows.

# 2. Data and methods

## 2.1. General data

A retrospective analysis was conducted on the clinical data of 79 EICU inpatients who underwent tracheal intubation and mechanical ventilation from January 2023 to May 2025. Based on the intervention protocols received, patients were divided into a control group (conventional airway management process, n = 40) and a study group (standardized airway management process empowered by intelligent technology, n = 39). A comparison of the general data between the two groups was presented in **Table 1**, demonstrating comparability. This study complied with the Declaration of Helsinki and received informed consent exemption.

**Table 1.** Comparison of baseline demographic and clinical characteristics between the two groups [$\overline{x} \pm s$, n]

| Group | Number of cases (n) | Age (years) | Gender (M/F, n) | BMI (kg/m$^2$) | APACHE II score |
|---|---|---|---|---|---|
| Control group | 40 | 60.15 ± 10.02 | 23 / 17 | 23.44 ± 2.15 | 18.55 ± 3.41 |
| Research group | 39 | 61.24 ± 9.67 | 25 / 14 | 23.19 ± 2.08 | 18.98 ± 3.17 |
| Test statistic ($\chi^2/t$) | - | -0.492 | 0.361 | 0.525 | -0.580 |
| *p*-value | - | 0.624 | 0.548 | 0.601 | 0.564 |

## 2.2. Inclusion criteria

(1) Patients receiving mechanical ventilation for the first time via oral or nasal tracheal intubation;
(2) Aged 18 years or older;
(3) Expected mechanical ventilation duration exceeding 48 hours;
(4) Complete baseline data.

## 2.3. Exclusion criteria

(1) Patients with a hospital stay in the EICU of less than 48 hours due to rapid deterioration or transfer;
(2) Patients diagnosed with or highly suspected of having pneumonia within 48 hours of admission or the initiation of mechanical ventilation;
(3) Pregnant or lactating women;
(4) Patients with severe infections or diseases in other organs;
(5) Patients with severe immunodeficiency, such as AIDS or neutropenia following chemotherapy;
(6) Patients with severe craniofacial trauma, oral and maxillofacial deformities, or a recent surgical history, presenting contraindications for oral care procedures;
(7) Patients with a history of severe chronic pulmonary diseases, such as chronic obstructive pulmonary disease or bronchiectasis.

## 2.4. Methods

The control group received routine standardized airway management. Nurses trained in airway management theory performed the interventions, relying on individual awareness and empirical judgment for practical operations. Information such as body position, cuff pressure measurements, and oral care timing was manually recorded.

The study group received smart technology-enabled interventions in addition to the control group's routine care.

(1) Smart-enabled visual management

A large electronic bulletin board was installed at the nursing station, connected in real-time to the hospital's HIS system. Given the multitasking nature of EICU care, the right side of the board featured a dynamic "bulletin" section and task reminder area, transforming implicit airway management orders (such as cuff pressure measurement, subglottic suctioning, and oral care) into intuitive task lists with numerical sequences (1, 2, 3...). The system automatically sorted tasks based on order times, ensuring nurses had up-to-date information on pending nursing tasks. Additionally, a small whiteboard was placed beside each bed as an extension of the electronic system, used to record personalized handover priorities, such as specific information like "thick sputum requiring enhanced humidification".

(2) Inspection and evaluation closed loop

Based on the standardized system template, print the dedicated "Oral Care Management Implementation Form for Patients with Artificial Airways" and hang it at the foot of the bed. This form integrates the core elements of the modified Beck Oral Assessment Scale, mandating that nurses must first conduct real-time observations of the patient's oral cavity and manually check and score it before performing the prescribed frequency of operations at 08:00, 16:00, 22:00, etc. After completing the operation, they should check the corresponding time slot and sign.

(3) Standardized intervention process

Complete the initial assessment within 6 hours of the patient's mechanical ventilation, and then assess every 8 hours using the Beck Oral Assessment Scale. Elevate the head of the bed to more than 30° provided there are no contraindications. Use a cuff pressure gauge to maintain the tracheal tube cuff pressure between 25–30 $cmH_2O$, measuring and adjusting it every 6 hours. Perform oral care every 8 hours using an irrigation-type oral suction tube, and perform subglottic secretion suctioning before and after the procedure.

(4) Medical-nursing collaboration and dynamic quality control

Establish a data-driven feedback decision-making mechanism. The department appoints a quality control team leader who regularly reviews the "Implementation Form" at the foot of the bed daily to calculate the trend of changes in Beck scores. If an increase in score or abnormal recording is detected, the medical-nursing collaboration procedure is initiated immediately. The nurse reports the quantitative data to the attending physician, who dynamically adjusts the intervention plan based on the score, such as "increasing the nursing frequency from q8h to q6h", "adjusting the type of irrigation solution", or "requesting an oral surgery consultation".

## 2.5. Observation indicators

### 2.5.1. Oral health indicators

The modified Beck Oral Assessment Scale was used to evaluate oral damage in patients at the time of enrollment and after 7 days of treatment. This evaluation mainly covered five aspects: lips, tongue, teeth, saliva, and gums/mucous membranes, with each aspect scored from 0 to 4 points, for a total possible score of 20 points. A higher score indicated more severe oral damage. The sense measurement method was employed to assess patients' oral malodor, with scores ranging from 0 to 5 points; a higher score indicated more severe oral malodor. The dental plaque index of patients was also evaluated, with scores assigned from 0 to 3 points based on the severity of dental plaque, from low to high; a higher score indicated more severe dental plaque.

### 2.5.2. Infection and inflammation indicators

Fasting venous blood samples were collected from patients at the time of enrollment and after 7 days of treatment. An automatic biochemical analyzer was used to measure serum levels of C-reactive protein (CRP) and procalcitonin (PCT). Additionally, patients underwent a Clinical Pulmonary Infection Score (CPIS), which primarily included six items such as body temperature, white blood cell count, and airway secretions, with a total possible score of 12 points. A higher score suggested more severe infection.

### 2.5.3. Clinical outcome indicators and procedural compliance rate

The occurrence of ventilator-associated pneumonia (VAP), duration of mechanical ventilation, and length of stay in the EICU were observed and compared between the two groups of patients. Additionally, the comprehensive compliance rate of nurses with the five core measures of the procedure (positioning, cuff pressure, subglottic suctioning, frequency of oral care, and tool usage) was evaluated. The compliance rate was calculated as follows: Compliance rate = (number of times accurately performed in practice / total number of times required to be performed) × 100%.

## 2.6. Statistical methods

Data analysis was performed using SPSS 22.0 statistical software. After confirming normal distribution through the Shapiro-Wilk test, measurement data were expressed as mean ± standard deviation ($\overline{x} \pm s$), and comparisons between groups were made using the independent samples *t*-test. Categorical data were expressed as rates (%), and differences between the two groups were compared using the $\chi^2$ test. A $p$-value < 0.05 was considered statistically significant.

# 3. Results

## 3.1. Comparison of oral health indicators between the two groups of patients

The baseline Beck oral scores, oral malodor scores, and dental plaque indices were consistent between the two groups before intervention. After corresponding interventions, all three indicators significantly decreased in both groups, with the study group showing lower Beck oral scores, oral malodor scores, and dental plaque indices than the control group ($p < 0.05$). See **Table 2**.

**Table 2.** Comparison of oral health indicators between the two groups of patients ($\overline{x} \pm s$, points)

| Group | Number of cases (n) | Beck oral assessment scale (BOAS) score | | Oral malodor score | | Plaque index (PI) | |
|---|---|---|---|---|---|---|---|
| | | Pre-intervention | Post-intervention | Pre-intervention | Post-intervention | Pre-intervention | Post-intervention |
| Control group | 40 | 11.52 ± 1.60 | 9.88 ± 1.54* | 3.11 ± 0.50 | 2.65 ± 0.45* | 2.12 ± 0.51 | 1.75 ± 0.43* |
| Research group | 39 | 11.15 ± 1.93 | 6.45 ± 1.12* | 3.23 ± 0.61 | 1.14 ± 0.32* | 2.19 ± 0.62 | 0.90 ± 0.26* |
| *t*-value | - | 0.929 | 11.297 | -0.957 | 17.149 | -0.549 | 10.599 |
| *p*-value | - | 0.356 | $p < 0.001$ | 0.341 | $p < 0.001$ | 0.585 | $p < 0.001$ |

Note: Compared with before intervention, *$p < 0.05$.

## 3.2. Comparison of infection and inflammation indicators between the two groups of patients

The baseline levels of infection and inflammation indicators were consistent between the two groups before intervention. After corresponding interventions, the control group showed increased levels of CRP, PCT, and CPIS scores, while the study group showed significant decreases. After intervention, the study group had significantly lower levels of CRP, PCT, and CPIS scores than the control group ($p < 0.05$). See **Table 3**.

**Table 3.** Comparison of infection and inflammation indicators between the two groups of patients ($\overline{x} \pm s$)

| Group | Number of cases (n) | CRP (mg/L) | | PCT (ng/mL) | | CPIS (points) | |
|---|---|---|---|---|---|---|---|
| | | Pre-intervention | Post-intervention | Pre-intervention | Post-intervention | Pre-intervention | Post-intervention |
| Control group | 40 | 74.11 ± 10.29 | 88.43 ± 12.05* | 0.63 ± 0.20 | 0.89 ± 0.25* | 4.15 ± 1.02 | 5.01 ± 1.10* |
| Research group | 39 | 74.88 ± 9.68 | 45.10 ± 9.81* | 0.67 ± 0.17 | 0.30 ± 0.11* | 4.03 ± 0.95 | 3.12 ± 0.88* |
| *t*-value | - | -0.342 | 17.502 | -0.957 | 13.516 | 0.541 | 8.420 |
| *p*-value | - | 0.733 | $p < 0.001$ | 0.342 | $p < 0.001$ | 0.590 | $p < 0.001$ |

Note: Compared with before intervention, *$p < 0.05$.

## 3.3. Comparison of clinical outcomes and process compliance rates between the two groups of patients

The incidence of VAP, duration of mechanical ventilation, and length of stay in the EICU were significantly lower in the study group compared to the control group, while the process compliance rate was higher in the study group ($p < 0.05$). See **Table 4**.

**Table 4.** Comparison of clinical outcomes and process compliance rates between the two groups of patients [$\overline{x}$ ± s, n(%)]

| Group | Number of cases (n) | VAP incidence | Duration of mechanical ventilation (days) | EICU length of stay (days) | Compliance rate (%) |
|---|---|---|---|---|---|
| **Control group** | 40 | 8 (20.00) | 10.22 ± 3.11 | 13.89 ± 4.05 | 62.33 ± 5.15 |
| Research group | 39 | 1 (2.56) | 7.14 ± 2.02 | 10.35 ± 3.15 | 95.12 ± 2.04 |
| Test statistic ($\chi^2/t$) | - | 4.345 | 5.206 | 4.329 | 37.026 |
| *p*-value | - | 0.037 | < 0.001 | < 0.001 | < 0.001 |

## 4. Discussion

The colonization of oral flora and micro-aspiration in patients undergoing mechanical ventilation are the primary causes of VAP, and meticulous oral care targeting these factors is a crucial aspect of VAP prevention. However, the disconnect between traditional nursing management processes and their execution limits the effectiveness of nursing care [3]. Therefore, this study aimed to overcome the compliance challenges of traditional management by intelligently empowering standardized airway management. The specific intervention effects are as follows.

In the results of this study, the average process compliance rate among nurses in the study group was 95.12 ± 2.04%, significantly higher than the 62.33 ± 5.15% observed in the control group. This suggests that intelligent empowerment significantly improved compliance with airway management processes. The reason for this is that traditional nursing management methods have limitations in terms of timeliness and initiative when defining nursing management procedures. In contrast, the study group adopted an airway management process empowered by information technology, which first triggered nurses' attention to tasks through intuitive and visual bulletin boards, transforming abstract time concepts into intuitive visual stimuli. Furthermore, small whiteboards were placed at the bedside to remind nurses of key handover points, avoiding potential omissions in high-pressure environments and allowing them to focus on the quality of nursing care itself [4]. On the other hand, the application of nursing management implementation forms can compel nursing staff to conduct secondary confirmations during operations, helping them transition from subconscious actions to conscious verifications, thereby effectively overcoming potential oversights in their work [5]. Through the feedback decision-making mechanism of daily inspections of implementation forms by head nurses, nursing interventions can shift from empirical execution to precise decision-making. This ensures nurses' compliance with nursing interventions on one hand and enhances the precision of interventions on the other [6]. After intervention, both groups of patients showed significant improvements in Beck oral health scores, odor scores, and dental plaque indices. The reason for this lies in the fact that standardized procedures ensure the proper implementation of oral care measures. Through mechanical rinsing and negative pressure suction, these measures effectively disrupt the dental plaque biofilm, flush out debris between teeth, and remove dental plaque, improving the oral microenvironment while preventing the accumulation of dislodged plaque and waste fluids in the oropharynx [7]. The improved adherence to procedures directly translates into benefits for patients' oral health, as evidenced by more significant improvements in oral health scores [8]. Additionally, this study observed that in the control group, CPIS, CRP, and PCT levels increased after intervention, whereas in the study group, these levels significantly decreased. The reason for this is that intelligent nursing procedures may improve patients' oral environments, reduce the colonization of pathogenic bacteria in patients' mouths, significantly lower the proportion of bacteria entering the lower respiratory tract,

thereby significantly reducing the risk of VAP and the associated systemic inflammatory response, and avoiding prolonged mechanical ventilation and EICU stays as a result [9]. This is consistent with the viewpoint proposed by Liao Mingyu et al. in their study that the combined detection of indicators such as CPIS, CRP, and PCT can effectively evaluate the risk of VAP occurrence and prognosis [10].

## 5. Conclusion

In conclusion, the standardized airway management process empowered by intelligence can significantly improve the compliance of EICU nurses in implementing nursing measures. It may be beneficial for improving the oral health status of mechanically ventilated patients, reducing the risk of infection and systemic inflammatory response, and shortening the duration of mechanical ventilation and EICU hospitalization. However, this study still has certain limitations. As a retrospective study, there may be unobserved selection bias, and since it is a single-center study, the extrapolation of its intervention effects may be limited. In the future, multi-center, prospective randomized controlled trials are needed to enhance the credibility of the research results.

## Disclosure statement

The author declares no conflict of interest.

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# Examining the Impact of Heparin-Free Dialysis Supplemented with Infrared Lamp Irradiation on Coagulation in Dialyzers

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**Abstract:** *Objective*: To investigate the effects of infrared lamp irradiation therapy on the risk of arteriovenous fistula thrombosis in patients undergoing heparin-free dialysis and those receiving appropriate reductions in heparin anticoagulation dosage during dialysis. *Methods*: This study was conducted from January 1, 2021, to December 31, 2021, involving 19 patients who regularly underwent heparin-free dialysis for more than three months at our hospital, totaling 70 patient encounters. Each patient underwent heparin-free dialysis for more than two cycles during the experimental period. The study employed a self-control design. Prior to the experiment, an experienced medical team established an emergency management group and formulated relevant emergency measures, ensuring the long-term stability of patients' vital signs before enrollment. Patients requiring heparin-free dialysis as per medical advice underwent the procedure according to the treatment manual without additional interventions. During the second heparin-free dialysis session within the experimental period, patients received 40 minutes of infrared lamp irradiation as an adjunctive therapy during the dialysis process. The study observed coagulation in the dialyzer, blood biochemical indicators, the occurrence of adverse reactions, and patient satisfaction during treatment. *Results:* The use of heparin-free dialysis combined with infrared irradiation therapy resulted in better coagulation outcomes compared to heparin-free dialysis alone ($p < 0.05$). There was no statistically significant difference in blood biochemical indicators between patients receiving heparin-free dialysis combined with infrared irradiation therapy and those receiving heparin-free dialysis alone ($p > 0.05$). There was no statistically significant difference in the number of patients experiencing adverse clinical symptoms such as angina, dizziness, and lower limb cramps, leading to treatment interruption, between those receiving heparin-free dialysis combined with infrared therapy and those receiving heparin-free dialysis alone ($p > 0.05$). Patient satisfaction was higher among those receiving heparin-free dialysis combined with infrared therapy compared to those receiving heparin-free dialysis alone ($p < 0.05$). *Conclusion:* The use of infrared lamp irradiation therapy as an adjunct to heparin-free dialysis can reduce the risk of coagulation to a certain extent without affecting the stability of core blood biochemical indicators in patients. It also reduces the incidence of clinical adverse reactions caused by coagulation, demonstrating good safety and improving patient satisfaction.

**Keywords:** Heparin-free dialysis; Infrared lamp; Heparin anticoagulation

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# 1. Introduction

Heparin is the most commonly used anticoagulant in extracorporeal circulation for blood purification techniques. However, with the increasing number of uremic patients in recent years, the number of cases with active bleeding has gradually risen, leading to more frequent clinical use of heparin-free dialysis [1]. Heparin-free dialysis primarily reduces the risk of coagulation by increasing blood flow velocity and regularly flushing the circuit with physiological saline. Nevertheless, in practice, it still faces the issue of a high incidence of coagulation in the extracorporeal circulation circuit, especially within the dialyzer. Moderate to severe coagulation not only decreases dialyzer efficiency and leads to inadequate treatment but may also cause blood loss, increase medical costs, and even endanger patient safety due to frequent circuit replacements or premature treatment termination [2]. Far-infrared rays are a type of electromagnetic wave with a wavelength range of 3–1000 μm, possessing penetrability and thermal effects [3]. Studies have shown that irradiation with far-infrared rays of specific wavelengths in the field of cardiovascular medicine exhibits multiple biological effects, such as improving vascular endothelial function, promoting microcirculation, inhibiting platelet aggregation, and reducing inflammatory responses [4]. However, there are few reports both domestically and internationally on the use of far-infrared irradiation as an adjunctive physical anticoagulant method in heparin-free dialysis, directly applied to the extracorporeal circulation circuit and the patient's limbs to reduce coagulation within the circuit. At our hospital's hemodialysis center, under the premise of stable patient conditions, we conducted a study comparing heparin-free dialysis with and without adjunctive infrared therapy. The results indicated that adjunctive infrared lamp irradiation therapy could, to a certain extent, reduce the risk of coagulation and the incidence of clinical adverse reactions caused by coagulation. The report is as follows.

# 2. Materials and methods

## 2.1. General information

The study subjects were 19 patients who underwent regular dialysis at our hospital for more than three months from January 1, 2021, to December 31, 2021, and required heparin-free dialysis.

### 2.1.1. Inclusion criteria

(1) Presence of active bleeding symptoms or high risk of bleeding;
(2) No use of any procoagulant medications in the recent period;
(3) No interventions that may promote coagulation, such as blood transfusions or intravenous infusions, during hemodialysis procedures;
(4) Excellent vascular access status, with blood flow rates through autogenous arteriovenous fistulas or central venous catheters stably reaching 240 mL/min.

### 2.1.2. Exclusion criteria

(1) Age under 18 years old;
(2) Individuals unable to complete the entire treatment regimen;
(3) Presence of broken skin, ulcers, or photosensitive lesions at the irradiation site;
(4) Platelet count exceeding the upper limit or falling below the lower limit of the normal reference range;
(5) Patients with diabetic nephropathy and multiple organ failure;

(6) Patients with insufficient blood flow velocity to meet the basic requirements for hemodialysis operation.

### 2.1.3. Study groups

Among the 19 patients, there were 11 males and 8 females; their ages ranged from 22 to 75 years, with an average age of (61.02 ± 14.76) years; the primary diseases included diabetic nephropathy (4 cases), polycystic kidney disease (2 cases), hypertensive nephropathy (6 cases), lupus nephritis (4 cases), and chronic glomerulonephritis (3 cases). Among the 19 patients, there were 2 cases of gastrointestinal bleeding, 12 cases of gingival bleeding, 1 case of skin and mucous membrane bleeding, and 4 cases were in menstruation. All patients underwent heparin-free hemodialysis three times within one week, with the treatment cycle determined according to medical advice. A description of the relevant research conducted on patients who met the inclusion criteria was provided, and both patients and their families were fully informed of the research risks and benefits and signed informed consent forms. This study was approved by the hospital's ethics committee.

## 2.2. Methods

Before the experiment, an emergency management team was established by experienced medical staff, and relevant emergency measures were formulated in advance to ensure long-term stability of vital signs in patients before enrollment. For patients undergoing heparin-free hemodialysis, no additional treatment was administered during the first cycle of heparin-free hemodialysis as per medical advice; during the second cycle of heparin-free hemodialysis, patients received 40 minutes of infrared lamp irradiation as an adjunctive therapy during dialysis, as per medical advice. During the experiment, close attention was paid to the patients' mental state and whether they exhibited symptoms such as angina, dizziness, and lower limb cramps, with records made accordingly. Biochemical examination indicators were monitored monthly throughout the experimental period, with hemoglobin and platelet data collected for each group of patients. The usage status of arteriovenous fistulas was assessed on a monthly basis.

## 2.3. Evaluation indicators

(1) Observe and compare the coagulation occurrence in the dialyzer and venous chamber, as well as the completion of dialysis procedures, following the implementation of two different flushing protocols for heparin-free dialysis. The grading criteria for evaluating the degree of coagulation in the dialysis circuit and dialyzer are as follows. Grade A: No obvious signs of coagulation, or only a small amount of fibrous cord-like coagulation is observed, with no other adverse events occurring. Grade B: Local coagulation or bundled coagulation clots are present, accompanied by mild dizziness, with no other adverse events occurring. Grade C: Relatively obvious coagulation or coagulation in more than half of the fibers is observed in the dialyzer, with some patients experiencing symptoms such as angina, dizziness, and lower limb cramps. Grade D: Severe coagulation necessitates the replacement of the dialyzer, accompanied by symptoms such as angina, dizziness, and lower limb cramps.

(2) Observe and compare changes in patients' blood biochemical indicators. Collect 5 mL of peripheral venous blood from patients and send it to the hospital's laboratory for the detection of hemoglobin, blood phosphorus, blood creatinine, and blood potassium levels using an automatic biochemical analyzer.

(3) Observe and compare the occurrence of adverse reactions in patients, including angina, dizziness, and lower limb cramps.

(4) Patient satisfaction was assessed using a self-designed satisfaction questionnaire from our hospital.

### 2.4. Statistical methods

Data were analyzed using SPSS 23.0 statistical software, with a significance level set at $p < 0.05$.

## 3. Results

### 3.1. Comparison of coagulation status

The coagulation status was significantly better in patients treated with heparin-free dialysis combined with infrared irradiation compared to those treated with heparin-free dialysis alone ($p < 0.05$), as shown in **Table 1**.

**Table 1.** Comparison of coagulation status

| | Frequency of coagulation occurrence | | | Total number of cases | Overall clotting proportion |
|---|---|---|---|---|---|
| | Grade | Frequency | Total frequency of coagulation | | |
| No heparin | A | 98 | 16 | 19 | 14.0% |
| | B | 11 | | | |
| | C | 5 | | | |
| | D | 0 | | | |
| No heparin + infrared | A | 105 | 9 | 19 | 7.9% |
| | B | 6 | | | |
| | C | 3 | | | |
| | D | 0 | | | |

### 3.2. Comparison of changes in blood biochemical indicators among patients

There was no statistically significant difference in the levels of blood biochemical indicators between patients treated with heparin-free dialysis combined with infrared irradiation and those treated with heparin-free dialysis alone ($p > 0.05$), as shown in **Table 2**.

**Table 2.** Comparison of changes in blood biochemical indicators among patients

| | Heparin-free protocol | Heparin-free + infrared protocol | Within-subject max-min difference |
|---|---|---|---|
| Hemoglobin (g/L) | 81–146 g/L | 75–155 g/L | -19 to +23 |
| Phosphorus (mmol/L) | 1.90–5.61 μmmol/L | 1.93–4.64 μmmol/L | -0.51 to +0.55 |
| Pre-dialysis creatinine (μmol/L) | 930–2300 μmmol/L | 900–2340 μmmol/L | -200 to +240 |
| Potassium (mmol/L) | 4.9–6.8 mmol/L | 4.7–6.8 mmol/L | -1.2 to +1.3 |

### 3.3. Comparison of adverse reactions during dialysis among patients

There was no statistically significant difference in the number of patients experiencing adverse clinical symptoms or treatment interruptions between those treated with heparin-free dialysis combined with infrared irradiation and those treated with heparin-free dialysis alone ($p > 0.05$), as shown in **Table 3**.

**Table 3.** Comparison of adverse reactions during dialysis among patients

| Adverse symptom | Heparin-free protocol (n = 112) | Heparin-free + infrared protocol (n = 114) |
|---|---|---|
| Angina Pectoris | 0 | 0 |
| Dizziness/Vertigo | 4 | 4 |
| Lower limb cramps | 5 | 5 |
| Treatment interruption | 1 | 0 |
| Total frequency of adverse symptoms | 10 | 9 |
| Overall incidence of adverse symptoms | 8.9% | 7.9% |

## 3.4. Comparison of patient satisfaction

Patient satisfaction was significantly higher in those treated with heparin-free dialysis combined with infrared irradiation compared to those treated with heparin-free dialysis alone ($p < 0.05$), as shown in **Table 4**.

**Table 4.** Comparison of patient satisfaction

| Protocol | Total cases (n) | Satisfaction rate |
|---|---|---|
| Heparin-free | 19 | 64% |
| Heparin-free + infrared | 19 | 75% |

# 4. Discussion

Heparin-free dialysis is an important dialysis modality for end-stage renal disease (ESRD) patients with a high risk of bleeding. The coagulation status of patients undergoing heparin-free dialysis poses significant risks to their life and health safety, as well as presenting substantial challenges to healthcare providers in terms of treatment [5]. Heparin-based anticoagulants are commonly used in clinical dialysis; however, for patients with high bleeding risks, such as those with active bleeding, severe coagulation disorders, or recent surgery, the use of heparin drugs significantly increases the risk of bleeding. Therefore, heparin-free dialysis becomes the preferred dialysis method for such patients [6]. Nevertheless, during heparin-free dialysis, the contact between blood and artificial materials such as dialysis circuits and filters can easily activate the endogenous coagulation pathway, leading to platelet adhesion, aggregation, and fibrin deposition, which in turn can cause adverse events such as filter clotting and circuit coagulation. These issues not only affect the adequacy of dialysis but may also increase the patient's need for blood transfusions and medical expenses, and even endanger the patient's life [7]. How to effectively prevent coagulation during heparin-free dialysis while avoiding bleeding risks remains a pressing clinical challenge.

In recent years, the application of physical interventions in vascular protection and coagulation management for hemodialysis patients has garnered attention. Infrared lamp irradiation, as a non-invasive physical therapy method, emits far-infrared rays that can penetrate skin tissue, improve local blood circulation, dilate blood vessels, and inhibit platelet aggregation while regulating the activity of coagulation factors. It has demonstrated certain effects in the maintenance of arteriovenous fistulas and the prevention of thrombosis [8]. Studies have confirmed that infrared lamp irradiation can increase the blood flow of arteriovenous fistulas and reduce the risk of stenosis and thrombosis in fistulas [9]. The results of this study indicate that heparin-free dialysis combined with infrared irradiation is superior to heparin-free dialysis alone in terms of coagulation status ($p < 0.05$). The anticoagulant

mechanism of infrared lamp irradiation may be related to its physical properties: the far-infrared rays emitted by the infrared lamp can penetrate tissues, dilate blood vessels through thermal effects, improve local blood circulation, reduce blood viscosity, and decrease platelet aggregation. Additionally, far-infrared rays can regulate the activity of coagulation factors and inhibit the activation of the coagulation cascade, thereby delaying the coagulation process.

There was no statistically significant difference in biochemical indicator levels between patients undergoing heparin-free dialysis combined with infrared therapy and those undergoing heparin-free dialysis alone ($p > 0.05$). The stability of hemoglobin suggests that the intervention did not affect the patient's hematopoietic function or iron metabolism balance, avoiding the potential risk of worsening anemia and increasing cardiovascular complications due to the intervention. The stable levels of blood phosphorus, serum creatinine, and blood potassium indicate that infrared lamp irradiation did not interfere with the solute diffusion and convection clearance mechanisms during dialysis, nor did it affect the residual renal excretion function. By regulating the activity of coagulation factors and inhibiting platelet aggregation through far-infrared rays, the intervention did not involve pathways related to the hematopoietic system or renal solute transport, and therefore did not have adverse effects on the aforementioned core blood biochemical indicators. There was no statistically significant difference in the occurrence of adverse clinical symptoms and treatment interruption between patients undergoing heparin-free dialysis combined with infrared therapy and those undergoing heparin-free dialysis alone ($p > 0.05$), indicating that infrared irradiation therapy does not affect patient treatment and does not increase the incidence of adverse reactions, demonstrating good safety. Patients who underwent heparin-free dialysis supplemented with infrared therapy reported higher satisfaction levels compared to those who received heparin-free dialysis alone ($p < 0.05$). The reduction in coagulation-related events and adverse reactions directly enhanced the comfort of the dialysis process, alleviating discomfort caused by filter clotting, increased venous pressure, muscle cramps, and other issues, without affecting the adequacy of dialysis, the stability of core blood biochemical indicators, or increasing adverse reactions, thereby improving patient satisfaction. Although the duration of infrared irradiation used as an adjunctive therapy in this study exceeded the amounts reported in current domestic literature [10].

## 5. Conclusion

In summary, adjunctive treatment with infrared lamp irradiation can, to a certain extent, reduce the risk of coagulation without affecting the stability of patients' core blood biochemical indicators. It also lowers the incidence of clinical adverse reactions caused by coagulation, thereby improving patient satisfaction and demonstrating good safety and clinical value. However, this study has certain limitations: firstly, the sample size is relatively small, and it is a single-center study, which may introduce selection bias and limit the generalizability of the findings. Secondly, the observation period is relatively short, making it impossible to evaluate the long-term effects of infrared lamp irradiation. Additionally, the molecular mechanisms by which infrared lamp irradiation affects coagulation function, such as its impact on coagulation factor gene expression and platelet activation markers, were not thoroughly explored. Therefore, future research should involve multi-center, large-sample, long-term follow-up clinical studies to further validate the effects of infrared lamp irradiation and delve deeper into its mechanisms of action, providing more robust evidence for its clinical application.

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## Disclosure statement

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# Research on the Efficacy of Autologous Periosteum Graft Combined with PRP in the Treatment of Long Bone Fractures in the Extremities

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**Abstract:** *Objective*: To analyze the clinical application value of autologous periosteum graft combined with platelet-rich plasma (PRP) in the treatment of long bone fractures in the extremities. *Methods*: A total of 40 patients with long bone fractures in the extremities admitted to Santai Hospital Affiliated to North Sichuan Medical College from January 2023 to January 2025 were included, including cases of upper extremity forearm fractures and lower extremity femoral and tibial fractures. The patients were evenly divided using a random number table, with the control group undergoing open reduction and internal fixation (ORIF) combined with autologous periosteum graft, and the observation group undergoing ORIF, autologous periosteum graft, and PRP injection. Surgical indicators, complication rates, excellent fracture healing rates, functional satisfaction, and joint range of motion were compared between the two groups. *Results:* The surgical indicators in the observation group were similar to those in the control group ($p > 0.05$). The complication rate in the observation group was lower than that in the control group, while the excellent fracture healing rate and functional satisfaction were higher in the observation group ($p < 0.05$). *Conclusion:* Autologous periosteum graft combined with PRP technology is safe and reliable for the treatment of long bone fractures in the extremities, with satisfactory clinical outcomes.

**Keywords:** Periosteum graft; Long bones of the extremities; PRP; Complication rate; Fracture healing

**Online publication:** Feb 11, 2026

## 1. Introduction

Patients with fractures of the long bones of the extremities are at a higher risk of developing nonunion after surgery. Factors such as complex fractures caused by high-energy violence, infection, and improper internal fixation methods for fractures can all potentially lead to fracture nonunion. The treatment of fracture nonunion is time-consuming and challenging, representing a significant dilemma in current orthopedic trauma care [1,2]. Therefore, to enhance the likelihood of primary fracture healing, this study treated long bone fractures with high-risk factors for nonunion by combining autologous periosteal transplantation with Platelet-Rich Plasma (PRP) on the basis of internal fracture fixation. A retrospective analysis was conducted on cases from our hospital from

January 2023 to January 2025, and the report is presented as follows.

## 2. Data and methods

### 2.1. General information

Forty patients with fractures of the long bones of the extremities admitted to Santai Hospital Affiliated to North Sichuan Medical College from January 2023 to January 2025 were selected and evenly divided using a random number table into a control group and an observation group, with 20 patients in each group. In the control group, there were 10 males and 10 females, aged between 20 and 64 years, with an average age of (42.65 ± 4.18) years. In the observation group, there were 11 males and 9 females, aged between 18 and 62 years, with an average age of (42.30 ± 4.29) years. There were no significant differences in the data between the two groups ($p > 0.05$).

#### 2.1.1. Inclusion criteria

(1) Patients with comminuted fractures of the ulna, radius, tibia, or femur who are planned to undergo surgical treatment;
(2) Patients aged between 18 and 65 years;
(3) Patients with complete postoperative follow-up for more than 6 months.

#### 2.1.2. Exclusion criteria

(1) Patients with extremely poor cardiopulmonary function;
(2) Patients unwilling to participate in the study;
(3) Patients with surgical contraindications.

### 2.2. Methods

#### 2.2.1. Control group

(1) Preparation of PRP

Blood Collection and Anticoagulation: After routine disinfection of the skin, use a blood collection needle along with a dedicated separation tube to collect venous blood up to the 8 mL mark (black indicator). Immediately after blood collection, gently invert the test tube 10–20 times to ensure thorough mixing of the anticoagulant with the blood. If collecting multiple tubes, complete the inversion and mixing simultaneously with the assistance of an assistant, ensuring gentle handling throughout the process to prevent hemolysis. First Centrifugation and Plasma Separation: Place the balanced blood collection tubes symmetrically in the centrifuge and centrifuge at a speed of 3500–4000 rpm for 5–10 minutes. After the machine stops, remove the tubes and let them stand for 3–5 minutes to ensure full precipitation of platelets. Then, use a 10 mL syringe equipped with an elongated needle (≥ 7 cm) to aspirate the supernatant layer by layer from top to bottom, which is the platelet-poor plasma (PPP), until approximately 1–2 mL of serum remains.

(2) Surgical procedure

Taking the tibial intramedullary nailing operation as an example, after achieving the desired anesthetic effect, apply and inflate a pneumatic tourniquet. Position the patient in a supine position and use a parapatellar approach. Make a longitudinal incision along the medial side of the patellar tendon to open the expansion portion of the extensor retinaculum. Use retractors to pull the patellar tendon laterally and protect it with a

protective sleeve. Select the intersection point approximately 3 cm medial to the tibial crest and the anterior margin of the tibial plateau as the needle entry point. Use an awl to create an opening, insert a guidewire, and drill through the cortical bone along the guidewire using a trephine. Expand the medullary canal with a flexible reamer, insert an intramedullary nail of appropriate size and length, lock the distal screws, and use an aiming device to lock the proximal screws. Finally, install the end cap.

(3) Periosteal preparation

Taking the ipsilateral tibia as an example. Make a longitudinal incision centered on the fracture site, exposing the skin and subcutaneous tissue, and create an appropriately sized incision. Bluntly dissect the subcutaneous tissue to reach the medial aspect of the tibia. Given that the periosteum in the anteromedial region of the tibia is relatively thick, while the lateral periosteum is thinner, the anteromedial region is typically chosen for harvesting. Incise the periosteum longitudinally along the tibial crest and the anterolateral margin of the diaphysis, and make a transverse incision at the distal end of the initial incision to form a rectangular periosteal flap. The area of this flap should be 10–15% larger than the bone defect area. Subsequently, use a periosteal elevator to gently elevate the entire layer of periosteum from the distal to the proximal end, keeping it closely adhered to the bone surface. Rotate the vascularized periosteal flap to cover approximately one-half to two-thirds of the fracture circumference, and then suture the periosteum to the adjacent soft tissue with a few stitches using antibacterial Vicryl sutures for fixation.

### 2.2.2. Observation group

PRP Resuspension and Collection: Shake the remaining serum portion approximately 20–30 times to thoroughly wash off the platelets adhering to the tube walls and separating gel. Finally, invert the tube and use a 3 mL syringe to extract all the liquid from the tube, which is the required platelet-rich plasma (PRP). The surgical procedure and periosteal preparation methods are the same as those in the control group. After suturing the periosteum and adjacent soft tissues, irrigate the wound cavity with normal saline and inject the prepared PRP into the wound cavity, leaving a drainage tube in place.

Within 24 hours after surgery, all patients are routinely administered intravenous cefuroxime sodium (1.5 g, q8h) to prevent infection. Oral analgesics (celecoxib capsules + tramadol hydrochloride sustained-release tablets) are also given. For patients undergoing lower limb surgery, low molecular weight heparin calcium (4000 IU) is routinely administered subcutaneously starting 12 hours after surgery, once daily. The plasma drainage tube is removed on the second day after surgery.

## 2.3. Observation indicators

(1) Surgical indicators

Observe indicators such as surgical time and intraoperative blood loss.

(2) Complication rate

Observe the probability of complications such as skin infection around the incision, skin necrosis, nonunion, malunion, vascular nerve injury, and ipsilateral intermuscular venous thrombosis.

(3) Excellent and good rate of fracture healing

Patients are followed up in the outpatient clinic 12 months after surgery, and anteroposterior and lateral DR images of the long bone fracture site are taken to assess fracture healing. Excellent indicates no abnormalities such as pain or infection, no malunion, adjacent joint mobility exceeding 90% of the healthy

side, or normal mobility, and normal daily activity ability; good indicates mild pain or mild infection, no malunion, adjacent joint mobility exceeding 70% to 90% of the healthy side, and basically normal daily activity ability; poor indicates severe pain and infection, malunion, adjacent joint mobility less than 70% of the healthy side, and failure to recover daily activity ability.

(4) Functional satisfaction

A self-made functional satisfaction scale was used, covering aspects such as joint range of motion and weight-bearing walking, with a total score of 100 points. Scores exceeding 75 points indicated high satisfaction, scores between 40 and 75 points indicated basic satisfaction, and scores below 40 points indicated dissatisfaction.

### 2.4. Statistical analysis

Data processing was conducted using SPSS 28.0 statistical software. Count data were expressed as [n/%], and the chi-square ($c^2$) test was used for analysis. Measurement data were tested for normal distribution using the K-S method and expressed as [$\overline{x} \pm s$]. Comparisons between groups were made using the independent samples t-test, while comparisons within groups were made using the paired *t*-test. A *p*-value less than 0.05 was considered statistically significant.

## 3. Results

### 3.1. Comparison of surgical indicators between the two groups

The surgical indicators in the observation group were similar to those in the control group ($p > 0.05$), refer **Table 1**.

**Table 1.** Comparison of surgical indicators between the two groups [$\overline{x} \pm s$]

| Group | Number of cases (n) | Operative time (min) | Intraoperative blood loss (mL) |
|---|---|---|---|
| Observation group | 20 | 108.67 ± 9.74 | 101.98 ± 7.71 |
| Control group | 20 | 110.81 ± 9.87 | 103.86 ± 6.98 |
| *t*-value | - | 0.690 | 0.808 |
| *p*-value | - | 0.494 | 0.424 |

### 3.2. Comparison of complication rates between the two groups

The complication rate in the observation group was lower than that in the control group ($p < 0.05$) (see **Table 2**).

**Table 2.** Comparison of complication rates between the two groups [n/%]

| Group | Number of cases (n) | Incision infection | Skin necrosis | Nonunion | Malunion | Vascular/nerve injury | Ipsilateral intermuscular vein thrombosis | Overall incidence rate |
|---|---|---|---|---|---|---|---|---|
| Observation group | 20 | 0 | 0 | 0 | 0 | 0 | 1 (5.00) | 5.00 (1/20) |
| Control group | 20 | 1 (5.00) | 1 (5.00) | 1 (5.00) | 0 | 1 (5.00) | 2 (10.00) | 30.00 (6/20) |
| $\chi^2$-value | - | - | - | - | - | - | - | 4.329 |
| *p*-value | - | - | - | - | - | - | - | 0.038 |

### 3.3. Comparison of excellent and good fracture healing rates between the two groups

The excellent and good fracture healing rate in the observation group was higher than that in the control group ($p < 0.05$), refer **Table 3**.

**Table 3.** Comparison of excellent and good fracture healing rates between the two groups [n/%]

| Group | Number of cases (n) | Excellent | Good | Poor | Excellent/good rate |
|---|---|---|---|---|---|
| Observation group | 20 | 12 (60.00) | 7 (35.00) | 1 (5.00) | 95.00 (19/20) |
| Control group | 20 | 7 (35.00) | 6 (30.00) | 7 (35.00) | 65.00 (13/20) |
| $\chi^2$-value | - | - | - | - | 5.625 |
| *p*-value | - | - | - | - | 0.018 |

### 3.4. Comparison of functional satisfaction between the two groups

Functional satisfaction in the observation group was higher than that in the control group ($p < 0.05$). (see **Table 4**).

**Table 4.** Comparison of functional satisfaction between the two groups [n/%]

| Group | Number of cases (n) | Excellent | Good | Poor | Excellent/good rate |
|---|---|---|---|---|---|
| Observation group | 20 | 11 (55.00) | 7 (35.00) | 2 (10.00) | 90.00 (18/20) |
| Control group | 20 | 6 (30.00) | 6 (30.00) | 8 (40.00) | 60.00 (12/20) |
| $\chi^2$-value | - | - | - | - | 4.800 |
| *p*-value | - | - | - | - | 0.029 |

## 4. Discussion

During the process of fracture healing, the integrity of the periosteum is crucial for successful bone repair. The periosteal tissue at the fracture site of long bone diaphysis is often damaged due to trauma, leading to insufficient local blood supply after surgery [3]. The introduction of exogenous osteogenic growth factors can selectively recruit and activate osteogenic precursor cells within the periosteum, promoting their proliferation and differentiation into osteoblasts. This, in conjunction with the body's inherent repair mechanisms, facilitates the acceleration of fracture and bone defect healing. Based on this, periosteal transplantation techniques have increasingly become an important clinical option for treating non-union fractures. Periosteal transplantation, a method involving the harvesting of autologous periosteum or local periosteal inversion and suture, is fixed to the cleaned-out area of articular cartilage lesions or defects, or to areas with significant periosteal loss due to fracture reduction and avulsion, has been studied in animal models and clinical applications in recent years for repairing cartilage injuries and periosteal defects [4].

Platelet-rich plasma (PRP) is a platelet suspension obtained through centrifugation and concentration. Its primary function lies in the release of various high-concentration growth factors upon activation, such as TGF-β, IGF, bFGF, and PDGF, which initiate and regulate the tissue repair process. These biologically active substances not only promote the repair and regeneration of bone and cartilage tissues but also stimulate peripheral angiogenesis. Based on these biological properties, PRP has been widely used in the medical field for the treatment of fractures, bone tissue necrosis, and degenerative joint diseases [5]. Numerous clinical studies have confirmed that

PRP demonstrates remarkable efficacy in promoting bone healing. Its application not only accelerates new bone formation in areas of bone defects but also helps improve the mechanical quality and structure of the newly formed bone. It is effective in promoting the healing of limb bones and reducing the incidence of nonunion. Compared to single surgical intervention, the synergistic treatment of PRP combined with surgery can more effectively promote postoperative healing of limb fractures and significantly elevate the levels of bone metabolism markers in patients' serum, including osteocalcin, bone-specific alkaline phosphatase, and the concentration of β-I type collagen carboxy-terminal peptide [6].

Advantages of periosteal transplantation:

(1) The periosteal flap is rich in perforating and communicating vascular networks, ensuring abundant blood supply.
(2) A large area of the periosteal flap can be harvested, with options available from both the medial and lateral sides of the tibia.
(3) It does not cause damage to the main vessels or affect the blood supply to the calf muscles.
(4) It promotes osteogenesis, especially when a vascularized periosteal flap is used, which provides a rich blood supply and increases local oxygen content, accelerating the differentiation and proliferation of mesenchymal stem cells into osteoblasts, ultimately leading to the formation of new bone [7].
(5) It accelerates the formation of callus by increasing the differentiation and proliferation of a large number of osteoprogenitor cells into osteoblasts. The germinal layer of the periosteum contains a large number of osteoprogenitor cells, which ultimately form new callus.
(6) It undergoes remodeling to form hard cortical bone. The harvested tibial periosteal flap is rotated and repositioned, with the cancellous bone surrounded by a periosteum rich in blood supply, facilitating the re-establishment of blood circulation at the fracture site and ultimately leading to the formation of new cortical bone.
(7) The periosteum provides abundant blood vessels, conferring strong anti-infective capabilities and reducing the risk of infection [8].

This study employed autologous periosteal transplantation combined with PRP injection therapy for the treatment of long bone shaft fractures, utilizing PRP as a supplementary intervention to the core treatment. The results indicated that the surgical indicators in the observation group were comparable to those in the control group ($p > 0.05$). The complication rate in the observation group was lower, while the excellent fracture healing rate and functional satisfaction were higher than those in the control group ($p < 0.05$). The analysis revealed that this combined therapy, by activating biologically active factors released from platelets, stimulates the directional differentiation of bone marrow mesenchymal stem cells in cancellous bone with periosteum, leading to their transformation into chondrocyte lineage and subsequently accelerating the formation of cartilage matrix [9]. This synergistic effect not only significantly shortened the callus mineralization period but also optimized the cartilage repair process, effectively reducing postoperative adverse events and ultimately achieving more reliable clinical outcomes. Based on clinical case observations at our hospital, for comminuted fractures of the extremities' shafts with a high likelihood of nonunion, adjacent periosteal transplantation to the fracture site combined with PRP intra-wound cavity injection can enhance fracture healing rates and reduce complication rates, outperforming simple internal fixation surgery [10]. The short-term follow-up results of autologous periosteal transplantation combined with PRP for long bone fractures were satisfactory. However, due to the small sample size and limited follow-up duration in this study, the long-term efficacy and safety require further evaluation through extended

follow-up and expanded sample sizes.

## 5. Conclusion

In summary, the combined application of autologous periosteal transplantation and platelet-rich plasma (PRP) technology demonstrates a safe and effective therapeutic strategy for the management of long bone fractures in the extremities. This synergistic approach leverages the osteogenic potential and structural support of the autologous periosteum with the concentrated growth factors and enhanced biological healing environment provided by PRP. Clinical evidence indicates that this combination not only promotes robust bone union and accelerates functional recovery but also exhibits a reliable safety profile with minimal complications. Therefore, it represents a satisfactory and promising option for improving outcomes in patients with such fractures.

## Disclosure statement

The author declares no conflict of interest.

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# Qualitative Research on the Current Implementation Status and Barriers of Nurses' Non-Pharmacological Prescription Authority

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**Abstract:** *Objective*: To systematically review the current implementation status of nurses' non-pharmacological prescription authority and analyze the barriers encountered during its implementation in China, providing countermeasures and references for promoting the standardized implementation of nurses' non-pharmacological prescription authority. *Methods*: A secondary analysis of literature was conducted to systematically search for domestic and international literature related to nurses' non-pharmacological prescription authority. Meta-analysis was performed on eligible literature to evaluate the implementation effects. Simultaneously, semi-structured in-depth interviews were conducted with healthcare workers, patients, and policymakers. Content analysis was used to organize the interview data and extract core issues and barriers. *Results:* A total of 46 international articles were included in the Meta-analysis, which revealed that the implementation of nurses' non-pharmacological prescription authority significantly improved patients' health management outcomes, enhanced healthcare service efficiency, and increased patient satisfaction. *Conclusion:* The implementation of nurses' non-pharmacological prescription authority has demonstrated significant positive effects. However, China faces multiple barriers in its advancement, necessitating efforts in optimizing policy systems, constructing collaborative models, strengthening professional skills training, and improving social awareness to guide the scientific and rational implementation of nurses' non-pharmacological prescription authority.

**Keywords:** Nurses; Non-pharmacological prescription authority; Implementation status; Barrier factors; Qualitative research

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## 1. Introduction

With the aging population and the increasing number of individuals with chronic conditions, the demand for medical services continues to rise, exacerbating the already strained healthcare resources. The prescription authority of nurses has gradually entered the public spotlight as a potential solution to meet patients' health needs,

enhance medical efficiency, and improve the accessibility of healthcare resources. Nurse prescription authority has been implemented abroad for many years, and the effectiveness of nurse prescriptions has been confirmed through practice. Moreover, the positive impact of nurse prescription authority on healthcare providers, patients, and nurses themselves has gained international recognition. From the perspective of doctors, granting nurses prescription authority helps alleviate their diagnostic and treatment burdens, enabling them to focus on complex and challenging cases, thereby mitigating the shortage of medical resources to a certain extent. For nurses, the prescription authority reasonably utilizes their professional skills, increases their autonomy in clinical work, enhances their professional fulfillment, and reduces the loss of nursing talent at its source. For patients, granting nurses prescription authority facilitates the continuity of medical services, improves their healthcare experience, and reduces their medical costs. Currently, research on the implementation status of non-pharmacological prescription authority for nurses in some developed countries has formed a relatively complete system and set of norms [1]. However, research on this topic in China is still in its infancy, with pilot programs implemented only in a few regions, failing to demonstrate their service effectiveness.

# 2. Theoretical basis and research status

## 2.1. Theoretical basis

### 2.1.1. Role theory

Role theory posits that individuals are required to fulfill corresponding responsibilities in accordance with specific role norms during social interactions [2]. Granting nurses the right to prescribe non-pharmacological treatments represents an expansion and reshaping of the nursing role, demanding a transition from traditional prescriber-followers to health managers.

### 2.1.2. Collaborative governance theory

Collaborative governance theory suggests that multiple entities can achieve effective management of public affairs through collaborative interactions [3]. The implementation of nurses' right to prescribe non-pharmacological treatments involves various stakeholders, including nurses, doctors, patients, and policymakers, necessitating clear delineation of responsibilities and collaborative efforts among all parties.

### 2.1.3. Health management theory

Health management theory advocates for a prevention-oriented approach, emphasizing the maintenance and promotion of individual health through comprehensive intervention measures [4]. The fundamental goal of nurses' right to prescribe non-pharmacological treatments is to employ non-pharmacological interventions to provide comprehensive health supervision and management for patients throughout all stages, particularly implementing long-term interventions for patients with chronic diseases.

## 2.2. Research status

Foreign countries started relatively early in the research and practice of nurses' non-pharmacological prescription rights, and have formed a relatively mature system. Starting from the 1990s, the United States began to explore the system of nurses' prescription rights, and has now achieved comprehensive coverage of non-pharmacological prescription rights. Some states have granted nurses limited pharmacological prescription rights.

The implementation of non-pharmacological prescription rights for nurses in the United States has significantly improved medication adherence and health indicator control among chronic disease patients, while also reducing certain medical expenses [5]. The United Kingdom has clarified the legal status of nurses' non-pharmacological prescription rights through the implementation of the Nursing and Midwifery Council Act, establishing a standardized training and assessment system. British research has focused on the implementation effects of non-pharmacological prescription rights for community nurses, finding that non-pharmacological prescriptions such as health guidance and rehabilitation training prescribed by community nurses can effectively reduce hospitalizations and increase the accessibility of primary healthcare services [6].

Research on nurses' non-pharmacological prescription rights in China began in the early 21st century, with early studies mostly focusing on introducing and learning from foreign experiences. With the implementation of the Healthy China strategy, some regions in China have started pilot programs for nurses' non-pharmacological prescription rights, granting nurses the authority to prescribe non-pharmacological interventions such as health guidance and rehabilitation. Existing domestic research primarily investigates the implementation status in pilot regions, finding that the implementation of nurses' non-pharmacological prescription rights is widely recognized by patients and can significantly enhance patients' health awareness and self-management abilities [7]. Studies also indicate that the implementation of non-pharmacological prescription rights for nurses in China faces numerous challenges, such as the lack of a unified legal protection system, substandard professional training for nurses, inadequate medical collaboration mechanisms, and social misconceptions [8,9].

# 3. Research methodology

## 3.1. Secondary literature analysis and meta-analysis

### 3.1.1. Literature search strategy

A systematic search was conducted across databases including PubMed, Web of Science, CNKI (China National Knowledge Infrastructure), Wanfang Data Knowledge Service Platform, and VIP (Chinese Scientific Journal Database), covering the period from the inception of each database to December 2024. The search terms encompassed key concepts such as nurses, non-pharmacological prescription rights, health guidance, rehabilitation prescriptions, and implementation effects, with adjustments made to the Chinese and English search terms based on the specific characteristics of each database.

### 3.1.2. Literature screening and data extraction

Two researchers independently performed literature screening and data extraction. In cases of disagreement, a third-party consultation was employed to resolve differences. The extracted information included basic literature details, study subjects, total sample size, intervention protocols, evaluation metrics, and implementation outcomes.

### 3.1.3. Quality assessment and meta-analysis

The study employed the quality assessment tool from the Joanna Briggs Institute (JBI) Evidence-Based Nursing Center to evaluate the quality of the included literature. Meta-analysis was conducted using Rev Man 5.4 software, and heterogeneity among studies was assessed using the $I^2$ test. If $I^2$ exceeded 50%, a random-effects model was adopted, and the sources of heterogeneity were analyzed simultaneously.

### 3.2. Semi-structured in-depth interviews

#### 3.2.1. Interviewees

Healthcare professionals, patients, and policymakers were selected as interviewees using purposive sampling methods. The sample size was determined based on the principle of information saturation, ultimately recruiting 32 interviewees, including 18 healthcare workers, 8 patients, and 6 policymakers.

#### 3.2.2. Interview outline

Based on the research objectives and the results collated from relevant literature, a semi-structured interview outline was prepared. The outline for healthcare workers included questions on their awareness of nurses' non-pharmacological prescription rights, issues encountered during implementation, self-assessment of professional competence, and collaboration with other entities. For patients, the outline covered their understanding of nurses' non-pharmacological prescription rights, willingness to accept, service experience, and concerns. The outline for policymakers addressed the progress of policy formulation regarding nurses' non-pharmacological prescription rights, challenges encountered during implementation, and factors hindering policy advancement.

#### 3.2.3. Data analysis

The interview data was organized and analyzed using content analysis methodology. Subsequently, core categories and themes were extracted, the logical connections between various themes were clarified, and ultimately, the effectiveness of the interviews was established.

## 4. Results

### 4.1. Meta-analysis results of the implementation of non-pharmacological prescription rights for international nurses

#### 4.1.1. Literature screening results

Initially, 1,256 pieces of literature were retrieved, and ultimately, 46 pieces were included in the meta-analysis, including 24 English articles and 22 Chinese articles. The included literature covered a total of 12 countries, including the United States, the United Kingdom, Australia, and Canada, with a cumulative sample size of 18,623 cases.

#### 4.1.2. Meta-analysis results of implementation effectiveness

(1) Implementation effectiveness in patient health management

38 pieces of literature were selected to analyze the impact of nurses' non-pharmacological prescription rights on patient health management outcomes. The heterogeneity test indicated an $I^2$ value of 38%. Using a fixed-effects model, it was found that the effectiveness rate of health indicator control in patients in the group with nurses' non-pharmacological prescription rights was significantly higher than that in the control group (OR = 1.86, 95%CI: 1.52–2.28, $p < 0.001$). This was particularly evident in the control of blood pressure and blood sugar for patients with chronic diseases such as hypertension and diabetes.

(2) Efficiency level of medical services

A total of 26 articles were included to analyze indicators related to medical service efficiency. The heterogeneity test indicated an $I^2$ value of 42%. Using a fixed-effects model, it was found that granting

nurses non-pharmacological prescription rights could significantly reduce patient waiting times (MD = -15.32, 95% CI: -18.65 to -11.99, $p < 0.001$) and increase the number of patients receiving medical services (OR = 2.13, 95% CI: 1.75 to 2.59, $p < 0.001$).

(3) Patient satisfaction level

When analyzing patient satisfaction, 32 articles were included. The heterogeneity test showed an $I^2$ value of 35%. Using a fixed-effects model, it was found that implementing nurses' non-pharmacological prescription rights could significantly improve patient satisfaction (OR = 2.35, 95% CI: 1.98 to 2.79, $p < 0.001$).

## 4.2. Obstacles to the implementation of nurses' non-pharmacological prescription rights in China

Through coding and analysis of interview data, three core categories of obstacles were identified, as follows.

### 4.2.1. Inadequate institutional framework

Policy makers and nursing administrators generally reflected that, at the current stage in China, there is a lack of unified legal and policy documents to regulate nurses' non-pharmacological prescription rights. The connotations, scope, implementing entities, and boundaries of authority for nurses' non-pharmacological prescription rights have not been clearly defined, and there is a lack of a comprehensive training, assessment, and supervision system, resulting in a lack of institutional support for the implementation of nurses' non-pharmacological prescription rights.

### 4.2.2. Insufficient professional competence among nurses

Some nurses believe that their professional knowledge and skills are inadequate to meet the requirements for implementing non-pharmacological prescription rights. In China's nursing education, there is limited coverage of relevant knowledge such as health management, rehabilitation medicine, and psychology. Nurses have not received systematic training related to non-pharmacological prescriptions, resulting in a lack of confidence when prescribing.

### 4.2.3. Social cognitive biases

Both patients and nurses indicate that the general public has a low level of awareness regarding nurses' non-pharmacological prescription rights. Some patients do not recognize non-pharmacological prescriptions issued by nurses and prefer to follow doctors' guidance. Additionally, media portrayals of nurses' roles are often limited to traditional nursing tasks, failing to enhance societal recognition of nurses' non-pharmacological prescription rights.

# 5. Countermeasures and suggestions

## 5.1. Improve the policy and institutional framework to strengthen institutional safeguards

Firstly, accelerate the legislative process. Health administrative departments should collaborate with legislative bodies to formulate legal norms and policy documents related to nurses' non-pharmacological prescription rights, clarifying the concept, scope, implementing entities, boundaries of authority, and legal responsibilities associated with nurses' non-pharmacological prescription rights. This will provide legal safeguards for the advancement of practice and establish a unified catalog of non-pharmacological prescriptions for nurses and operational procedures

to standardize the prescription issuance process.

Second, establish a comprehensive framework for training, assessment, and supervision. Administrative departments should prioritize the establishment of a tiered and categorized training system for non-pharmacological prescriptions for nurses, providing targeted training for nurses at different levels and in various specialized fields. The content should cover multiple areas such as health management, rehabilitation medicine, psychology, and communication skills. A rigorous assessment model should be implemented, linking assessment results to nurses' professional title promotions and performance-based pay distributions. A multi-dimensional supervision system should be constructed to strengthen oversight and control over the prescription and execution of non-pharmacological prescriptions, ensuring their standardization and safety [10].

## 5.2. Strengthen professional training for nurses and enhance core competencies

First, reform the nursing education system. Higher education institutions should optimize the curriculum for nursing programs, incorporating relevant course content in health management, rehabilitation medicine, psychology, public health, and other fields to enhance nurses' professional capabilities and knowledge related to non-pharmacological prescriptions. Students should be arranged to intern at community health centers, chronic disease management institutions, and other settings to accumulate practical experience in non-pharmacological prescriptions.

Second, improve the continuing education system. Health administrative departments and medical institutions should collaborate to offer continuing education programs related to non-pharmacological prescriptions for nurses, providing convenient and efficient training services through a combination of online and offline methods. Expert scholars and clinical leaders can be invited to conduct special lectures and case-sharing sessions to expand nurses' professional knowledge and practical skills. Nurses should also be encouraged to participate in research projects to enhance their evidence-based practice capabilities and proficiency.

## 5.3. Strengthen social publicity and guidance to enhance cognitive level

Firstly, increase media publicity efforts. Relevant departments can utilize diverse media channels such as television, newspapers, and the internet to publicize the critical significance, implementation effects, and typical cases of nurses' non-pharmacological prescription rights. This will enhance the public's awareness and approval of nurses' non-pharmacological prescription rights, promote the professional value and role transformation of nurses, and guide the public to establish an appropriate perception of the nurse's role.

Secondly, carry out health science popularization activities. Nurses should actively engage in health science popularization activities, employing various methods such as community lectures, health consultations, and online science popularization to disseminate health management knowledge and the importance of non-pharmacological interventions to the public. This will elevate the public's health literacy level and drive changes in social cognition through practical outcomes.

# 6. Conclusion

In conclusion, while nurse prescribing rights have demonstrated significant benefits, their implementation in China requires focused efforts to optimize policies, establish collaborative models, enhance professional training, and raise public awareness to ensure their scientific and rational application.

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# Research Advances in Modern Analytical Techniques for Quality Control and Clinical Application of Ganmai Dazao Decoction

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**Abstract:** Ganmai Dazao Decoction, originating from "Jin Gui Yao Lue" (Synopsis of the Golden Chamber), is a classical prescription for treating visceral agitation. Composed of three medicinal and edible substances—licorice (Gancao), wheat (Xiaomai), and jujube (Dazao), it functions to nourish the heart and calm the mind, harmonize the middle burner and regulate Qi, and alleviate urgency and restlessness. As its clinical application has expanded from traditional emotional disorders to neurological, endocrine, and various psychosomatic diseases, establishing a scientifically precise quality control system and deeply elucidating its pharmacodynamic material basis and mechanism of action have become critical tasks. Modern analytical methods, typified by chromatography, spectroscopy, and their hyphenated techniques, with their high sensitivity, high resolution, and powerful substance characterization capabilities, have become the core driving force for standardizing the quality control and modernizing the clinical application research of this formula. This paper systematically reviews the progress of the aforementioned analytical techniques and chemometrics in interpreting the chemical composition, establishing fingerprint profiles, controlling process quality, and researching the pharmacodynamic material basis of Ganmai Dazao Decoction. Furthermore, it discusses integrated approaches combining analytical techniques with pharmacology and clinical medicine to reveal mechanisms of action and explore therapeutic biomarkers. Finally, it provides an outlook on future directions and challenges, including technological integration and innovation, standardization of whole-process quality control systems, and evidence-based research aimed at internationalization.

**Keywords:** Ganmai Dazao Decoction; Quality control; Modern analytical techniques; Fingerprint; Pharmacodynamic material basis; Clinical application

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## 1. Introduction

The vitality of traditional Chinese medicine (TCM) stems from its well-established clinical efficacy. Classical formulas like Ganmai Dazao Decoction serve as important repositories of TCM theoretical principles and

clinical wisdom. However, issues such as complex composition, an imprecise pharmacodynamic material basis, and a weak quality control system have long hindered the modernization and internationalization of Chinese herbal compound formulas. Traditional quality control approaches often rely on a single marker component or morphological identification of herbs, which struggle to systematically represent the holistic, multi-component, multi-target action characteristics of a compound formula. With the rapid advancement of analytical technology, modern techniques such as high-performance liquid chromatography (HPLC), gas chromatography (GC), mass spectrometry (MS), nuclear magnetic resonance (NMR), and their hyphenations have been extensively applied in TCM research. These provide crucial technical support for comprehensively analyzing the chemical composition of Ganmai Dazao Decoction, establishing holistic quality control models, and correlating chemical constituents with pharmacological mechanisms. This actively promotes the transition of this formula from traditional empirical use towards modern precision application. This paper systematically summarizes research progress in the application of modern analytical techniques for the quality control and clinical application of Ganmai Dazao Decoction, aiming to provide theoretical and practical guidance for its further development and scientific utilization.

## 2. Overview of Ganmai Dazao Decoction and quality control challenges

### 2.1. Formula composition and traditional application

Ganmai Dazao Decoction was first documented in "Jin Gui Yao Lue: Fu Ren Za Bing Mai Zheng Bing Zhi" (Synopsis of the Golden Chamber: Miscellaneous Diseases of Women, Pulse Syndromes and Treatment) for treating "visceral agitation in women, characterized by a proclivity to sadness and weeping, as if possessed by spirits, and frequent yawning and stretching". The formula consists of only three herbs: *Glycyrrhizae Radix et Rhizoma* (Gancao, licorice), *Tritici Aestivi Semen* (Xiaomai, wheat), and *Jujubae Fructus* (Dazao, jujube). Its composition is simple yet meticulously balanced. It specializes in harmonizing the middle burner and relieving spasms/urgency, excelling at nourishing the heart and spleen, dispelling irritability, and calming the spirit. It also possesses the functions of supplementing the middle burner and augmenting Qi, nourishing blood and tranquilizing the mind, and harmonizing the various herbs. Together, these actions achieve the effects of nourishing the heart to calm the mind and regulating the middle burner to alleviate spasms [1]. It is primarily indicated for symptoms such as mental confusion, sadness with a tendency to weep, heart vexation, and insomnia caused by excessive worry and contemplation, deficiency of both the heart and spleen, and insufficiency of visceral Yin. This formula fully embodies the TCM therapeutic principle of "when the liver suffers from urgency, sweet substances should be consumed promptly to moderate it", making it a classic prescription for treating emotional disorders. Its significant efficacy has been verified through long-term clinical practice.

### 2.2. Modern clinical application and pharmacodynamic material basis

In modern clinical practice, the application scope of Ganmai Dazao Decoction has significantly expanded. It is widely used to treat various psychosomatic conditions such as anxiety disorders, depression, insomnia, menopausal syndrome, attention deficit hyperactivity disorder (ADHD) in children, and emotional disturbances related to cancer, demonstrating integrated effects in regulating mood, improving sleep, and alleviating somatic symptoms. This broad range of indications reflects the formula's multi-component, multi-target pharmacodynamic material basis and complex mechanism of action. The active components mainly involve triterpenoid saponins

and flavonoids from licorice; amino acids and polysaccharides from wheat; and cyclic adenosine monophosphate (cAMP), flavonoids, and triterpenic acids from jujube. These components may synergistically regulate the levels of neurotransmitters such as serotonin and γ-aminobutyric acid (GABA), inhibit neuroinflammatory responses, modulate the function of the hypothalamic-pituitary-adrenal (HPA) axis, and reduce oxidative stress damage. Through these multiple pathways, they collectively achieve the holistic regulatory functions of calming the spirit and relieving urgency, reflecting the characteristic of compound formulas to intervene through integrated, multi-pathway approaches.

### 2.3. Challenges in quality control

Quality control for Ganmai Dazao Decoction still faces multiple challenges. The quality of its raw herbs is susceptible to factors such as geographical origin, cultivar, cultivation practices, harvesting process, and storage conditions, leading to instability in key component content. Critical components like glycyrrhizic acid in licorice and sugars and cyclic nucleotides in jujube show significant variation. During the decoction process, components may undergo complex physicochemical changes including dissolution, transformation, polymerization, and precipitation, resulting in a chemical composition for the decoction that is not a simple sum of the individual herb components. This complicates standardized quality evaluation [2]. Traditional quality control measures are often limited to the determination of a single marker component (e.g., glycyrrhizic acid), failing to comprehensively represent the overall chemical profile of the compound formula or effectively correlate it with clinical calming efficacy. Establishing a quality evaluation system that can systematically reflect the overall chemical characteristics of the formula, correlate with efficacy, and demonstrate good stability has become a key task for advancing its modernization.

## 3. Application of modern analytical techniques in component analysis of Ganmai Dazao Decoction

### 3.1. The leading role of chromatographic techniques

High-performance liquid chromatography (HPLC), in particular, plays a dominant role in the chemical component analysis of Ganmai Dazao Decoction due to its excellent separation efficiency, rapid analysis capability, and good reproducibility. By systematically optimizing chromatographic columns, mobile phases, and detection conditions, HPLC can simultaneously separate and accurately quantify multiple active components such as liquiritin and glycyrrhizic acid from licorice; jujubosides I, II, and III from jujube; isoliquiritin apioside; and tricin from wheat. This enables a comprehensive assessment of the quality contribution from multiple herbs within the prescription, promoting the shift in quality control approaches from single markers towards multi-marker coordination. Gas chromatography (GC) focuses on analyzing volatile components or derivatized substances like sugars and amino acids, providing an important supplement for interpreting the overall aroma characteristics and nutritional composition of the formula. The application of chromatographic techniques lays a crucial methodological foundation for the quantitative analysis and quality standardization of Ganmai Dazao Decoction.

### 3.2. Refined analysis via spectroscopy and hyphenated techniques

Spectroscopic techniques (such as ultraviolet and infrared spectroscopy) play a role in the rapid identification of herbs but have limitations in resolving complex compound formula systems. Hyphenated techniques like liquid

chromatography-mass spectrometry (LC-MS), combining efficient separation with high-sensitivity structural identification, have become key pathways for the in-depth interpretation of the chemical substance group of Ganmai Dazao Decoction. LC-MS/MS technology, utilizing accurate molecular weight and characteristic fragment ion analysis, comprehensively identifies dozens to hundreds of components in the decoction, including flavonoids, saponins, sugars, and amino acids [3]. High-resolution mass spectrometry can further provide accurate molecular formula data, aiding in the structural elucidation of unknown compounds. Metabolomic methods based on proton nuclear magnetic resonance ($^1$H-NMR) spectroscopy can unbiasedly and comprehensively acquire the overall profile of small molecule metabolites in a sample, presenting a holistic picture of the chemical composition. This approach is suitable for evaluating the quality consistency of products from different batches or produced with different processes and serves as a reliable tool for discovering and screening potential quality markers.

# 4. Analytical technology-driven innovation in quality control strategies

## 4.1. Fingerprint profiling and pattern recognition technology

The integration of fingerprint profiling technology with chemometric analysis provides a holistic quality control method to overcome the limitations of single-component control. Utilizing modern analytical techniques such as HPLC-DAD (diode array detection) and LC-MS to obtain chromatographic or spectral fingerprints of Ganmai Dazao Decoction enables systematic characterization of its overall chemical profile [4]. Employing pattern recognition methods like similarity analysis, principal component analysis (PCA), and cluster analysis allows for quality consistency evaluation and difference tracking among samples from different sources, batches, or manufacturers, identifying key factors affecting quality stability. Further correlation analysis between characteristic peaks in the fingerprint and pharmacological activities such as calming the mind and relieving urgency can help screen “efficacious component groups” closely related to therapeutic effects. This facilitates the construction of a comprehensive evaluation system integrating overall fingerprint recognition with multi-marker component quantification, promoting the evolution of quality control models towards greater holism and correlation.

## 4.2. Process quality control and standardization practice

The in-depth application of Process Analytical Technology (PAT) drives the paradigm shift in Ganmai Dazao Decoction quality control from end-product testing towards dynamic monitoring throughout the production process. In standardized production, techniques like near-infrared (NIR) spectroscopy can enable real-time, non-destructive testing of moisture content and key active components in raw materials during the feeding stage, ensuring material uniformity and controllability. During the decoction process, online monitoring of parameters such as pH, conductivity, and the concentration changes of marker components allows for dynamic optimization of various process parameters, ensuring batch-to-batch consistency in the decoction’s chemical composition and process reproducibility. Further integration of key process parameters with fingerprint information enables the creation of a full-chain quality transmission and digital traceability system from the herb source to the final preparation, thereby achieving precise control over the product’s overall chemical profile. This systematic strategy provides an important technical foundation and quality assurance for the large-scale, standardized production of modern dosage forms of Ganmai Dazao Decoction, such as granules and oral liquids.

## 5. Integration of analytical techniques in clinical application and mechanism research

### 5.1. Elucidating pharmacodynamic material basis and mechanism of action

Modern analytical techniques, integrated with approaches such as serum pharmaco-chemistry and network pharmacology, provide key methodologies for systematically elucidating the pharmacodynamic material basis and mechanism of action of Ganmai Dazao Decoction. Techniques like LC-MS can accurately identify prototype components and their metabolites that enter the bloodstream after oral administration of the decoction, thereby screening for substances potentially exerting direct effects **in vivo*. Based on this, bioinformatics databases can be utilized to predict the action targets and associated signaling pathways of these components, constructing a multi-dimensional association model of "chemical components–biological targets–pathway network–disease phenotype". Subsequently, integrating animal behavioral evaluations with molecular biology experiments allows for the validation of key predicted targets. Metabolomic techniques can then be employed to comprehensively investigate the dynamic changes in endogenous metabolite profiles before and after treatment, systematically revealing the integrative mechanisms through which the formula exerts antidepressant and anxiolytic effects by regulating endogenous metabolic networks related to tryptophan metabolism, energy metabolism, neuroinflammatory pathways, etc. This research framework aids in a deep, multi-dimensional analysis of the scientific rationale behind the "simple formula with potent effects" characteristic of Ganmai Dazao Decoction, from the perspectives of multi-component, multi-target, and multi-pathway synergy [5].

### 5.2. Exploring clinical efficacy biomarkers

Applying high-throughput analytical techniques such as metabolomics and proteomics to clinical research is of great significance for exploring therapeutic biomarkers of Ganmai Dazao Decoction and advancing its application in precision medicine. By systematically analyzing the dynamic changes of endogenous metabolites (e.g., specific amino acids, hormones, lipid molecules) in biological samples like blood and urine from patients with depression or menopausal syndrome before and after treatment, potential biomarkers highly correlated with clinical symptom improvement can be screened. Integrating therapeutic drug monitoring (TDM) to quantitatively analyze the exposure levels of pharmacodynamic components like glycyrrhizic acid and liquiritin in patients allows for the combination of multi-dimensional data: exogenous component concentrations, dynamic changes in endogenous biomarker profiles, and clinical efficacy scores. This facilitates the construction of efficacy prediction models, enabling the identification of patient subtypes with differential responses to treatment. This strategy can provide objective evidence for developing individualized treatment plans in clinical practice, promoting the evolution of Ganmai Dazao Decoction application from the traditional empirical model based on population experience towards a biomarker-based, individualized precision treatment model.

## 6. Future prospects and challenges

### 6.1. Directions for technological integration and innovation

The future development of analytical techniques in Ganmai Dazao Decoction research will exhibit a trend of multi-dimensional deep integration. Combining spatially resolved mass spectrometry imaging with histopathology can visualize the distribution of formula components within target organs such as the brain and gut at the tissue level, directly revealing their spatial sites of action. Artificial intelligence (AI) and machine learning can perform deep

mining of complex multi-omics data, automatically screening key chemical and biological markers highly relevant to quality control and clinical efficacy, thereby enhancing the intelligence level of quality control and efficacy prediction. Developing rapid, environmentally friendly **in situ** and online analytical techniques, combined with minimally invasive sampling methods, can facilitate real-time monitoring and dynamic adjustment during clinical treatment, guiding research on this formula towards increasingly precise, personalized, and practical directions.

### 6.2. Pathways towards standardization and internationalization

Promoting the internationalization of Ganmai Dazao Decoction hinges on constructing a scientifically evidence-based quality standard system that aligns with international requirements. This necessitates, based on existing research findings, identifying Critical Quality Attributes (CQAs) that encompass both quality control and efficacy correlation, and establishing corresponding acceptable ranges. Research processes must strictly adhere to internationally recognized drug development standards, utilizing multicenter, large-sample randomized controlled trials (RCTs) and employing modern analytical techniques to build objective, reproducible evidence chains linking chemical composition to biological effects. Furthermore, transforming TCM syndrome improvement into quantifiable, comparable biological indicators is crucial. Only by deeply integrating the core tenets of TCM theory with modern analytical science and clinical evidence-based medicine, and establishing a comprehensive quality control and evaluation system covering the entire chain from herb source, through production, to **in vivo** efficacy assessment, can Ganmai Dazao Decoction be understood and accepted by the international community in a more scientific and transparent manner.

## 7. Conclusion

The continuous advancement of modern analytical techniques provides core methodological support for the systematic research of Ganmai Dazao Decoction, permeating the entire process from exploring its chemical material basis, constructing holistic quality control systems, searching for pharmacologically active components, to interpreting clinical efficacy mechanisms. The deep integration of chromatography, mass spectrometry, spectroscopy, and their hyphenated techniques with chemometrics, metabolomics, and other systems biology methods is gradually revealing the multi-component, multi-target, multi-pathway synergistic mechanisms underlying its “simple formula with potent effects”. Achieving precise quality control and clinical application of this formula still relies on the deep interdisciplinary integration of TCM pharmacy, clinical medicine, analytical chemistry, and information science. Furthermore, continuous innovation is needed in analytical technologies, quality standards, and research paradigms. While adhering to the core principles of TCM’s holistic view and syndrome differentiation/treatment determination, actively adopting modern scientific and technological means for in-depth investigation is essential. Ganmai Dazao Decoction is anticipated to exert more targeted and scientifically meaningful clinical application value in the fields of psychosomatic medicine and health promotion.

## Disclosure statement

The author declares no conflict of interest.

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# Curvilinear Supine Position for Pressure Injury Prevention in Pediatric Cardiac Surgery Patients: A Randomized Controlled Trial

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**Abstract:** *Background:* Pressure injury (PI) is a prevalent complication in pediatric cardiac surgery, with higher incidence than in general pediatric populations due to children's thin skin, underdeveloped subcutaneous tissue, and prolonged intraoperative pressure. Objective: To evaluate the effectiveness of the curvilinear supine position (CSP) in preventing PI among children undergoing congenital heart disease (CHD) surgery. *Methods*: Between October 2024 and February 2025, a single-center randomized controlled trial was conducted. Of the 80 children initially enrolled for congenital heart disease (CHD) surgery, 77 (aged 1 month to 14 years) completed the study and were included in the final analysis after 3 were excluded due to protocol violations. Participants were randomly assigned to the CSP group (n = 38) or the conventional supine position group (n = 39). *Results:* The incidence of PI was significantly lower in the CSP group (2.6%) compared to the control group (20.5%) (p = 0.029). Postoperative LDH levels were also significantly reduced in the CSP group (422.67 ± 86.52 U/L vs. 592.92 ± 215.71 U/L; $p$ = 0.031), while preoperative LDH and surgical variables (e.g., cardiopulmonary bypass time) were comparable between groups. Although the CSP group had a shorter hospital stay (17.24 vs. 22.51 days), the difference was not statistically significant (p = 0.085). Caregiver satisfaction was significantly higher in the CSP group (100.0% vs. 84.6%; $p$ = 0.025). *Conclusion:* CSP effectively reduces PI incidence, mitigates tissue injury, and enhances caregiver satisfaction in pediatric cardiac surgery, offering a safe and feasible strategy for perioperative PI prevention.

**Keywords:** Curvilinear supine position; Pressure injury; Children; Perioperative nursing; Cardiac surgery

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# 1. Introduction

Pressure injury (PI) is a common complication among pediatric patients undergoing cardiac surgery [1]. Children are particularly vulnerable due to their thinner epidermal layers, immature skeletal development, and reduced soft tissue padding over bony prominences, which offer less cushioning against prolonged pressure. Additionally, their limited cardiovascular compensatory capacity increases susceptibility to localized ischemia during extended surgical procedures, thereby elevating PI risk compared to adults [2–4]. Epidemiological data indicate that the incidence of PI in children undergoing cardiac surgery ranges from 16.9% to 25%, significantly higher than that observed in general pediatric inpatients [5]. PIs not only prolong hospital stays and increase healthcare costs but may also lead to serious complications such as infection, ultimately impairing postoperative recovery [6,7]. Therefore, identifying effective preventive strategies for PI in this population is of critical clinical importance.

The curvilinear supine position (CSP) is a positioning technique that utilizes specialized support surfaces or adjustable operating table segments to align with the patient's natural spinal curvature.

By increasing the contact area between the body and the supporting surface, CSP aims to reduce localized interface pressure and mitigate the risk of PI development [8]. While CSP has demonstrated promising results in adult surgical populations, evidence regarding its application in pediatric surgery, particularly in children undergoing cardiac procedures, remains scarce, with a notable lack of rigorous efficacy evaluations [9–12].

This study aims to investigate the impact of CSP on PI-related outcomes in children undergoing cardiac surgery, thereby providing evidence-based insights to optimize perioperative PI prevention protocols in pediatric cardiac care.

# 2. Materials and methods

## 2.1. Study participants

This study enrolled 80 pediatric patients who underwent congenital heart surgery in the cardiac surgery department of a tertiary hospital between October 2024 and February 2025.

### 2.1.1. Inclusion criteria

(1) Age between 1 month and 14 years;
(2) Scheduled for surgery in the supine position;
(3) No preoperative pressure injury (PI);
(4) Voluntary participation with informed consent provided by the patient's legal guardian.

### 2.1.2. Exclusion criteria

(1) Presence of comorbid systemic diseases (e.g., severe hepatic or renal impairment);
(2) Preexisting dermatological conditions that could interfere with skin assessment.

### 2.1.3. Sample size estimation

Based on previously published data, the expected incidence of PI was 25% in the control group and 5% in the intervention group [5]. Using PASS 15.0 software with a two-sided significance level of $\alpha = 0.05$ and statistical power of 90% ($\beta = 0.10$), the minimum required sample size was calculated to be 36 participants per group. Anticipating a 10% attrition rate, a total of 80 patients were ultimately recruited and randomly allocated to either

the intervention or control group.

All procedures involving human participants were conducted in accordance with the ethical standards of the institutional research ethics committee (Approval No.: 2024178). Written informed consent was obtained from the legal guardians of all enrolled participants prior to study initiation.

## 2.2. Study design

### 2.2.1. Group allocation

A randomized controlled trial design was employed. The 80 enrolled patients were assigned to either the intervention or control group using a random number table, following their order of admission, with 40 participants allocated to each group.

During the study, three participants were excluded due to violation of eligibility criteria: one in the intervention group developed abnormal liver function, another had atopic dermatitis; and one in the control group presented with eczema, conditions that could confound skin assessment.

Consequently, 77 participants completed the study: 38 in the intervention group and 39 in the control group. The intervention group received care in the curvilinear supine position (CSP), while the control group was positioned in the standard supine position throughout surgery.

### 2.2.2. Blinding procedure

Blinding was implemented for pressure injury (PI) assessors. Two intensive care unit (ICU) nurses who were not involved in intraoperative care were designated as independent evaluators. Prior to assessment, they were blinded to the participants' group allocation. Both assessors received standardized training to ensure consistency and reliability in PI evaluation.

### 2.2.3. Intervention protocol

Both groups received standard perioperative care for congenital heart disease (CHD) surgery, including preoperative fasting, intraoperative vital sign monitoring, and routine postoperative nursing care. On this foundation, different positioning strategies were implemented.

(1) Control group

Patients were placed in the conventional supine position. Pressure injury (PI) prevention measures followed the Expert Consensus on Prevention of Intraoperative Acquired Pressure Injury [13]. Specifically, the operating table remained level throughout surgery. Memory foam positioning pads were placed under the heels and sacrococcygeal region. Position adjustments were made only as clinically required by the surgical procedure, without intentional modification of joint angles or use of specialized supports to alter body alignment.

(2) Intervention group

In addition to standard care, patients were positioned using the curvilinear supine position (CSP), as follows:

(3) Positioning protocol

For children with height ≥ 150 cm: the headboard, backrest, and seat sections of the operating table were elevated by 10°, while the leg section was lowered by 10°. For children with height < 150 cm: a defatted cotton pad (6–8 cm thick) was placed beneath the shoulders to gently elevate the thorax; a full-length

pressure-relieving pad was placed under the calves to maintain knee flexion at 5–10°; and an inflatable head cushion was used to support the head. The goal was to align the body with its natural physiological curvature, maximize contact surface area with the supporting surface, and minimize pressure on bony prominences [11,12].

Skin assessments were performed by ICU nurses using the blanching test (applying finger pressure to erythematous areas for 3 seconds and observing for blanching) at four time points: during handover from the operating room, and at 24, 48, and 72 hours postoperatively. Any occurrence of pressure injury was documented according to standardized criteria.

#### 2.2.4. Outcome measures

(1) Primary outcome

Incidence of pressure injury (PI): Assessed according to the 2019 guidelines of the National Pressure Injury Advisory Panel (NPIAP) [14]. All assessing nurses received standardized training prior to evaluation. Any skin lesion classified as Stage I or higher was defined as a PI occurrence.

(2) Secondary outcomes

Length of hospital stay: Total number of days from admission to discharge. Serum lactate dehydrogenase (LDH) levels: Venous blood samples were collected at two time points on the day before surgery and 24 hours postoperatively, and analyzed using an automated biochemical analyzer. Caregiver satisfaction: Measured using the Caregiver Satisfaction Survey on PI Prevention, a validated instrument comprising five dimensions: preoperative education, postoperative skin assessment, effectiveness of preventive interventions, communication, and overall nursing care. The scale demonstrated strong internal consistency (Cronbach's $\alpha = 0.85$) and content validity (Content Validity Index, CVI = 0.92). Total scores range from 0 to 100, with scores ≥ 80 indicating "satisfied". Caregiver satisfaction rate was calculated as: Satisfaction rate (%) = (Number of satisfied cases / Total number of cases) × 100%

#### 2.2.5. Statistical analysis

Data were analyzed using IBM SPSS Statistics version 27.0 (IBM Corp., Armonk, NY, USA).

Continuous variables were first tested for normality using the Shapiro–Wilk test. Data that followed a normal distribution are presented as mean ± standard deviation (mean ± SD) and compared between groups using the independent-samples *t*-test. Non-normally distributed continuous data are reported as median (interquartile range [IQR]), i.e., M ($Q_1$, $Q_3$), and analyzed using the Mann–Whitney U test.

Categorical variables are expressed as frequencies and percentages (n [%]) and compared between groups using the chi-square ($\chi^2$) test or Fisher's exact test, as appropriate.

A two-sided $p$ value < 0.05 was considered statistically significant.

## 3. Results

### 3.1. Baseline characteristics

There were no statistically significant differences between the two groups in baseline characteristics, including sex, age, and body weight ($p > 0.05$). Detailed data are presented in **Table 1**.

**Table 1.** Comparison of baseline characteristics between the two groups of pediatric patients

| Variable | Control group (n = 39) | Intervention group (n = 38) | Test statistic | *p* value |
|---|---|---|---|---|
| Sex, n (%) | | | 0.108[a] | 0.742 |
| Male | 23 (59.0) | 21 (55.3) | | |
| Female | 16 (41.0) | 17 (44.7) | | |
| Age (months), median (IQR) | 8.0 (1.0, 24.0) | 12.0 (5.0, 48.0) | -1.72[b] | 0.086 |
| Weight (kg), median (IQR) | 6.8 (4.3, 13.0) | 9.4 (6.0, 15.1) | -1.58[b] | 0.115 |
| Height (cm), median (IQR) | 66.0 (53.0, 95.0) | 79.0 (63.8, 102.3) | -1.73[b] | 0.084 |
| Preoperative albumin (g/L), mean ± SD | 40.01 ± 4.26 | 41.23 ± 4.20 | 0.976[c] | 0.335 |
| Preoperative hemoglobin (g/L), mean ± SD | 121.95 ± 24.68 | 126.24 ± 25.02 | 0.757[c] | 0.451 |
| Preoperative CORN score, mean ± SD | 11.03 ± 0.84 | 11.05 ± 0.96 | -0.131[c] | 0.896 |
| Diagnosis, n (%) | | | 30.003[d] | 0.671 |
| Atrial septal defect | 12 (30.8) | 14 (36.8) | | |
| Ventricular septal defect | 16 (41.0) | 17 (44.8) | | |
| Patent ductus arteriosus | 5 (12.8) | 4 (10.5) | | |
| Anomalous pulmonary venous return | 3 (7.7) | 1 (2.6) | | |
| Aortic valvuloplasty | 1 (2.6) | 0 (0.0) | | |
| Pulmonary valvuloplasty | 2 (5.1) | 2 (5.3) | | |

Notes.

[a] Chi-square test;

[b] Mann–Whitney U test (reported as *Z* statistic);

[c] Independent-samples *t*-test;

[d] Fisher–Freeman–Halton exact test was used because 97.1% of cells had expected frequencies < 5.

## 3.2. Comparison of pressure injury incidence at pressure-prone sites between groups

Pressure injuries (PIs) occurred in 8 patients in the control group, all classified as Stage I (2 at the sacrococcygeal region and 6 at the occiput). In the intervention group, only 1 patient developed a Stage I PI at the sacrococcygeal area. The incidence of PI was significantly lower in the intervention group compared to the control group ($p$ = 0.029). Detailed results are presented in **Table 2**.

**Table 2.** Incidence of pressure injury in the two groups

| Variable | Control group (n = 39) | Intervention group (n = 38) | *p* value |
|---|---|---|---|
| Pressure injury, n (%) | | | 0.029[a] |
| Yes | 8 (20.5) | 1 (2.6) | |
| No | 31 (79.5) | 37 (97.4) | |

Note. [a] $p$ value calculated using Fisher's exact test.

## 3.3. Comparison of length of hospital stay between groups

There was no statistically significant difference in length of hospital stay between the control group and the intervention group ($p$ = 0.085). See **Table 3** for details.

### 3.4. Comparison of serum lactate dehydrogenase (LDH) levels before and after surgery

There was no statistically significant difference in preoperative LDH levels between the two groups ($p > 0.05$). However, postoperative LDH levels were significantly lower in the intervention group compared to the control group ($p = 0.031$).

To account for potential confounding factors, we further analyzed variables such as operative duration and cardiopulmonary bypass time.

No significant between-group differences were observed for these factors ($p > 0.05$), suggesting that the observed LDH reduction was unlikely attributable to procedural variability. Detailed data are provided in **Table 3**.

**Table 3.** Comparison of length of hospital stay and lactate dehydrogenase (LDH) levels between the two groups

| Variable | Control group (n = 39) | Intervention group (n = 38) | Test statistic | *p* value |
|---|---|---|---|---|
| Length of hospital stay (days, mean ± SD) | 22.51 ± 10.90 | 17.24 ± 7.91 | -1.747[a] | 0.085 |
| Preoperative LDH (U/L, mean ± SD) | 305.72 ± 114.96 | 290.82 ± 115.99 | -0.566[a] | 0.573 |
| Postoperative LDH (U/L, mean ± SD) | 592.92 ± 215.71 | 422.67 ± 86.52 | -2.378[a] | 0.031 |
| Operative time (minutes, mean ± SD) | 205.05 ± 112.91 | 174.61 ± 70.87 | -1.413[a] | 0.162 |
| Cardiopulmonary bypass time (minutes, mean ± SD) | 142.46 ± 102.85 | 113.08 ± 71.26 | -1.460[a] | 0.149 |

Note. [a]*p* values were calculated using independent-samples *t*-tests.

### 3.5. Comparison of caregiver satisfaction between the two groups

Caregiver satisfaction was significantly higher in the intervention group than in the control group ($p = 0.025$). Specifically, 33 out of 39 caregivers (84.6%) in the control group reported satisfaction, compared to all 38 caregivers (100%) in the intervention group. These results are summarized in **Table 4**.

**Table 4.** Comparison of caregiver satisfaction between the two groups

| Variable | Control group (n = 39) | Intervention group (n = 38) | *p* value |
|---|---|---|---|
| Caregiver satisfaction, n (%) | | | 0.025[a] |
| Satisfied | 33 (84.6) | 38 (100.0) | |
| Not satisfied | 6 (15.4) | 0 (0.0) | |

Note. [a]*p* value was calculated using Fisher's exact test.

## 4. Discussion

### 4.1. Effectiveness of the curvilinear supine position (CSP) in reducing pressure injury incidence

Pressure injury (PI) arises from prolonged localized pressure that compromises tissue perfusion, leading to ischemia and hypoxia [14]. Children are particularly vulnerable due to their thinner skin, reduced subcutaneous fat, and insufficient cushioning over bony prominences, which collectively diminish their tolerance to mechanical stress [3,15]. In the conventional supine position, pressure becomes concentrated on these bony areas, with local interface pressures often exceeding 100 mmHg, well above capillary closing pressure (about 32 mmHg), thereby predisposing tissues to damage [11,16].

In this study, the intervention group was positioned using the curvilinear supine position (CSP), which aligns the body along its natural physiological curvature by adjusting operating table angles or employing supportive positioning pads. This approach increases the contact surface area between the patient's back and buttocks and the supporting surface. Additionally, heel-offloading pads and an inflatable head cushion were used to further redistribute pressure. Collectively, these measures effectively minimized sustained focal pressure on vulnerable tissues.

Consistent with our hypothesis, the PI incidence in the CSP group was significantly lower than in the control group. This finding aligns with the results of a recent meta-analysis by Chen et al., thereby reinforcing the evidence that CSP is an effective strategy for preventing intraoperative pressure injuries in pediatric patients undergoing cardiac surgery [12].

## 4.2. Effect of CSP on length of hospital stay

Length of hospital stay is influenced by multiple factors, including surgical outcomes and postoperative complications. Pressure injury (PI), as a common iatrogenic complication, has been associated with prolonged hospitalization [17,18]. In the present study, the intervention group exhibited a slightly shorter duration of hospital stay compared to the control group; however, this difference did not reach statistical significance ($p = 0.085$). This lack of significance may be attributed to the fact that, in pediatric congenital heart disease (CHD) surgery, length of stay is primarily determined by the recovery of cardiac function and hemodynamic stability, factors that likely overshadowed the potential impact of PI prevention on hospital duration.

## 4.3. Impact of CSP on serum lactate dehydrogenase (LDH) levels

Lactate dehydrogenase (LDH) is a sensitive, albeit non-specific, biomarker of tissue injury. When skin and subcutaneous tissues experience ischemia and hypoxia due to prolonged pressure, cellular damage occurs, leading to cell membrane rupture and subsequent release of LDH into the bloodstream [19]. However, serum LDH levels can also be influenced by various systemic factors, including hemolysis, myocardial injury, hepatic dysfunction, and cardiopulmonary bypass [20,21].

In this study, preoperative LDH levels were comparable between the two groups. Postoperatively, LDH concentrations were significantly lower in the intervention group than in the control group. Notably, no significant differences were observed between groups in potential confounding variables such as operative duration and cardiopulmonary bypass time. These findings suggest that the curvilinear supine position (CSP) may mitigate local tissue pressure, improve microcirculatory perfusion at pressure-prone sites, and thereby reduce cellular necrosis, ultimately leading to decreased LDH release.

## 4.4. Impact of CSP on caregiver satisfaction

Caregiver satisfaction is a key indicator of nursing care quality. Parents and family members of children undergoing congenital heart disease (CHD) surgery often exhibit heightened concerns regarding surgical risks and their child's pain, leading them to place greater emphasis on the quality and communication of nursing interventions [22].

In the intervention group, the implementation of the curvilinear supine position (CSP) effectively prevented pressure injuries and minimized postoperative skin complications. Furthermore, caregivers received detailed preoperative explanations of the positioning care plan and timely updates regarding their child's skin condition

during the perioperative period. These practices fostered greater trust in the nursing team and enhanced perceived care quality [23].

Consistent with these observations, caregiver satisfaction was significantly higher in the intervention group compared to the control group. This finding suggests that CSP not only offers clinical benefits but also positively influences the overall healthcare experience of families, reinforcing its value as a patient- and family-centered intervention.

### 4.5. Limitations

This study has several limitations. First, it was conducted at a single center with a relatively small sample size, which may limit the generalizability of the findings. Second, we did not perform a dose–response analysis to evaluate how specific parameters of the curvilinear supine position (CSP), such as angle of inclination or type of positioning support which might influence outcomes. Future research should involve multicenter, large-scale randomized controlled trials to further validate the efficacy of CSP, optimize its procedural parameters, and provide more robust evidence to guide positioning protocols in pediatric cardiac surgery.

## 5. Conclusion

The curvilinear supine position (CSP) was associated with a reduced incidence of pressure injury, less tissue damage at pressure-prone sites, and higher caregiver satisfaction among children undergoing cardiac surgery. These findings support CSP as a safe and feasible perioperative intervention that may contribute to improved pressure injury prevention in pediatric cardiac surgical care.

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## Disclosure statement

The authors declare no conflict of interest.

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# The Application Value of Chest CT Combined with Serum Vanin-1 and SPP1 in Diagnosing the Severity of Chronic Obstructive Pulmonary Disease

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**Abstract:** *Objective:* To investigate the quantitative assessment efficacy of chest CT combined with serum Vanin-1 and SPP1 in determining the progression stage of chronic obstructive pulmonary disease (COPD). *Methods:* A total of 100 COPD subjects from our hospital from January 2020 to December 2023 were included and randomly divided into a healthy control group and an experimental group (50 cases each). The healthy control group underwent slow vital capacity measurement using a spirometer, while the experimental group underwent high-resolution thin-slice CT scans and serum Vanin-1 and SPP1 concentration measurements. Pulmonary function parameters, symptom burden, biomarker concentrations, and imaging characteristics were compared between the two groups. *Results:* The FEV1/FVC ratio in the experimental group (58.3 ± 7.2) was lower than that in the healthy control group (92.1 ± 4.8); the total CAT score (22.4 ± 3.5) was higher than that in the healthy control group (3.1 ± 1.2); both Vanin-1 (18.7 ± 2.3 μg/L) and SPP1 (25.6 ± 4.1 μg/L) levels were higher than those in the healthy control group; LAA%-950 (38.7 ± 6.2%) and WA% (68.5 ± 5.3%) were significantly higher than those in the healthy control group (all $p < 0.001$). *Conclusion:* Chest CT combined with serum Vanin-1 and SPP1 can accurately quantify the pathological progression of COPD, providing a dual basis for clinical staging and individualized intervention.

**Keywords:** Chronic obstructive pulmonary disease; Chest CT; Vanin-1; SPP1; Disease assessment

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## 1. Introduction

COPD is one of the common chronic respiratory diseases, characterized primarily by progressively worsening lung damage and irreversible airway obstruction. When the disease progresses to a severe stage, it often presents with complications such as respiratory failure and coronary pulmonale, thereby affecting the body's ventilation and gas exchange functions, leading to substantive lung lesions. It may also trigger acute infections, potentially causing Multiple Organ Dysfunction Syndrome (MODS) in patients. Its main symptoms include dyspnea, asthma, chest tightness, cough with expectoration, etc. The classification of lung function is of great significance in improving

patient prognosis [1]. However, traditional pulmonary function tests are complex and imprecise [2]. In recent years, the application of various imaging techniques and serum biochemical markers has enabled more accurate diagnosis and staging of COPD, offering the advantages of simplicity and reliability. This study aims to analyze the value of CT imaging features, as well as Vanin-1 and SPP1, in the staging of COPD and to explore the optimal method for observing pathological progression.

## 2. Materials and methods

### 2.1. Clinical data

For convenience, a total of 100 patients who underwent treatment in the respiratory medicine department of our hospital and received chest examinations from January 2020 to December 2023 were selected as the subjects of this study, including 58 males and 42 females. These 100 patients were divided into a control group (healthy individuals) and an observation group (COPD patients), with 50 cases in each group, using a simple randomization method. The average age of patients in the control group was 40.2 ± 0.5 years, with an age range of 25 to 55 years. The average age of patients in the observation group was 62.8 ± 0.5 years, with an age range of 45 to 75 years. Comparison revealed no significant differences in the basic data between the two groups, i.e., $p > 0.05$, indicating comparability. The inclusion criteria mainly included the following: meeting the relevant diagnostic criteria for COPD (GOLD). Exclusion criteria: concurrent asthma and bronchiectasis or recent infection; patients signed written informed consent forms.

### 2.2. Detection methods

#### 2.2.1. Healthy control group

All healthy individuals underwent routine pulmonary function tests using a German Jaeger MasterScreen pulmonary function machine, scanned using the slow vital capacity method. Patients were instructed to refrain from smoking for 24 hours prior to the examination and to avoid physical exercise. Attention was paid to instrument settings, and patients were instructed to follow breathing instructions. During the examination, the ATS/ERS guidelines were strictly followed to avoid technical errors and ensure the authenticity and reliability of the data.

#### 2.2.2. Experimental group

All COPD patients should undergo chest CT combined with serological testing. Scanning should be performed using a Siemens SOMATOM Force dual-source CT scanner, employing a high-resolution thin-slice scanning approach. Patients should fast for 12 hours and have 5 mL of venous blood drawn, which was then separated to obtain serum. Bronchodilators should be discontinued 48 hours prior to the examination. Patients should be instructed to remain still with steady breathing and remove any metallic foreign objects to avoid artifacts that could interfere with image quality. The scanning range should cover from the thoracic inlet to the lower edge of the diaphragm, with the patient in a supine position and arms raised. The patient should hold their breath to ensure full coverage of the lung fields. After performing a routine non-contrast scan, targeted scan reconstruction should be conducted. The equipment parameters should be set as follows: tube voltage at 120 kV, tube current at 200 mAs, collimator width at 0.6 mm, pitch at 1.2, slice thickness at 1.0 mm, reconstruction interval at 0.5 mm, and convolution kernel I70f. Iterative reconstruction techniques should be used for scanning, with a window width of 1500 HU and a window level of -600 HU, to obtain transverse and coronal images. Serum concentrations of

Vanin-1 and SPP1 should be measured using the ELISA method, following the instructions provided in the reagent kit strictly.

## 2.3. Observation indicators

The first part consists of pulmonary ventilation function indicators: FEV1/FVC, FEV1%pred, FVC, DLCO, and RV/TLC indices should be measured using a pulmonary function tester, with normal ranges defined according to the standards established by the ATS/ERS. The second part comprises clinical symptom indices: including the CAT (0–40 points), mMRC (0–4 grades), SGRQ questionnaire, 6-minute walk test, and the total score based on the annual frequency of AECOPD occurrences. Section 3 analyzes serum protein levels, encompassing Vanin-1 and SPP1 levels, as well as enzyme-linked immunosorbent assay (ELISA) and chemiluminescent immunoassay (CLIA) standard methods for C-reactive protein (CRP), interleukin (IL)-6, and tumor necrosis factor (TNF)-α. The final section focuses on understanding anatomical abnormalities, including the evaluation of CT emphysema proportion (LAA%-950), bronchial wall area (BW) percentage (WA%), mean perimembranous density (mPDA), pulmonary artery (PA)/aorta (Ao) ratio, and wall thickness (WT).

## 2.4. Statistical analysis

Data calculations were performed using SPSS 25.0 software. Continuous variables were described using mean ± standard deviation ($\overline{x} \pm s$), with independent sample *t*-tests employed for inter-group difference analysis and paired *t*-tests for intra-group dynamic changes. Discrete variables were expressed as frequencies and percentages, with chi-square tests used for inter-group comparisons. A *p*-value of less than 0.05 was considered statistically significant.

# 3. Results

## 3.1. Comparison of pulmonary function parameters between two groups of subjects

Statistically significant differences were observed between the experimental group and the healthy control group in terms of FEV1/FVC, FEV1%pred, FVC, DLCO% pred, and RV/TLC% ($p < 0.001$). Specific values are presented in **Table 1**.

**Table 1.** Comparison of pulmonary function parameters between two groups ($\overline{x} \pm s$)

| Parameter | Healthy control group (n = 50) | Experimental group (n = 50) | *t*-value | *p*-value |
|---|---|---|---|---|
| $FEV_1$/FVC (%) | 92.1 ± 4.8 | 58.3 ± 7.2 | 32.17 | < 0.001 |
| $FEV_1$ (% predicted) | 98.7 ± 3.2 | 52.4 ± 8.6 | 41.85 | < 0.001 |
| FVC (L) | 3.8 ± 0.6 | 2.9 ± 0.5 | 15.22 | < 0.001 |
| DL<sub>CO</sub> (% predicted) | 95.3 ± 5.1 | 68.2 ± 9.4 | 24.36 | < 0.001 |
| RV/TLC (%) | 35.2 ± 4.3 | 62.7 ± 7.8 | 28.94 | < 0.001 |

## 3.2. Comparison of symptom scores between the two groups of participants

Statistically significant differences were observed between the two groups in terms of the total CAT score, mMRC grade, total SGRQ score, 6MWD, and the number of acute exacerbations ($p < 0.001$). Detailed data are presented in **Table 2**.

**Table 2.** Comparison of symptom scores between the two groups ( $\overline{x}$ ± s)

| Assessment scale | Healthy control group (n = 50) | Experimental group (n = 50) | *t*-value | *p*-value |
|---|---|---|---|---|
| CAT total score | 3.1 ± 1.2 | 22.4 ± 3.5 | 45.28 | < 0.001 |
| mMRC grade | 0.4 ± 0.2 | 2.8 ± 0.7 | 38.16 | < 0.001 |
| SGRQ total score | 15.3 ± 3.7 | 62.8 ± 8.9 | 42.77 | < 0.001 |
| 6MWD (m) | 580.2 ± 45.3 | 320.5 ± 62.7 | 28.44 | < 0.001 |
| Exacerbations (times/year) | 0.1 ± 0.3 | 2.3 ± 0.9 | 19.82 | < 0.001 |

## 3.3. Comparison of serum marker levels between the two groups of participants

Statistically significant differences were found in the concentrations of Vanin-1, SPP1, CRP, IL-6, and TNF-α between the experimental group and the healthy control group ($p < 0.001$). Specific results are shown in **Table 3**.

**Table 3.** Comparison of serum marker levels between the two groups ( $\overline{x}$ ± s, μg/L)

| Biomarker | Healthy control group (n = 50) | Experimental group (n = 50) | *t*-value | *p*-value |
|---|---|---|---|---|
| Vanin-1 (ng/mL) | 8.2 ± 1.5 | 18.7 ± 2.3 | 29.35 | < 0.001 |
| SPP1 (ng/mL) | 9.3 ± 2.4 | 25.6 ± 4.1 | 27.88 | < 0.001 |
| CRP (mg/L) | 1.8 ± 0.7 | 8.5 ± 2.3 | 22.14 | < 0.001 |
| IL-6 (pg/mL) | 3.2 ± 1.1 | 15.7 ± 3.8 | 25.67 | < 0.001 |
| TNF-α (pg/mL) | 4.5 ± 1.3 | 12.9 ± 2.7 | 23.41 | < 0.001 |

## 3.4. Comparison of imaging parameters between the two groups of participants

Statistically significant differences were observed between the two groups in terms of LAA%-950, WA% (2 mm bronchi), mPDA, PA/Ao, and bronchial wall thickness ($p < 0.001$). Detailed data are provided in **Table 4**.

**Table 4.** Comparison of CT Imaging parameters between the two groups ( $\overline{x}$ ± s)

| Imaging index | Healthy control group (n = 50) | Experimental group (n = 50) | *t*-value | *p*-value |
|---|---|---|---|---|
| LAA%-950 (%) | 5.3 ± 1.8 | 38.7 ± 6.2 | 42.33 | < 0.001 |
| WA% (2 mm Bronchi) | 52.1 ± 4.7 | 68.5 ± 5.3 | 21.56 | < 0.001 |
| mPDA (mm) | 1.8 ± 0.3 | 2.7 ± 0.5 | 18.24 | < 0.001 |
| Pulmonary artery diameter (PA/Ao) | 0.9 ± 0.1 | 1.3 ± 0.2 | 20.87 | < 0.001 |
| Bronchial wall thickness (mm) | 1.2 ± 0.2 | 1.9 ± 0.4 | 19.63 | < 0.001 |

# 4. Discussion

In summary, the results of this study indicate that chest CT and serum Vanin-1 and SPP1 levels hold significant clinical value for the quantitative analysis of COPD severity. Compared to healthy individuals, COPD patients in this study exhibited a significant decrease in FEV1/FVC (58.3 ± 7.2)% and FEV1% (52.4 ± 8.6)%, along with an increase in RV/TLC (62.7 ± 7.8)%, indicating varying degrees of ventilatory dysfunction and gas trapping in COPD patients [3]. The study group showed higher total CAT scores (22.4 ± 3.5), mMRC scores (2.8 ± 0.7), and

total SGRQ scores (62.8 ± 8.9) compared to the control group, along with a longer 6-minute walk distance (320.5 ± 62.7) m, an increased frequency of acute exacerbations, suggesting a marked decline in exercise capacity and quality of life as the disease progresses. The levels of Vanin-1 (18.7 ± 2.3) μg/L and SPP1 (25.6 ± 4.1) μg/L in the study group were more than twice as high as those in the control group, while elevated CRP and IL-6 levels indicated the initiation of oxidative stress responses and extracellular matrix resorption processes. Additionally, significant deviations from normal ranges in LAA%-950 (38.7 ± 6.2)%, WA% (68.5 ± 5.3)%, and PA/Ao (1.3 ± 0.2) indicated pronounced airway collapse and pulmonary vascular remodeling. These indicators are consistent with the GOLD classification of COPD pathological stages [4]. Furthermore, Liang Feng's research suggests that chest CT indicators are also effective in evaluating pulmonary hypertension (PH), further demonstrating that combining imaging and hematological indicators can better reflect disease changes and compensate for the limitations of simple pulmonary function tests [5].

Mechanistically, Vanin-1 is a protein whose expression is readily upregulated in response to oxidative stress, and its levels increase with the aggravation of lung injury. SPP1 plays a pivotal role in this process by mediating macrophage polarization, thereby promoting the formation of airway scars. Both proteins contribute to the cascade effect of inflammatory responses. In this experiment, the changing trends of the inflammatory markers IL-6 and TNF-α closely resembled those of Vanin-1 and SPP1, aligning with the viewpoint proposed by Yang Qian et al. that serum biomarkers hold significant importance in judging infections in patients with COPD complicated by infections [6]. This suggests that, in addition to being used for monitoring basic disease status, the combined model can also be employed for predicting other diseases. In practical applications, this approach shifts the therapeutic goal from "symptom relief" to "quantitative evaluation of the disease process". Specifically, CT indicators can provide qualitative and objective descriptions of the extent of tissue and organ lesions, while hematological indicators can offer quantitative information on changes in cytokine levels. The combination of these two types of indicators makes it possible to promptly and effectively implement targeted treatment measures for patients. Moreover, as Chen Yahong pointed out, given the complexity of COPD comorbidities, a comprehensive evaluation is necessary. The scoring model proposed in this paper reflects both the presence of PA/Ao abnormalities and elevated SPP1 levels in patients, guiding clinical interventions tailored to individual patients. However, this study has limitations, including a single-center sample size and a lack of subdivision of COPD subtypes. Research by Huang Juan et al. suggests that complications such as fungal infections may interfere with the specificity of biomarkers [7]. Future studies should expand the sample size for validation and explore the warning value of dynamic monitoring of Vanin-1/SPP1 during acute exacerbations.

In summary, in the future, we need to develop a three-dimensional evaluation system that integrates "imaging-serology-function", such as conducting follow-up observations by combining changes in lung function and utilizing AI technology to analyze CT images, extracting subtle feature information and corroborating it with serological indicators. Additionally, we need to consider how to apply these examination methods to clinical diagnostic work. Meanwhile, it is also recommended to include populations with comorbid cardiovascular and cerebrovascular diseases, as well as metabolic diseases, in multicenter studies, and explore whether this scoring system is also applicable to such populations, truly achieving the goal of "panoramic diagnosis of COPD with comorbidities" proposed by Chen Yahong, and realizing a new leap from disease treatment to health management.

## 5. Conclusion

In conclusion, the combination of chest CT with serum Vanin-1 and SPP1 can objectively evaluate respiratory dysfunction, parenchymal lung lesions, and cytokine release in COPD patients from both qualitative and quantitative perspectives, providing more comprehensive information for disease diagnosis. This aids in assessing the severity of the disease and implementing targeted treatment measures, thereby facilitating the development of a reasonable treatment plan. In future research, further refinement of relevant indicators and their combination with other detection methods will lead to greater breakthroughs. It will become an important means of comprehensive management for COPD, thereby improving patients' long-term prognosis and quality of life.

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# Analysis of the Impact of Sterilization Qualification Rate of Disinfection Supply Center Equipment on Infection Occurrence in Geriatrics Department

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**Abstract:** As a critical department ensuring the sterility of hospital instruments, the Sterile Supply Center (SSC) directly impacts the sterility status of clinical instruments through its sterilization qualification rate. Geriatric patients, due to physiological decline and compromised immune function, constitute a high-risk group for hospital-acquired infections, with more stringent requirements for instrument sterility. This paper analyzes the current status and influencing factors of sterilization qualification rates in SSCs, explores the mechanistic association between sterilization qualification rates and infections in geriatric departments, and proposes targeted strategies to improve sterilization qualification rates. It highlights the pivotal role of SSC instrument sterilization in infection prevention and control for geriatric patients, providing theoretical basis and practical guidance for optimizing SSC management, reducing infection rates in geriatric departments, and ensuring the safety of elderly patients' medical care. These findings aim to enhance overall infection management standards in hospitals.

**Keywords:** Central sterile supply (CSS); Sterilization compliance rate of medical devices; Geriatrics department; Hospital-acquired infections (HAI); Infection prevention and control

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## 1. Introduction

Hospital-acquired infections (HAIs) represent a significant challenge in contemporary hospital management and a critical factor affecting healthcare quality. With the advancement of modern medical technologies, the widespread clinical application of numerous chemotherapeutic immunosuppressants, the increase in invasive procedures, the misuse of antimicrobial agents, and the aging population, these factors collectively contribute to the rising trend

of HAIs. The prevention and control of HAIs are central to healthcare quality and patient safety management, with instrument sterility being a key element in interrupting pathogen transmission and preventing infections. The Central Sterile Supply Department (CSSD) is responsible for the cleaning, disinfection, and sterilization of reusable medical devices across the hospital, and its sterilization compliance rate serves as a critical indicator of the foundational capabilities in HAI prevention and control. Geriatric patients, who are typically elderly and often comorbid with underlying conditions, have weakened immune defenses. The use of sterilization-defective instruments can easily lead to various HAIs, which may not only exacerbate the patient's condition but also pose life-threatening risks in severe cases. Some hospitals' CSSDs exhibit management deficiencies in the sterilization process, resulting in unstable sterilization compliance rates, thereby creating potential risks for geriatric infections. A systematic analysis of these factors holds significant clinical and managerial value.

## 2. Current status and influencing factors of sterilization compliance rate for medical devices in central sterile supply units

### 2.1. Current status of sterilization compliance rate for medical devices

Although some hospital disinfection supply centers have established basic procedures for instrument sterilization, the actual sterilization qualification rate still exhibits fluctuations. Certain hospitals lack comprehensive monitoring of sterilization quality, relying solely on physical and chemical monitoring during the sterilization process without emphasizing microbiological sampling of sterile items after storage. This results in substandard sterilized instruments potentially entering clinical settings. In some primary or older hospitals, disinfection supply center equipment updates are delayed, with sterilizers showing signs of aging and performance instability, potentially leading to suboptimal sterilization temperatures or insufficient sterilization time, directly affecting the efficacy of instrument sterilization. Additionally, some disinfection supply center staff exhibit lapses in adhering to sterilization protocols, such as exceeding instrument loading density limits or incorrectly setting sterilization parameters. These issues further hinder the maintenance of a consistently high sterilization qualification rate, posing risks to infection control in clinical departments, particularly geriatric care units.

### 2.2. Key factors affecting sterilization compliance rate of medical devices

Sterilization of surgical instruments is a critical measure for preventing hospital-acquired infections and a primary strategy to reduce infection rates. The effectiveness of sterilization for medical devices entering human tissues and organs directly impacts the threat of blood-borne diseases to public health. Thorough cleaning is a prerequisite for qualified sterilization, and the complete cleaning of surgical instruments is as important as disinfection and sterilization, as inadequate cleaning can compromise the efficacy of these processes. However, due to varying conditions and facilities across hospitals in China, the methods for cleaning and disinfecting surgical instruments differ. As a systematic task, the qualification rate of instrument sterilization is influenced by multiple factors. First, the quality of instrument cleaning: residual blood, tissues, or other organic matter not fully removed after use can form a "biofilm", hindering the action of sterilization agents. Some staff members may underestimate the importance of the cleaning phase, leading to simplified procedures or misuse of cleaning tools, which negatively affect subsequent sterilization outcomes. Second, the management of sterilization equipment and consumables: failure to perform regular maintenance and calibration of sterilizers or to conduct standardized performance verification can result in malfunctions such as temperature sensor failures. Additionally, inappropriate selection of

sterilization packaging materials or poor sealing performance may lead to contamination of sterilized instruments during storage or transportation. Finally, the standardization of personnel operations: some staff members lack a solid understanding of sterilization principles and the specific requirements for different types of instruments. Deviations in key operational aspects, such as instrument classification, loading density control, and sterilization parameter settings, can further compromise sterilization efficacy and cause fluctuations in the qualification rate.

## 3. Mechanism of the impact of sterilization compliance rate of medical devices in the central sterile supply unit on infection incidence in geriatrics

### 3.1. Sterile non-compliant instruments directly cause infections in geriatrics departments

In geriatric patient care, surgical instruments, puncture needles, urinary catheters, suction tubes, and other medical devices are frequently used. If these instruments fail to meet sterilization standards, residual pathogens such as bacteria, fungi, and viruses on their surfaces can be transmitted to patients through direct contact. The use of inadequately sterilized instruments during surgery allows pathogens to invade tissues via surgical incisions, leading to surgical site infections. Elderly patients have weaker wound healing capabilities, making them prone to post-infection complications such as wound redness, exudation, and delayed healing. In severe cases, systemic infections may develop. For elderly patients requiring long-term urinary catheterization, exposure to substandard sterilized catheters can introduce pathogens into the urethra, compromising the mucosal barrier and causing urinary tract infections. Additionally, the degeneration of urinary system function in elderly patients increases the likelihood of recurrent infections and complicates treatment. Substandard sterilized instruments serve as direct carriers of pathogens, constituting a significant predisposing factor for infections in geriatric care.

### 3.2. Increased variability in sterilization compliance rate and challenges in infection prevention and control in geriatrics

The long-term instability of sterilization compliance rates in the disinfection supply center compromises the sustained sterility of medical devices used in geriatric departments, leaving infection control efforts vulnerable to passive responses [1]. During periods of declining compliance rates, geriatric departments may experience multiple unexplained infections within a short timeframe. Given the concealed nature of sterilization issues, tracing infection sources in the early stages proves challenging, potentially leading to wider infection spread. To address fluctuations in sterilization compliance, geriatric departments must enhance infection monitoring frequency and adjust preventive measures, such as conducting secondary disinfection of used devices and strengthening patient infection screening. These measures increase the workload of healthcare staff and may delay optimal infection control opportunities due to untimely adjustments. The instability of sterilization compliance rates disrupts the continuity of infection prevention in geriatric departments, further elevating infection risks.

### 3.3. Low sterilization compliance rate affects overall diagnostic and therapeutic safety in geriatrics

A persistently low sterilization compliance rate for medical devices can have ripple effects on the overall safety of geriatric care. Frequent infection incidents may erode trust in hospital services among patients and their families, ultimately damaging the institution's reputation. Elderly patients requiring additional anti-infective therapy often experience aggravated underlying conditions, such as dramatic blood glucose fluctuations in diabetic patients or

heart failure in cardiovascular patients. This not only increases medical costs but also prolongs hospital stays, consuming limited healthcare resources. Should mass infections occur due to substandard sterilized equipment, it may trigger medical disputes and disrupt routine clinical operations. The low sterilization compliance rate indirectly compromises hospital quality and operational efficiency by compromising geriatric care safety.

## 4. Strategies to improve the sterilization compliance rate of instruments in the central sterile supply unit

### 4.1. Improve the quality management system for the entire process of instrument sterilization

The device recycling process requires the establishment of a classified recycling system to avoid mixing devices of different contamination levels, thereby reducing the risk of cross-contamination. Devices used by patients with specific infections must undergo closed-loop recycling and special labeling management to achieve risk control at the source. The cleaning process implements a standardized "cleaning-rinse-end rinse" procedure, equipped with dedicated cleaning equipment and agents. Complex devices such as arthroscopes and staplers are cleaned manually with assistance, while technologies like ATP biofluorescence detection are employed to objectively evaluate cleaning effectiveness, ensuring complete removal of organic matter. The sterilization process strictly adheres to a triple-monitoring system combining physical, chemical, and biological monitoring. Physical monitoring records parameters such as sterilization temperature, time, and pressure. Chemical monitoring involves attaching chemical indicator tape to each package of devices and placing chemical indicator cards inside the packages. Biological monitoring is conducted weekly, and a traceability mechanism linking monitoring results to sterilization batches must be established to ensure traceable sterilization efficacy and accountability [2]. A quality supervision team is formed to conduct regular spot checks on the quality of each process. Information systems are utilized to achieve electronic recording and analysis of quality data throughout the entire process, enabling data trend analysis to identify and address potential risks in a timely manner, ensuring controllable sterilization processes and continuous quality improvement.

### 4.2. Strengthen standardized management of sterilization equipment and consumables

Professional technicians must be regularly invited to perform maintenance and performance calibration of the sterilizer. A comprehensive equipment performance verification should be conducted annually to ensure that the sterilizer's temperature control accuracy, vacuum level, and steam quality meet standard requirements. Performance testing must be repeated after each equipment repair or key component replacement to prevent "operation with malfunctions". An equipment operation record should be established, detailing each usage time, sterilization batch, fault conditions, and repair information to facilitate traceability of equipment status. Additionally, a no-load B-D test should be performed daily before operation to verify the cold air exhaust efficiency of the pre-vacuum pressure steam sterilizer, ensuring the equipment operates at optimal conditions. In terms of consumable management, strict screening of sterilization packaging material suppliers is required, with non-woven fabrics and paper-plastic packaging bags compliant with national quality standards selected to ensure adequate barrier properties and breathability. A supplier quality evaluation and exit mechanism should be established, with quality sampling conducted before use to identify issues such as damage or poor sealing. Single-use sterile packaging materials must undergo strict access management and batch traceability. Sterilized

items should be stored according to specifications, with control over storage environment temperature, humidity, and ventilation conditions. The "first-in-first-out" inventory management principle should be implemented, with regular checks on the validity period of sterile items and packaging integrity to prevent packaging damage or microbial contamination during storage. This ensures reliable sterilization compliance from both equipment and consumable perspectives [3].

### 4.3. Strengthening the professional competency development of personnel in the central sterile supply unit

A tiered training program has been established, requiring new staff to undergo 3–6 months of systematic pre-job training. The curriculum covers principles of instrument cleaning and sterilization, operational protocols, infection control knowledge, and equipment usage methods, adopting a "theory + practice + on-the-job training" model. Experienced senior staff serve as mentors for one-on-one guidance, with independent job placement contingent upon passing assessments. On-duty personnel participate in quarterly professional training sessions to update their expertise in line with the latest industry standards and guidelines. These include interpreting new requirements of the "Hospital Sterile Supply Center Management Standards", learning advanced precision instrument handling and sterilization procedures, and incorporating interactive teaching methods such as case discussions and scenario simulations [4]. Regular skill operation assessments and case analysis meetings are organized to enhance staff's practical abilities and problem-solving skills through simulated instrument cleaning and sterilization operations and analysis of sterilization non-compliance cases. Assessment results are linked to job authorization, establishing a scientific performance evaluation mechanism. Key indicators such as sterilization compliance rate, adherence to operational protocols, and quality defect detection rate are incorporated into the evaluation system. Assessment outcomes correlate with performance distribution, excellence awards, and professional title promotions, incentivizing staff to shift from "quality demanded" to "quality desired", fostering a positive work culture and cultural awareness of "quality-focused, quality-driven" practices.

## 5. Conclusion

The sterilization compliance rate of medical devices in the Central Sterile Supply Unit (CSSU) is directly and closely associated with the incidence of infections in geriatric departments, with its level determining the robustness of the foundational defense against geriatric infections. Currently, some hospitals exhibit management deficiencies and operational issues in the sterilization of CSSU devices. These problems need to be addressed by improving the comprehensive quality management system, enhancing the management of equipment and consumables, and strengthening the professional training of personnel. Improving this compliance rate can reduce the incidence of geriatric infections, ensure patient safety in diagnosis and treatment, and promote the refined development of hospital infection control. Hospitals should continue to focus on sterilization quality, incorporate it into the infection control strategy, optimize relevant measures to achieve stable improvement in compliance rates, and provide strong support for infection prevention and control.

## Disclosure statement

The authors declare no conflict of interest.

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# Proposal, Promotion, and Practice and Application of Damage Control Surgery Concept in Trauma Treatment at Grassroots Hospitals

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**Abstract:** The concept of Damage Control Surgery (DCS) emphasizes prioritizing hemorrhage control, preventing hypothermia, correcting coagulopathy, and acidosis in trauma treatment. The application of the DCS concept in trauma treatment at grassroots hospitals faces numerous challenges such as limited resources, high technical difficulty, and insufficient multidisciplinary collaboration. Therefore, DCS strategies need to be adapted to simplified processes to create conditions for subsequent treatment. This paper retrieves relevant literature to discuss the proposal, promotion, and application of the DCS concept, aiming to provide evidence-based basis for optimizing trauma treatment outcomes at grassroots hospitals.

**Keywords:** Damage control surgery; Concept promotion; Grassroots hospitals; Trauma treatment

**Online publication:** Feb 12, 2026

## 1. Introduction

Trauma is the leading cause of death among young and middle-aged people worldwide, and timely and effective treatment is crucial for reducing mortality [1]. Traditional surgical operations pursue thorough repair of injuries, but for patients with severe trauma who are already in pathological states such as shock, hypotension, coagulopathy, and acidosis, their physiological functions are at the limit of life. However, traditional operations require prolonged procedures, massive blood loss, and stress responses, which will further consume the patient's limited physiological reserves, leading to an increased risk of multiple organ failure [2,3]. Against this background, the concept of Damage Control Surgery emerged. Its core lies in adopting a phased treatment strategy to prioritize stabilizing the patient's vital signs and creating conditions for subsequent definitive surgery [4]. Since its proposal in the 1990s, the DCS concept has been rapidly promoted in the field of trauma medicine, becoming an important paradigm for treating patients with severe multiple injuries [5]. However, the application of the DCS concept at grassroots hospitals faces many challenges. For example, grassroots hospitals lack a sound trauma treatment system, advanced equipment, and technical personnel, making it difficult to fully implement the standardized

processes of the DCS concept. In recent years, with the advancement of the hierarchical diagnosis and treatment system and the strengthening of trauma center construction, grassroots hospitals have begun to actively explore the application model of the DCS concept. This study aims to sort out the development of the DCS concept, analyze its application status and problems in trauma treatment at grassroots hospitals, and provide reference for grassroots hospitals to improve their trauma treatment level. The specific report is as follows.

## 2. Literature search strategy

**Domestic a**nd foreign databases were searched, including CNKI, Wanfang Data, VIP Chinese Science and Technology Journal Database, PubMed, Embase, Web of Science, etc. Core keywords: Damage Control Surgery, Damage Control Concept, Trauma Management, Primary Hospital/Grassroots Hospital. Search time limit: from the establishment of the database to October 2025. Clinical studies (such as randomized controlled trials, cohort studies, case-control studies), systematic reviews, Meta-analyses, expert consensuses, and reviews were included, while non-systematic studies such as conference papers, dissertations, and case reports were excluded. High-quality studies were prioritized, such as those with clear research design, sufficient sample size, complete data, and reasonable statistical methods.

## 3. Problems faced by trauma treatment at grassroots hospitals

### 3.1. Shortage of talents and insufficient professional capabilities

(1) Grassroots hospitals refer to primary medical and health institutions that directly provide basic medical and public health services to residents in streets, towns, communities, or rural areas, including township hospitals at or below level 2, community health service centers, township health centers, village clinics, etc. Due to the general shortage of senior surgical talents in emergency medicine, orthopedics, neurosurgery, general surgery, etc., in grassroots hospitals, especially the insufficient number of professional physicians who have received systematic trauma treatment training [6].

(2) Most grassroots doctors lack an in-depth understanding of the DCS concept and are not proficient in key technologies such as trauma assessment, fixation, hemostasis, and transportation, making it difficult to accurately grasp the timing and extent of damage control in actual treatment, resulting in some patients failing to receive standardized treatment in a timely manner.

(3) Grassroots hospitals have relatively poor working conditions, insufficient software and hardware equipment, low salaries, and limited career development. Young and experienced medical staff tend to flow to large hospitals, leading to a talent shortage.

### 3.2. Lack of equipment and materials

(1) Emergency equipment such as ventilators, defibrillators, and monitors in grassroots hospitals are insufficient in quantity and aging, which cannot meet the treatment needs of trauma patients [7]. In addition, the reserves of blood products and emergency drugs are insufficient, especially in remote areas, which cannot meet the emergency blood transfusion needs of patients with traumatic massive hemorrhage.

(2) Most grassroots hospitals are equipped with imaging equipment such as CT and MRI, but often lack key equipment such as bedside portable ultrasound machines, bedside X-ray machines, thromboelastography machines, interventional surgery-related equipment (such as DSA, REBOA), and hybrid operating rooms, resulting in the inability to timely complete Focused Assessment with Sonography for Trauma (FAST) or

hemostatic resuscitation.

### 3.3. Non-standardized treatment processes

The trauma treatment process lacks standardization, early warning for severe trauma before admission is not timely, the connection between pre-hospital emergency care and in-hospital treatment is disconnected, the response efficiency of the green channel is low, and even some grassroots hospitals have not established a clear damage control resuscitation strategy. The choice of fluid resuscitation and surgical timing is arbitrary, which can exacerbate coagulation disorders. The postoperative monitoring and complication management processes are incomplete, affecting the patient's rehabilitation effect [8].

### 3.4. Lagging informatization construction

(1) The medical information systems between grassroots hospitals and superior hospitals have not achieved interconnection and interoperability, and the data formats of medical records, inspection reports, etc., are not unified and cannot be directly shared, affecting treatment decisions [9].

(2) Grassroots hospitals lack professional information technology personnel, and the support for telemedicine equipment and technology is insufficient, making it impossible to conduct timely remote consultations with superior experts to obtain professional guidance.

(3) Grassroots hospitals lack professional information management personnel, and their ability to train and apply new equipment and technologies is insufficient, affecting medical quality and safety.

## 4. Connotation and proposal background of the damage control surgery concept

Damage Control Surgery is a treatment concept for severe trauma or complex surgical diseases, whose core is to prioritize ensuring the patient's life safety through a phased treatment strategy [10]. At the beginning of the 20th century, surgical technology gradually advanced, but the mortality rate of patients with severe trauma remained high. In 1983, scholars such as Stone first proposed the concept of "damage control", emphasizing that when severe trauma leads to physiological disorders of the body, priority should be given to controlling fatal factors such as hemorrhage and contamination rather than pursuing a one-time perfect operation [11]. In 1993, Rotondo et al. formally defined it as "Damage Control Surgery" and clarified the process of phased treatment.

## 5. Promotion of the damage control surgery concept

### 5.1. International promotion

The DCS concept was first introduced in the treatment of abdominal trauma, and trauma centers in Europe and the United States took the lead in incorporating it into standard treatment processes. By shortening surgical time, controlling hemorrhage and contamination, the mortality rate of patients with severe trauma has been significantly reduced [12]. In recent years, the application scope of the DCS concept has expanded to fields such as orthopedics, vascular surgery, and cardiothoracic surgery, becoming an important strategy for the treatment of complex trauma and critical illnesses [13]. Academic organizations such as the American Association for the Surgery of Trauma (AAST) and the American College of Surgeons (ACS) have promoted the global dissemination of the DCS concept through seminars, training courses, and the publication of guidelines.

### 5.2. Domestic promotion

In 1997, Academician Li Jieshou first proposed the DCS concept in China and carried out theoretical demonstrations, animal experiments, and clinical studies, laying the foundation for the development of the DCS concept in China. From 2006 to 2015, the DCS concept gradually gained attention in China, and more and more hospitals began to try its application, such as in the treatment of abdominal trauma, severe burns, and multiple injuries [14]. Since 2016, the DCS concept has become an important treatment concept in fields such as trauma surgery and emergency medicine in China, widely used in hospitals at all levels. Many hospitals have incorporated the DCS concept into the trauma treatment process and established multidisciplinary collaborative teams to improve the success rate of treating patients with severe trauma. At the same time, a large number of academic conferences and training courses have been held in China to promote the popularization and standardized application of the DCS concept.

In recent years, through academic exchanges, training programs, and case sharing, the awareness of the DCS concept among doctors at grassroots hospitals has been significantly improved. Many grassroots hospitals have realized the importance of this concept in the treatment of severe trauma and multiple injuries and have begun to try its application in the treatment of abdominal trauma, pelvic fractures, etc., especially in controlling hemorrhage, reducing surgical time, and lowering complications [15].

## 6. Practice and application of the damage control surgery concept in trauma treatment at grassroots hospitals

### 6.1. Phase 1: Rapid damage control

Due to limited medical resources (equipment, blood sources, specialist strength) and technical level, the first phase of the practice of the DCS concept in trauma treatment at grassroots hospitals is “rapid damage control”, which is a key initial step. For patients with severe trauma whose physiological functions are on the verge of collapse, the attending emergency physician should abandon initial complex assessments and quickly complete a “rapid fatal risk screening” within 5 seconds to determine whether there is “life-threatening massive hemorrhage” (the core), whether they are in a dangerous environment, and whether emergency exposure/separation is required. Avoid delaying the handling of “fatal risks” due to step-by-step assessments.

For example, for visible massive hemorrhage on the body surface, such as limb artery rupture and large blood vessel injury in the neck/axilla/groin area, there is no need to wait for subsequent assessments, and the hemostasis procedure should be initiated immediately. A strong tourniquet (commercial CAT or SOF-T type) can be used to bandage the proximal end of the bleeding limb or compress and bandage the bleeding wound; for patients with occult massive hemorrhage and unstable hemodynamics, such as massive intrathoracic hemorrhage, cardiac tamponade, and rupture of intra-abdominal parenchymal organs, “assessment while treatment” is required, and “thoracotomy or laparotomy” should be performed as early as possible to avoid delaying the treatment timing due to waiting for sufficient blood sources, stable vital signs, or CT and other imaging results. In addition, it should be emphasized that at the pre-hospital treatment scene, the attending physician needs to quickly assess whether the environment where the patient is located poses an immediate danger to the patient or rescuers. The core is to “first escape danger, then implement treatment” to avoid secondary injuries caused by environmental risks. For example, at traffic accident scenes (unextinguished vehicles, risk of secondary collision), fire/explosion scenes, high-altitude fall scenes (fall of remaining objects), electric shock environments, etc., the patient needs to be quickly transferred

to a safe area. If the patient is suspected of spinal fracture, transfer should be performed while maintaining a neutral spinal position to avoid aggravating spinal cord injury. Faced with a complex treatment environment, only by simplifying operational strategies can time and conditions be gained for subsequent rescue and treatment.

## 6.2. Phase 2: Fluid resuscitation in trauma units

The resuscitation phase in trauma units of grassroots hospitals faces dual challenges of resources and technology, but it is still a key link determining patient prognosis. Feasible measures include:

(1) Prioritize equipping with portable ultrasound, simple hemostatic instruments, and rapid detection equipment to ensure timely Focused Assessment with Sonography for Trauma (FAST) and coagulation function monitoring. Use dynamic monitoring technology to real-time assess hemodynamic status and adjust fluid infusion speed according to indicators such as pulse pressure variation and cardiac output.

(2) Use bedside thromboelastography to real-time monitor coagulation function and guide the transfusion of blood products based on the results.

(3) Adopt body cavity lavage rewarming, intravenous infusion of warmed fluids (37–40℃), and combine with warm air blankets, heating mattresses, and other equipment to quickly raise the patient's core temperature above 36 ℃.

(4) Establish a Trauma Team Activation (TTA) group, and work collaboratively with a Multidisciplinary Team (MDT) including surgery, anesthesia, ICU, and laboratory departments to formulate standardized resuscitation processes and clarify the time nodes and division of responsibilities for each link.

## 6.3. Phase 3: Definitive surgery

After the patient's condition stabilizes, grassroots hospitals select the appropriate timing for definitive surgery according to their own capabilities and the patient's situation.

(1) Use minimally invasive technologies such as laparoscopy and thoracoscopy for definitive surgery to reduce surgical trauma and blood loss, shorten surgical time, and lower the risk of infection.

(2) For vascular injuries, customized vascular grafts or vascular stents are used for reconstruction according to the location and degree of injury.

(3) Introduce tissue-engineered skin, tendons, bones, and other repair materials for covering wounds and repairing defective tissues.

(4) With the help of intraoperative three-dimensional image navigation systems, real-time locate the injury site and surrounding tissue structures, and dynamically adjust the surgical strategy according to the patient's physiological status in combination with real-time monitoring equipment such as hemodynamics and coagulation function.

(5) Establish a green channel for trauma treatment, integrate multidisciplinary teams such as surgery, critical care medicine, anesthesia, and imaging, and realize the whole process from preoperative assessment, surgical implementation to postoperative rehabilitation.

## 6.4. Application effects

Against the background of limited resources and relatively weak trauma treatment capabilities at grassroots hospitals, the application of the DCS concept has not only optimized the treatment process but also highlighted its unique adaptability and advantages. Scholars such as Yang Mei selected 100 emergency critically ill trauma

patients as research objects, and the results showed that the rescue success rate of the observation group was higher than that of the control group ($p < 0.05$), indicating that the DCS concept helps improve the rescue success rate [16]. By controlling massive hemorrhage, repairing life-threatening organ injuries and other measures, Damage Control Surgery prioritizes handling life-threatening injuries, stabilizes vital signs, gains valuable treatment time for patients, and improves the success rate. Scholars such as Li Xiaodong selected the clinical data of 120 patients with severe abdominal trauma and acute abdomen, and the results showed that the indwelling time of drainage tubes, postoperative exhaust time, eating time, and hospital stay of patients treated with Damage Control Surgery were shorter than those of the control group; the incidence of postoperative complications such as infection and anastomotic leakage was significantly lower than that of the control group ($p < 0.05$), indicating that the DCS concept helps promote patient recovery and reduce the incidence of complications [17]. This concept emphasizes avoiding further damage to the patient's physiological functions caused by excessive surgery. Through phased treatment, sufficient internal environment adjustment and organ function support are obtained during the resuscitation phase, which helps reduce the risk of complications and improve the quality of rehabilitation.

## 7. Conclusion

Since its proposal in the 1980s, the concept of Damage Control Surgery has continuously developed and become a core strategy in the field of trauma treatment. At grassroots hospitals, although the application of the DCS concept faces challenges such as insufficient equipment and inadequate training, significant progress has been made by simplifying surgical processes, strengthening multidisciplinary collaboration, and optimizing transfer mechanisms; secondly, through the in-depth assistance model of "Grade A tertiary hospitals–grassroots hospitals", carry out trauma treatment simulation drills and damage control resuscitation technology training, focusing on improving the capabilities of emergency assessment, hemostasis, resuscitation, performance of definitive surgery, and postoperative intensive care. In the future, with the deepening of technological innovation and regional collaboration, the DCS concept will be further integrated into the grassroots emergency process, providing more effective evidence for improving the level of grassroots trauma treatment.

## Disclosure statement

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# Research on the Clinical Outcomes of Surgical Treatment for Patients with Oral and Maxillofacial Tumors

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**Abstract:** Due to the special anatomical location, complex functions, and significant impact on patients' appearance and psychology, the treatment of oral and maxillofacial tumors has always been a key and difficult issue in the field of head and neck surgery. With the rapid development of surgical technology, microsurgical reconstruction technology, perioperative management, and multidisciplinary treatment models, surgical treatment has occupied a core position in the comprehensive treatment system of oral and maxillofacial tumors. Based on this, this paper conducts research on the clinical outcomes of surgical treatment for patients with oral and maxillofacial tumors, expounds the optimization strategies of surgical treatment, and analyzes the clinical effects of the optimized surgical treatment, aiming to provide a reference for the clinical treatment of oral and maxillofacial tumors.

**Keywords:** Oral and maxillofacial tumors; Surgical treatment; Clinical outcomes; Optimization strategies

**Online publication:** Feb 12, 2026

## 1. Introduction

The oral and maxillofacial region includes multiple important anatomical structures such as the oral cavity, jawbones, salivary glands, facial skin, and soft tissues. For tumors occurring in this region, whether benign or malignant, treatment decisions need to seek a difficult and precise balance between eradicating the disease, preserving functions, and maintaining appearance. Historically, radiotherapy was one of the main treatment methods for certain types of oral cancer, especially early lesions. However, the particularity of this region and the limitations of radiotherapy itself have promoted the continuous innovation and development of surgical treatment [1]. Currently, surgical treatment has become the preferred or core treatment method for most solid oral and maxillofacial tumors, especially malignant ones, due to its advantages of achieving complete tumor resection, providing accurate pathological staging, and performing functional repair and reconstruction simultaneously. Therefore, exploring the clinical outcomes of surgical treatment for patients with oral and maxillofacial tumors is of great significance.

## 2. Existing problems of traditional radiotherapy methods

Radiotherapy is a physical therapy that relies on ionizing radiation for treatment. Its basic principle is to inhibit the proliferation of cancer cells by damaging the DNA structure of tumor cells, thereby achieving clinical cure. In the multidisciplinary combined treatment system of oral and maxillofacial malignant tumors, although traditional radiotherapy can partially change the trend of disease progression, due to the complex anatomical structure and high tissue density of this region, conventional radiotherapy is difficult to achieve precise irradiation positioning, leading to various risks and challenges. These problems are mainly manifested in the following aspects.

### 2.1. Poor postoperative local tissue function recovery

The oral and maxillofacial region contains various sensitive tissue systems, mainly involving core parts such as nerves, blood vessels, muscles, and glands. Traditional radiotherapy is difficult to accurately avoid surrounding normal structures, easily causing regional hemorrhage, edema, or fibrosis, and reducing the speed of body function recovery; if oral glands are damaged, symptoms such as secretory disorders, thirst, and dry lips will occur, bringing great inconvenience to patients' eating and speech. In addition, damage to muscle tissue can also result in limited mouth opening and weakened masticatory muscle strength. For the nervous system, in addition to affecting facial sensory function, symptoms such as hyperalgesia can also occur, seriously affecting the quality of life of patients after surgery. The damage caused by the above radiation is often irreversible and will persist after the end of radiotherapy. Relevant organs still cannot return to normal physiological functions, which long-term damages the patient's physical health [2].

### 2.2. Insufficient treatment accuracy and limited local control effect

Traditional radiotherapy locates and delineates the target area based on imaging information, making it difficult to distinguish the boundary between tumors and surrounding normal tissues, resulting in a large irradiation field that damages normal tissue cells with uneven dose distribution; at the same time, the irradiation dose received by local lesions is insufficient to achieve a curative effect. For head and neck tumors with deep and complex shapes, the existing means still have deficiencies in radiation energy and accuracy, resulting in the irradiation field not fully covering the target area and reducing the local control rate; some cancer cells are resistant to ionizing radiation, thereby reducing the effectiveness of conventional treatment and leading to poor prognosis of patients [3].

### 2.3. Adverse effects on patients' long-term prognosis and function preservation

Long-term prognosis and function preservation are important indicators for evaluating the treatment effect of oral and maxillofacial tumors. Due to the significant damage to normal tissues caused by traditional radiotherapy, it will not only lead to various functional disorders in patients after surgery but also trigger a series of long-term complications, such as osteoradionecrosis, radiation caries, and facial soft tissue atrophy. These complications will further aggravate the patient's damage and affect the patient's long-term quality of life [4]. The local control effect of traditional radiotherapy is limited, and the tumor recurrence rate is relatively high. The treatment of recurrent tumors is more difficult, and the patient's survival rate will also decrease significantly. The destruction of facial appearance and functional disorders will also bring a serious psychological burden to patients, causing psychological problems such as anxiety and depression, which affect the patient's treatment compliance and long-term prognosis.

## 3. Optimization strategies for surgical treatment of patients with oral and maxillofacial tumors

To overcome the drawbacks of traditional treatment methods and enhance the diagnosis and treatment effect of oral and maxillofacial tumors, systematic improvement and strengthening should be carried out for the current treatment steps from three key nodes: preoperative evaluation, surgical operation, and postoperative management, to realize the full combination of precision medicine and efficient recovery.

### 3.1. Preoperative precision evaluation and personalized surgical plan formulation

Preoperative precise evaluation is the key basis for formulating personalized surgical plans and the core guarantee for improving treatment effects. During evaluation, multimodal imaging examination technology should be used to comprehensively analyze the anatomical characteristics, location, size, shape, infiltration degree, and regional lymph node metastasis of the tumor, combined with various factors such as the patient's overall health status. Currently, commonly used technical means include oral and maxillofacial CT, MRI, and ultrasound imaging. CT and MRI can accurately show the spatial relationship between the tumor and surrounding structures and its extension range; ultrasound is suitable for detecting cervical lymph node status; pathological biopsy can determine the histological type and differentiation degree, providing a reliable basis for clinical decisions [5]. Based on precise evaluation, an individual surgical plan should be established according to the patient's individual situation. If the tumor is small in size and limited in infiltration range, local resection can be adopted first to completely remove the lesion while preserving surrounding normal tissues and functional structures as much as possible; if the tumor is large in size and highly invasive, extended radical resection should be performed, and neck lymph node dissection should be combined if necessary to greatly reduce the recurrence rate; if the lesion involves important facial areas or key organ systems, functional protection and aesthetic repair needs should be considered in the initial design, and auxiliary means such as flap transfer and bone reconstruction should be arranged in advance to achieve both postoperative appearance optimization and physiological function recovery. In addition, age factors and other possible health risks should be considered, the risks related to surgery should be comprehensively weighed, and targeted interventions should be implemented to effectively ensure the safety of diagnosis and treatment and the achievement of expected curative effects [6].

### 3.2. Intraoperative precision operation and integrated application of minimally invasive technology

Precise surgical operation is a key factor in improving clinical efficacy and reducing tissue damage. During diagnosis and treatment, advanced equipment and technical means should be used to perform precise resection of tumor lesions, and efforts should be made to protect the safety of adjacent normal tissues and important neurovascular structures. For example, the intraoperative navigation system can real-time feedback the spatial positional relationship of instruments, providing efficient positioning assistance for surgeons and preventing operational errors due to visual limitations; intraoperative frozen pathological examination can determine whether the margin status meets the standards in a short time, so as to ensure the complete removal of cancerous parts, thereby greatly reducing the possibility of local recurrence. The use of minimally invasive technology not only reduces the scope of surgical wounds but also improves the efficiency of patients' postoperative recovery [7]. Currently, this technology is widely used in the treatment of oral and maxillofacial tumors and is gradually expanding towards diverse directions such as endoscopic assistance and robotic intervention. Precise operation

with endoscopes shows unique advantages in tumor resection in complex anatomical regions due to its small incisions, excellent field of view, and low bleeding rate; robotic surgery performed with high-precision mechanical arms and high-definition imaging systems further improves the diagnosis and treatment effect and ensures operational safety with its excellent spatial positioning ability. During clinical operations, strict adherence to sterile principles should be followed to prevent infection risks, and the total operation time should be reduced through refined process design to prevent tissue ischemic damage and related complications [8].

### 3.3. Construction of a postoperative multidimensional rehabilitation management system

Postoperative rehabilitation management is a key link in tissue function recovery and improvement of patients' quality of life, which is of great significance. Clinically, a systematic management model including physiological regulation, psychological intervention, nutritional support, and other aspects should be established to provide theoretical support for the comprehensive rehabilitation of patients, and personalized nursing strategies should be implemented to achieve the best curative effect. In terms of rehabilitation medicine, personalized training plans should be formulated to comprehensively assess the patient's surgical type and postoperative recovery status [9]. For example, for individuals after oral and maxillofacial surgical reconstruction, special training such as masticatory muscle group exercise, swallowing function improvement, and articulatory organ coordination should be carried out in stages to promote the recovery of various functions to normal. If the patient is accompanied by symptoms such as local swelling and pain, measures such as alternating hot and cold therapy and ultrasonic physical therapy can be used to improve blood circulation and relieve discomfort. At the same time, the wound care process should be strictly followed, dressings should be changed regularly, the wound should be cleaned correctly, the wound healing status should be closely observed, and potential infections, bleeding, and other conditions should be detected and resolved as early as possible. In terms of psychological intervention, since oral and maxillofacial tumor surgery will affect the patient's facial appearance and physiological functions, it is easy to cause negative emotions such as anxiety, depression, and damaged self-esteem in patients [10]. Therefore, it is necessary to focus on doctor-patient communication, pay close attention to the patient's psychological changes, and provide personalized psychological support services in a timely manner; cases of treatment effects and successful rehabilitation of related diseases can be shown to patients to enhance their treatment confidence; it is recommended that the patient's family also pay more attention to and support the patient to help reduce postoperative stress reactions and promote the smooth progress of the postoperative recovery process [11]. In terms of nutritional support, postoperative patients are at risk of insufficient nutritional intake due to limited chewing and swallowing functions. A nutritional support plan should be formulated according to the individual recovery process. For example, in the early postoperative period, patients can be provided with liquid or semi-liquid diets, and adequate protein and vitamin supply should be ensured to facilitate wound healing and body rehabilitation; as the patient's physiological functions gradually improve, they can gradually transition to a normal diet mode. Health education and guidance should also be strengthened to avoid irritating foods such as spicy and hard foods, thereby reducing the risk of oral mucosal injury [12].

## 4. Clinical outcomes of surgical treatment for patients with oral and maxillofacial tumors

By implementing optimization strategies such as preoperative precision evaluation, intraoperative precision

operation combined with minimally invasive technology, and postoperative multidimensional rehabilitation management, the clinical outcomes of surgical treatment for patients with oral and maxillofacial tumors have been significantly improved, mainly reflected in various aspects such as postoperative tissue function recovery, postoperative complication rate, patient's quality of life, and psychological state.

## 4.1. Significant effect on postoperative tissue function recovery

The optimized surgical treatment plan relies on preoperative precise evaluation and personalized planning, which not only ensures the complete resection of tumor tissue but also preserves the patient's normal anatomical structure and physiological functions as much as possible. The application of precise technology and minimally invasive methods during the implementation process greatly reduces the risk of damage to important tissues such as surrounding nerves, blood vessels, and muscles, providing a solid guarantee for postoperative functional reconstruction. The subsequent formulated systematic rehabilitation exercise plan also promotes the effective recovery of functions such as chewing, swallowing, and speech [13]. Compared with traditional radiotherapy, this therapy has significantly improved the overall recovery effect of oral and maxillofacial functions. Most subjects can gradually achieve self-care in diet and recovery of language communication ability, maintaining good facial appearance characteristics, thereby greatly reducing the decline in quality of life caused by functional impairment.

## 4.2. Effective reduction in postoperative complication rate

Traditional radiotherapy causes significant damage to surrounding tissues, which is likely to lead to symptoms such as dry mouth, mucosal ulceration, limited mouth opening, and osteomyelitis. The updated surgical plan reduces trauma and infection to a lower level through intraoperative precise operation, maintenance of a strict sterile environment, and application of minimally invasive technology; under the established sound wound management and comprehensive follow-up mechanism after surgery, most potential disease risks can be detected and addressed early. This new plan can effectively reduce the incidence of complications. For common manifestations such as delayed wound healing, wound bleeding, or local swelling, they can be successfully controlled under professional and technical care. The patient's entire condition converges rapidly, the length of hospital stay is significantly reduced, and the feeling of mental fatigue is alleviated [14].

## 4.3. Significant improvement in patients' quality of life and psychological state

Quality of life and psychological state are key comprehensive indicators for evaluating the treatment effect of patients with oral and maxillofacial tumors. The optimized surgical treatment plan not only improves the patient's postoperative tissue function and reduces the incidence of complications but also provides psychological intervention and nutritional support after surgery, relieving the patient's negative psychological emotions such as anxiety and depression and improving the psychological state. With the gradual recovery of the patient's facial appearance and physiological functions, self-confidence is significantly enhanced, and they can face life with a more positive attitude. The recovery of normal physiological functions enables patients to re-participate in social activities such as social interaction and work, and their quality of life is improved. Compared with patients after traditional radiotherapy who have a low quality of life due to functional disorders and psychological problems, the overall quality of life of patients after surgical treatment has been qualitatively improved [15].

## 5. Conclusion

In summary, in the treatment pattern of oral and maxillofacial tumors, radiotherapy and surgical treatment each have their clear positions and indications. However, for resectable lesions, especially advanced lesions, modern surgical treatment has shown more definite tumor eradication ability, more proactive functional recovery strategies, and a more manageable complication spectrum compared with traditional radiotherapy through comprehensive optimization of its technology. With the continuous development of medical technology, more precise and minimally invasive surgical treatment technologies should be further explored, postoperative management plans should be improved, the treatment effect should be continuously enhanced, the clinical prognosis of patients should be improved, and the harm of the disease to patients' physical and mental health should be further reduced.

## Disclosure statement

The author declares no conflict of interest.

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# A Case of Severe Trauma with Iliac Vascular Injury was Treated using a Time-Based Chain Approach

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**Abstract:** Severe trauma often involves complex injuries, leading to high disability and fatality rates. Effective treatment requires prompt and coordinated efforts across multiple disciplines to enhance success rates. Time-based chain rescue is crucial in managing severe trauma. A patient with chest and abdominal injuries and hemorrhagic shock was transferred from an ambulance to our hospital. Our trauma team-initiated pre-hospital first aid, utilized an emergency green channel, and conducted rapid ultrasound, collaborating across disciplines. The patient eventually recovered and was discharged.

**Keywords:** Severe trauma; Hemorrhagic shock; Time point of trauma; Chain-type treatment

**Online publication:** Feb 12, 2026

## 1. Introduction

With societal development, trauma has become the fifth leading cause of death globally, while severe trauma has emerged as the primary cause of death among young and middle-aged adults in China [1,2]. Severe trauma is often caused by violent factors such as falls from heights, traffic accidents, and workplace injuries. These patients present with critical conditions that progress rapidly, frequently leading to multi-tissue and multi-organ dysfunction. Such injuries are often accompanied by adverse events like massive hemorrhage and vascular occlusion. The key factor for patient survival is receiving timely, accurate, and highly efficient team-based treatment within a short timeframe [3]. This study presented a case report of a patient with severe trauma complicated by iliac vascular injury admitted to the Emergency Trauma Center of Changzhou Seventh People's Hospital. Drawing on our center's clinical experience in managing such cases, we discuss the diagnosis and treatment of severe trauma complicated by iliac vascular injury, aiming to provide insights for the management of similar trauma patients.

## 2. Case data

Patient, male, 58 years old, laborer. On July 5, 2024, at 08:50, he was transported to the hospital via 120 emergency services after being struck in the chest and abdomen by a steel pipe for 10 minutes. At 08:40, while working, the patient was accidentally struck in the chest and abdomen by a steel pipe. Immediately after the injury, he developed abdominal pain that progressively worsened, accompanied by numbness in the right lower limb. The prehospital emergency physician assessed the patient as conscious with a distressed expression. Physical examination findings: Temperature: 36.8 ℃, Heart rate: 125 beats/min, Blood pressure: 102/81 mmHg, Oxygen saturation: 90%. TISS score: 17. Intravenous access was established for fluid resuscitation, supplemented with oxygen via face mask. Preliminary assessment indicated the patient met the criteria for "Ambulance Critical Trauma Patient Early Warning" and was triaged via telephone alert to the emergency department. At 09:15, the ambulance arrived at the emergency department. The patient was admitted directly to the resuscitation room via the green channel. The emergency surgeon examined the patient: T 36.6 ℃, heart rate 135 bpm, blood pressure 92/78 mmHg, oxygen saturation 95%, shock index 1.47, altered mental status, agitated and restless, unable to communicate verbally. No external head injuries. Bilateral pupils equal and round, diameter 3 mm, with active light reflexes. Scattered contusions on chest and abdominal walls. Right lower abdomen purple and swollen. Right thigh swollen with limited mobility. Patient uncooperative for remainder of examination. No significant past medical history; denies history of hypertension, diabetes, coronary heart disease, or other chronic conditions. 09:20 Initial assessment completed. Preliminary diagnosis: 1. Multiple trauma: Thoracic injury, abdominal injury, vascular injury? 2. Complication of injury: Traumatic hemorrhagic shock. 09:25 Bedside rapid ultrasound reveals splenic hematoma, perihepatic hematoma, and pelvic hematoma. The patient is in critical condition. Immediately activate the trauma response team. Simultaneously initiated emergency transfusion protocol. At 09:30, completed central venous catheterization and administered tranexamic acid for hemostasis, supplemented with analgesic and sedative therapy. At 09:48, commenced infusion of 2 units of Type A red blood cells and 200 mL of frozen plasma. At 09:55, completed plain and contrast-enhanced CT scans of the chest and abdomen (see **Figure 1**). Examination findings: Fracture of the left 11th rib; suspected splenic rupture with subcapsular hematoma, minimal perihepatic hemorrhage, and pelvic hematoma; occlusion of the right iliac artery. ISS score: 27. Admitted to the operating room at 10:00 for surgery. Intraoperatively, complete transverse transection of the small intestine and mesentery in the right lower abdomen was observed, with bleeding from the mesenteric stump (see **Figure 2**). Partial small bowel resection with intestinal anastomosis and mesenteric repair was performed. Surgery concluded at 12:25, with the patient's vital signs gradually stabilizing. At 13:40, the Interventional Radiology Department conducted percutaneous selective angiography, confirming occlusion of the right external iliac artery (see **Figure 3**). Right external iliac artery stenting was performed, followed by right iliac artery balloon angioplasty and right external iliac artery thrombectomy. Good blood supply was restored to the external iliac artery (see **Figure 4**). The patient was admitted to the ICU for further treatment postoperatively. The patient was discharged in good condition on July 31, 2024.



**Figure 1.** Abdominal CT reveals intra-abdominal hemorrhage.

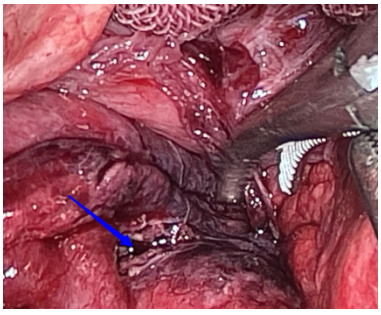


**Figure 2.** Intraoperative findings reveal intestinal perforation and mesenteric hemorrhage.



**Figure 3.** Contrast imaging reveals occlusion of the external iliac artery.

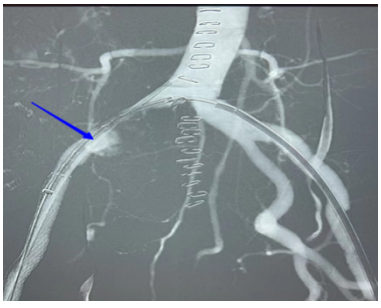


**Figure 4.** Lateral iliac artery recanalization.

## 3. Discussion

Multiple trauma constitutes a distinct disease category, and how to provide more effective treatment for patients with severe multiple injuries has become a hot topic and major challenge in the field of emergency medicine [4]. The previous treatment model primarily involved transporting patients to the emergency department for initial care. Upon admission, emergency physicians would sequentially call for specialist consultations based on the location and severity of injuries. This approach resulted in prolonged treatment times, low efficiency, and a lack of comprehensive treatment capabilities [5]. Patients with this condition often present a "triple contradiction": the contradiction between the complexity of injuries and the urgency of treatment, the contradiction between multiple organ injuries and the fragmentation of specialized care, and the contradiction between high treatment costs and uncertain prognosis [6]. The traditional treatment model reveals three major shortcomings: 1. Time delay: Studies indicate that the average time from hospital admission to surgery for severely injured patients reaches 118 minutes, with mortality increasing by 12% for every 30-minute delay [7]. 2. Inefficient collaboration: The single-specialty consultation model increases decision-making time by over 40%. 3. Fragmented resources: A study by Peking Union Medical College Hospital indicates that the lack of an integrated treatment system reduces medical resource utilization by 35% [8]. The International Trauma Care Consortium (ITACCS) proposes the "Time Window Theory", emphasizing that the first 60 minutes post-injury constitute the golden hour for critical care. Within this period, the initial 10 minutes (the platinum hour) determine the survival rate for 80% of hemorrhagic shock patients [9]. Recent studies suggest that improving critical care for severely injured patients requires shifting from individual efforts to collaborative teamwork, and replacing tiered consultations and hierarchical reporting with rapid response, swift

decision-making, and prompt treatment by team members, a necessary approach to enhance the quality of care for critically injured patients [10].

Starting in June 2023, our hospital implemented a time-based chain-of-care approach for treating severely injured patients, which essentially represents a restructuring of the trauma care process. The system encompasses two major modules: pre-hospital emergency care and in-hospital treatment. It establishes standard timelines for each treatment phase, dividing complex resuscitation procedures into distinct time-based milestones. Each milestone is assigned a target time threshold, with individual accountability assigned for resuscitation responsibilities. This approach breaks away from traditional sequential workflows, enabling simultaneous execution of diagnostic procedures and resuscitation efforts. The successful treatment of this patient was achieved through the hospital's time-based chain-of-care model and the comprehensive trauma-related specialty care capabilities.

This patient's journey from injury to operating room took only 80 minutes (injured at 08:40, surgery commenced at 10:00). The 15-minute rapid prehospital transport secured critical time for subsequent treatment, aligning with findings reported by Liu Haixia et al. on the effectiveness of "battle trauma treatment centers". Through prehospital alerts and pre-positioned hospital teams, the time to resuscitation for critically ill patients can be reduced to under 45 minutes. The core advantages of this model are twofold: First, it enables earlier intervention by initiating critical care measures, such as establishing intravenous access and maintaining vital signs, during the prehospital phase to prevent deterioration. Second, it facilitates resource prepositioning through an "ambulance critical care alert" mechanism, allowing the hospital trauma team to prepare personnel, equipment, and blood products before patient arrival, significantly accelerating response times. During the prehospital emergency phase, prehospital emergency physicians rapidly conduct trauma assessments and initiate prehospital resuscitation. The 5G transmission system enables real-time sharing of vital signs. Establishing intravenous access for fluid resuscitation and administering oxygen via face mask maintains blood oxygen levels, alleviating patient anxiety while stabilizing vital functions. Seamless coordination with hospital emergency triage reduces in-hospital handover time and minimizes preparation delays for in-hospital resuscitation. Rapid prehospital treatment and transport lay the foundation for subsequent in-hospital care, achieving "hospital admission upon arrival".

Treatment time is an independent factor influencing the prognosis of patients with severe trauma. Zhang Jigang et al. confirmed through a study of 1,263 trauma patients that those with a pre-hospitalization delay exceeding 60 minutes had a 30-day mortality rate 2.3 times higher than patients with delays under 30 minutes. In this case, the treatment process strictly adhered to critical time points at each stage, with a total emergency room and resuscitation time of 45 minutes. This fully complies with the "time-sensitive" principle for managing severe trauma. During the in-hospital resuscitation phase, our trauma resuscitation team comprises emergency department and trauma center medical staff with clearly defined responsibilities. Each team consists of 3 physicians and 2 nurses: Physician C handles endotracheal intubation, airway protection, and central venous catheterization. Nurse A manages venous access, while Nurse B is responsible for blood collection and medication preparation. Upon receiving prehospital emergency notification for a severely injured patient, the hospital immediately activates its emergency response team. A green channel is opened upon the patient's arrival. Within 5 minutes of admission, initial assessment and venous blood sampling are completed. Within 10 minutes, bedside rapid ultrasound confirms visceral bleeding, triggering the trauma team response. Deep venous catheterization is completed within 15 minutes. Blood transfusion begins within 33 minutes. Contrast-enhanced CT is completed within 40 minutes. The patient enters the operating room for surgery within 45 minutes. The rescue process is

seamlessly interconnected, minimizing the time patients with severe trauma spend waiting for treatment while enhancing the continuity and rigor of care. The efficient implementation of this process relies on three key measures: First, the application of standardized assessment tools, the TI score (17 points) is used pre-hospital to rapidly identify critically ill patients, while the ISS score (27 points) is employed in-hospital to quantify injury severity, providing objective criteria for determining treatment priorities. Second is the integration of point-of-care rapid diagnostic technologies: Bedside ultrasound (FAST examination) can identify splenic, hepatic, and pelvic hemorrhages within 10 minutes, eliminating the time delays associated with traditional imaging studies. This aligns with the "ultrasound-guided injury control" concept proposed by Du Zhe et al., the technique elevates the diagnostic accuracy for intra-abdominal hemorrhage to 92%, significantly reducing decision-making time for surgical interventions. Finally, the optimization of the emergency transfusion process: From initiating the transfusion protocol to commencing red blood cell infusion took only 18 minutes (09:30–09:48). This achievement stems from the hospital's implementation of a "rapid blood transfusion pathway for trauma patients". Through measures such as pre-stocking blood and rapid ABO blood typing, the traditional transfusion preparation time was reduced by 50%. Precise control of critical time points not only enhances rescue efficiency but also enables visual management of treatment quality through "timeline tracing". In this case, each operational node is documented, providing data support for subsequent process optimization. This aligns with the findings of comparative studies by Jiang Shirong et al., the integrated trauma emergency model achieves a 68% higher treatment documentation completeness rate than traditional models, facilitating continuous improvement.

The primary challenge in treating this patient lies in the combination of abdominal organ injuries and iliac vascular injuries, requiring on-site decision-makers to possess multidisciplinary trauma management capabilities. Iliac vascular injuries occur in approximately 3–5% of severe trauma cases, yet carry a mortality rate as high as 40–60%, primarily due to uncontrollable massive hemorrhage and subsequent distal limb ischemia and necrosis [11]. This patient also presented with a ruptured mesentery and intra-abdominal hemorrhage, significantly increasing the complexity of treatment. Research has demonstrated that the MDT model can reduce treatment decision errors in complex trauma patients by 42% and increase treatment success rates by 27%. In this case, our department established a clear sequence of "damage control first, staged reconstruction second" through preoperative discussions, thereby avoiding the limitations of single-specialty decision-making. This approach was crucial to the successful treatment. Following thorough consultation between the Trauma Center and the Vascular Intervention Department, exploratory laparotomy is performed first to identify the bleeding site, followed by damage control surgery (DCS). Definitive surgery is then conducted by the relevant specialty. This strategy aligns with the damage control surgery (DCS) concept recommended by the International Trauma Society, for patients with an ISS score > 25, the mortality rate for definitive surgery performed in a single stage reaches 58%, whereas DCS reduces mortality to 29% [7]. During the emergency room phase, through the collaborative efforts of the emergency trauma team, the patient was smoothly transferred to the operating room with a delay time of 45 minutes. In the surgical phase, the trauma center performed exploratory laparotomy to confirm the diagnosis, followed by intestinal resection and mesenteric repair to promptly "turn off the tap" and control bleeding. Once vital signs stabilized, the patient was transferred to the interventional radiology department for vascular management, where endovascular intervention was performed, achieving rapid vascular recanalization. Endovascular therapy has now become the preferred treatment for iliac artery occlusion. Studies indicate that the vascular recanalization rate achieved through endovascular therapy is comparable to that of open surgery, while offering advantages such as minimal trauma, rapid postoperative recovery, and shorter hospital stays. Additionally, endoscopic treatment

avoids the trauma of secondary surgery, making it particularly suitable for patients with concomitant abdominal infections or coagulation disorders. This aligns with the rapid postoperative recovery observed in this case. The patient underwent intensive care unit (ICU) monitoring postoperatively, receiving anti-inflammatory therapy and treatment to correct coagulation dysfunction. The patient recovered well and was discharged successfully 26 days after surgery.

One of the key factors in this patient's survival was the timely provision of effective treatment. The timeliness of trauma care demonstrates that patients can achieve optimal therapeutic outcomes through interventions administered within a specific "time window". The successful treatment of this patient was achieved by the hospital's implementation of a severe trauma timeline as the central framework. By using time as the key metric, the hospital integrated pre-hospital and in-hospital care, strictly controlled the duration of each treatment phase, and enhanced the efficiency of the rescue efforts. This approach ensured the patient received effective treatment within the shortest possible timeframe. Pre-hospital care for the patient; definitive diagnosis and maintenance of vital signs in the emergency resuscitation room; damage control surgery at the trauma center; specialized definitive surgery. This seamless chain of care ensured successful treatment outcomes, demonstrating the hospital's multidisciplinary collaborative capabilities in managing severe trauma. However, continuous optimization remains possible in the following areas: Early warning technology for vascular injury: Iliopsoas artery injuries often present insidiously. While this case was definitively diagnosed via CTA, the examination took 40 minutes. Introducing bedside vascular ultrasound contrast imaging could provide preliminary assessment of vascular occlusion or rupture within 10 minutes, enabling earlier decision-making for surgical intervention. Regular Team Training: The efficient operation of chain-based treatment relies on seamless coordination among team members. Our hospital conducts monthly trauma simulation drills, focusing on training "time-sensitive response protocols" (e.g., deep venous catheterization within 15 minutes), which has increased team collaboration efficiency by 50%. This achieves seamless integration between skills training and real-world application, consistent with the effectiveness of the "Combat Trauma Center" regular drill mechanism [12].

## 4. Conclusion

In summary, while models for treating severe trauma vary, the overarching principle remains consistent. Time-based chain-of-care approaches offer advantages such as efficiency and speed, thereby enhancing the success rate of resuscitation for severely injured patients and ensuring effective treatment outcomes. It can comprehensively document the entire treatment process for patients, trace and address issues at each stage for improvement, optimize clinical workflows, control medical quality, enhance the hospital's capacity to treat severely injured patients, reduce adverse event rates, and provide a replicable clinical pathway for complex trauma care. Future efforts should focus on strengthening prehospital-to-hospital information exchange, introducing precision diagnostic technologies, and optimizing team training to address increasingly complex trauma care challenges.

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## Disclosure statement

The authors declare no conflict of interest.

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# Comparative Study on the Efficacy and Safety of Faricimab and Conbercept in the Treatment of Diabetic Macular Edema

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**Abstract:** *Objective*: To compare the clinical efficacy and safety of intravitreal injection of faricimab and conbercept in the treatment of diabetic macular edema (DME). *Methods*: A total of 50 patients diagnosed with DME in our hospital from January 2023 to May 2025 were selected and randomly divided into an observation group and a control group, with 25 cases in each group, using a random number table method. The observation group received intravitreal injection of faricimab, while the control group received intravitreal injection of conbercept. Both groups adopted a loading phase plus maintenance phase treatment regimen. The best-corrected visual acuity (BCVA, expressed in logMAR) and central subfield thickness (CST) of the two groups were compared before treatment and at 1, 3, and 6 months after treatment, and the incidence of adverse events during treatment was recorded. *Results:* The logMAR BCVA in the observation group was lower than that in the control group at 3 and 6 months after treatment (both $p < 0.05$). The CST in the observation group was smaller than that in the control group at 1, 3, and 6 months after treatment (all $p < 0.05$). There was no statistically significant difference in the overall incidence of adverse events between the two groups ($\chi^2 = 0.189$, $p = 0.663$). *Conclusion:* Both intravitreal injections of faricimab and conbercept are effective in improving visual acuity and reducing macular edema in patients with DME, with good safety profiles. However, faricimab demonstrates superior efficacy in the medium to long term (3 and 6 months) compared to conbercept, making it more suitable for long-term treatment of patients with DME.

**Keywords:** Diabetic macular edema; Faricimab; Conbercept; Intravitreal injection; Efficacy; Safety

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## 1. Introduction

Diabetic macular edema (DME) is one of the common microvascular complications of diabetes, characterized by the accumulation of fluid in the macular region and the disruption of the blood-retinal barrier as its core pathological features. It can lead to a sharp decline in central vision and metamorphopsia, posing a severe threat to the visual function of patients and being one of the primary causes of blindness in diabetic patients [1,2]. With the

clinical application of anti-vascular endothelial growth factor (anti-VEGF) drugs, breakthrough progress has been made in the treatment of DME, which has become a first-line treatment option [3]. Faricimab, as a novel dual-target anti-VEGF drug, can simultaneously inhibit VEGF-A and Ang-2, while Conbercept is a domestically produced anti-VEGF drug with widespread clinical application [4]. However, regarding the comparative efficacy, differences in the extent of visual improvement, and safety risks of these two drugs in the treatment of DME, the current clinical research evidence is insufficient, and there is still a lack of clear guidance for their clinical application selection. Based on this, this study aims to clarify the differences in clinical efficacy between Faricimab and Conbercept in the treatment of DME through prospective clinical comparative analysis, systematically evaluate their improvement effects on patients' best-corrected visual acuity and central macular thickness, and monitor and compare the types and incidence rates of adverse reactions, providing high-quality evidence-based medical evidence for clinically optimizing DME treatment plans and individualizing drug selection.

## 2. Materials and methods

### 2.1. General information

A total of 50 patients diagnosed with diabetic macular edema (DME) who visited the ophthalmology department of our hospital from January 2023 to May 2025 were selected as the study subjects.

#### 2.1.1. Inclusion criteria

(1) Meeting the diagnostic criteria for DME outlined in the 2024 edition of the "Clinical Practice Guideline for Diabetic Retinopathy" by the American Academy of Ophthalmology [5];
(2) Foveal-involving macular edema, with optical coherence tomography (OCT) showing a central subfield thickness (CST) ≥ 320 μm;
(3) Best-corrected visual acuity (BCVA) ranging from 0.3 to 0.8 (logMAR 0.1 to 0.5);
(4) A diabetes duration of ≥ 3 years with stable glycemic control (glycated hemoglobin < 7.5%);
(5) Informed consent obtained from the patients, who signed the informed consent form.

#### 2.1.2. Exclusion criteria

(1) Coexistence of other retinal diseases (e.g., age-related macular degeneration, retinal vein occlusion);
(2) Previous history of intravitreal injections or ocular surgery;
(3) Presence of other ocular conditions affecting vision, such as ocular infections, glaucoma, or cataracts;
(4) Severe systemic organic diseases affecting the heart, liver, or kidneys;
(5) Allergy to any component of the study drug.

#### 2.1.3. Study groups

Patients were randomly assigned to the observation group and the control group using a random number table method, with 25 patients in each group. In the observation group, there were 14 males and 11 females; ages ranged from 45 to 72 years, with a mean age of (58.6 ± 6.3) years; the duration of diabetes ranged from 3 to 15 years, with a mean duration of (8.2 ± 2.5) years; the logMAR BCVA before treatment was (0.32 ± 0.08), and the CST was (426.8 ± 35.2) μm. In the control group, there were 13 males and 12 females, aged between 46 and 73 years old, with an average age of (59.2 ± 6.5) years old. The duration of diabetes ranged from 3 to 16 years, with an average

of (8.5 ± 2.7) years. Before treatment, the logMAR BCVA was (0.33 ± 0.09), and the CST was (430.2 ± 36.5) μm. There were no statistically significant differences in general data such as gender, age, duration of diabetes, logMAR BCVA, and CST between the two groups before treatment ($p > 0.05$), indicating comparability.

## 2.2. Treatment methods

Before treatment, both groups of patients underwent comprehensive routine ocular examinations (including visual acuity, intraocular pressure, slit-lamp examination, fundus ophthalmoscopy, OCT, etc.) and general physical examinations to assess the feasibility of treatment. All injection procedures were performed by the same experienced ophthalmologist, strictly adhering to aseptic techniques. Three days before injection, levofloxacin eye drops were administered four times a day to prevent infection. During the injection, surface anesthesia was applied, and the eyelids were held open with a speculum. The needle was inserted 3.5 mm posterior to the inferotemporal corneal limbus, and the drug was slowly injected before withdrawing the needle. The puncture site was then pressed for 3 to 5 minutes, and the procedure was concluded after observing no abnormalities.

The observation group received an intravitreal injection of Faricimab at a dose of 6 mg each time, while the control group received an intravitreal injection of Conbercept at a dose of 0.5 mg each time. Both groups adopted a loading phase + maintenance phase treatment regimen: during the loading phase, injections were administered once a month for three consecutive times; the maintenance phase commenced in the fourth month, during which the resolution of macular edema was evaluated based on OCT examination results. If the central subfield thickness (CST) was < 320 μm and visual acuity remained stable, injections were given once every three months; if CST was ≥ 320 μm, injections were administered once every two months. The total follow-up period was six months.

## 2.3. Observation indicators

(1) Best-corrected visual acuity (BCVA)

Assessed using a standard logarithmic visual acuity chart, with visual acuity converted to logMAR values for statistical analysis. Lower logMAR values indicate better visual acuity. Measurements were taken before treatment and at 1, 3, and 6 months post-treatment.

(2) Central subfield thickness (CST)

Measured using spectral-domain OCT by scanning a 5 mm area of the macular region and averaging three measurements of retinal thickness at the fovea. Measurements were taken before treatment and at 1, 3, and 6 months post-treatment.

(3) Safety indicators

Adverse events occurring in patients in both groups during treatment were recorded, including ocular adverse events (conjunctival hemorrhage, ocular pain, increased intraocular pressure, vitreous opacity, etc.) and systemic adverse events (headache, nausea, fluctuations in blood pressure, etc.). The incidence of adverse events was calculated.

## 2.4. Statistical methods

Data analysis was performed using SPSS 26.0 statistical software. Measurement data were expressed as mean ± standard deviation ($\overline{x} \pm s$). Paired *t*-tests were used for comparisons within groups before and after treatment, while independent sample *t*-tests were used for comparisons between groups. Categorical data were expressed as rates (%), and comparisons were made using the $\chi^2$ test. A *p*-value of less than 0.05 was considered statistically significant.

## 3. Results

### 3.1. Comparison of logMAR BCVA between the two groups before and after treatment

The logMAR BCVA in the observation group was lower than that in the control group at 3 and 6 months after treatment (both $p < 0.05$). See **Table 1**.

**Table 1.** Comparison of logMAR BCVA between the two groups before and after treatment

| Group | Before treatment | 1 month of treatment | 3 months of treatment | 6 months of treatment |
|---|---|---|---|---|
| Observation group (n = 25) | 0.32 ± 0.08 | 0.24 ± 0.07 | 0.18 ± 0.06 | 0.13 ± 0.05 |
| Control group (n = 25) | 0.33 ± 0.09 | 0.25 ± 0.08 | 0.22 ± 0.07 | 0.18 ± 0.06 |
| *t*-value (vs. control) | 0.415 | 0.470 | 2.169 | 3.201 |
| *p*-value (vs. control) | 0.680 | 0.640 | 0.035 | 0.002 |

### 3.2. Comparison of CST between the two groups before and after treatment

The CST in the observation group was smaller than that in the control group at 1, 3, and 6 months after treatment (all $p < 0.05$). See **Table 2**.

**Table 2.** Comparison of CST between the two groups before and after treatment

| Group | Before treatment | 1 month of treatment | 3 months of treatment | 6 months of treatment |
|---|---|---|---|---|
| Observation group (n = 25) | 426.82 ± 35.21 | 358.63 ± 28.55 | 312.44 ± 22.36 | 298.63 ± 18.54 |
| Control group (n = 25) | 430.22 ± 36.51 | 375.45 ± 29.86 | 338.64 ± 25.77 | 324.84 ± 21.62 |
| *t*-value (vs. control) | 0.335 | 2.036 | 3.840 | 4.601 |
| *p*-value (vs. control) | 0.739 | 0.047 | < 0.001 | < 0.001 |

### 3.3. Comparison of adverse events between the two groups

During the treatment period, a small number of adverse events occurred in both groups, all of which were mild to moderate in severity. These events were relieved after symptomatic treatment, and no serious adverse events (such as endophthalmitis, retinal detachment, or severe systemic allergic reactions) occurred. There was no statistically significant difference in the overall incidence of adverse events between the two groups ($\chi^2 = 0.189$, $p = 0.663$). See **Table 3**.

**Table 3.** Comparison of adverse events between the two groups

| Group | Conjunctival hemorrhage | Eye pain | Elevated intraocular pressure | Overall incidence rate (%) |
|---|---|---|---|---|
| Observation group (n = 25) | 1 | 1 | 0 | 2 (8.0) |
| Control group (n = 25) | 2 | 1 | 1 | 4 (16.0) |
| $\chi^2$-value | - | - | - | 0.189 |
| *p*-value | - | - | - | 0.663 |

## 4. Discussion

DME (Diabetic Macular Edema) is a common complication of diabetic retinopathy with a complex pathogenesis.

It is primarily associated with the overexpression of VEGF (Vascular Endothelial Growth Factor) and the accumulation of fluid in the macular region due to the disruption of the blood-retina barrier. If left untreated, it can lead to a severe decline in vision or even blindness, significantly affecting the patient's quality of life [6]. Currently, intravitreal injection of anti-VEGF drugs is the first-line treatment for DME, aiming to alleviate macular edema and improve visual acuity by inhibiting VEGF activity [7].

Conbercept is an anti-VEGF drug independently developed in China, belonging to the class of fusion proteins. It can specifically bind to multiple subtypes of VEGF-A, inhibiting angiogenesis and vascular leakage. Conbercept has been widely used in the treatment of DME with proven efficacy [8]. Faricimab is a novel bispecific antibody that not only inhibits VEGF-A but also inhibits angiopoietin-2 (Ang-2). Ang-2 can exacerbate macular edema by disrupting vascular stability, so faricimab can exert its effects through a dual pathway, more effectively stabilizing the blood-retina barrier and reducing macular edema [9]. This study compared the efficacy of the two drugs in treating DME. The results showed that after 1, 3, and 6 months of treatment, the logMAR BCVA (Best Corrected Visual Acuity) of both groups significantly decreased compared to before treatment, and the CST (Central Subfield Thickness) significantly decreased compared to before treatment. This indicates that both drugs can effectively improve visual acuity and macular edema in patients with DME, consistent with previous research findings.

Further analysis revealed that at 3 and 6 months of treatment, the logMAR BCVA in the observation group was lower than that in the control group, and the CST was smaller than that in the control group, with statistically significant differences. However, there were no statistically significant differences in these indicators between the two groups at 1 month of treatment. This suggests that the short-term efficacy of faricimab is generally comparable to that of conbercept, but faricimab demonstrates superior medium- to long-term efficacy. The reason for this may be related to the dual mechanism of action of faricimab: on the one hand, by specifically inhibiting the VEGF-A signaling pathway, it effectively reduces leakage from retinal choroidal neovascularization, thereby alleviating fluid accumulation in the macular region from the source [9]. On the other hand, its inhibitory effect on Ang-2 stabilizes the morphology and function of vascular endothelial cells, reduces vascular permeability, and subsequently decreases the recurrence of macular edema, ultimately achieving a more sustained therapeutic effect [10]. Additionally, pharmacokinetic analysis shows that faricimab has a relatively longer half-life, enabling it to maintain stable and effective drug concentrations in ocular tissues, significantly prolonging its duration of action. This may also be one of the key factors contributing to its superior medium- to long-term efficacy compared to conbercept.

In terms of safety, there was no statistically significant difference in the incidence of adverse events between the two groups in this study, and all adverse events were mild to moderate in severity. They were alleviated after symptomatic treatment, with no serious adverse events such as endophthalmitis or severe hemorrhage occurring. The two most common ocular adverse events were conjunctival hemorrhage. Based on the analysis of clinical operation records, this symptom was primarily associated with injection procedures and constituted a transient reaction that resolved spontaneously without the need for special intervention. In the control group, one case of transient intraocular pressure elevation occurred, which rapidly returned to the normal range after treatment with topical antihypertensive eye drops, without causing adverse effects on the patient's visual function. The aforementioned safety data fully demonstrate that both Faricimab and Conbercept exhibit good safety profiles for the treatment of diabetic macular edema (DME), with controllable clinical application risks.

Although this study clarified the differences in short-term and mid-term efficacy between the two drugs

in treating DME, it still has certain limitations and requires an objective assessment of the applicability of the research findings. Firstly, the sample size was relatively small, and the follow-up period was short, which limited the ability to evaluate the long-term durability and safety of the two drugs. Additionally, as this was a single-center study, the results may have geographical limitations, potentially leading to insufficient representativeness and difficulty in fully extrapolating the findings to DME patient populations with different regional and clinical characteristics, thereby introducing potential geographical and selection biases. Future research should involve large-sample, multicenter studies with long-term follow-up to further validate the efficacy and safety of the two drugs, providing more comprehensive and reliable evidence-based medical support for optimizing individualized treatment plans for DME.

## 5. Conclusion

In conclusion, both Faricimab and Conbercept administered via intravitreal injection are effective in improving visual acuity and reducing macular edema in patients with DME, with good safety profiles. However, Faricimab demonstrates superior mid- to long-term (3- and 6-month) efficacy compared to Conbercept, making it more suitable for long-term treatment in patients with DME.

## Disclosure statement

The authors declare no conflict of interest.

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# The Impact of Early Postoperative Rehabilitation Training on Balance Ability and Quality of Life in Elderly Patients with Hip Fracture

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**Abstract:** Objective: To analyze the improvement effect of early postoperative rehabilitation training on balance ability and quality of life in elderly patients with hip fracture. Methods: A total of 50 elderly patients with hip fracture admitted to our hospital from January 2023 to January 2024 were selected and divided into the observation group (25 cases) and the control group (25 cases) by random number table method. The control group received routine nursing, while the observation group received early rehabilitation training on the basis of routine nursing. The balance ability (Berg Balance Scale, BBS) and quality of life (SF-36) of the two groups were compared. *Results:* The BBS scores of the observation group at all postoperative time points were significantly higher than those of the control group ($p < 0.05$), and the quality-of-life scores of the observation group were also significantly higher than those of the control group ($p < 0.05$). *Conclusion:* Early postoperative rehabilitation training for elderly patients with hip fracture can improve their balance ability, enhance their quality of life, and reduce the incidence of postoperative complications, which is worthy of clinical promotion.

**Keywords:** Elderly hip fracture; Early postoperative rehabilitation training; Balance ability; Quality of life; Complications

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## 1. Introduction

Hip fracture in the elderly is a common traumatic disease in orthopedics, including femoral neck fracture and intertrochanteric fracture. With the aggravation of aging, the incidence of this disease is increasing year by year. According to relevant statistics, the annual incidence of hip fracture in the elderly over 65 years old in the world is 3–5%, and the disability rate within 1 year after operation is 50–60%. Due to the decline of physical function, weakened muscle strength and decreased balance ability, elderly patients are prone to complications such as muscle atrophy, joint stiffness and deep vein thrombosis after long-term bed rest and immobilization after fracture, which seriously affects the recovery of patients' balance ability, reduces their quality of life, and causes a huge burden on families and society. At present, surgical treatment is still the main treatment method for elderly hip

fracture, which can restore the anatomical structure of the fracture and facilitate early activities. However, the timeliness and scientificness of postoperative rehabilitation training are crucial for patients' rehabilitation. The traditional rehabilitation model mostly starts intervention after the patient's condition stabilizes after operation, at which time the patient has developed varying degrees of disuse muscle atrophy, increasing the difficulty of rehabilitation. Based on the above situation, this study selected 50 elderly patients with hip fracture as research objects, and analyzed the actual effect of early postoperative rehabilitation training through group comparison, so as to provide certain reference for improving the postoperative rehabilitation program of elderly hip fracture [1].

## 2. Materials and methods

### 2.1. Clinical data

A total of 50 elderly patients with hip fracture admitted to the orthopedics department of our hospital from January 2023 to January 2024 were selected and divided into the observation group (25 cases) and the control group (25 cases) by random number table method. In the observation group, there were 11 males and 14 females, aged 65–88 years, with an average of (76.32 ± 5.41) years. In the control group, there were 12 males and 13 females, aged 66–89 years, with an average of (77.15 ± 5.63) years. This study has been approved by the medical ethics committee [2].

#### 2.1.1. Inclusion criteria

(1) Diagnosis of elderly hip fracture conforms to the standard, confirmed by X-ray or CT examination;
(2) Patients and their families are informed and consent to sign the informed consent form.

#### 2.1.2. Exclusion criteria

(1) Complicated with severe heart, liver, kidney and other organ failure;
(2) Complicated with malignant tumors and coagulation disorders. There were no statistically significant differences in general data such as gender, age, fracture type, cause of injury and comorbidities between the two groups ($p > 0.05$), which were comparable.

### 2.2. Methods

Both groups underwent routine surgery and basic nursing (vital sign monitoring, wound care, anti-infection, pain management, etc.) [3,4].

#### 2.2.1. Control group

Routine postoperative rehabilitation nursing. During bed rest, ankle flexion and extension and isometric contraction training of quadriceps were performed twice a day, 15 to 20 minutes each time; after the condition improved 2 to 3 weeks after operation, help patients sit up, stand and walk, and gradually increase the difficulty.

#### 2.2.2. Observation group

On the basis of the control group, the observation group carried out early postoperative rehabilitation training. A rehabilitation team composed of rehabilitation physicians, responsible nurses and rehabilitation therapists formulated an individualized rehabilitation training plan according to the patient's surgical method and physical condition.

### 2.2.3. Training strategy

Training started 1–3 days after operation, and the training content was carried out in stages.

Stage 1 (1–7 days after operation): Bedside passive training + active assisted training to prevent muscle atrophy and joint restriction.

(1) Passive training

Rehabilitation therapists helped patients complete passive flexion and extension training of hip and knee joints, with the angle starting from 30° and gradually increasing to 90°, 10–15 min each time, twice a day;

(2) Active assisted training

Guided patients to carry out ankle dorsiflexion and plantar flexion training, 10 min each time, three times a day; isometric contraction training of quadriceps, contraction for 5–10 s each time, 10–15 times per group, three groups a day; gluteus maximus contraction training, 10 times per group, three times a day;

(3) Respiratory function training

Guided patients to carry out abdominal breathing training, 10 min each time, twice a day, to prevent pulmonary infection.

Stage 2 (8–14 days after operation): Focus on active training and preliminary balance function training to enhance muscle strength and joint range of motion.

(1) Active training

Patients independently completed active flexion and extension training of hip and knee joints, gradually increasing the training angle and range, about 15 min each time, twice a day; straight leg raising training, the lifting height starts from 10 cm and gradually increases to 30 cm, 10 times per group, three groups a day;

(2) Balance function training

Assisted patients to sit by the bed with both feet on the ground for sitting balance training, 10 min each time, twice a day

(3) Transfer training

Guided patients to perform bed-chair transfer training with the help of walkers, 10–15 min each time, twice a day.

Stage 3 (15d after operation–discharge): Focus on intensive balance function training and walking training to improve activities of daily living.

(1) Balance function training

Single-leg standing and eyes-closed standing, 5–10 min each time, twice a day;

(2) Walking training

Straight-line walking and turning walking, gradually extending the walking distance and increasing the walking speed, 20–30 min each time, twice a day;

(3) Activities of daily living training

Dressing, washing, eating, etc., 15–20 min each time, twice a day. Patients were followed up for 6 months after discharge, and rehabilitation training was regularly guided through telephone and outpatient review.

## 2.3. Observation indicators

(1) Balance ability

Evaluated by Berg Balance Scale (BBS) at 1 month, 3 months and 6 months after operation, with a total

of 14 items, 0–4 points per item, total score 0–56 points, higher score indicates better balance [5].

(2) Quality of life

Evaluated by the 36-Item Short Form Health Survey (SF-36) at 6 months after operation, including 7 aspects such as physical function, bodily pain, general health and social function, 0–100 points per dimension, higher score indicates better quality of life [6].

### 2.4. Statistical methods

The data in this group were processed and analyzed with SPSS21.0 software. Measurement data were expressed as ($\bar{x} \pm s$) and tested by *t* test; count data were expressed as % and tested by $\chi^2$ test. $p < 0.05$ was considered statistically significant.

## 3. Results

### 3.1. Comparison of BBS scores between the two groups at different postoperative time points

At 1 month, 3 months and 6 months after operation, the BBS scores of the observation group were significantly higher than those of the control group ($p < 0.05$). The specific results are shown in **Table 1**.

**Table 1.** Comparison of BBS scores between the two groups at different postoperative time points ($\bar{x} \pm s$)

| Groups | Number of cases | 1 month after operation (points) | 3 months after operation (points) | 6 months after operation (points) |
|---|---|---|---|---|
| Observation group | 25 | 32.45 ± 4.21 | 41.68 ± 5.32 | 50.32 ± 4.89 |
| Control group | 25 | 25.12 ± 3.89 | 33.25 ± 4.98 | 42.15 ± 5.12 |
| *t* | - | 6.3939 | 5.7841 | 5.7698 |
| *p* | - | 0.0000 | 0.0000 | 0.0000 |

### 3.2. Comparison of SF-36 scores between the two groups at 6 months after operation

At 6 months after operation, the scores of each dimension of SF-36 in the observation group were significantly higher than those in the control group ($p < 0.05$). The specific results are shown in **Table 2**.

**Table 2.** Comparison of SF-36 scores between the two groups at 6 months after operation ($\bar{x} \pm s$)

| Groups | Number of cases | Physical function (points) | Bodily pain (points) | General health (points) | Social function (points) |
|---|---|---|---|---|---|
| Observation group | 25 | 78.32 ± 6.54 | 75.12 ± 5.89 | 72.45 ± 6.12 | 79.68 ± 5.98 |
| Control group | 25 | 65.15 ± 5.98 | 62.35 ± 6.12 | 60.12 ± 5.89 | 66.32 ± 6.45 |
| *t* | - | 7.4307 | 7.5172 | 7.2581 | 7.5947 |
| *p* | - | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

## 4. Discussion

The core of postoperative rehabilitation for elderly hip fracture is to restore limb function, improve balance ability

and quality of life. Elderly patients recover slowly after operation, and if not intervened in time, adverse outcomes such as muscle atrophy and joint adhesion are likely to occur. The results of this study showed that the BBS scores of the observation group at all postoperative time points were higher than those of the control group, indicating that early rehabilitation training can significantly improve the patient's balance ability. The reason is that early rehabilitation carries out passive, active and balance training in stages, stimulates muscle contraction, enhances muscle strength, improves joint range of motion, and balance training improves body stability [6–10]. The BBS score of the observation group was significantly improved 1 month after operation, indicating that early intervention can break the vicious circle of bed rest, muscle atrophy and balance decline; the score was close to normal 6 months after operation, indicating long-term effectiveness. Quality of life is an important evaluation index of postoperative rehabilitation effect, which is affected by limb function, pain, social participation, etc. This study showed that at 6 months after operation, the observation group scored higher than the control group in all dimensions of SF-36, indicating that early rehabilitation can improve the patient's quality of life. Because early rehabilitation improves balance and muscle strength, promotes the recovery of limb function, reduces dependence on others, and improves physical function and general health scores; improved limb function reduces pain and improves sleep and vitality levels; patients participate in social activities as soon as possible, improving social function and mental health scores [11–13]. The control group started rehabilitation late, had slow recovery of limb function, long duration of pain, limited social participation, and poor improvement in quality of life. Early rehabilitation focuses on individualization, formulates rehabilitation plans according to the type of surgery and physical condition, advances them step by step in stages, and strengthens training monitoring. No serious complications such as prosthesis loosening occurred in the observation group, which verified the safety of the program. However, this study has a small sample size, single center and short follow-up time, so the results may be biased [14,15]. In the future, the sample size should be increased, and multi-center research and long-term follow-up are needed to determine the long-term effect.

## 5. Conclusion

In conclusion, early postoperative rehabilitation training for elderly patients with hip fracture can improve balance ability, enhance quality of life, and have high safety, which is worthy of clinical promotion. Clinically, attention should be paid to early rehabilitation intervention, a professional team should be established, individualized plans should be formulated, guidance and monitoring should be strengthened, and rehabilitation effects should be improved.

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## Disclosure statement

The authors declare no conflict of interest.

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# Effects of Continuous Care on Children with Enterostomy and Their Families in China

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**Abstract:** *Background:* Continuous care for children with enterostomy and their families has been gaining popularity in China. *Objective*: To evaluate the feasibility of continuous care for children with enterostomy and their families in China. *Methods*: The PubMed, Web of Science, Embase, Cochrane Library, EBSCO, CNKI, CBM, VIP, and WanFang were searched for clinical trials until December 30, 2025. Two reviewers independently searched articles, evaluated quality and extracted data. This review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). *Results:* 33 studies involving 2774 participants were included. The meta-analysis showed that continuous care strategy can significantly reduce the incidence of complications in children with enterostomy (OR = 0.20, 95% CI = 0.16–0.26, $p < 0.001$, I2 = 0%), effectively improve the family caregiver ability for enterostomy (MD = -10.34, 95% CI= -13.82 to -6.85, $p < 0.001$, I2 = 99%), shorten the time for family members to replace stoma bags (MD= -13.57, 95% CI=-19.66 to -7.49, $p < 0.001$, I2 = 100%), and alleviate negative emotions such as anxiety (SMD= -1.80, 95% CI = -2.36 to -1.23, $p < 0.001$, I2 = 92%) and depression (SMD= -1.54, 95% CI= -2.04 to -1.04, $p < 0.001$, I2 = 89%) in the families of the affected children. *Conclusions*: Continuous care can reduce complications of enterostomy in children, improve the family caregiver ability for enterostomy and alleviate negative emotions of family members such as anxiety and depression.

**Keywords:** Continuous care; Pediatric enterostomy; Family members; Enterostomy nursing; Meta-analysis

**Online publication:** Feb 9, 2026

## 1. Introduction

Pediatric enterostomy is a surgical method that lifts the intestine to the abdominal wall as a temporary excretory outlet. It is mainly adopted to rescue critically ill children with acute abdominal diseases such as intestinal obstruction, intestinal necrosis, and congenital anorectal malformation [1,2]. Because of the pathological

characteristics of affected children, the primary disease is complex, and their resistance is poor. After enterostomy, they are susceptible to pathogen invasion and various complications, which not only increase the pain of children but also endanger their lives [3,4]. Children's stomas are usually temporary, and they will be closed after 3 to 6 months [5,6]. After the children with enterostomy are discharged from the hospital, the family will be the main place for care, and parents will be the primary caregivers. However, since a lack of medical knowledge and professional training, it is usually difficult for parents to fully grasp the nursing methods after enterostomy surgery during short-term hospitalization. They will encounter various challenges in the process of home care, such as enterostomy care, complications of infant diseases, and life stress [7,8].

Continuous care interventions can enable pediatric patients to continue receiving professional nursing in different healthcare settings, such as from hospitals to homes. It is widely considered to be a key element in high-quality medical services and is crucial for children with enterostomy and their families [9,10]. Currently, continuous care interventions are mostly supplied by enterostomal therapists (ETs) or professional nursing staff trained in enterostomy treatment, including all elements of enterostomy care, which help affected children and their families obtain extended and professional nursing services from medical staff after enterostomy [11–13]. For example, reading enterostomy care manuals and video nursing guidance, using online platforms, and telephone-assisted outpatient follow-up or home visits [14–16].

In China, continuous care strategy has been widely applied in children with enterostomy and their families and has achieved many potential benefits. Wu et al. reported that continuous care can not only markedly promote the postoperative quality of life for children with enterostomy but also alleviate their anxiety and depression by providing appropriate psychological counseling to family members [17]. Geng et al. found that continuous care after discharge can effectively decrease the complications of children with enterostomy, increase their care satisfaction, and promote their postoperative quality of life [18]. Gao et. al reported that WeChat-based continuous care can significantly improve the nursing ability and quality of life of parents, and decrease the incidence of complications in children with enterostomy [3].

Although individual trials on continuous care have achieved numerous potential benefits, there is a lack of a systematic review and meta-analysis on its promising outcomes in children with enterostomy and their families. Thus, the study intended to analyze the optimum existing proofs, summarize the feasibility of the reported survey results, and evaluate the effectiveness of continuous care on children with enterostomy and their families in China, to afford an evidence-based approach for medical nursing staff and provide a continuous care strategy for children with enterostomy and their families.

## 2. Methods

This review was carried out by the PRISMA declaration guidelines [19]. The protocol has been registered on PROSPERO with registration number CRD42023479320. Moreover, primary searches of the major data libraries did not discover any ongoing or published systematic reviews and meta-analyses with this objective.

### 2.1. Search strategy

Clinical trials of continued care strategy adopted for children with enterostomy and their families were searched by computer in Embase, EBSCO, Web of Science, PubMed, China Biology Medicine (CBM), Cochrane Library, Wanfang Data (Wanfang), China National Knowledge Infrastructure (CNKI) and VIP Chinese Science and

Technology Journal Database (VIP). Each database was retrieved up to December 30, 2025, without any language restrictions.

## 2.2. Inclusion and exclusion criteria

### 2.2.1. Inclusion criteria

(1) Study design
Randomized controlled trials, quasi-randomized controlled trials, or cohort studies;

(2) Participants
Children with enterostomy in China (≤ 18 years);

(3) Interventions
Continuous care provided by ETs or professional nursing staff who have received training in enterostomy care;

(4) Outcomes
Health variables of affected children and their families, including complications of children with enterostomy, enterostomy care ability of family members and negative emotions of family members.

### 2.2.2. Exclusion criteria

(1) Studies did not use a control group;
(2) Studies that only included adult patients (> 18 years);
(3) Studies from case reports, conference abstracts, reviews, letters, or duplicate publications;
(4) Literature that the full text was unavailable, outcomes were unclear, or interventions were different.

## 2.3. Data synthesis

Review Manager software (version 5.4) was adopted for the meta-analysis. For binary variables such as complications of children with enterostomy, odds ratio (OR) with 95% confidence interval (CI) was calculated as an effect indicator. For continuous variables such as family caregiver ability for enterostomy, length of time for family members to replace stoma bags, and anxiety and depression of family members; if the scales used were the same, mean difference (MD) with 95% CI was select for effect measures; if the scales adopted were different, standardized mean difference (SMD) with 95% CI was calculated as effect indicators [20]. The heterogeneity test of the included literature was carried out with $\chi^2$ test and $I^2$ statistics [21]. The fixed-effects model was adopted if $p > 0.1$ or $I^2 < 50\%$; the random-effects model was employed if $p < 0.1$ or $I^2 > 50\%$. Funnel plots, Egger's test and Begg's test were adopted to evaluate the publication bias when the number of included literatures was greater than or equal to 10 [22]. $p < 0.05$ was recognized statistically significant. The sensitivity analysis was performed by successively deleting the individual literature to assess the robustness and reliability of the results [23].

# 3. Results

## 3.1. Complications of children with enterostomy

27 studies including 2030 pediatric patients (1030 in continuous care group and 1000 in routine care group) reported complications in children with enterostomy [3,14–16,18,24–45]. The fixed effects model was adopted to carry out the meta-analysis due to no statistical heterogeneity was observed (I2 = 0%, $p = 0.94$). The results revealed

that the incidence of complications of children with enterostomy in the continuous care group was remarkably less than that in the conventional care group, with statistical significance (OR = 0.20, 95% CI = 0.16–0.26, $p < 0.001$), illustrating that the continuous care intervention could decrease the complications of children with enterostomy, as shown in Figure 1.

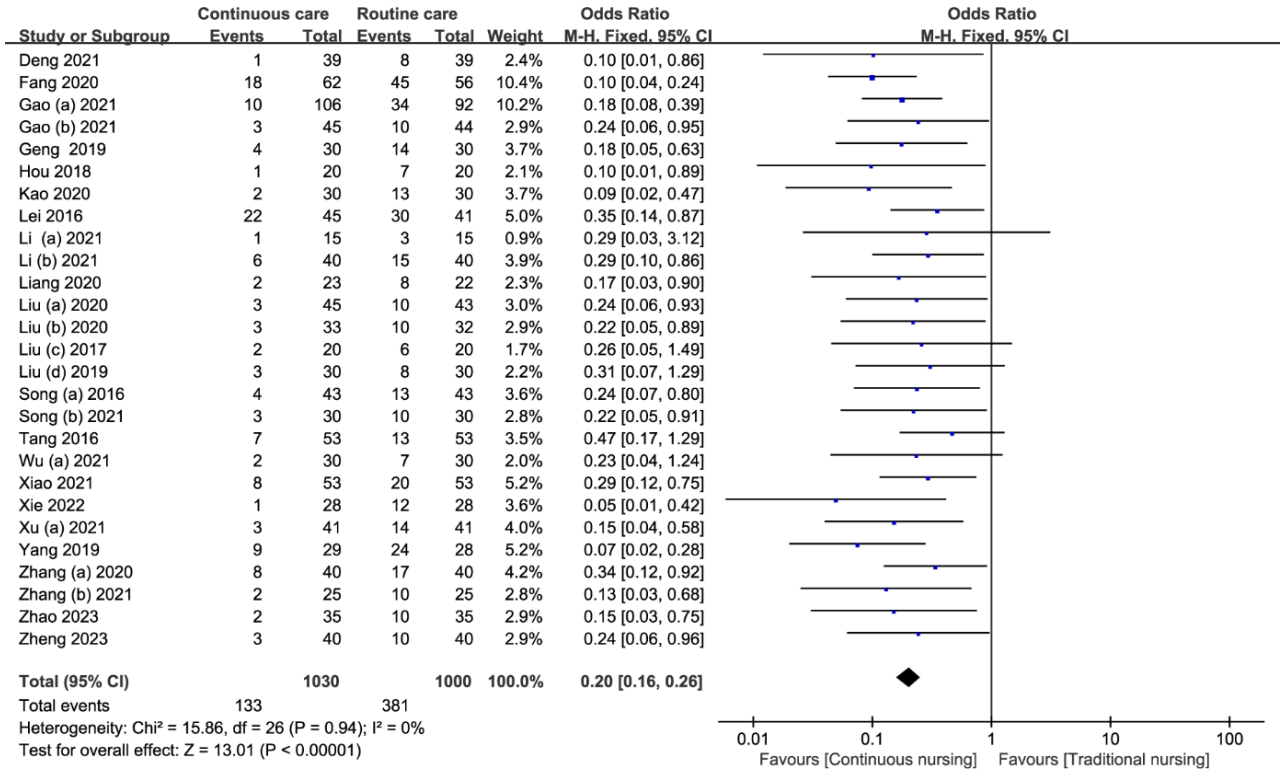



**Figure 1.** Forest plot of complications in children with enterostomy.

## 3.2. Family caregiver ability for enterostomy

Five studies involving 474 participants (244 in continuous care group and 230 in routine care group) reported the family caregiver ability for enterostomy, all evaluated using the family caregiver task inventory (FCTI) [3,31,41,46,47]. The random effects model was employed to conduct the meta-analysis because the statistical heterogeneity was significant ($I^2 = 99\%$, $p < 0.001$). The results showed that the family caregiver ability for enterostomy in the continuous care group was remarkably higher than that in the routine care group, and the diversity between the two groups was statistically remarkable (MD = -10.34, 95% CI = -13.82 to -6.85, $p < 0.001$). Thus, the continuous care strategy could promote the family caregiver ability for enterostomy, as illustrated in **Figure 2**.

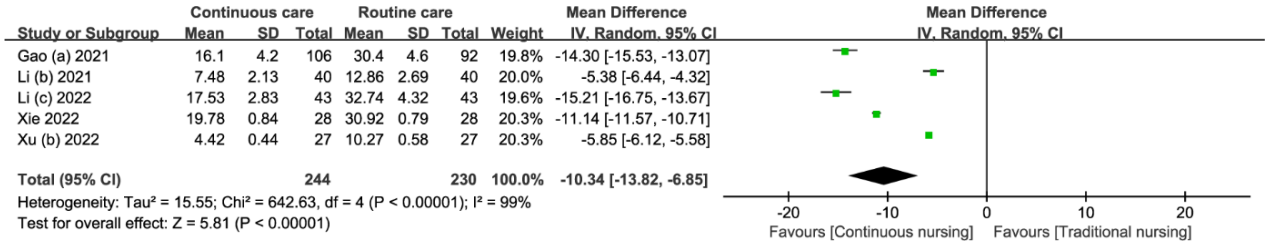



**Figure 2.** Forest plot of family caregiver ability for enterostomy.

## 3.3. Length of time for family members to replace stoma bags

Seven studies including 431 participants (216 in continuous care group and 215 in routine care group) reported the duration of family member replacement of stoma bags [14,15,27,34–36,45]. The random effects model was adopted to perform the meta-analysis due to the statistical heterogeneity was significant ($I^2$ = 100%, $p$ < 0.001). The results revealed that the duration of family members replacing stoma bags in the continuous care group was significantly shorter than that in the conventional care group, and the diversity between the two groups was statistically remarkable (MD = -13.57, 95% CI = -19.66 to -7.49, $p$ < 0.001). Thereby, the continuous care strategy could shorten the length of time for family members to replace stoma bags, as displayed in **Figure 3**.

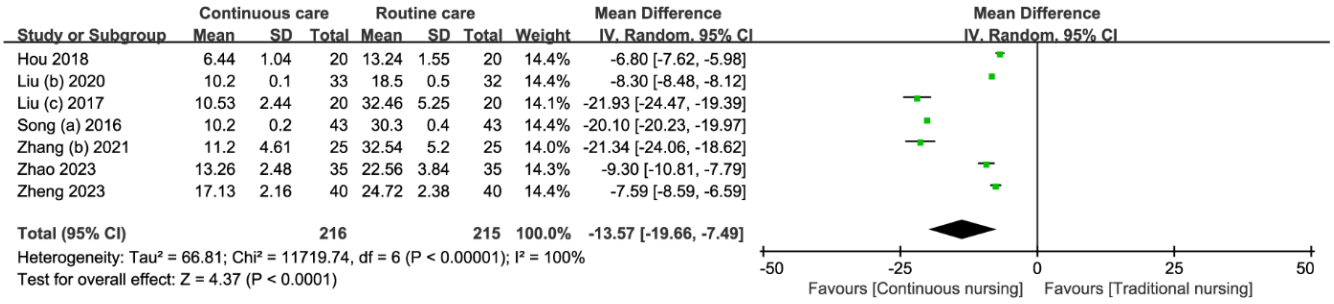



**Figure 3.** Forest plot of length of time for family members to replace stoma bags.

## 3.4. Anxiety of family members

Nine studies involving 941 participants (481 in continuous care group and 460 in routine care group) reported the anxiety of family members, of which eight studies used the self-rating anxiety scale (SAS) as the evaluation tool and one study adopted the generalized anxiety disorder (GAD) as the evaluation tool [17,18,37,40,43,47–50]. The random effects model was employed to conduct the meta-analysis due to the statistical heterogeneity was significant ($I^2$ = 92%, $p$ < 0.001). The results revealed that the anxiety of family members in the continuous care group was remarkably lower than that in the conventional care group, and the diversity between the two groups was statistically remarkable (SMD = -1.80, 95% CI = -2.36 to -1.23, $p$ < 0.001), indicating that the continuous care intervention could alleviate the anxiety of family members, as shown in **Figure 4**.

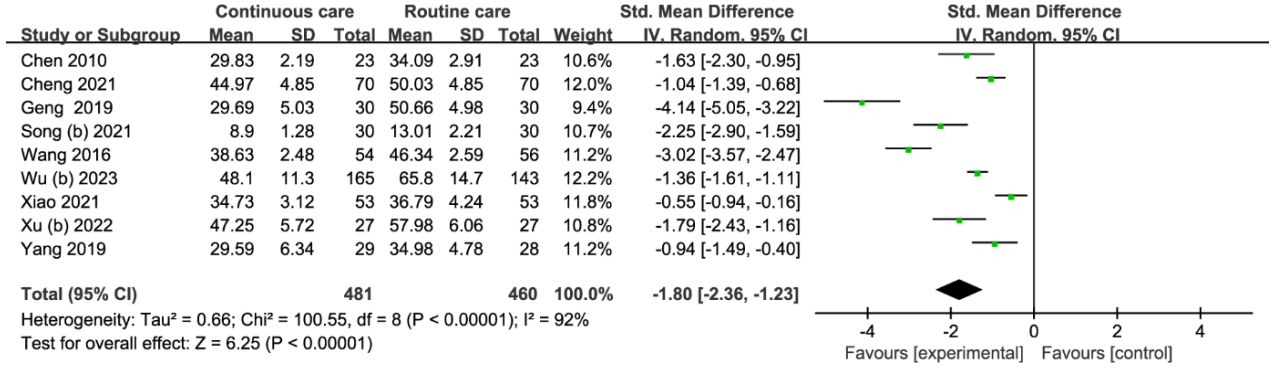



**Figure 4.** Forest plot of anxiety of family members.

## 3.5. Depression of family members

Eight studies including 863 participants (443 in continuous care group and 420 in routine care group) reported the depression of family members, of which seven studies adopted the self-rating depression scale (SDS) as the evaluation tool and one study used the Edinburgh postnatal depression scale (EPDS) as the evaluation

tool [17,18,33,43,47–50]. The random effects model was employed to conduct the meta-analysis due to the statistical heterogeneity was significant ($I^2$ = 89%, $p$ < 0.001). The results illustrated that the depression of family members in the continuous care group was significantly lower than that in the routine care group, and the diversity between the two groups was statistically remarkable (SMD = -1.54, 95% CI = -2.04 to -1.04, $p$ < 0.001), indicating that the application of continuous care strategy could alleviate the depression of family members, as displayed in **Figure 5**.

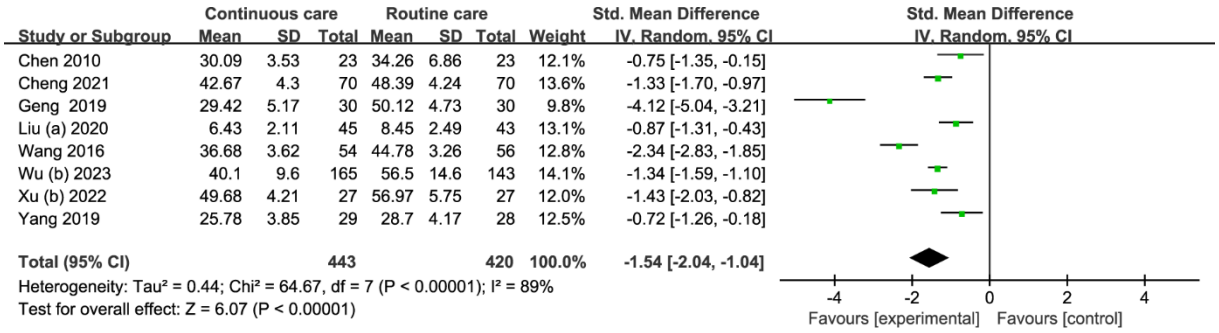



**Figure 5.** Forest plot of depression of family members

## 4. Conclusion

The findings of this review suggest that continuous care for children with enterostomy and their families in China can significantly decrease the complications of children with enterostomy, effectively promote the enterostomy care ability of family members, and alleviate negative emotions of primary caregivers such as depression and anxiety. Due to the positive effects of continuous nursing intervention on children with enterostomy and their families, it is necessary to incorporate continuous care strategy into clinical practice and conduct further research.

## Disclosure statement

The authors declare no conflict of interest.

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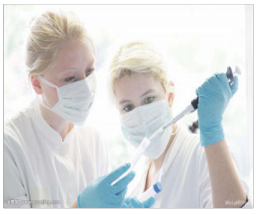


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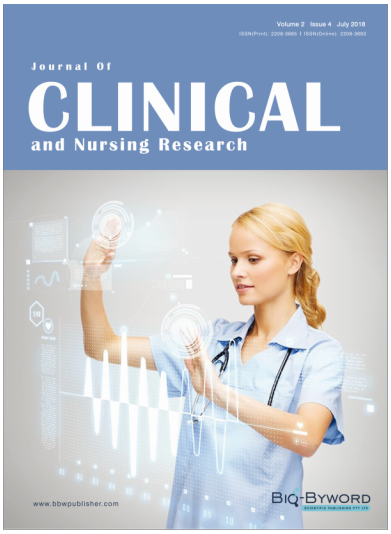
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