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Research Progress on the Prevention of Complications Related to Patient Positioning in Laparoscopic Robotic Surgery

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Abstract: With the rapid development of minimally invasive surgical techniques, laparoscopic and robot-assisted surgery has become the preferred treatment for many surgical diseases. These surgeries often require specific patient positioning, such as extreme head-down, feet-up, lithotomy, and lateral decubitus positions, to meet the needs for surgical field exposure and instrument operation space. However, these non-physiological positions, combined wiThe prolonged surgery and pneumoperitoneum pressure can significantly alter the patient's respiratory, circulatory, and nervous system functions, leading to a series of position-related complications such as pressure injury, nerve damage, compartment syndrome, and ocular complications. This article systematically reviews recent domestic and international research on the prevention of positioning complications in laparoscopic robotic surgery, focusing on risk assessment, improvement of positioning equipment, intraoperative management strategies, and multidisciplinary collaboration to summarize key preventive measures.

Keywords: Laparoscopic surgery; Robotic surgery; Patient positioning; Complication prevention; Perioperative nursing

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1. Common complications of patient positioning in laparoscopic robotic surgery

1.1. Pressure injuries and nerve injuries

In the process of performing laparoscopic robotic surgery, in order to meet the needs of the operation, patients often need to maintain a fixed and unchanging special non-physiological position for a long time. The bony prominences and the relatively thin subcutaneous tissues will be subjected to continuous external pressure and cannot be relaxed in time, which will lead to obstructed blood circulation in the compressed local tissues, poor delivery of oxygen and nutrients, and gradual development into a state of ischemia and hypoxia. Gao Xinglian et al. [1] pointed out in their research on laparoscopic robotic surgery that compared with traditional open surgery and ordinary laparoscopic surgery, robotic surgery has the characteristics of the instrument arm

occupying the operating space, restricting the patient's position adjustment, longer overall operation time, and the inability to change the patient's position as needed. Therefore, the risk of patients suffering from medical device-related pressure injury will be significantly increased.

1.2. Ocular complications

In the process of robot-assisted pelvic and abdominal surgery, the continuous maintenance of an extremely low head-down position, coupled with the need to maintain carbon dioxide pneumoperitoneum during the operation, has become a clear risk factor for postoperative visual loss (POVL) in patients. This conclusion has been repeatedly verified by clinical studies. A review study published in 2025 by Barud et al. [2] pointed out that in the Trendelenburg position, which is widely used in current robot-assisted surgery, the greater the angle of tilt, the higher the carbon dioxide pneumoperitoneum pressure set by the surgeon during the operation, the more obvious the increase in intraocular pressure during the operation, and the more significant the continuous impact on ocular circulation and pressure status. A clinical study conducted by Yang Chunlei et al. [3] on da Vinci robot-assisted radical prostatectomy pointed out that, in the process of this type of robot surgery that requires maintaining a low head-down position for a long time, strengthening the targeted protection of the patient's ocular tissues and selecting an appropriate tilt angle of the low head position based on the individual patient situation are the core key measures to prevent ocular complications related to robot surgery.

1.3. Respiratory and circulatory system complications

The extreme head-down position and the continuous carbon dioxide pneumoperitoneum pressure during the operation will directly compress the patient's abdominal organs and push the diaphragm upward. After the diaphragm is raised, its range of motion is greatly compressed, which significantly reduces the space for lung expansion and relaxation, and lung compliance is significantly reduced. This leads to a sustained increase in the patient's peak airway pressure and plateau pressure, greatly increasing the risk of lung barotrauma during the operation. The study by Plis and Tsarev [4] pointed out that patients undergoing robot-assisted surgery often need to maintain the Trendelenburg head-down position for several hours. This position, combined with the effect of continuous carbon dioxide pneumoperitoneum during the operation, will significantly increase the venous return resistance in the head and neck. The edema in the head and neck tissues will often continue to worsen after the long operation. Wang Ying et al. [5] conducted a special study on patients undergoing robot-assisted radical prostatectomy. The results showed that as the intraoperative pneumoperitoneum pressure increased and the head-down tilt angle gradually increased, the patient's overall respiratory function was significantly affected.

2. Prevention strategies for positioning complications in laparoscopic robotic surgery

2.1. Preoperative risk assessment and individualized treatment plan development

The primary core element in preventing position-related complications in laparoscopic robotic surgery is to conduct a comprehensive and detailed preoperative risk assessment for each surgical patient. The systematic review study completed by Bentsen et al. [6] gave clear recommendations that the entire medical team involved in the surgery should conduct a detailed and comprehensive position-related risk assessment for the patient

before the operation, and formulate a standardized surgical positioning procedure based on this. Furthermore, a systematic physical assessment of the patient from head to toe should be conducted in accordance with the standard before and after the operation to screen for potential position-related complications. Based on the aforementioned research, Shi Rui et al. [7] further refined and improved the whole-process risk management process in the operating room for this type of surgery, and clearly divided the risk assessment work into three core parts: preoperative special risk assessment, dynamic monitoring of position-related indicators during the operation, and secondary assessment during the postoperative patient transfer and handover stage, thus constructing a risk prevention and control assessment system covering the entire surgical cycle.

2.2. Improvement and selection of postural equipment

The innovation and optimization of surgical positioning tools are key to preventing pressure injuries and peripheral nerve damage in patients undergoing robotic surgery in clinical practice. A randomized controlled trial conducted by Yang Liping [8] specifically compared the clinical application effects of traditional positioning pads and gel positioning pads in laparoscopic robotic prostate cancer surgery. The results showed that the incidence of postoperative skin redness in the sacrococcygeal region and the patients' visual analog scale scores for pain were significantly lower in the experimental group using gel pads than in the control group using conventional positioning pads. Moreover, gel pads can effectively disperse local pressure on bony prominences such as the cheekbone and mandible.

2.3. Standardized procedures for intraoperative positioning

Establishing a standardized positioning procedure is the foundation for ensuring patient safety. Hou Xiaomin et al. [9] conducted a study on the clinical application effect of the modified 70° lateral decubitus position in da Vinci robot-assisted partial nephrectomy. The results showed that the application of this modified position can effectively shorten the positioning time before surgery and can also significantly reduce the probability of intraoperative iatrogenic pressure injury and the incidence of mechanical arm collision during surgery. Lu Tong et al. [10] also showed that the modified positioning management program for da Vinci robot surgery can effectively prevent medical device-related pressure injury in patients undergoing da Vinci robot surgery.

2.4. Prevention and protection of the circulatory and nervous systems

Godier [11] officially released the French guidelines for the prevention of perioperative venous thromboembolism. This newly released guideline is specifically designed for the risk of venous thromboembolism caused by the special body position in laparoscopic robotic surgery. It clarifies the core points of venous thromboembolism prevention in this scenario and provides clear and evidence-based guidance. It provides an authoritative reference for the clinical implementation of venous thromboembolism prevention related to body position in robotic surgery in various countries. In the clinical practice of robot-assisted adolescent idiopathic scoliosis correction surgery, researchers such as Chen Biya [12] applied a standardized process nursing plan that was prepared in advance for this type of surgery, based on the body position characteristics and perioperative safety requirements of this type of surgery. From preoperative body position assessment, intraoperative body position maintenance, to postoperative body position transfer, the entire process comprehensively ensured the perioperative safety of patients undergoing this type of surgery.

2.5. Management of special populations

Bruni et al. [13] specifically targeted obese gynecologic tumor patients undergoing robotic surgery. Combining the weight characteristics, difficulties in surgical positioning, and risk of complications of this type of patient, they put forward targeted management suggestions from multiple practical levels. These suggestions included using a widened special operating table adapted to the body size of obese patients, having the surgical team actively adjust the positioning angle of the robotic arm during the operation to avoid direct collision and compression between the robotic arm and the patient's thigh, appropriately reducing intraoperative pneumoperitoneum pressure according to the patient's weight parameters and specific surgical operation requirements, and strengthening special protection for high-risk points of pressure injury in the whole-body stress area.

Yang Man et al. [14] noticed that the physical condition of obese patients would bring many nursing difficulties that conventional nursing plans could not cover. Therefore, in clinical practice, they explored and adopted a systematic operating room nursing cooperation measure that included preoperative individualized risk assessment, precise intraoperative positioning and cooperation, and postoperative complication follow-up observation.

Li Run et al. [15] focused on the clinical nursing needs of the da Vinci robotic surgery currently widely used in clinical practice. Combining the operational characteristics and complication prevention and control requirements of the da Vinci robotic surgery, they constructed a standardized nursing cooperation and management system for da Vinci robotic surgery based on the goal-oriented theory, which effectively improved the overall nursing quality of outpatients and inpatients receiving robotic surgery.

3. Conclusion

Positioning during laparoscopic and robotic surgery is an operation that integrates technology, science, and art, and the prevention of complications is a core issue in perioperative safety management. Current research has clearly established a causal relationship between specific positions such as head-down, feet-up, and lithotomy positions and pressure injuries, nerve injuries, ocular complications, and compartment syndrome. The risk of these complications can be effectively reduced through individualized preoperative assessment, selection of new protective equipment, implementation of standardized placement procedures, meticulous intraoperative management, and multidisciplinary collaboration. Ultimately, translating mature research evidence into standardized prevention guidelines covering preoperative, intraoperative, and postoperative stages is essential to improving patient safety in minimally invasive surgery worldwide.

Disclosure statement

The author declares no conflict of interest.

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