

REVIEW ARTICLE

Advances in thermal insulation nursing
for hypothermia prevention in total hip
arthroplasty: A reviewPing Ren[†], Peiqi He[†], Jiaying Xu, Wen Wang, Xin Men, and Ting Tang*

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Abstract

Background: Population aging has driven rapid growth in total hip arthroplasty (THA), with over 60% of patients being elderly. However, perioperative hypothermia occurs in 30–60% of cases and is a key risk factor for poor prognosis. Despite this, clinical temperature management remains non-standardized. **Aim:** To systematically review advances in thermal insulation nursing for perioperative hypothermia in THA, providing evidence to support standardized temperature management pathways and optimize targeted thermal insulation strategies. The analyses cover the causes and impacts of hypothermia, thermal insulation nursing measures, evaluation indicators, and research hotspots. **Results:** Perioperative hypothermia in THA is mainly induced by anesthetic effects, body cavity exposure, cold fluid infusion, and elderly physiology. It increases the risks of intraoperative and postoperative bleeding and postoperative infection, prolongs anesthesia recovery and operative time, and worsens rehabilitation outcomes and patient satisfaction. The whole-process thermal insulation nursing—comprising preoperative risk assessment and prewarming, intraoperative active warming, and postoperative temperature management—effectively maintains core temperature (36–37.5 °C) and significantly reduces the incidence of hypothermia and the risk of related complications. Evaluation indicators include temperature changes and complication rates, while contraindications and individualized application principles are clarified. Current research focuses on intelligent temperature control systems and hypothermia risk prediction models. However, challenges remain, including limited individualization for high-risk groups, non-standardized evaluation systems, and low implementation in primary care settings. **Conclusion:** Whole-process thermal insulation nursing is essential for enhanced recovery in THA, improving safety and outcomes, while reducing healthcare burden. Future efforts should prioritize individualized strategies for high-risk groups, standardized evaluation systems, and cost-effective, intelligent warming technologies to establish a comprehensive, widely applicable framework for perioperative temperature management. **Relevance for patients:** Thermal insulation nursing may improve rehabilitation outcomes in elderly patients undergoing THA.

Keywords: Hypothermia; Thermal insulation nursing; Total hip arthroplasty; Research progress

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1. Introduction

With increased population aging and the advancement of orthopedic techniques, the annual volume of total hip arthroplasty (THA) has grown rapidly, with elderly patients (≥ 65 years old) accounting for over 60% of cases.¹ However, perioperative hypothermia occurs in 30–60% of THA cases² and is a key risk factor affecting patient prognosis. Studies^{3,4} have confirmed that hypothermia can induce vasoconstriction, immune dysfunction, and coagulation disorders, significantly increasing the risks of surgical site infection, intraoperative blood transfusion requirement, and prolonged hospital stay. Despite the well-established hazards of hypothermia, non-standardized temperature management remains a prevalent issue in clinical practice. Against this backdrop, the Enhanced Recovery After Surgery (ERAS) guidelines have explicitly identified temperature management as a core measure, emphasizing that maintaining normal intraoperative body temperature can reduce the risk of intraoperative and postoperative complications and markedly shorten the rehabilitation cycle.⁵ Nevertheless, there is still a lack of systematic summaries of perioperative thermal insulation nursing in THA at present. By reviewing advances in this field, this review aims to provide evidence to construct a standardized temperature management pathway for clinical THA practice and promote the optimization of precise thermal insulation strategies under multidisciplinary collaboration.

2. Methodology

Database searches were conducted in PubMed and the China National Knowledge Infrastructure for articles published from 2016 to 2025, including clinical studies, meta-analyses, systematic reviews, and expert consensus statements. Subject-based search was adopted with search terms including hypothermia, accidental hypothermia, thermal insulation nursing, surgical operation, and THA. Additionally, manual screening of the references cited in the retrieved articles was performed to enhance comprehension. After screening the titles and abstracts, 63 articles were included, covering the causes of intraoperative hypothermia, the postoperative effects of hypothermia in THA patients, the implementation of thermal insulation nursing, research hotspots in thermal insulation nursing, and relevant evaluation indicators.

3. Overview of perioperative hypothermia in total hip arthroplasty

Hypothermia is a pathological state in which the body temperature falls below the normal range. In medicine, a core body temperature lower than 36 °C is generally

defined as hypothermia, which has long existed in surgical procedures. With the development of medical technology, the understanding of intraoperative hypothermia is gradually increasing. In the early stage, due to the limitations of monitoring methods, intraoperative hypothermia failed to receive adequate attention. It was not until the end of the 20th century that relevant studies began to focus on the phenomenon of intraoperative hypothermia and its impacts.^{2,6} Previous studies⁶ have shown that hypothermia occurs in approximately 30% to 60% of surgical operations, a challenge also faced by THA. Therefore, thermal insulation nursing targeting hypothermia is particularly important. Currently, the clinical consensus on the target range of intraoperative temperature control is to maintain the patient's core body temperature between 36 °C and 37.5 °C. Maintaining this temperature range helps to reduce the occurrence of hypothermia-related complications, thereby promoting patients' postoperative rehabilitation and improving the therapeutic effect of surgery.

4. Causes of intraoperative hypothermia in total hip arthroplasty

4.1. Anesthetic drug interference

Anesthetic drugs are one of the core causes of intraoperative hypothermia. General anesthetics (e.g., propofol and inhalational anesthetics) can inhibit the function of the hypothalamic temperature regulation center, leading to peripheral vasodilation and accelerated heat loss, while muscle relaxants can suppress skeletal muscle thermogenesis. Studies⁷ have shown that core body temperature may drop by 0.5–1.5 °C within 30 min after anesthesia induction, and the drop is more pronounced in elderly patients due to their lower metabolic rate and slower drug metabolism. Most THA patients require general anesthesia, and anesthesia drugs interfere with the neurohumoral mechanisms of temperature regulation, which significantly reduces patients' adaptability to low-temperature environments and increases the risk of intraoperative body temperature fluctuation.⁸

4.2. Body cavity exposure

Total hip arthroplasty involves large incisions and prolonged deep joint exposure, particularly via the posterolateral approach in the lateral decubitus position.⁹ Such sustained exposure causes substantial evaporative and radiative heat loss, while repeated irrigation with unheated saline further removes heat through conduction.¹⁰ Qian *et al.*¹¹ proposed that each liter of unheated irrigation fluid at 23 °C can cause a 0.3 °C drop in core body temperature. Accelerated air convection in laminar flow operating rooms also increases heat dissipation, affecting elderly patients more significantly.¹²

4.3. Cold fluid infusion

Intraoperative massive infusion of unheated fluids (e.g., crystalloids and blood products) is a direct cause of hypothermia.^{13,14} Transfusion of 4 °C stored blood triggers a marked “cold dilution effect” leading to rapid core temperature decline.¹⁵ Room-temperature fluids (23 °C) also reduce body temperature, with elderly patients showing greater drops due to poor circulatory compensation.^{11,16} Large-volume fluid replacement for intraoperative bleeding further elevates hypothermia risk in THA.¹⁷

4.4. Special risks in elderly patients

As the main population undergoing THA, elderly patients have unique physiological characteristics that make them a high-risk group for perioperative hypothermia. Reduced metabolic rate is one of the core risk factors^{18,19}; elderly patients have a basal metabolic rate 10–20% lower than that of young people, resulting in significantly reduced thermogenic capacity. They are more likely to fall into a state of negative body temperature balance, especially after anesthesia inhibits the thermogenic response. Thinning of the subcutaneous fat layer further aggravates heat loss, and the weakened thermal insulation capacity of the body surface easily leads to increased rates of radiation and convection heat dissipation. Studies²⁰ have shown that heat loss is significantly greater in elderly patients than in middle-aged populations. In addition, various chronic diseases can also interfere with temperature regulation. Diabetic peripheral neuropathy weakens vasomotor function, and reduced compensatory circulatory capacity in patients with cardiovascular disease both contribute to body temperature fluctuations. Moreover, the depletion of energy reserves caused by preoperative fasting and water restriction, combined with hypermetabolism induced by surgical stress, forms a vicious circle of “low intake and high consumption,” which further limits the body’s thermogenic potential.²¹ Therefore, elderly patients are more prone to hypothermia.

Hypothermia in THA results from the combined action of multiple factors, with anesthesia interference, exposure of the body cavities, cold fluid infusion, and the physiological characteristics of elderly patients as the core causes. In light of these mechanisms, comprehensive measures such as prewarming, fluid warming, and reduced exposure time should be implemented, with special attention paid to individualized nursing care for elderly patients.

5. Impacts of hypothermia in total hip arthroplasty

Hypothermia not only directly threatens surgical safety

through pathophysiological mechanisms such as inhibiting coagulation function and weakening immune defense, but also indirectly increases medical burden by prolonging anesthesia recovery time, increasing the difficulty of surgical operation, and reducing patient compliance.

5.1. Increased risk of intraoperative and postoperative bleeding

Hypothermia can significantly affect patients’ coagulation function by inhibiting platelet function, reducing thrombin activity, and promoting fibrinolytic activation. Studies²² have shown that for every 1.6 °C drop in intraoperative core body temperature in THA patients, blood loss can increase by approximately 500 mL, and the blood transfusion requirement rises synchronously. The main mechanisms are as follows: low temperature reduces the fluidity and aggregation capacity of platelet membranes, decreases thrombin production, and slows fibrinogen lysis; meanwhile, the low-temperature environment accelerates plasminogen activation and promotes thrombolysis. A study by Tan *et al.*²³ found that postoperative hemoglobin levels in the intraoperative hypothermia group decreased more significantly than in the normal body temperature group, and the probability of blood transfusion increased markedly.

5.2. Increased probability of postoperative infection

Hypothermia can weaken the body’s immune function through multiple pathways and increase the risk of postoperative infection.²⁴ Hypothermic conditions can inhibit neutrophil chemotaxis, phagocytosis, and bactericidal functions, and reduce the release of inflammatory factors. At the same time, hypothermia leads to peripheral vasoconstriction, reduced tissue oxygen supply, and delayed wound healing, creating conditions for pathogen colonization. If the intraoperative body temperature of THA patients is lower than 36 °C, the incidence of postoperative surgical site infection can be three times that of the normal body temperature group.^{25–27}

5.3. Prolonged anesthesia recovery time

Hypothermia can significantly prolong anesthesia recovery time by slowing drug metabolism, impairing liver and kidney function, and altering drug distribution volume.^{8,28} In a hypothermic state, the clearance rate of anesthetics such as propofol and muscle relaxants can decrease by 20%, leading to delayed recovery and prolonged extubation time.²⁹ A study on intraoperative thermal insulation in patients undergoing joint replacement showed¹⁰ that the time to complete awakening and tracheal extubation in the hypothermia group was significantly longer than that in the normal body temperature group. In addition,

hypothermia inhibits the function of the central nervous system, reduces patients' sensitivity to arousal stimuli, and prolongs the residence time in the post-anesthesia care unit.

5.4. Prolonged operation time and increased surgical risk

Hypothermia and prolonged operation time may reinforce each other.³⁰ On the one hand, the risk of hypothermia increases by 50% when the operation time exceeds two h; on the other hand, coagulation disorders and surgical field oozing caused by low temperature can interfere with surgical operations and lead to prolonged hemostasis time.³¹ In addition, chills and muscle tremors induced by hypothermia can affect the accuracy of prosthesis positioning and increase the risks of prosthesis loosening and dislocation, with a particularly significant impact on THA performed via the posterior approach.³²

5.5. Impaired patient satisfaction and rehabilitation outcomes

Chills, restlessness, and metabolic disorders caused by hypothermia directly impair patient satisfaction and exacerbate postoperative complications. Chills can double the body's oxygen consumption and increase the risk of myocardial ischemia. The average postoperative visual analog scale score in the hypothermia group increased by 1.5 points, and analgesic drug dosage increased by more than 30%.³³ In addition, delayed wound healing caused by low temperatures prolongs hospital stays and increases medical expenses, thereby significantly reducing patient satisfaction with the surgery.

The impacts of hypothermia on THA are characterized by multi-system and multi-dimensional features, involving coagulation, immunity, metabolism, nerve function, and other aspects. Intraoperative and postoperative hypothermia not only increases surgical risks but also significantly reduces patients' quality of life and medical benefits.

6. Prevention of hypothermia in total hip arthroplasty

Perioperative thermal insulation nursing is a key link to reducing the incidence of hypothermia in THA patients and improving their prognosis. A continuous temperature management system covering the preoperative, intraoperative, and postoperative periods can be constructed, and comprehensive measures such as risk prediction, active warming, environmental regulation, process optimization, and dynamic monitoring can be adopted to maintain the stability of patients' core body temperature and effectively improve the quality of

perioperative nursing for THA (Table 1).

6.1. Preoperative thermal insulation nursing

6.1.1. Prediction model

Preoperative hypothermia risk assessment is a critical step in the prevention of perioperative hypothermia. Studies^{34,35} have shown that prediction models constructed by statistical models (e.g., logistic regression and Cox regression) or machine learning can comprehensively evaluate the quantitative relationship between factors such as patient age, underlying diseases, body mass index, anesthesia method, and the risk of hypothermia, thus formulating individualized prevention strategies. For elderly patients with high-risk factors such as osteoporosis, malnutrition, or cardiovascular diseases, the risk of hypothermia increases significantly.³⁶ Literature³⁷ has pointed out that THA patients are more prone to hypothermia due to factors such as long operation time and vasodilation caused by anesthesia drugs; therefore, high-risk groups should be screened through multi-dimensional evaluation models before surgery. Currently, although various prediction models have been developed, their construction methods and efficacy still need further standardization and verification.

6.1.2. Prewarming

The core goal of prewarming is to reduce heat loss during the anesthesia induction period. The guidelines of the National Institute for Health and Care Excellence recommend prewarming with inflatable warming blankets or forced-air heating systems for 30 min before anesthesia to narrow the temperature difference between the peripheral and core body temperatures, thereby significantly reducing the incidence of intraoperative hypothermia.³⁸ Studies³⁹ have shown that prewarming combined with continuous intraoperative warming can significantly reduce the frequency of postoperative chills and the incidence of hypothermia in THA patients. In addition, prewarming can also improve peripheral circulation and reduce the risk of postoperative complications in elderly or physically weak patients.

6.1.3. Operating room humidity and temperature

The regulation of operating room environmental parameters is an important part of preoperative thermal insulation. Studies have indicated that maintaining the operating room temperature at 21–25 °C and the relative humidity at 40–60% can effectively reduce the evaporative heat loss of the patients' exposed body surface.⁴⁰ In a large number of cases of hip replacement in the elderly^{41–43}, adjusting the operating room temperature and humidity, combined with active warming measures, resulted in

Table 1. Literature summary of perioperative hypothermia prevention

Thermal insulation nursing stage	Reference	Article type	Journal	Evidence level
Preoperative thermal insulation nursing	Li <i>et al.</i> ³⁴	Observational study	Journal of Perianesth Nursing	Level 2
	Lu <i>et al.</i> ³⁵	Systematic review	Chinese Nursing Management	Level 2
	Li <i>et al.</i> ³⁶	Narrative review	Nursing Research	Level 2
	Li <i>et al.</i> ³⁷	Observational study	Journal of Clinical Nursing	Level 2
	Zhang <i>et al.</i> ³⁸	Systematic review	Journal of Nursing	Level 2
	Chen <i>et al.</i> ³⁹	Narrative review	Yunnan Medical Journal	Level 3
	Yu <i>et al.</i> ⁴⁰	Others	Journal of Medical Biomechanics	Level 4
	Liu & Jiang ⁴¹	RCT	Dialysis and Artificial Organs	Level 2
	Ju & Li ⁴²	RCT	Journal of Thrombosis and Hemostasis	Level 2
Intraoperative thermal insulation nursing	Pan & Yi ⁴³	RCT	Chinese Journal of Gerontology	Level 2
	Ni ⁴⁴	RCT	China Health Standard Management	Level 3
	Liang <i>et al.</i> ³³	RCT	Chinese Journal of Geriatric Care	Level 2
	Huang <i>et al.</i> ⁴⁵	RCT	Orthopedic Journal of China	Level 2
	Rao <i>et al.</i> ⁴⁶	RCT	Journal of Clinical Anesthesiology	Level 2
	Lax <i>et al.</i> ⁴⁷	RCT	SAGE Open Medicine	Level 1
	Sun <i>et al.</i> ⁴⁸	RCT	Qilu Nursing Journal	Level 2
	Fu <i>et al.</i> ⁴⁹	Systematic review	Chinese Journal of Infection Control	Level 2
	Lu <i>et al.</i> ⁵⁰	Others	China Medical Device Information	Level 4
Postoperative thermal insulation nursing	Campodoni <i>et al.</i> ⁵¹	Others	ACS Applied Polymer Materials	Level 4
	Lee <i>et al.</i> ⁵²	Systematic review	Korean Journal of Anesthesiology	Level 2
	Jiang <i>et al.</i> ²⁸	Retrospective study	The Practical Journal of Medicine	Level 3
	National Center for Quality Assurance of Anesthesia ²	Expert consensus	Medical Journal of Peking Union Medical College Hospital	Level 4
	Lu <i>et al.</i> ⁵³	RCT	China Medical Herald	Level 2
	Qiao <i>et al.</i> ⁵⁴	RCT	Heilongjiang Medicine and Pharmacy	Level 2

Abbreviation: RCT: Randomized controlled trial.

significantly better postoperative coagulation function and markedly shorter anesthesia recovery time in patients compared with the conventional nursing group.

6.1.4. Thermal insulation nursing during transfer

Patients may experience heat loss due to exposure to low-temperature environments during the transfer from the ward to the operating room. It is recommended to cover the patient's trunk and limbs with warming blankets and shorten the transfer time. Combining prewarming measures during the transfer period can reduce the amplitude of core body temperature drop and create stable temperature conditions for subsequent surgery. It

is advisable to open a green surgical channel to minimize heat loss in surgical patients, especially those undergoing THA, to the greatest extent.

Preoperative thermal insulation nursing needs to integrate risk prediction, prewarming, environmental regulation, and whole-process temperature monitoring, which has significant clinical value, especially for elderly THA patients with underlying diseases.

6.2. Intraoperative thermal insulation nursing

6.2.1. Active intraoperative warming measures

Intraoperative active warming is a key measure in

maintaining the patient's core body temperature. THA patients have a significantly increased risk of intraoperative hypothermia due to factors such as long operation time and a large exposed incision range. Covering non-surgical areas with inflatable warming equipment or circulating-water warming blankets can effectively reduce heat loss. For example, a study by Ni⁴⁴ showed that the incidence of hypothermia in the observation group with intraoperative thermal insulation nursing (inflatable warming blankets) was only 5.71%, which was significantly lower than the 25.7% in the conventional nursing group. In addition, combined thermal insulation nursing (integrating physical warming and fluid warming) has a particularly prominent effect in elderly patients^{33,45}; the amplitude of intraoperative body temperature fluctuation in the study group was 0.5–1.2 °C lower than that in the control group, and the incidence of postoperative chills was reduced by 30%. Inflatable warming equipment can narrow the temperature difference between the body surface and the core and improve peripheral circulation by continuously delivering warm airflow, making it particularly suitable for elderly patients or those with cardiovascular disease.

6.2.2. Intravenous infusion warming equipment

Intraoperative infusion of unheated fluids or blood products can directly lead to a drop in core body temperature. Studies^{46,47} have shown that preheating intravenous infusions and irrigation fluids to 37 °C can reduce heat loss associated with the infusion of cold fluids. In elderly patients undergoing THA⁴⁸, core body temperature in the combined warming group remained at 36.2 ± 0.3 °C at 30 min after anesthesia induction, with warming infusion equipment combined with operating table heating, which was significantly higher than the 35.6 ± 0.4 °C in the conventional nursing group.

6.2.3. Shortening of operation time and reduction in patient skin exposure time

Prolonged operation time is positively correlated with the incidence of hypothermia. Optimizing the surgical process, such as maintaining a consistent surgical team and adopting minimally invasive techniques, can limit operative time to within one hour, effectively avoiding a sudden drop in body temperature caused by prolonged exposure and reducing the risks of surgical infection and bleeding.⁴⁹ In addition, covering the non-surgical areas with sterile warming towels during surgery and reducing unnecessary body surface exposure can lower evaporative heat loss.

6.2.4. Application of heat and moisture exchangers

Respiratory tract heat dissipation accounts for 10–15%

of intraoperative heat loss. Connecting the endotracheal tube to a heat and moisture exchanger can maintain the temperature and humidity in the respiratory tract and reduce heat loss during gas exchange.^{50,51} A large number of studies have confirmed that intraoperative respiratory heat dissipation in patients using heat and moisture exchangers can be reduced by 40%, and postoperative extubation time can be shortened by 15 min, making this particularly suitable for elderly patients undergoing hip replacement with a long duration of general anesthesia. In addition, heat and moisture exchangers can also reduce airway mucosal dryness and the risk of postoperative pulmonary infection, which is highly consistent with the concept of ERAS.⁵²

Due to surgical complexity and the particularity of the population (e.g., advanced age and underlying diseases), THA patients are more sensitive to temperature regulation, thus imposing higher requirements for intraoperative thermal insulation. It is necessary to integrate multi-dimensional measures such as active warming equipment, fluid warming technology, surgical process optimization, and respiratory tract thermal insulation to reduce the occurrence of hypothermia.

6.3. Postoperative thermal insulation nursing

6.3.1. Thermal insulation in the post-anesthesia care unit

The postoperative anesthesia recovery period is a high-risk stage for patients' body temperature fluctuation. Due to severe surgical trauma, residual effects of anesthesia drugs, and sustained intraoperative heat loss, the incidence of hypothermia in THA patients during the anesthesia recovery period can reach up to 20–30%. At this time, combined thermal insulation nursing should be implemented, including covering the trunk with inflatable warming blankets, adjusting the recovery room temperature to 24–26 °C, and monitoring core body temperature in real time. A study by Ni⁴⁴ showed that the body temperature and incidence of complications in the observation group using inflatable warming equipment combined with environmental temperature control were significantly lower than those in the control group. Jiang *et al.*²⁸ found that the Plan-Do-Check-Act cycle management can effectively reduce the occurrence of hypothermia in the post-anesthesia care unit. In addition, due to their low metabolic rate and poor temperature regulation capacity, elderly patients require the warming time to be extended to two h after surgery, and the nursing strategy should be dynamically adjusted accordingly.

6.3.2. Ward temperature regulation

The temperature and humidity management of the

ward environment is the foundation of postoperative thermal insulation. Studies suggest maintaining the ward temperature at 22–24 °C and the relative humidity at 50–60% to reduce heat evaporation from the exposed parts of patients.² For THA patients, especially the elderly group, it is necessary to avoid aggravated vasoconstriction and pain caused by sudden changes in environmental temperature after surgery. Therefore, the amplitude of body temperature fluctuations can be controlled to ± 0.3 °C within 24 h after surgery using the ward constant-temperature system combined with local warming blanket coverage, thereby significantly reducing the risk of infection and deep vein thrombosis.⁵³ The ward temperature can be appropriately increased by 1–2 °C at night to alleviate the drop in body temperature in elderly patients caused by circadian rhythm disturbance.

6.3.3. Intravenous infusion warming equipment

Postoperative drug infusion is a potential factor leading to hypothermia. Infusion of unheated fluids (e.g., antibiotics and blood products) can cause a significant drop in core body temperature. Therefore, postoperative intravenous infusions and irrigation fluids should be preheated to 37 °C, and intelligent warming infusion equipment should be used to maintain a constant fluid temperature.² For patients requiring a large amount of fluid replacement (e.g., those with massive postoperative bleeding), a phased warming infusion strategy can be adopted to avoid chills caused by the input of excessively cold fluids in a short time.

6.3.4. Activities and cooperation of family members and patients

The combination of early postoperative activities and thermal insulation nursing is crucial for the prevention of hypothermia and the promotion of rehabilitation. Family members need to receive standardized training and master the skills of assisting patients in turning over, massaging the lower limbs, and monitoring temperature. For example, family members should be guided to assist patients in performing ankle pump exercises every day to promote peripheral circulation and reduce uneven heat distribution caused by immobilization. Moreover, patients need to cooperate in the implementation of the “progressive thermal insulation rehabilitation plan.”^{54,55} Within 24 h postoperatively, electric blankets are used to maintain trunk temperature during bed rest, along with compression stockings to prevent lower extremity deep vein thrombosis. At 48–72 h after surgery, patients begin assisted ambulation with a walker while wearing warm knee pads and waist supports to reduce heat consumption caused by muscle tremors. Before discharge, patients receive education on thermal care strategies, including

local warming with infrared physiotherapy instruments and avoidance of prolonged exposure to low-temperature environments.

Postoperative thermal insulation nursing needs to integrate environmental regulation, dynamic monitoring, fluid warming, and multi-role collaboration, with particular attention to the needs of elderly patients and complex cases. When necessary, an intelligent body temperature feedback system can be explored to realize real-time linkage between ward temperature control equipment and warming devices to achieve precise individualized management. In addition, the optimization of the thermal insulation pathway based on the ERAS concept (e.g., shortening transfer time and reducing body surface exposure) will further promote the improvement of the nursing quality of THA.

7. Precautions for thermal insulation nursing

Although active thermal insulation nursing can effectively reduce the incidence of hypothermia, most patients undergoing THA are frail elderly individuals, among whom a considerable number have unstable cardiovascular function, resulting in significant potential risks during implementation. Rapid active warming can easily cause sudden dilation of peripheral blood vessels, leading to blood redistribution and a sharp decrease in venous return, which greatly increases the risks of hypotension, myocardial ischemia, and arrhythmia. The increased heart rate caused by warming will further exacerbate cardiac load.⁵⁵ Local warming equipment may also cause scalds due to impaired skin sensation in patients, and pressurized warming devices can aggravate lower extremity venous stasis and increase the risk of deep vein thrombosis.⁵⁶ Massive infusion of warmed fluids is prone to induce body fluid balance disorders and may trigger acute exacerbation of the condition in patients with heart failure.⁵⁷ Excessive warming may also adversely affect coagulation function and increase the risk of bleeding.⁵⁸

Therefore, in clinical practice, patients with severe peripheral vascular diseases, acute heart failure, and other conditions are absolute contraindications for aggressive thermal insulation, while those with mild to moderate cardiac insufficiency, severe asthma, and other disorders are relative contraindications. For such patients, high-intensity warming should be abandoned, with the goal of maintaining the core body temperature at 36.0–36.5 °C.² Passive warming should be prioritized, and low-dose local slow warming can be applied when necessary. Vital signs should be monitored throughout the process, and multidisciplinary evaluations should be conducted to formulate individualized nursing plans.

8. Observation indicators for evaluating the efficacy of thermal insulation nursing in total hip arthroplasty

8.1. Primary outcome indicators

Changes in body temperature are one of the key indicators for evaluating the efficacy of thermal insulation nursing. Accurate monitoring of patients' core body temperature at different perioperative stages (e.g., before anesthesia induction, at different intraoperative time points, at the end of surgery, and at specific postoperative time points) can directly reflect the effect of thermal insulation nursing on body temperature regulation. A study by Chen and Dong⁵⁹ confirmed the effectiveness of thermal insulation nursing in maintaining body temperature stability by recording core body temperature at these time points. The incidence of hypothermia is also an important indicator: defining the hypothermia standard (core body temperature below 36 °C) and counting the number and proportion of hypothermia cases in different nursing groups can measure the preventive effect of thermal insulation nursing on hypothermia. A study by Wang⁶⁰ compared the incidence of hypothermia between the conventional nursing group and the thermal insulation nursing group, highlighting the advantages of thermal insulation nursing.

8.2. Secondary observation indicators

Coagulation function indicators, including prothrombin time, activated partial thromboplastin time, thrombin time, and fibrinogen, are commonly used secondary observation indicators. A study by Ju and Li⁴² showed that patients receiving comprehensive thermal insulation nursing had smaller fluctuations in these postoperative coagulation indicators, confirming the role of thermal insulation nursing in improving coagulation function. Postoperative recovery parameters, including tracheal extubation time, post-anesthesia care unit stay time, time to full consciousness, and anesthesia recovery time, are also secondary observation indicators. Studies have demonstrated that the thermal insulation nursing group outperformed the conventional nursing group in all these indicators, reflecting the positive effect of thermal insulation nursing on promoting postoperative awakening.⁴³ The incidence of complications (e.g., shivering, arrhythmia, hypoxemia, surgical site infection) is another important aspect for evaluating the efficacy of thermal insulation nursing. A study by Zhang and Zheng⁶¹ indicated that perioperative comprehensive thermal insulation nursing can significantly reduce the incidence of complications in THA patients, improving surgical safety and patient prognosis.

9. Current and emerging research directions in preoperative warming for total hip arthroplasty

9.1. Development and application of intelligent temperature control systems

The international cutting-edge research focuses on the integration of wireless body temperature monitoring and artificial intelligence feedback regulation technology.^{62,63} For example, Internet of Things-based wireless body temperature sensors can track patients' core body temperature in real time, and combined with artificial intelligence algorithms, can dynamically adjust the temperature of inflatable warming blankets, controlling the fluctuation of intraoperative core body temperature within ± 0.2 °C and reducing the incidence of unplanned hypothermia to less than 10%. In addition, improvements in robotic surgery and surgical navigation can reduce surgical time by decreasing the area of tissue exposure, further lowering intraoperative heat loss, and forming a synergistic effect with intelligent temperature control systems.⁶⁴

9.2. Optimization of hypothermia risk prediction models

The development of multivariate prediction models based on big data analysis has also become a key research focus. Long *et al.*⁶⁵ accurately predicted hypothermia in THA patients by monitoring indicators such as prewarming time, irrigation fluid volume, intraoperative infusion volume, anesthesia duration, surgical time, and core temperature after intubation. By monitoring these factors, clinical staff can achieve early detection and intervention of hypothermia in patients undergoing total joint arthroplasty, and prewarming measures guided by such models can significantly reduce the incidence of hypothermia. Such models can also incorporate operating room environmental parameters (e.g., air velocity, humidity) to improve prediction accuracy.

9.3. Integrated thermal insulation strategies of traditional Chinese and Western medicine

Domestic scholars have explored the combination of traditional Chinese medicine external therapies with Western medicine warming technologies.⁶⁶ For example, postoperative moxibustion at acupoints such as Guanyuan (CV4) and Zusanli (ST36) combined with inflatable warming blankets can promote peripheral circulation and significantly reduce the incidence of postoperative shivering.⁶⁶ The application of traditional Chinese medicine herbal plasters on the non-surgical areas of the lower extremities can improve microcirculation through

transdermal absorption and shorten anesthesia recovery time.

9.4. Localized practice of the enhanced recovery after surgery concept

Domestic hospitals achieve thermal insulation by optimizing surgical processes.⁴⁹ For instance, shortening disinfection time and improving team coordination efficiency can control the duration of THA within one hour, reducing heat loss caused by body cavity exposure.

10. Conclusion

Perioperative thermal insulation nursing has important clinical applications in THA. The whole-process comprehensive nursing measures, including preoperative hypothermia risk prediction and prewarming intervention, intraoperative active warming combined with surgical process optimization, and postoperative environmental temperature and humidity regulation with full-course body temperature monitoring, can effectively maintain patients' core body temperature and significantly reduce the incidence of perioperative hypothermia. Additionally, it can improve patients' coagulation function, shorten anesthesia recovery time, and reduce the occurrence of related complications such as surgical site infection, intraoperative bleeding, and postoperative shivering. This nursing measure is also a core component of the clinical application of the ERAS concept in the perioperative period of THA, which is of great significance for improving the safety of surgical treatment, optimizing patient postoperative rehabilitation outcomes, and reducing clinical medical burdens.

Currently, although perioperative thermal insulation nursing for THA has received increasing attention, there are still many urgent issues to be addressed in clinical practice and related research. For example, the individualized adaptability of thermal insulation nursing plans for hypothermia high-risk groups (e.g., frail elderly patients and those with cardiovascular diseases) is insufficient, and there is a lack of unified clinical norms for the selection of warming intensity and intervention methods. The evaluation system for the efficacy of thermal insulation nursing has not yet been standardized: existing studies mostly focus on short-term clinical indicators, and follow-up studies on patients' long-term rehabilitation outcomes are relatively scarce. Restricted by factors such as nursing manpower, equipment configuration, and professional technical capabilities, primary medical institutions find it difficult to conduct standardized and precise thermal insulation nursing.

The future research and clinical development of perioperative thermal insulation nursing for THA should take standardization and popularization as the core directions. First, it is necessary to focus on conducting large-sample, multicenter randomized controlled clinical trials to formulate safe and effective individualized thermal insulation nursing strategies for high-risk groups. Second, a standardized outcome evaluation index system covering body temperature changes, coagulation function, complication occurrence, and long-term rehabilitation effects should be established to realize a scientific and comprehensive evaluation of the efficacy of thermal insulation nursing. Third, it is essential to further optimize hypothermia risk prediction models and develop cost-effective intelligent temperature control equipment to improve the precision and intelligent clinical application level of thermal insulation nursing. Fourth, hierarchical and classified thermal insulation nursing norms should be formulated in combination with the clinical reality of medical institutions at different levels and types. Clinical research on integrated thermal insulation strategies of traditional Chinese and Western medicine should be enhanced, with consideration given to both the cost-effectiveness and clinical popularization of thermal insulation nursing. Ultimately, a scientific, practical, and universal perioperative temperature management system for THA should be constructed to continuously improve the quality of clinical nursing and optimize patient clinical prognosis.

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The authors declare that they have no competing interests.

Author contributions

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Ethics approval and consent to participate

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