Perioperative Medicine

REVIEW

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Advances in the multimodal management of perioperative hypothermia: approaches from traditional Chinese and Western medicine

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Abstract

Purpose Maintaining normothermia during the perioperative period is crucial for preventing complications, such as surgical site infections, prolonged hospital stays, and adverse cardiovascular events. This study aimed to elucidate methods of perioperative temperature management by integrating Western and traditional Chinese medicine (TCM) approaches. By combining advanced techniques of Western medicine with holistic and preventative practices of TCM, we aimed to provide a comprehensive strategy for effective perioperative thermal regulation.

Methods And a comprehensive literature review was conducted to analyze the causes of perioperative hypothermia and methods of perioperative temperature management from both Western and traditional Chinese medicine (TCM) perspectives. Special emphasis was placed on evaluating the underlying factors contributing to perioperative hypothermia, as well as the effectiveness, selection criteria, indications, contraindications, adverse reactions, and potential complications associated with various temperature management techniques.

Results Effective prevention and management strategies include preoperative risk assessment, physical warming measures, environmental temperature control, pharmacological interventions, perioperative temperature monitoring, comprehensive warming protocols, and postoperative warming and monitoring. Integrating traditional Chinese medicine provides additional methods to enhance overall effectiveness and patient outcomes. By combining these approaches, healthcare providers can significantly reduce the incidence of inadvertent perioperative hypothermia (IPH) and its associated complications, improving patient safety and recovery.

Conclusion For IPH, a complex and challenging medical condition, both traditional Chinese medicine and Western medicine have established their own theoretical bases and developed corresponding prevention and treatment methods. However, it is important to note that although each of these methods has unique value and potential, they also have specific indications and unavoidable limitations. Therefore, by integrating and combining the complementary strengths and resources of traditional Chinese medicine and Western medicine, we can achieve a more comprehensive and effective prevention of IPH, ultimately improving the health and well-being of those affected.

Keywords Perioperative hypothermia, Traditional Chinese medicine, Thermoregulation, Enhanced Recovery after Surgery (ERAS), Temperature management, Integrated care

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Introduction

Maintaining stable body temperature is crucial for ensuring normal physiological functions (Tansey et al. 2015). The human core temperature is typically maintained at 37 °C, which is the foundation for proper physiological and immune function. Inadvertent perioperative hypothermia (IPH) refers to a condition where the core temperature drops below 36 °C during anesthesia and surgery, with an incidence rate ranging from approximately 25.7 to 90% (Akhtar et al. 2016; Diamond A 2021; Lee et al. 2021). IPH increases the risk of blood transfusions, cardiovascular events, postoperative shivering, delayed awakening, and agitation during the recovery period and significantly compromises the immune system. IPH is a major risk factor for surgical site infection (SSI), with patients experiencing mild perioperative hypothermia having a 6.3-fold higher rate of SSI than those with a normal body temperature (Bu et al. 2019; Kurz et al. 1996; Xu et al. 2020).

Therefore, prevention of IPH and its associated complications is of paramount importance. With the ongoing development of Enhanced Recovery After Surgery (ERAS), prevention and treatment of IPH have become a vital component of ERAS protocols. Current clinical practice guidelines provide recommendations for the prevention and treatment of IPH, primarily focusing on physical warming measures. However, the best practices to prevent IPH remain unclear (Burger et al. 2009; Duff et al. 2018; Torossian et al. 2015). Despite the use of various warming measures in clinical practice, the incidence rate of IPH remains high.

In recent years, with deepening research on the application of traditional Chinese medicine (TCM) techniques in ERAS, their advantages have gradually become apparent, yielding positive clinical outcomes. The integration of traditional Chinese and Western medicine methods shows promise in preventing and treating IPH, potentially offering a complementary approach that addresses both symptoms and underlying causes (Huang 2017). This article reviews the latest advancements in Chinese and Western medicine for the prevention and treatment of IPH, compares and discusses the effectiveness of existing IPH prevention strategies, and explores the future prospects of integrating Chinese and Western medicine for IPH prevention and treatment. The aim was to provide more effective methods for preventing IPH, guide clinical practice, and ultimately promote rapid patient recovery.

Methods

Study design

This narrative review aimed to synthesize current evidence on the multimodal management of perioperative hypothermia, with a specific focus on integrating traditional Chinese medicine (TCM) and Western medical approaches. The goal was to provide a comprehensive overview of temperature management strategies to improve patient outcomes during the perioperative period.

Literature search

A comprehensive literature search was conducted using PubMed, Cochrane Library, and Embase to identify relevant studies on perioperative hypothermia and the integration of TCM with Western medicine for its management. The search strategy was designed to capture studies published between January 2013 and December 2023, ensuring that the recent advances in the field were included. Search terms included a combination of keywords such as follows: "Perioperative hypothermia," "surgical hypothermia," "temperature regulation," "temperature management""Traditional Chinese Medicine," "Chinese herbal medicine," "acupuncture," "moxibustion," "acupoint stimulation""Multimodal management," "integrated management," "perioperative care," "postoperative care," "intraoperative hypothermia." The search was limited to English- and Chinese-language studies to ensure accessibility and relevance.

Inclusion and exclusion criteria

Inclusion criteria

(1) Studies that investigated the prevention and management of perioperative hypothermia through multimodal approaches involving both Western medical techniques and TCM practices
(2) Studies on human subjects undergoing surgical procedures
(3) Studies reporting outcomes related to the incidence, prevention, or management of perioperative hypothermia, including temperature regulation and patient recovery

Exclusion criteria

(1) Studies unrelated to perioperative hypothermia
(2) Studies involving nonhuman subjects or those conducted in nonclinical settings
(3) Articles without relevant outcome measures regarding hypothermia prevention or management

Data extraction

Data were extracted from the included studies based on the following variables:

(1) *Study design*: Randomized controlled trials (RCTs), cohort studies, case–control studies, case reports, etc.
(2) *Patient characteristics*: Age, sex, type of surgery, and underlying conditions
(3) *Interventions used*: Including both Western medical techniques (e.g., forced-air warming, intravenous fluid warming) and TCM methods (e.g., acupuncture, moxibustion, and herbal treatments)
(4) *Outcomes*: Incidence of perioperative hypothermia, effectiveness of temperature management, postoperative complications, patient recovery time, and overall patient outcomes

Study selection and review process

The initial search yielded 162 studies, of which 91 were published within the last 5 years (2018–2023). Two independent reviewers screened the studies by their titles and abstracts to determine their relevance. The full texts of potentially relevant articles were retrieved for further review. Any discrepancies between reviewers regarding study inclusion were resolved through discussion and consensus.

The final list of the included studies was reviewed and approved by all authors. Data from the selected studies were then synthesized to provide a comprehensive analysis of multimodal approaches integrating TCM and Western medicine for perioperative hypothermia management.

Causes of IPH

Causes based on Western medicine theories

The causes of IPH are complex, primarily involving inhibition of thermoregulation by anesthetic drugs, heat loss during surgery, and the comprehensive influence of various patient factors such as age, body mass index, and health status. After general anesthesia, the patient's core temperature typically undergoes three phases of decline. In the rapid decline phase, within the first hour after anesthesia induction, anesthetic drugs suppress the thermoregulatory center, lower the thresholds for vasoconstriction and shivering, cause vasodilation, and redistribute heat from the core to peripheral tissues, leading to a rapid decrease in core temperature. In slow linear decline phase, heat loss due to radiation and convection exceeds the metabolic heat production, causing a slow and continuous temperature drop over 2–3 h. In plateau phase, hypothermia induces vasoconstriction, limiting further core heat loss and establishing a new balance between heat production and heat loss, leading to a hypothermic equilibrium state (Torossian et al. 2015). Research suggests that the causes of IPH can be broadly categorized into surgical, anesthesia-related, patient-related, environmental, and intraoperative management factors, as described in Table 1 (Sari et al. 2021; Yang et al. 2015).

Causes based on traditional Chinese medicine (TCM) theories

In TCM, the causes of inadvertent perioperative hypothermia (IPH) are multifaceted, encompassing factors such as yin-yang imbalance, qi deficiency, dysfunction of the triple burner (San Jiao), and impairment of organ function. These TCM concepts provide a holistic framework for understanding how temperature regulation is affected during surgery.

Yin-yang imbalance

The balance between yin and yang is fundamental to health in TCM. Yin represents the cold, cooling, and nourishing aspects, whereas yang symbolizes warmth, energy, and defense. Hypothermia is often associated with a predominance of yin and yang deficiencies, disrupting the dynamic equilibrium needed for proper temperature regulation (Gao et al. 2021).

Yangqi is responsible for warming and protecting the body. When yang qi is weak, the body's ability to resist

Table 1 The causes of IPH in Western medicine

Causes of IPH	Factors
Surgical factors	Surgery duration > 2 h, major or open surgeries
Anesthesia-related factors	Type and duration (> 2 h) of anesthesia, use of anesthetic drugs
Patient-related factors	Age ≥ 65 years, BMI < 25 kg/m^2, ASA classification > II, baseline hypothermia or a tendency toward hypothermia, comorbidities such as peripheral vascular disease, endocrine disorders, trauma, or burn history
Environmental factors	Low ambient temperature
Intraoperative management factors	Excessive body surface exposure during surgery, lack of necessary coverage for nonsurgical areas, ineffective warming measures and infusion of unwarmed fluids > 1000 ml, use of unwarmed irrigation fluids > 500 ml during surgery

cold decreases, leading to hypothermia. External factors, such as cold surgical environments and cold fluids, can further suppress yang qi, resulting in an inability to maintain core body temperature (Zhang et al. 2015). This leads to an increased vulnerability to cold pathogens, which may stagnate qi and cause blood stasis, further impeding the body's natural warmth.

Defensive qi (wei qi), associated with yang, circulates on the surface of the body, protecting it from the external cold, while nutritive qi (ying qi), associated with yin, nourishes internal organs (Su 2014). Surgery, especially with blood loss, can deplete both forms of qi, leading to an imbalance that manifests as weakened defense mechanisms and impaired warming functions. This disharmony disrupts the interaction between the body's internal and external energy, contributing to failure to maintain body temperature.

Qi and blood are intrinsically linked in TCM, with qi propelling the circulation of blood and blood nourishing organs. Anesthesia and surgical trauma can obstruct the movement of qi, leading to stagnation and blood stasis. This disrupts the warming function of qi and impairs the body's ability to regulate temperature (Li et al. 2022; Su 2014).

Qi deficiency

Qi, as a vital force in TCM, is fundamental to all physiological processes, including temperature regulation. Qi deficiency can result from congenital factors or postnatal influences such as poor digestion and nutrition. In the context of surgery, qi deficiency weakens yang qi, which maintains warmth, leading to hypothermia (Xinyue et al. 2022; Fan 2014; Gao et al. 2021). This is particularly concerning in elderly patients or those with chronic illnesses, where preexisting qi deficiencies may predispose them to more severe drops in body temperature during surgery.

Dysfunction of the triple burner (San Jiao)

The triple burner (San Jiao) is a key organ system in TCM that is responsible for the regulation and distribution of qi, body fluids, and metabolic heat. Disruption of the San Jiao due to surgery and anesthesia can lead to qi stagnation, impaired fluid metabolism, and failure to maintain body temperature (Li et al. 2022).

Surgical trauma and the effects of anesthetic drugs can disrupt the smooth flow of qi, causing stagnation that leads to blood stasis. This stagnation prevents proper circulation and warming and contributes to hypothermia. Blockage of qi and blood further compromises the body's ability to generate warmth.

Disruptions in the upper, middle, and lower sections of San Jiao affect fluid metabolism, leading to the accumulation of cold and dampness within the body (Li et al. 2022; Gao et al. 2021). Surgical blood loss and the use of cold intravenous fluids can exacerbate these imbalances and further impair temperature regulation.

Impairment of organ functions

In TCM, the coordinated function of the organs is essential for maintaining the balance of yin-yang and circulation of qi and blood. Surgical trauma can disrupt the function of key organs, particularly the heart, lungs, kidneys, and spleen, all of which play a role in maintaining the body temperature (Li 2017).

The lungs govern the movement of qi and the opening and closing of pores, which regulate the body temperature. Anesthetic drugs and mechanical ventilation can disrupt lung function, impede the circulation of defensive qi, and reduce the body's ability to retain warmth (Chen et al. 2022; Guo et al. 2020; Yi et al. 2017).

The heart and kidneys work together to balance the yin and yang within the body. Surgery and anesthesia can disrupt this balance, weakening the heart yang and kidney yin and resulting in impaired temperature regulation (Zhang et al. 2015). This is particularly evident in procedures involving large blood loss or prolonged anesthesia.

Strategies for preventing and managing intraoperative hypothermia (IPH)

IPH intervention strategies from the perspective of Western medicine

Preoperative IPH risk assessment

Effective preoperative assessment and development of corresponding IPH prevention strategies can significantly reduce the incidence of IPH and its associated complications. Yi et al. incorporated major risk factors, such as patient BMI, preoperative basal temperature, surgery grade, and anesthesia duration, into a multicenter study to construct a risk prediction model for IPH in patients under general anesthesia. They developed a predictor score to predict IPH risk and analyzed the necessity and effectiveness of temperature protection measures (Yi et al. 2017). An app for perioperative hypothermia risk prediction was also developed based on this model, which categorizes risk into low, medium, and high and recommends corresponding interventions (Chen et al. 2022; Dai et al. 2022). The preliminary validation demonstrated its accuracy. However, since this prediction model is currently limited to specific clinical settings and lacks comparative studies with other models, prospective, large-sample, multicenter clinical trials are needed to validate its predictive power across broader populations and to enhance its generalizability.

Physical warming measures

Passive warming measures were designed to retain heat and minimize heat loss. Common methods include reducing skin exposure and using fabric coverings, artificial noses, reflective blankets, and thermal blankets (Cobb et al. 2016; Min et al. 2018; Thiel et al. 2020). The AORN guidelines recommend the application of at least one passive warming technique during the perioperative period (Van Duren 2022). Single-layer passive warming can reduce the heat loss by 30%, which is influenced by the material, area, and number of layers used. When passive warming alone is insufficient, it is recommended to promptly combine it with active warming methods to prevent IPH (Hooper 2009). Reflective blankets are more effective than cotton blankets in maintaining peripheral warmth during the preoperative phase, reducing the core-to-peripheral temperature gradient, and increasing peripheral temperatures (Koenen et al. 2017). A single-center study comparing the Orve + Wrap® thermal blanket with forced-air warming (FAW) found that both methods were similarly effective in rewarming postoperative IPH patients, with no significant differences in adverse event rates. This suggests that Orve + Wrap is a potential alternative for short-term postoperative warming, although further research is needed for its application throughout the perioperative period (Smith et al. 2020).

Active warming measures work by increasing the heat supply and transfer, with common methods including warming devices for blood and fluids and active surface warming systems such as FAW blankets, circulating water blankets, and electric blankets. For patients under general anesthesia, the transfusion of every 1000 ml of room temperature fluid or one unit of 0.5 °C stored blood can lower body temperature by 0.25–0.5 ℃, which is why intravenous fluids should be warmed to 37 ℃ (Roxby et al. 2020). Studies have shown that warming intravenous fluids to 37–41 ℃ raises core temperature more effectively and reduces shivering compared to room-temperature fluids, although the difference between warmed and room-temperature irrigation fluids is less significant (Campbell et al. 2015). Active body surface warming (ABSW), including FAW blankets, circulating water blankets, and electric blankets, is among the most frequently used technologies for preventing IPH (Madrid et al. 2016). FAW, widely recognized for its effectiveness, transfers heated air to the patient through convective and conductive processes, reducing heat loss and maintaining the core temperature. Systematic reviews have shown that FAW is more effective than circulating water blankets and electric blankets for treating IPH (Warttig et al. 2014). Factors such as the warming site, duration, and temperature influence the effectiveness of FAW (Lee et al. 2021). Research suggests that upper-body warming is more effective than lower-body warming in patients undergoing lateral thoracoscopic surgery (Min et al. 2018). In elderly patients undergoing knee or hip replacement surgery, setting the FAW at 42 °C results in faster rewarming, higher efficiency, and fewer instances of arrhythmias and shivering. The combined preoperative and perioperative use of FAW has been shown to be the most effective approach, with preoperative use alone providing limited benefits (Min et al. 2018; Thiel et al. 2020). A study on elderly patients by Wang et al. found that maintaining FAW at 42 °C during the first hour after anesthesia induction, followed by a reduction to 38 °C during surgery, significantly lowered the incidence of intraoperative and postoperative IPH (Wang et al. 2022).

Laparoscopic surgeries present additional challenges for IPH owing to the use of cold and dry CO2 gas. This can lead to substantial heat loss when the gas contacts the abdominal surface, resulting in a decrease in the body temperature. Studies suggest that warming and humidifying CO2 insufflation can help maintain the core temperature, although the clinical significance is limited (Balayssac et al. 2017; Birch et al. 2016; Dean et al. 2017). Some evidence indicates that combining warm and humidified CO2 with FAW can effectively reduce the incidence (Noll et al. 2018; Wittenborn et al. 2022). Additionally, visceral fat insulation during pneumoperitoneum has been found to reduce organ temperature loss, especially in patients with higher levels of visceral fat (Miyazaki et al. 2019). Therefore, laparoscopic patients may benefit from a personalized warming strategy that considers visceral obesity and combines the various warming methods.

Preoperative prewarming, which involves actively warming the peripheral tissues or skin before anesthesia, has been demonstrated to reduce the core-to-peripheral temperature gradient and lower the incidence of IPH. This approach is effective for patients undergoing general or neuraxial anesthesia (Glosten et al. 1993; Van Duren 2022). A study by Lau et al. found that patients who were prewarmed with FAW for at least 30 min had lower intraoperative IPH incidence and shorter exposure to low temperatures compared to those using electric blankets (Lau et al. 2018). The effectiveness of prewarming depends on both the preoperative temperature and duration of prewarming. NICE guidelines recommend starting active warming in the ward for patients with temperatures below 36 ℃ and prewarming for 30 min before anesthesia induction for those with temperatures above 36 ℃ ("Hypothermia: prevention and management in adults having surgery" 2016). Prewarming for 30 min sufficiently increases peripheral heat to offset heat redistribution during the first hour after anesthesia,

significantly reducing the incidence (Connelly et al. 2017). In urological laparoscopic surgeries, short-term prewarming at 43 ℃ for 5–30 min has been shown to effectively reduce the incidence of IPH. Jun et al. found that short-term (20 min) and high-temperature (45 °C) FAW prewarming in elderly patients undergoing prostatectomy increased the core temperature at PACU entry, significantly reducing postoperative IPH and shivering. However, short-term prewarming alone was insufficient to completely prevent intraoperative core temperature drops, suggesting the need for continuous prewarming until anesthesia induction or combined intraoperative active warming for surgeries with significant expected heat loss (Jun et al. 2018).

Environmental temperature control

Maintaining an appropriate operating room temperature (21–25 ℃) reduces the temperature difference between the patient's skin and the environment, thereby minimizing heat loss through radiation. Increasing the operating room temperature is one of the simplest and most effective methods to reduce the incidence of IPH. A study by Pei et al. found that every 1 °C decrease in room temperature resulted in a 0.13 ℃ drop in core temperature in patients using only passive warming. In contrast, patients receiving FAW experience no significant impact from room temperature changes (Pei et al. 2018). Operating room temperatures below 23 °C are considered a high-risk factor for IPH, but increasing the temperature above 26 °C while reducing the incidence of IPH may lead to higher infection risks and discomfort for the surgical team (Yang et al. 2015). Thus, dynamic temperature control should be part of comprehensive warming measures, adjusting the environment based on patient needs and surgical procedures.

Pharmacological interventions

Pharmacological interventions focus on reducing the heat redistribution and enhancing the metabolic heat production. Vasoconstrictive agents, such as phenylephrine, reduce heat redistribution by inducing vasoconstriction, whereas amino acids and fructose enhance the metabolic rate and increase the vasoconstriction threshold (Gupta et al. 2019; Mizobe et al. 2006; Palanisamy et al. 2022). A randomized controlled trial (RCT) comparing different anesthesia induction techniques found that sevoflurane inhalation or prophylactic phenylephrine before propofol induction reduced redistribution-related IPH by 0.4–0.5 °C in patients aged 18–55 (Roth et al. 2019). A meta-analysis of 14 RCTs conducted by Aoki et al. confirmed that continuous intravenous phenylephrine infusion significantly reduced intraoperative core temperature drops, particularly in patients with low baseline MAP or in those undergoing surgeries with significant blood or heat loss (Aoki et al. 2017).

Perioperative temperature monitoring

Continuous perioperative temperature monitoring is crucial for diagnosing IPH and adjusting preventive or therapeutic measures in real time. Core temperature monitoring is considered to be more reliable than peripheral temperature monitoring (Robertson et al. 2019). Common core monitoring sites include the esophagus, nasopharynx, bladder, rectum, and tympanic membrane, whereas peripheral sites include the axilla, skin, and oral cavity. Core sites better reflect true body temperature as they are less influenced by external factors. Guidelines recommend esophageal or nasopharyngeal monitoring for patients under general anesthesia and bladder or rectal monitoring for patients receiving neuraxial anesthesia (Sessler 2008). Continuous monitoring allows for timely adjustments to warming strategies and significantly reduces the incidence of IPH in high-risk patients.

Comprehensive warming protocols

A comprehensive warming protocol that combines prewarming, intraoperative active warming, and environmental temperature control is considered the most effective approach for preventing IPH (Insler et al. 2006). Tailoring interventions based on individual patient risk factors, surgery type, and anesthesia methods ensures more effective temperature management. For high-risk patients or those undergoing major surgeries, preoperative prewarming followed by continuous FAW and warmed intravenous fluids is recommended. Passive warming combined with environmental temperature control may be sufficient for minor surgeries or low-risk patients.

Postoperative warming and monitoring

Postoperative warming and monitoring are critical to prevent IPH complications and ensure optimal recovery. FAW, circulating water blankets, and electric blankets are commonly used in the PACU to maintain normal body temperature (Hopf 2015). Continuous temperature monitoring in the PACU allows for timely intervention in case of temperature drops. Monitoring IPH-related complications such as shivering and arrhythmias is essential. Combining postoperative warming with pain management and fluid therapy improves patient comfort and facilitates recovery (Chen et al. 2024).

IPH intervention strategies from the perspective of traditional Chinese medicine

TCM offers various approaches for the prevention and treatment of perioperative hypothermia, targeting the underlying imbalances of qi, blood, yin, and yang. These

interventions include preoperative assessments, herbal medicine, moxibustion, and acupuncture-based therapies.

Pre-evaluate the possible IPH from the perspective of traditional Chinese medicine

In TCM, a comprehensive preoperative evaluation includes assessing the patient's complexion, pulse, and tongue coating to detect signs of qi deficiency, blood stagnation, or yang weakness. Pale or purplish skin, a deep and weak pulse, or a white moist tongue coating may indicate a predisposition to hypothermia due to yang deficiency and poor circulation. Patients presenting with symptoms such as cold limbs, fatigue, and fear of cold are considered to have a higher risk of intraoperative hypothermia.

Herbal medicine

Herbal medicines play a central role in the prevention and treatment of IPH in TCM. Warming herbs, such as ginger, cinnamon, and aconite, are frequently used to boost energy, promote circulation, and dispel cold (Bao et al. 2023; Miyamoto et al. 2015; Zhao et al. 2012). Herbal formulations are tailored to individual patients, focusing on restoring qi and yang to prevent temperature drop during surgery. Clinical studies have shown that these herbal formulas can effectively increase core temperature and reduce the incidence of IPH.

Moxibustion

Moxibustion is a TCM therapy that involves burning moxa (a form of mugwort) on or near the skin to warm yang energy and stimulate the circulation. It is particularly effective for treating yang deficiency-induced hypothermia. The application of moxibustion to acupoints such as Yongquan and Taixi has been shown to significantly improve postoperative temperature recovery in postoperative patients (Chen et al. 2014). The heat generated by moxibustion penetrates deeply, restoring the body's ability to generate and retain heat.

Acupoint application

Acupoint application involves the use of herbal plasters or patches applied to specific acupoints to enhance energy in yang and promote qi flow. This therapy is often used to prevent hypothermia by stimulating acupoints that regulate the temperature. For example, application to the Dazhui acupoint has been shown to prevent hypothermia in patients undergoing urological surgeries (Yu et al. 2020). Dazhui acupoint application invigorates yang energy and regulates qi and blood, beneficial for imbalanced yin and yang and insufficient yang energy. The Zhongwan acupoint application regulates middle burner function, qi, and blood flow, preventing stasis and fluid imbalance. Acupoint applications in Pishu and Weishu improved organ function and enhanced temperature regulation.

Acupoint massage

Acupoint massage stimulates specific points on the body to harmonize qi and blood, enhance energy in yang, and restore warmth. Massaging acupoints, such as Zusanli and Yongquan, are used in perioperative settings to quickly stimulate meridian qi and regulate organ function, improving the body's temperature control (Lin et al. 2020).

Herbal fomentation

Herbal fomentation combines thermal stimulation with the therapeutic effects of herbs to warm meridians and boost yang energy. This technique has been successfully used in postoperative patients to restore normal body temperature and prevent hypothermia. Application to key acupoints, such as Yongquan, Guanyuan, and Zusanli, has been shown to accelerate the recovery of body temperature in patients recovering from orthopedic surgery (Sun et al. 2019; Zeng et al. 2020).

Transcutaneous electrical acupoint stimulation (TEAS)

TEAS is a modern adaptation of acupuncture that uses electrical stimulation to activate acupoints and enhance the qi flow. Preoperative application of TEAS to acupoints, such as Dazhui and Mingmen, has been shown to slow intraoperative temperature decline and reduce postoperative shivering (Greif et al. 2002; Liang et al. 2019). TEAS integrates traditional acupuncture with modern technology to improve outcomes in patients at a risk of hypothermia.

Summary

IPH is a common and significant complication of perioperative care, with various adverse effects on patient outcomes. Effective prevention and management strategies include preoperative risk assessments, physical warming measures, environmental temperature control, pharmacological interventions, perioperative temperature monitoring, comprehensive warming protocols, and postoperative warming and monitoring. Integrating traditional Chinese medicine provides additional methods to enhance overall effectiveness and patient outcomes. By combining these approaches, healthcare providers can significantly reduce the incidence of IPH and its associated complications, thereby improving patient safety and recovery.

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Authors' contributions
Data extraction, Bin zhang, Hongmei Zhou, Xiahui wang; Writing-origin draft, Bin zhang, yeping zheng; writing-review and editing, Li Hu. All authors have read and approved the final manuscript. All authors have agreed on the manuscript that will be submitted, gave final approval of the version to be published, and agree to be accountable for all aspects of the work.

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Data availability
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Written consent was given in writing by all subjects.

Competing interests
The authors declare no competing interests.

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