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Evidence Summary of Hypothermia Prevention and Management in Patients with General Anesthesia During Recovery Period

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Abstract: ***Purpose To summarize the best evidence for the prevention and management of hypothermia in patients with general anesthesia during recovery period. Method Domestic and foreign databases and related websites were searched to collect guidelines, clinical decisions, systematic reviews, expert consensuses, and randomized controlled trials related to the prevention and management of hypothermia during recovery from general anesthesia. The search time limit was from the establishment of the database to November 2024.Result A total of 9 guidelines, 1 clinical decision support, 1 evidence summary, 5 systematic reviews, 2 expert consensuses, and 4 randomized controlled trials were included, including 5 dimensions and 26 best evidences. Conclusion Summing up the evidence provides a scientific basis for the nursing of hypothermia in the recovery period of general anesthesia patients, which has strong operability and provides evidence-based basis for clinical nursing.***

1. Foreword

Postanesthesia care unit (PACU) is a key place for patients to wake up and recover after operation. It provides professional monitoring and nursing support for patients to smoothly transition from anesthesia state to awake state, which is an indispensable part of perioperative period. Hypothermia refers to the patient's core body temperature below 36℃. The incidence of hypothermia in PACU is 3.3%~22.8%, Hypothermia is a common perioperative complication [1]. Hypothermia can increase patients' discomfort and cause a variety of complications, including increased risk of surgical site infection, prolonged action time of anesthetic drugs, impaired coagulation function, increased blood loss and blood transfusion requirements, affected drug metabolism, and prolonged postoperative recovery time [2,3]. Although preoperative and intraoperative heat preservation can reduce heat loss, patients may still have hypothermia after entering the PACU due to gender, age, BMI, surgical method, operation time, anesthesia time, room temperature, surgical trauma, blood transfusion volume and anesthetic drugs [4]. Due to the influence of anesthetic drugs, the temperature regulation ability of PACU patients is weakened, and their tolerance to hypothermia is reduced. However, there are some deficiencies in the understanding and application of perioperative hypothermia guidelines by nursing staff. Continuous education is needed to enhance the attention to postoperative core body temperature and the understanding of the clinical significance and prevention and treatment measures of hypothermia [5]. There are a variety of heat preservation measures, but hypothermia management faces problems such as incomplete knowledge, insufficient awareness, lack of manpower and equipment, poor organizational atmosphere, and unsystematic processes. This study used evidence-based methods to provide evidence-based basis for prevention and management of hypothermia patients in PACU.

2. Materials and Methods

2.1 The Establishment of Research Questions

Using the PIPOST model [6] to construct evidence-based practice questions. P (Population) PACU patients with hypothermia; i (Intervention) active warmth or passive warmth or combined warmth; p (Professional) Health Promoters (nurses, doctors); o (Outcome) body temperature recovery time, rewarming rate, tracheal extubation time, anesthesia recovery time; s (Setting) anesthesia recovery room; t (Type of Evidence) expert consensus, clinical decision-making, guidelines, systematic reviews, evidence summary, randomized controlled trials.

2.2 Literature Retrieval Strategy

According to the ' 6S ' evidence model, multiple databases were searched from top to bottom: in BMJ Best Practice, Up To date, Global Initiative for Standards in Evidenced-based Health Care (GIN), National Institute for Health and Care Excell Cance guideline (NICE), Cochrane Library, JBI evidence-based health care center database, Association of PeriOperative Registered Nurses (AORN), Yimaitong, Clinicalkey for Nursing, Web of Science, PubMed, Embase, Ovid, Scopus, ScienceDirect, Springer link, Proquest, Wiley Online Library, China National Knowledge Infrastructure (CNKI), Wanfang Data, VIP and SinoMed were searched.The search strategy of subject words plus free words is applied, and the search time limit is November 2024. The Chinese search terms were: 'surgery / postoperative / perioperative / recovery period / PACU'; 'heating / heating / rewarming'; 'hypothermia / hypothermia / loss of temperature / hypothermia / unplanned hypothermia'; 'Expert consensus / guidelines / evidence summary / systematic review / meta-analysis / randomized controlled trials', English search terms: "Anesthesia Recovery Period/Postoperative period/

post-anesthesia/recovery period/Recovery Period, Anesthesia /nursing, perioperative/PACU"; "Rewarming/warm*/heat*"; "Hypothermia / Unintended hypothermia / unplanned hypothermia / inadvertent perioperative hypothermia / accidental hypothermia / body temperature declin* / piloerection"; "Systematic review / meta-analysis / guideline / evidence summar* / consensus / randomiz*". Taking PubMed as an example, the search strategy is shown in Figure 1:

#1 "Anesthesia Recovery Period"[Mesh]

#2 Anesthesia Recovery Perido[Title/Abstract] OR Postoperative period[Title/Abstract] OR post-anesthesia[Title/Abstract] OR recovery period[Title/Abstract] OR Recovery Period, Anesthesia[Title/Abstract] OR nursing,perioperative[Title/Abstract] OR PACU[Title/Abstract]

#3 #1 OR #2

#4 (Rewarming[MeSH Terms]) OR (Rewarming[Title/Abstract] OR warm*[Title/Abstract] OR heat*[Title/Abstract])

#5 (Hypothermia[MeSH Terms]) OR Hypothermia[Title/Abstract] OR Unintended hypothermia[Title/Abstract] OR unplanned hypothermia[Title/Abstract] OR inadvertent perioperative hypothermia[Title/Abstract] OR accidental hypothermia[Title/Abstract] OR body temperature declin*[Title/Abstract] OR piloerection[Title/Abstract]

#6 Systematic review[Title/Abstract] OR meta-analysis[Title/Abstract] OR guideline[Title/Abstract] OR evidence summar*[Title/Abstract] OR consensus[Title/Abstract] OR randomiz*[Title/Abstract]

#7 #3 AND #4 AND #5 AND #6

Figure 1: Retrieval strategy with PubMed as an example

2.3 Literature Inclusion and Exclusion Criteria

Inclusion criteria: 1) Patients with hypothermia during the recovery period of general anesthesia for elective surgery; 2) body temperature assessment, monitoring, heat preservation or rewarming measures; the main outcome indicators include postoperative core temperature, recovery time, rewarming rate, etc. 3) Literature types included guidelines, evidence summary, systematic review, expert consensus and RCT. 4) Language: Chinese or English. Exclusion criteria: 1) unable to obtain the full text; 2) Literature types were clinical guideline interpretation, research plan, etc. 3) The overall quality is low.

2.4 Literature Quality Evaluation

The quality evaluation tools are as follows: (1) Guide: Application of the 2017 version of the AGREE II quality evaluation tool, a total of 23 items in 6 fields [7]. (2) Expert consensus: The JBI evidence-based health care center 2016 edition standard [8] was used for evaluation, with a total of 6 items, and each item was evaluated with 'yes', 'no', 'unclear' and 'not applicable'. (3) Systematic review: The 2016 version of the JBI system evaluation methodology quality evaluation standard was used to evaluate the system evaluation. A total of 11 items were included, each item was evaluated by 'yes', 'no', 'unclear' or 'not applicable' [8]. (4) Evidence summary, clinical decision-making, and recommended practice Trace the original literature, and select the corresponding evaluation system for quality evaluation according to the research type of the original literature. (5) Randomized control: The JBI evidence-based health care center (2016 edition) RCT quality evaluation tool [9] has 13 items, each evaluated with 'yes', 'no', 'unclear' or 'not applicable'. In addition, this study adds multiple rounds of cross-validation and expert discussion to ensure the objectivity and accuracy of the evaluation.

2.5 Evidence Extraction and Integration

An evidence-based group was composed of two graduate students, a head nurse in the anesthesia recovery room and an evidence-based nursing expert. Two graduate students independently extracted literature data information (publication year, author, evidence content and grade). The abstracts of the English literature were extracted and translated into Chinese, and the head nurse of the anesthesia recovery room reviewed and proofread them to form Chinese manuscripts and evidence entries. When extracting, each piece of evidence lists the research topic, source and type to ensure accurate traceability. Cross-validation was performed after extraction, and the disagreement was assessed by the third member to determine the result. When integrating, the same source of evidence was combined, high-quality and new literature was selected, combined with quality score and clinical correlation weighted analysis to ensure scientificity, accuracy and clinical applicability. On this basis, the evidence items are classified and integrated by graduate students, and graded according to the 2014 edition of the JBI evidence pre-classification system, and the JBI evidence recommendation level system (2014 edition) is used to evaluate the recommendation level A (strongly recommended)

or B (recommended) [10], considering the feasibility, suitability, clinical importance and effectiveness.

3. Result

3.1 Literature Inclusion Results

A total of 1484 articles were retrieved, and 1150 articles were excluded after repetition. 122 articles were screened by title and abstract, 37 articles were screened after reading the full text, and 22 articles were finally included [1, 2, 4, 11-29], It includes 9 guidelines [20-28], 1 clinical decision [15], 1 evidence summary [4], 5 systematic reviews [2, 16-19], 2 expert consensuses [1, 29] and 4 randomized controlled studies [11-14].

3.2 Literature Screening Information is Shown in Table 1.

Table 1: General characteristics of the included literature

Author / Institution	document type	publishing time	source of evidence	document subject
Fan Yu et al [11]	RCT	2023	Wanfang	Comparison of rewarming effect between combined warming and inflatable warming instrument in patients with mild hypothermia after operation
Smith et al [12]	RCT	2020	CL	On the effectiveness of reflective blanket and forced air heating to restore body temperature in the anesthesia recovery room
Frank et al [13]	RCT	2000	CL	Warming humidification oxygen inhalation can accelerate postoperative rewarming.
Xu et al [14]	RCT	2019	CL	The effect of inflatable heating system on preventing postoperative hypothermia in elderly patients
Up To Date [15]	clinical decision-making	2023	Up To Date	Perioperative temperature management
Simegn et al [2]	systematic review	2021	SD	Prevention and management of perioperative hypothermia in adult patients undergoing elective surgery: a systematic review
Pikus et al [16]	systematic review	2010	PubMed	Postoperative rewarming: In addition to warm hospital blankets, are there other options?
Warttig et al [17]	systematic review	2014	CL	Intervention measures for the treatment of accidental hypothermia after operation
Zhou et al [18]	systematic review	2014	PubMed	Effect of perioperative amino acid infusion on core body temperature: a systematic review
Nieh et al [19]	systematic review	2016	PubMed	The effectiveness of forced air warming on the prevention of perioperative hypothermia in patients undergoing surgery
Turkish Society of Anesthesia and Resuscitation [20]	Guideline	2013	Proquest	Turkish Society of Anesthesiology and Resuscitation Practice Guidelines for the Prevention of Unintentional Hypothermia during Perioperative Period
Crosland et al [21]	Guideline	2016	NICE	Hypothermia: prevention and management of adult surgery
Link et al [22]	Guideline	2020	Proquest	Guiding Principle in Practice: Low Temperature Prevention
Burlingame B L et al [23]	Guideline	2019	AORN	Practice guidelines for perioperative hypothermia
National Collaborating Centre for Nursing and Supportive Care [24]	Guideline	2008	NICE	Management of perioperative hypothermia in adults
Hooper et al [25]	Guideline	2010	AORN	Evidence-based clinical practice guidelines for promoting normal body temperature during perioperative period: second edition
Torossian et al [26]	Guideline	2015	PubMed	Prevention of unintentional perioperative hypothermia
Riley et al [27]	Guideline	2018	SD	Inadvertent perioperative hypothermia
Calvo et al [28]	Guideline	2018	SD	Clinical Practice Guideline: Unplanned Perioperative Hypothermia
Expert Committee on Accelerated Rehabilitation Surgery of Integrated Traditional Chinese and Western Medicine [29]	experts consensus	2021	Yimaitong	Shanghai Expert Consensus on Integrated Traditional Chinese and Western Medicine Accelerated Rehabilitation Surgery (2021 Edition)
National Center for Quality Control of Anesthesia [1]	experts consensus	2023	CNKI	Expert Consensus on Prevention and Treatment of Hypothermia in Perioperative Patients (2023 Edition)
Yunfang Liu et al [4]	evidence summary	2023	CNKI	Evidence summary of hypothermia prevention and management in anesthesia recovery room

Note: SD is 'scienceDirect', CL is 'Cochrane Library'.

3.3 Quality Evaluation of Included Literature

3.3.1 Guideline A total of 9 guidelines were included [20-28]. According to the evidence pre-classification system, the standardized percentages of the six areas of the guidelines can be included.

3.3.2 Experts consensus A total of 2 expert consensus [1, 29] were included, and the quality evaluation of 6 items was 'yes', which was of high quality and was included.

3.3.3 systematic review Five systematic reviews were included [2, 16-19]. Among them, the results of Pikus et al [16] were 'unclear' in terms of independent evaluation (item 6) and publication bias evaluation (item 9), and the remaining items were evaluated as 'yes'. The study of Simegn et al [2] was evaluated as 'unclear' in terms of independent evaluation (item 6) and error reduction measures (item 7), as 'not applicable' in terms of research recommendations (item 11), and as 'yes' in other items. The study of Warttig et al. [17] was evaluated as "yes" except for the publication bias assessment (item 9), which was evaluated as "no." The studies of Zhou B et al [18] and Nieh et al [19] were evaluated as 'yes' in all evaluation items. The quality of the above literature is high and all of them are allowed to be included.

3.3.4 Evidence summary and clinical decision-making 1 evidence summary [4], 1 clinical decision-making [15], 2 guidelines [21, 28], 1 clinical decision-making [15], 4 systematic reviews [17-19, 30], 2 guidelines [21, 28], 1 clinical decision-making [15], 3 systematic reviews [17-19] were all consistent with the literature included in this study. The item 1 (problem clarity), item 5 (appropriateness of evaluation criteria), item 10 (practical suggestions) and item 11 (practical suggestions) of the systematic review of 1 [30] were evaluated as 'yes'. The remaining items were 'unclear' and were excluded due to poor quality.

3.4 Best Evidence Summary

Relevant evidence was extracted from the included 22 articles. After sorting and merging, it was finally summarized into 5 dimensions, forming a total of 26 best evidences. See Table 2.

Table 2: Summary of evidence for prevention and management of hypothermia in patients undergoing general anesthesia during recovery period

dimensional		content of evidence	level of evidence	Level recommendation
Hypothermia assessment	risk factor identification	1.Identify potential risk factors for perioperative hypothermia, including patient-related factors (age, basal body temperature, body mass index (BMI), American Society of Anesthesiologists (ASA) classification, complications, etc.), surgery-related factors (complexity, type, duration, body cavity irrigation, liquid / blood infusion, etc.), anesthesia-related factors (anesthesia method, anesthesia plane, anesthesia duration, anesthetic drugs, etc.) and environmental-related factors (temperature control in the operating room, etc.) [20, 22-24, 26-28]	4	A
		2.Identification of high risk factors: operation time > 30 min, combined general anesthesia, ASA ≥ II, age > 65 years old, intraoperative use of unwarmed liquid, no intraoperative warming measures [1]	5	A
	risk stratification	3.Use risk stratification tools (such as ASPAN score) to distinguish low-risk and high-risk patients [25]	5	A
	symptom observation	4.Closely observe the symptoms of patients during anesthesia recovery, such as chills, vertical hair reaction, etc., timely detection of hypothermia symptoms, in order to take appropriate measures [1, 24]	5	A
	Monitoring timing and frequency	5.The patient's body temperature was measured and recorded in time after entering the PACU [1, 2, 15, 20, 21, 24, 26, 27]	5	A
temperature monitoring	Core body temperature monitoring	6.The core body temperature measurement sites were pulmonary artery, internal jugular vein, femoral artery, lower esophagus 1 / 3, nasopharynx, bladder, rectum, oral cavity, tympanic membrane, temporal artery, etc. During general anesthesia, the esophagus or nasopharynx is usually the most practical temperature monitoring site [20, 23, 24, 26, 28]	5	A
		7.The new body temperature monitoring technology can realize continuous monitoring and data network transmission, making the perioperative body temperature monitoring more real-time and accurate [1]	5	A
		8.Tympanic membrane temperature measurement is considered to be one of the more accurate methods, which can accurately reflect the core body temperature. This part is recommended for postoperative measurement, and the operation is relatively convenient [20, 24]	5	A
	Room temperature management	9.Maintain PACU temperature at 23℃and above [1, 24]	5	A
	Normal body temperature management	10.Inform patients and their families that they need to wear warm clothing before surgery. In the PACU, patients should be ensured to wear enough warm clothing, such as at least one layer of bed sheet, and be equipped with two blankets or one quilt to provide sufficient warm effect [24]	5	A
		11.Body temperature ≥ 36℃ using passive insulation, can be used cotton blanket, surgical sheet, plastic cloth, warm clothing, no velvet package or reflective composite fabric (such as space blanket) for passive insulation [1, 20, 23-25]	5	A
	passive heat preservation	12.The combination of reflective blanket and quilt is used to rewarm, which is equivalent to the rewarming effect of inflatable heater. It is suitable for postoperative rewarming of patients with mild hypothermia, and the reflective blanket is economical, easy to carry, and has no risk of burns or scalds [11]	1	A
Body temperature protection	active heat preservation	13.The forced air heating system is an effective method to prevent and treat hypothermia in the anesthesia recovery room, which can achieve rapid rewarming and reduce the risk of hypothermia-related complications [16, 24]	1	A
		14.If the patient's body temperature is ≤ 36℃, active warming measures (such as the application of forced air warming system) should be initiated to raise the temperature to 36 °C, and the body temperature and thermal comfort should be evaluated every 15 minutes until the normal body temperature is reached [1, 20, 21, 24, 25, 27]	5	A
		15.Forced air heating system is preferred, if forced air heating is not suitable for individuals, you can use resistance heating pad or resistance heating blanket as an alternative [2, 16, 19]	1	A
		16.For elderly patients with postoperative core body temperature lower than 36℃, the forced air heating system can be set to 42 °C. [14]	1	B
	drug intervention	17.It is recommended to heat intravenous infusion of liquid to prevent postoperative hypothermia [28]	1	A
		18.Intravenous infusion (500ml or more) and blood products should be heated to 37℃ by liquid heating equipment, and the connection time between blood and blood heating device should not exceed 4h [21, 24, 26]	1	A
		19.For patients who need flushing, the temperature of the warm flushing fluid is recommended to be controlled at 33 ℃~ 40℃ to reduce the occurrence of shivering and hypothermia [20, 23]	1	A
		20.Amino acids can be intravenously infused to improve hypothermia and thermal comfort [18, 19]	1	B
	Others	21.The patient's body temperature can be maintained by stimulating the patient's acupoints such as Baihui, Dazhui and Zusanli. The stimulation pathways include transcutaneous acupoint electrical stimulation and acupuncture. [29]	1	B
		22.Heating and humidifying Oxygen can accelerate the heating process and reduce the discomfort of dry mouth. [13]	1	B
Outdoor management	Outdoor standard	23.When the patient's core body temperature ≥ 36℃ and the thermal comfort is in a comfortable state, the ward transfer should be considered [2, 20, 21, 24, 27]	5	A
	Out-of-room guidance	24.After leaving the post-anesthesia care unit, patients and their caregivers should be instructed to maintain normal body temperature, including the use of warm fluids, blankets, socks, increased clothing, increased room temperature and other measures [1, 22, 25]	5	B
general management	record management	25.Record in the patient's medical record the measures taken to maintain the patient's normal body temperature, including the use of warm methods, warm equipment identifiers and the use of temperature settings [22, 23]	5	A
	equipment management	26.The selected temperature monitoring equipment should be calibrated according to the manufacturer's written instructions. Health care professionals should use the temperature measuring device and the heating device according to the manufacturer's instructions to ensure that the cleaning and maintenance of the temperature rising device are in line with the local infection control policy [22, 23]	5	A

4. Discussion

4.1 Hypothermia Assessment

This study systematically summarized the risk factors of perioperative hypothermia, including key factors such as patients, surgery, anesthesia and environment, which was consistent with previous research conclusions [26-28]. Risk stratification can accurately identify high-risk patients, help clinical priority to carry out prevention work, provide reference for medical staff to formulate personalized nursing and intervention measures, and improve prevention efficiency and effect, which is very important for the prevention and management of hypothermia [22]. At present, although the academic community has a certain understanding of the risk factors and risk stratification of perioperative hypothermia, there are still limitations such as incomplete assessment and failure to cover potential factors. At the same time, the risk

stratification standards and methods used in different studies are different, which affects the comparability of results. Therefore, increasing awareness, considering risk factors, and following guidelines for the prevention of perioperative hypothermia can reduce the high incidence. Future research needs to improve the risk factor assessment system and develop more scientific and reasonable risk stratification standards and methods to provide a reliable basis for clinical practice.

4.2 Temperature Monitoring

The patient's body temperature was monitored immediately when entering the room, continuous monitoring, once every 15 minutes [23]. The tympanic membrane temperature can better reflect the core temperature, which is convenient to measure and has no discomfort. It is commonly used in infrared thermometer measurement and has a good correlation with the central temperature. It is suitable for preoperative and postoperative patients. It is necessary to ensure that the thermometer is calibrated and tested regularly to prevent large measurement errors [3].

4.3 Body Temperature Protection

The prevention and intervention of hypothermia are divided into passive heat preservation and active heat preservation. Passive insulation reduces heat loss through thermal insulation measures (such as artificial nose, cotton blanket, surgical sheet, thermal insulation blanket, reflective blanket, etc.), and can reduce 30% heat loss throughout the perioperative period [1]. The thermal insulation effect of the combination of reflective blankets and quilts is similar to that of the forced air heating system and can be used as an alternative measure. The mechanism is to reduce heat loss by blocking convection and enhancing reflection [11]. Active heat preservation uses external devices to apply heat to patients. Forced air heating system is an effective method to prevent and treat hypothermia in PACU. It maintains core body temperature by reducing heat loss. When the patient's body temperature is ≤ 36℃ it is preferentially used until the core body temperature rises to 36℃ [24]. More than 1000 ml of liquid and refrigerated blood products should be heated to more than 37℃ before infusion (blood products heating does not exceed 43℃) [3], and the flushing fluid temperature should be controlled at 33°C ~ 40°C [23]. For patients with hypothermia, measures such as intravenous infusion assisted heating need to be initiated [25]. A systematic review by Campbell et al [2] showed that there was no significant difference in core body temperature between heated or room temperature flushing fluid, but due to the limitations of the study, it is still necessary to refer to clinical practice guidelines. JBI recommended that intraoperative intravenous infusion of liquid heating to 37°C~ 43°C, bladder lavage fluid heating to 32°C~40°C [31]. Drug intervention can reduce heat redistribution (such as phenylephrine) and increase metabolic thermogenesis (such as amino acids) [33, 34]. Intravenous phenylephrine can reduce core hypothermia [35]. Postoperative inhalation of humidified oxygen through nasal catheter can accelerate rewarming and reduce dry mouth discomfort, but this study has limitations [13]. In addition, TCM management can maintain the patient's body temperature constant by stimulating the acupoints [29].

4.4 Outdoor Management

Patients with body temperature ≥36°C and thermal comfort in a comfortable state to go out, record the room temperature [27], out of the room to guide patients and medical staff to maintain normal body temperature (such as the use of warm liquid, blankets, socks, increase clothing, improve room temperature, etc.) [22]. During the transfer process, the heat preservation measures are taken to shorten the transfer time, and the active insulation equipment can be continued in the ward if necessary.

4.5 General Management

During resuscitation, measures to maintain normal body temperature should be recorded in the patient's medical records, including warming methods, equipment identification and temperature settings. The temperature monitoring equipment was calibrated according to the manufacturer's instructions, and the medical staff was instructed to use the temperature measurement and heating device, and to ensure that its cleaning and maintenance were in accordance with the infection control policy [23].

5. Nodule

The best evidence summarized in this study provides a scientific basis for the prevention and management of hypothermia during the recovery period of general anesthesia patients in the anesthesia recovery room, and proposes an individualized management strategy, which has strong operability. By implementing these evidence-based management measures, the risk of hypothermia can be significantly reduced and the quality of postoperative recovery can be improved. Future research should further explore the applicability and effects of these measures in different environments, and how to better integrate them into daily clinical work, so as to provide more comprehensive and scientific guidance for the management of hypothermia in patients with general anesthesia during recovery period.

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