

Effect of 5-Minutes Prewarming on Perioperative Hypothermia During Gynecologic Surgery: A Randomized Controlled Trial

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ABSTRACT

Background: Perioperative hypothermia is a frequent complication of anesthesia, associated with delayed recovery, cardiovascular stress, infection, and coagulopathy. Current guidelines recommend active prewarming devices for at least 30 minutes before anesthesia induction; however, this duration is often impractical in routine clinical settings. Evidence suggests shorter prewarming may be beneficial, though data in gynecologic surgery with combined regional and general anesthesia are limited.

Objective: To compare the change in body temperature after anesthesia induction between patients receiving 5 minutes of prewarming and those without prewarming. Secondary objectives were to evaluate the incidence of intraoperative hypothermia, postoperative shivering, surgical site infections, and cardiovascular adverse effects.

Materials and Methods: A prospective randomized controlled trial was conducted in 39 patients undergoing elective gynecologic abdominal surgery with combined general-regional anesthesia. Patients were randomized to receive either 5 minutes of prewarming with an underbody forced-air blanket at 43°C or no prewarming. Core temperature was measured using the 3M™ Spot-On™ system 60 minutes following anesthesia induction. Data were specifically recorded at induction and every 5 minutes until the conclusion of surgery. Statistical analyses were performed with significance set at p-value less than 0.05.

Results: The prewarming group demonstrated a significantly smaller decrease in body temperature at 60 minutes (0.48°C vs. 0.92°C, mean difference -0.44°C, 95% CI -0.67 to -0.20, p<0.001). However, there were no significant differences in the incidence of intraoperative hypothermia, postoperative shivering, surgical site infections, or cardiovascular complications.

Conclusion: Brief prewarming with a forced-air underbody blanket reduced early intraoperative temperature decline but did not decrease the overall incidence of hypothermia or related complications. Short-duration prewarming may provide limited thermal benefit, though further studies are required to establish its clinical significance.

Keywords: Hypothermia; Active prewarming; Gynecologic surgery; Combined general-regional anesthesia; Body temperature; Shivering

Received 27 August 2025 | Revised 6 May 2026 | Accepted 22 May 2026

J Med Assoc Thai 2026;109(10):808-15

<https://doi.org/10.35755/jmedassocthai.2026.10.03571>

Hypothermia is defined as a core temperature below 36°C⁽¹⁾ signifies a significant deviation from the body's normal thermoregulatory state. Under physiological conditions, the body diligently maintains its core temperature within the narrow range of 36.7°C

to 37.1°C. However, this regulation is hindered during general anesthesia, exacerbated by the effects of anesthetic agents. Consequently, vasodilation occurs, resulting in the redistribution of heat from the body's core to its periphery. The substantial occurrence of

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How to cite this article:

Rutanaburee N, Chongarunngamsang W, Luanpholcharoenchai J, Jivaganont N, Chanta P, Ponkla P. Effect of 5-Minutes Prewarming on Perioperative Hypothermia During Gynecologic Surgery: A Randomized Controlled Trial. J Med Assoc Thai 2026;109:808-15.

What is already known about this topic?

Active prewarming for at least 30 minutes before anesthesia induction is recommended, even when baseline core temperature is $\geq 36.0^\circ\text{C}$. Evidence from previous studies demonstrates that forced-air prewarming increases peripheral tissue temperature, thereby reducing the core-to-peripheral temperature gradient. This mechanism limits redistribution hypothermia and helps maintain perioperative normothermia

What does this study add?

This study shows that a brief period of prewarming with a forced-air underbody blanket attenuates the early intraoperative decline in core temperature. However, short-duration prewarming did not significantly reduce the overall incidence of hypothermia or related complications, suggesting that its thermal benefits may be limited.

hypothermia following general anesthesia, ranging from 50% to 80%, underscores its critical implications for patient safety and postoperative outcomes⁽¹⁾.

The effects of both general anesthesia and regional anesthesia contribute to the occurrence of hypothermia in patients⁽²⁾. The combination of general and regional anesthesia, in particular, is recognized as a significant risk factor for intraoperative hypothermia⁽³⁾. These consequences include delayed drug metabolism and elimination, contributing to prolonged recovery from anesthesia⁽⁴⁾. Moreover, hypothermia affects the cardiovascular system by inducing shivering, which elevates oxygen demand and stimulates the release of catecholamines, leading to myocardial ischemia⁽⁵⁾. Additionally, hypothermia compromises the immune system by inducing tissue hypoxia, which makes the surgical wound more susceptible to infection⁽⁶⁾. Furthermore, hypothermia disrupts blood coagulation, leading to abnormal platelet function^(7,8).

Despite the recognized risks, the incidence of hypothermia remains high, suggesting that current preventive measures are either insufficient or not adequately implemented in clinical practice⁽⁹⁾. According to the recommendations for preventing hypothermia outlined in the National Institute for Health and Care Excellence (NICE) guidelines⁽¹⁰⁾ it is advisable for patients to maintain a core temperature above 36.0°C before undergoing surgery, which can be achieved through the use of warming devices. Furthermore, active warming should be implemented for a minimum of 30 minutes prior to anesthesia induction, regardless of whether the patient's temperature meets or exceeds 36.0°C. Studies by Erdling & Johansson⁽¹¹⁾, Sessler et al.⁽¹²⁾, Parameeanon⁽¹³⁾ have shown that prewarming with forced-air blankets for 30 minutes can elevate peripheral tissue temperature, reducing the core-to-peripheral tissue temperature gradient and minimizing heat loss during redistribution⁽¹⁴⁾.

In a study conducted by Horn et al.⁽¹⁴⁾, it was discovered that patients who utilized an upper-body blanket for 10 minutes before anesthesia induction experienced similar reductions in hypothermia compared to those who used the blanket for 30 minutes. Additionally, research by Furuichi & Sakamoto⁽¹⁵⁾ demonstrated that using an underbody blanket was more effective in reducing hypothermia than using a full upper body blanket. Systematic reviews support the role of preoperative warming in maintaining normothermia⁽¹⁶⁾. We observed that prewarming durations of 10-30 minutes might be too lengthy, potentially causing inconvenience for staff. Therefore, we suggest that reducing the prewarming

time, particularly by using an underbody blanket, may be more practical. Furthermore, due to the limited scope of research on prewarming's effects on patients undergoing combined general regional anesthesia, a demographic at high risk of hypothermia, the authors initiated a study to assess whether reducing prewarming time using underbody blankets could effectively prevent hypothermia in this population.

OBJECTIVE

The authors aimed to compare the mean change in core body temperature from baseline (the mean difference in body temperature) following anesthesia induction between patients receiving 5 minutes of underbody forced-air prewarming and a control group without prewarming. Secondary objectives included the evaluation of intraoperative hypothermia, postoperative shivering, surgical site infections (SSIs), and cardiovascular adverse effects.

MATERIALS AND METHODS

Ethics and Study Design

Following approval by the Research Ethics Committee of Srinakharinwirot University (Research Project Certificate No. SWUEC/F-028/2564), the authors initiated a prospective randomized controlled trial at the HRH Maha Chakri Sirindhorn Medical Center. The recruitment period extended from 25 June 2021 to 31 May 2022.

Participants

The study enrolled 40 patients undergoing elective open gynecologic surgery under combined general-regional anesthesia. Inclusion criteria were the American Society of Anesthesiologists (ASA) Physical Status Classification I-III, aged 18-65 years, and body mass index (BMI) of 18.0-34.9 kg/m². Exclusion criteria included current infection or tympanic membrane temperature >37.5°C (fever) or <36°C (hypothermia) upon arrival at the preoperative holding area, history of thyrotoxicosis or thyroid disease, substance abuse or alcoholism, pregnancy, and the use of paracetamol or non-steroidal anti-inflammatory drugs (NSAIDs) within 24 hours prior to surgery. Patients were also excluded for contraindications to regional anesthesia, including patient refusal of epidural placement, coagulopathy, thrombocytopenia, anticoagulant therapy, local anesthetic allergy, or significant spinal deformity.

Sample Size

The sample size calculation for this study was

derived from prior research by De Witte et al.⁽¹⁷⁾. In their study, the mean temperatures were set at 35.9°C for the control group and 36.2°C for the forced-air warming group, with a standard deviation of 0.3. The type I error (alpha) was set at 5%, and the power (beta) was set at 80%. However, considering the potential for a 20% dropout rate, we opted for a sample size of 20 patients in each group, resulting in a total of 40 patients for this study.

Following informed consent, 39 patients were randomly allocated to either the control (C) or prewarming (P) group in a 1:1 ratio using a computer-generated simple randomization sequence. Allocation was concealed in sealed, opaque envelopes until the time of intervention. Due to the nature of the intervention, the attending anesthesia providers could not be blinded; however, the investigators responsible for outcome assessment and data analysis remained blinded to group allocation to minimize bias.

Outcomes

The primary outcome is the mean difference in core body temperature between groups at 60 minutes after the induction of anesthesia, evaluating the efficacy of prewarming in mitigating redistribution hypothermia.

Secondary outcomes include the incidence of intraoperative hypothermia (core temperature <36°C), the occurrence of postoperative shivering, the rate of SSIs within 30 days, and the frequency of intraoperative cardiovascular adverse effects, specifically hypotension and cardiac arrhythmias.

Study Protocol

Upon arrival at the preoperative holding area, a baseline forehead temperature was measured using a 3M™ Spot On™ non-invasive thermometry system. Patients in the group C received standard perioperative care without preoperative warming. In contrast, patients in the group P were treated with an underbody forced-air warming blanket set at 43.0°C for 5 minutes immediately prior to the induction of anesthesia. To standardize thermal management, all participants received intraoperative hydration with an isotonic solution. This fluid was stored in a warming cabinet maintained at 40.0°C.

When patients entered the operating room, they underwent standard monitoring. Following this, both groups of patients underwent epidural catheter placement at the T12-L3 level, positioning the catheter tip in the epidural space 4-5 cm deep, and administering a test dose of 2% lidocaine with

epinephrine 1:200,000, 3 mL. After completing the epidural catheter placement, the underbody warming blanket at 43.0°C was applied for 5 minutes in group P, while the warming blanket was turned off for 5 minutes in group C. Body temperature was recorded every 5 minutes until the end of surgery. Vital signs—heart rate (HR), non-invasive blood pressure (NIBP), mean arterial pressure, and oxygen saturation (SpO₂), every 5 minutes until the end of surgery.

Standardized general anesthesia was induced using intravenous propofol (1-3 mg/kg) and fentanyl (1-2 µg/kg), with neuromuscular blockade achieved via cisatracurium (0.15 mg/kg). Anesthesia was maintained with sevoflurane (0.5-1.5 MAC) in a 50% N₂O/O₂ mixture. For intraoperative analgesia, an epidural infusion of 0.125% to 0.15% bupivacaine was administered at 3-6 mL/hour. Intraoperative thermal management was standardized for both groups: a forced-air warming blanket was activated at 43.0°C at the start of surgery. The blanket temperature was titrated to 32.0°C if the core temperature exceeded 36.8°C. In the event of persistent hypothermia (<36.0°C), the blanket was maintained at 43.0°C as a rescue measure; no other warming adjuncts, such as heated humidifiers or increased ambient operating room temperature, were employed.

Upon completion of the surgery, sevoflurane was discontinued, and neuromuscular blockade was reversed with neostigmine (0.05 mg/kg) and atropine (0.02 mg/kg). Extubation was performed at the anesthesiologist's discretion, and patients were subsequently transferred to the post-anesthesia care unit (PACU). In the PACU, patients exhibiting shivering or a core temperature <36.0°C were treated with a forced-air warming blanket at 43.0°C. If symptoms persisted for 10-15 minutes, pethidine (20 mg IV) was administered as rescue therapy. All postoperative adverse effects and clinical outcomes were documented for both groups.

Patients were excluded if the surgical duration was less than 60 minutes or if epidural failure occurred—defined as unsuccessful catheter placement or an inadequate sensory block to cold or pinprick prior to induction.

Statistical Analysis

Statistical analysis was conducted using IBM SPSS Statistics, version 21.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were utilized to present frequency and percentage for categorical data. The chi-square test was applied to examine differences between the two groups. For normally distributed quantitative

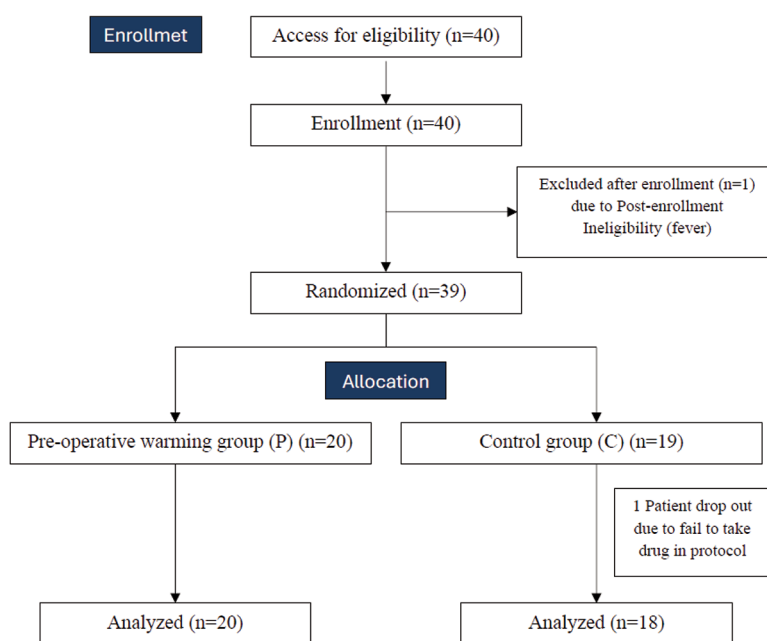


Figure 1. CONSORT diagram of patient flow through the study.

data, the mean and standard deviation (SD) were calculated and presented, with differences between the groups assessed using the independent t-test. Non-normally distributed quantitative data were presented using the median and interquartile range (IQR), and differences between groups were evaluated using the Mann-Whitney U test. A significance level of p-value less than 0.05 was considered statistically significant.

RESULTS

A study conducted between June 2021 and May 2022 at the HRH Maha Chakri Sirindhorn Medical Center, involving 39 patients undergoing elective open gynecologic surgery with combined general-regional anesthesia, divided the patients into two groups: a prewarming group of 20 patients who received prewarming for 5 minutes before anesthesia induction, and a non-prewarming group of 19 patients (Figure 1). It was found that the demographic and perioperative data in both groups, including age, BMI, ASA classification, diagnosis, operative time, room temperature, body temperature, epidural level, blood loss, fluid volume used, and urine output, showed no statistically significant differences between the two groups. Baseline demographic and perioperative characteristics are presented in Table 1.

A significant difference was found between the two groups in the mean difference of body temperature at 60 minutes after anesthesia induction, as measured

by the 3M™ Spot-On™ Temperature system. The mean core temperature difference in the prewarming group was 0.48°C, whereas in the non-prewarming group it was 0.92°C, indicating a difference of -0.44°C (95% CI -0.67 to -0.20, $p < 0.001$) (Table 2).

No significant difference was found between the two groups in terms of the incidence of hypothermia during anesthesia (Table 3).

When comparing the incidence of postoperative hypothermia and complications, no significant difference was found between the two groups (Table 4).

DISCUSSION

The authors found that the body temperature at 60 minutes after anesthesia induction decreased more in the non-prewarming group by 0.92°C, compared to the prewarming group by 0.48°C. This significant difference of 0.44°C aligns with the research by Chung et al.⁽¹⁸⁾ which studied patients undergoing cesarean section with spinal block. They found that prewarming for 15 minutes resulted in a statistically significant reduction in the change in core temperature in the prewarming group.

This finding is also consistent with the research by Jun et al.⁽¹⁹⁾, who studied patients undergoing prostate surgery under spinal block. They found that prewarming for 20 minutes resulted in a statistically significant reduction in the change in core temperature in the prewarming group. Additionally, research

Table 1. Baseline characteristics of patients undergoing gynecologic surgery under combined GA and epidural block, comparing pre-warming and non-prewarming groups

Variable	Group P (n=20)	Group C (n=18)	p-value
Age (years); mean [SD]	56.15 [13.90]	54.94 [12.33]	0.78
BMI (kg/m ²); mean [SD]	25.39 [4.13]	24.82 [4.82]	0.70
ASA physical status; n (%)			0.75
I	5 (25.0)	3 (16.67)	
II	9 (45.0)	11 (61.11)	
III	6 (30.0)	4 (22.22)	
Diagnosis; n (%)			0.46
Ovarian cancer	11 (55.00)	12 (66.67)	
Endometrial cancer	9 (45.00)	6 (33.33)	
Operative time (minutes); mean [SD]	160.50 [37.10]	171.67 [41.20]	0.39
Room temperature (°C); mean [SD]	22.89 [1.23]	22.71 [1.65]	0.71
Body temperature at preoperative holding area (°C); mean [SD]	36.81 [0.42]	36.83 [0.42]	0.87
Epidural level; n (%)			1.00
Thoracic-level	10 (50.00)	9 (50.00)	
Lumbar-level	10 (50.00)	9 (50.00)	
2% lidocaine with adrenaline bolus dose (mL); mean [SD]	5.20 [0.83]	4.94 [0.42]	0.23
Blood loss (mL/kg); mean [SD]	5.81 [4.25]	9.85 [10.39]	0.14
Crystalloid (mL/kg); mean [SD]	37.51 [11.86]	41.47 [11.87]	0.31
Colloid use; n (%)	2 (10.00)	1 (5.56)	0.61
Blood component use; n (%)	1 (5.00)	5 (27.78)	0.08
Urine output (mL/kg); mean [SD]	2.52 (1.55)	2.78 (1.46)	0.60

BMI=body mass index; ASA=American Society of Anesthesiologists; SD=standard deviation

Table 2. The reduction of BT at 60 minutes from baseline after anesthesia induction between groups

	Group P (n=20)	Group C (n=18)	Diff. (95% CI)	p-value
Mean difference of body temperature at 60 minutes (°C); mean [SD]	0.48 [0.40]	0.92 [0.31]	-0.44 (-0.67 to -0.20)	<0.001

SD=standard deviation; CI=confidence interval

Table 3. Incidence of intraoperative hypothermia

	Group P (n=20)	Group C (n=18)	p-value
Incidence of intraoperative hypothermia; n (%)	8 (40.00)	10 (55.56)	0.16

Table 4. Incidence of postoperative hypothermia and complications

Variable	Group P (n=20)	Group C (n=18)	p-value
Postoperative hypothermia; n (%)	0 (0.0)	1 (5.6)	0.31
Shivering; n (%)	0 (0.0)	0 (0.0)	-
Nausea/vomiting; n (%)	3 (15.0)	1 (5.6)	0.61
Cardiovascular complication (hypotension and cardiac arrhythmias); n (%)	0 (0.0)	0 (0.0)	-
Surgical site infection (within 30 days); n (%)	0 (0.0)	1 (5.6)	0.31
Renal complication; n (%)	1 (5.0)	0 (0.0)	1.00
Length of hospital stay (days); mean [SD]	5.7 [2.57]	6.5 [3.98]	0.46

SD=standard deviation

by Lee et al.⁽²⁰⁾, which studied patients undergoing gynecologic laparoscopic surgery under general

anesthesia, found that prewarming for 10 minutes significantly reduced the change in core temperature

in the prewarming group. Our results align with those of Kaufner et al.⁽²¹⁾, suggesting that pre-warming at 43°C, even for a brief 5-minute window during the establishment of epidural anesthesia, is sufficient to mitigate perioperative hypothermia in high-risk patients. This indicates that prewarming for at least 5 minutes can reduce the change in core temperature. This effect may be due to the fact that, during the initial hours of anesthesia, the body loses heat through core-to-peripheral redistribution. The extent to which the core temperature decreases depends on the core-to-peripheral tissue temperature gradient. Using a forced-air warming blanket before surgery (prewarming) at the appropriate time can increase the heat in peripheral tissues and reduce the core-to-peripheral tissue temperature gradient, thereby minimizing heat loss during the redistribution phase⁽¹⁴⁾.

However, the results of this study differ from the research conducted by Shenoy et al.⁽²²⁾, which investigated patients undergoing major abdominal surgery under general anesthesia using a full-body warming blanket set at 40°C for 60 minutes. They found no significant difference in core temperature change between the prewarming and control groups. Similarly, research by Plengpanich et al.⁽²³⁾ involving non-anesthetized volunteers found that 10 minutes of pre-warming at 38°C did not reduce the incidence of hypothermia. This lack of effect may be attributed to the fact that non-anesthetized subjects retain intact thermoregulatory mechanisms, and the 38°C setting used in that study was lower than the temperature used in our protocol. Furthermore, Yoo et al.⁽²⁴⁾ reported that 10 minutes of pre-warming at 47°C failed to reduce the incidence of hypothermia in patients undergoing elective surgery. This may be explained by the high temperature of the pre-warming environment; as ambient temperature increases, the rate of heat loss from the patient to the surroundings decreases, potentially limiting the effectiveness of forced-air warming if the thermal gradient is not managed effectively. Consequently, these discrepancies suggest that pre-warming may not always prevent heat loss as anticipated, depending on the surgical context, patient physiological state, and temperature settings used.

Regarding the incidence of intraoperative hypothermia, we observed a lower rate in the prewarming group compared to the control group (40% vs. 55.56%); however, this reduction did not reach statistical significance. This finding contrasts with the results reported by Lee et al.⁽²⁰⁾ who observed a significant reduction in hypothermia among patients undergoing gynecologic laparoscopic surgery after 10

minutes of pre-warming.

The discrepancy between our findings and those of Lee et al.⁽²⁰⁾ may be attributed to several factors. First, the mean duration of anesthesia in our study was considerably longer (160-170 minutes) than in their study (approximately 88-90 minutes). Prolonged anesthesia, particularly durations exceeding two hours, is a well-documented risk factor for perioperative hypothermia⁽²⁵⁾. Second, our cohort received combined general-regional anesthesia, which carries a higher risk of hypothermia than the general surgical population⁽¹⁰⁾. Finally, since pre-warming primarily mitigates the initial redistribution phase of heat loss, its protective effects may have been overwhelmed by the higher baseline risk and extended procedural length of our study population compared to previous research.

In the recovery room, the incidence of postoperative hypothermia and complications remained low and did not differ significantly between groups. While one patient in the control group experienced postoperative hypothermia, no cases were observed in the prewarming group. Similarly, there were no significant differences in the incidence of shivering, nausea, or vomiting, which may be attributed to the consistent use of forced-air warming blankets for both groups throughout the intraoperative period. Furthermore, other postoperative complications, including SSIs and renal complications, occurred at low, statistically comparable rates between the two cohorts.

The results of our study indicate that during the initial hours of surgery, there is a rapid loss of heat primarily due to core-to-peripheral redistribution. The extent of heat loss depends on the core-to-peripheral tissue temperature gradient. Prewarming for an appropriate duration of approximately five minutes or more can increase the heat in peripheral tissues, thereby reducing the core-to-peripheral tissue temperature gradient and minimizing heat loss during the redistribution phase. Using an active warmer is highly effective in reducing heat loss, as about 90% of heat is lost through the skin⁽²⁰⁾. If an underbody warmer blanket is used, the increased surface contact with the skin further enhances this efficiency.

This method is suitable for patients at high risk of developing hypothermia, such as those undergoing open surgery combined with general-regional anesthesia. For these patients, a longer duration of anesthesia further increases the risk of hypothermia, and prewarming may be less effective.

This study has several limitations that should be considered when interpreting the results. First, we did not assess the specific sensory block level during the

administration of epidural anesthesia; consequently, the exact anesthetic level for each patient remained unknown, which could result in varying degrees of vasodilation among participants and potentially influence the rate of heat redistribution. Furthermore, the final analyzed sample size was slightly smaller than originally planned due to post-enrollment factors. While 40 patients were initially enrolled, one was excluded due to post-enrollment ineligibility (fever), and another patient in the control group was excluded from analysis for failing to follow the medication protocol, leaving a final cohort of 20 patients in the pre-warming group and 18 in the control group. This limited sample size may reduce the statistical power to detect differences in secondary outcomes or rarer complications. Finally, while our findings demonstrate the efficacy of a 5-minute pre-warming period, the study was conducted on a specific high-risk cohort undergoing major surgery under combined general-regional anesthesia; therefore, these results may not be fully generalizable to lower-risk populations or different surgical contexts.

CONCLUSION

Brief pre-warming for 5 minutes with an underbody forced-air blanket at 43°C significantly mitigated the initial core body temperature drop in patients undergoing major surgery under combined anesthesia. It did not statistically reduce the overall incidence of intraoperative hypothermia due to the high-risk nature and long duration of the procedures. Short-duration prewarming may provide limited thermal benefit, though further studies are required to establish its clinical significance.

Authors' Contributions

NR was responsible for the conceptualization, project design, and methodology of the study, as well as the formal analysis, data interpretation, and the writing of the original manuscript. WC and JL contributed to the critical review and editing of the manuscript. NJ performed data collection, analysis, and interpretation, while PC and PP were responsible for data collection. All authors have read and approved the final version of the manuscript.

Clinical Trial Registration

The study was registered with the Thai Clinical Trials Registry (TCTR20250822001).

Conflicts of Interest

The authors declare no conflict of interest.

Data Availability Statement

The data supporting the findings of this study are available from the corresponding author, Wanida Chongarunngamsang, upon reasonable request. The data are not publicly available due to privacy or ethical restrictions regarding patient information.

Ethics Approval and Consent to Participate

This trial was approved by the Ethics Committee of the Faculty of Medicine, Srinakharinwirot University (SWUEC/F-028/2564). Written informed consent was obtained from all participants prior to enrollment in the study.

Funding Disclosure

This research received funding from the Faculty of Medicine, Srinakharinwirot University (Contract No.424/2564).

Use of Artificial Intelligence

Statement on AI Assistance in Manuscript Preparation: During the preparation of this manuscript, the authors used ChatGPT (version 5.5, v.1.2026.104) and Gemini (version 1.2026.1710205) for the purposes of checking grammar, refining sentence structure, and improving the overall accuracy and fluency of the text. After using these tools, the authors reviewed and edited the content as needed and took full responsibility for the content of the published article.

REFERENCES

1. Luo D, Fan Z, Yin W. Chronic post-surgical pain after total knee arthroplasty: A narrative review. *Perioper Med (Lond)* 2024;13:108. doi: 10.1186/s13741-024-00466-9.
2. Billeter AT, Hohmann SF, Druen D, Cannon R, Polk HC Jr. Unintentional perioperative hypothermia is associated with severe complications and high mortality in elective operations. *Surgery* 2014;156:1245-52. doi: 10.1016/j.surg.2014.04.024.
3. Riley C, Andrzejowski J. Inadvertent perioperative hypothermia. *BJA Educ* 2018;18:227-33. doi: 10.1016/j.bjae.2018.05.003.
4. Lenhardt R, Marker E, Goll V, Tschernich H, Kurz A, Sessler DI, et al. Mild intraoperative hypothermia prolongs postanesthetic recovery. *Anesthesiology* 1997;87:1318-23. doi: 10.1097/0000542-199712000-00009.
5. Frank SM, Fleisher LA, Breslow MJ, Higgins MS, Olson KF, Kelly S, et al. Perioperative maintenance of normothermia reduces the incidence of morbid cardiac events. A randomized clinical trial. *JAMA* 1997;277:1127-34.
6. Kurz A, Sessler DI, Lenhardt R. Perioperative

- normothermia to reduce the incidence of surgical-wound infection and shorten hospitalization. Study of Wound Infection and Temperature Group. *N Engl J Med* 1996;334:1209-15. doi: 10.1056/NEJM199605093341901.
7. Rajagopalan S, Mascha E, Na J, Sessler DI. The effects of mild perioperative hypothermia on blood loss and transfusion requirement. *Anesthesiology* 2008;108:71-7. doi: 10.1097/01.anes.0000296719.73450.52.
 8. Schmied H, Kurz A, Sessler DI, Kozek S, Reiter A. Mild hypothermia increases blood loss and transfusion requirements during total hip arthroplasty. *Lancet* 1996;347:289-92. doi: 10.1016/s0140-6736(96)90466-3.
 9. Liu J, Liu F, Xu W, Du L, Li Y, Liang A, et al. Risk prediction models for perioperative hypothermia: A systematic review. *J Multidiscip Healthc* 2025;18:4443-52. doi: 10.2147/JMDH.S538891.
 10. National Collaborating Centre for Nursing and Supportive Care (UK). The Management of Inadvertent Perioperative Hypothermia in Adults [Internet]. London: Royal College of Nursing (UK); 2008 [cited 2022 Jun 30]. Available from: <https://www.ncbi.nlm.nih.gov/books/NBK53852/>.
 11. Erdling A, Johansson A. Core temperature-the intraoperative difference between esophageal versus nasopharyngeal temperatures and the impact of prewarming, age, and weight: Randomized clinical trial. *AANA J* 2015;83:99-105.
 12. Sessler DI, Schroeder M, Merrifield B, Matsukawa T, Cheng C. Optimal duration and temperature of prewarming. *Anesthesiology* 1995;82:674-81. doi: 10.1097/00000542-199503000-00009.
 13. Parameeanon M. Effect of pre-warming by forced air warmer during total Hip and Knee arthroplasties for perioperative and postoperative hypothermia. *Thai J Anesthesiol* 2020;46:88-95.
 14. Horn EP, Bein B, Böhm R, Steinfath M, Sahili N, Höcker J. The effect of short time periods of pre-operative warming in the prevention of perioperative hypothermia. *Anaesthesia* 2012;67:612-7. doi: 10.1111/j.1365-2044.2012.07073.x.
 15. Furuichi Y, Sakamoto A. An under-body blanket is more effective than an over-body blanket in reducing intraoperative hypothermia in patients undergoing robot-assisted laparoscopic prostatectomy: A retrospective study. *Anesth Crit Care Open Access* 2017;7:128-31. doi: 10.15406/jacooa.2017.07.00277.
 16. Uçak A, Tat Çatal A, Karadağ E, Cebeci F. The effect of prewarming on perioperative hypothermia: A systematic review and meta-analysis of randomized controlled studies. *J Perianesth Nurs* 2024;39:611-23.e2. doi: 10.1016/j.jopan.2023.11.003.
 17. De Witte JL, Demeyer C, Vandemaele E. Resistive-heating or forced-air warming for the prevention of redistribution hypothermia. *Anesth Analg* 2010;110:829-33. doi: 10.1213/ANE.0b013e3181cb3ebf.
 18. Chung SH, Lee BS, Yang HJ, Kweon KS, Kim HH, Song J, et al. Effect of preoperative warming during cesarean section under spinal anesthesia. *Korean J Anesthesiol* 2012;62:454-60. doi: 10.4097/kjae.2012.62.5.454.
 19. Jun JH, Chung MH, Kim EM, Jun IJ, Kim JH, Hyeon JS, et al. Effect of pre-warming on perioperative hypothermia during holmium laser enucleation of the prostate under spinal anesthesia: A prospective randomized controlled trial. *BMC Anesthesiol* 2018;18:201. doi: 10.1186/s12871-018-0668-4.
 20. Lee SY, Kim SJ, Jung JY. Effects of 10-min prewarming on core body temperature during gynecologic laparoscopic surgery under general anesthesia: A randomized controlled trial. *Anesth Pain Med (Seoul)* 2020;15:349-55. doi: 10.17085/apm.20006.
 21. Kaufner L, Niggemann P, Baum T, Casu S, Schouli J, Bietenbeck A, et al. Impact of brief prewarming on anesthesia-related core-temperature drop, hemodynamics, microperfusion and postoperative ventilation in cytoreductive surgery of ovarian cancer: A randomized trial. *BMC Anesthesiol* 2019;19:161. doi: 10.1186/s12871-019-0828-1.
 22. Shenoy L, Krishna HM, Kalyan N, Prasad KH. A prospective comparative study between prewarming and cowarming to prevent intraoperative hypothermia. *J Anaesthesiol Clin Pharmacol* 2019;35:231-5. doi: 10.4103/joacp.JOACP_353_17.
 23. Plengpanich P, Chanthawong S, Nonphiaraj S, Prasongdee S, Suttinarakorn C, Ruenhansa T, et al. Effect of short duration use of active prewarming for preventing hypothermia in non-anesthetized volunteers: A randomized-controlled trial. *J Med Assoc Thai* 2023;106:95-101.
 24. Yoo JH, Ok SY, Kim SH, Chung JW, Park SY, Kim MG, et al. Effects of 10-min of pre-warming on inadvertent perioperative hypothermia in intraoperative warming patients: A randomized controlled trial. *Anesth Pain Med (Seoul)* 2020;15:356-64. doi: 10.17085/apm.20027.
 25. Zangmo K, Chatmongkolchart S, Sangsupawanich P. Perioperative Risk Factors for Intraoperative Hypothermia in Adult Patients Undergoing Elective Surgery at a National Referral Hospital in Bhutan: A Prospective Observational Study. *J of Health Sci and Med Res* 2019;37:313-20. doi: 10.31584/jhsmr.201966.