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Active Versus Passive Warming in the Prevention of Inadvertent Intraoperative Hypothermia

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ABSTRACT

Objective: To compare the efficacy of active warming versus passive warming in preventing inadvertent intraoperative hypothermia (IPH) in patients undergoing surgery under general anesthesia lasting longer than 30 minutes.

Methodology: This randomized controlled trial was conducted from April 1, 2023, to September 30, 2023, at PAEC General Hospital, Islamabad. Sixty patients scheduled for low- to moderate-risk surgery under general anesthesia lasting at least 30 minutes were randomly divided into two groups. Preoperative core temperature was measured upon arrival in the OR. The Active Warming group received forced air warming before anesthesia induction and throughout surgery, while the Control group was covered with cotton blankets and surgical drapes. Intraoperative core body temperature was monitored at 15-minute intervals using a nasopharyngeal probe, and postoperative temperature was recorded at 10-minute intervals in the PACU using an infrared tympanic membrane thermometer.

Results: The mean age of participants was 36.95 ± 9.66 years, with 38.3% males and 61.7% females. Active warming resulted in a 40% reduction in intraoperative and a 16% reduction in postoperative hypothermia. Mild hypothermia was significantly reduced (p-value < 0.015), but the reduction in moderate hypothermia was not statistically significant (p-value 0.09). Postoperative shivering occurred in 20% of the active warming group and 16.9% of the control group (p-value 0.399), which was not statistically significant.

Conclusion: Active warming using forced air effectively prevents intraoperative hypothermia in surgeries lasting over 30 minutes under general anesthesia, reducing the incidence and severity of both intraoperative and postoperative hypothermia.

Keywords: Hypothermia, Active warming, Passive warming, Forced air warming, Inadvertent Perioperative Hypothermia.

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Introduction

Normothermia is typically defined as a core body temperature of 36.5°C and 37.5°C [1], is one of the most strictly regulated physiological parameters of the human body and usually only differs by a tenth of a degree. [2] The hypothalamus is the central control responsible for maintaining this homeostasis at a set physiological thermostat with little variations, seen due to circadian rhythm (up to 0.7°C) and during ovulation (by as much as one °C).[2] General anesthetics alter this control and commonly result in a reduction of temperature by 1-3°C.[2]

Inadvertent perioperative hypothermia (IPH), a common anesthetic complication that occurs with a reduction in body temperature to <36°C, is seen in about 50-90% of patients unless interventions to prevent hypothermia are used.[3–5] Approximately 65% of patients undergoing surgery have been reported with first-hour- hypothermia with a fall in body temperature of 1.6°C. [6–8] This reduction is attributed to the redistribution of body heat from the core to the periphery caused by anesthetic-induced vasodilation.[6] The majority of enzyme systems are unable to tolerate temperature extremes, thereby associating IPH with adverse severe patient outcomes, including postoperative shivering (unacceptably increasing oxygen demand), impaired coagulation, platelet function and drug metabolism, delayed wound healing [6,9], surgical site infections, cardiac morbidities and increased PACU stay.

General anesthesia typically abolishes shivering and behavioral responses and reduces vasoconstriction and heat responses by increasing the inter-threshold range from a normal of <1°C to 4°C .[10] This fact, combined with decreased ambient temperature in operating theatre and exposure to large skin surfaces, significantly impacts normal homeostasis. Radiation (40%), convection (30%) and evaporation (25%) are responsible for the majority of heat loss. [10] Many different methods of active and passive warming have been proposed to prevent IPH, of which active methods are considered superior. [11]

This study is performed to compare active and passive means of warming and to determine the more effective method that reduces the incidence rate of hypothermia in patients undergoing surgery under general anesthesia. Limited data is available on the prevention of intraoperative hypothermia, and no such study has been done in our local population. We aspire to utilize a convenient and cost-effective method to prevent inadvertent intraoperative hypothermia that would help improve patient care and satisfaction. This study's results will help formulate treatment protocols for patients undergoing surgery under general anesthesia to decrease the severity and incidence of IPH.

Methodology

This study was conducted in the Operating Room (OR), Post Anesthesia Care Unit (PACU) at PAEC General Hospital, Islamabad, from April 2023 to September 2023. By using the WHO calculator, the sample size is 60, having 30 samples in each group with a level of significance of 5%, power of test 90%, the anticipated proportion for group 1 = 0.19, the anticipated population for group 2 = 0.571.

This prospective randomized control trial was commenced after obtaining approval from our institute's ethical committee. Patients requiring low to moderate-risk surgery lasting longer than at least 30 minutes under general anesthesia were sampled for this study. Sixty patients were sampled and then randomized into two groups using computer-generated sheets. The inclusion criteria were set as patients between the ages of 18 and 50 years, both male and female genders, American Society of Anesthesiologists Physical Status (ASA PS) 1-3 undergoing elective surgery with a duration longer than 30 minutes under general anesthesia. Exclusion criteria were patients with a preoperative baseline core body temperature of <36˚C or >38˚C, patients undergoing surgery with regional or combined regional and general anesthesia, patients requiring blood transfusion intraoperatively, patients having estimated blood loss of more than 500ml and pregnant patients. Patients diagnosed with peripheral vascular disease like Raynaud's disease and critically ill, hemodynamically unstable patients requiring infusion of rapid, large volumes of intravenous fluids were also excluded.

After obtaining approval from the ethical committee of PAEC General Hospital, Islamabad, informed consent was obtained from patients who met the inclusion criteria. The patients were then randomly assigned into two groups using computer-generated sheets: an active warming group (receiving active warming with forced-air warming) and a control group (receiving passive warming with cotton blankets and surgical drapes). For all patients, preoperative demographic details were recorded, including age, sex, ASA physical status classification, the procedure performed, duration of anesthesia, and the ambient temperature of both the OR and PACU.

Preoperative body temperature (initial baseline core body temperature) was recorded immediately after arrival in the OR. Postoperative body temperature was measured in PACU at 10-minute intervals until 30 minutes. The preoperative and postoperative temperatures were measured using an infrared tympanic membrane thermometer. Intraoperative core body temperature was measured using a nasopharyngeal probe immediately after induction, considered time 0 for intraoperative core readings with subsequent readings at 15-minute intervals. The last core body intraoperative measurement was taken at the end of surgery after the reversal of neuromuscular block with neostigmine and glycopyrrolate and immediately before the removal of the nasopharyngeal probe followed by extubation of the endotracheal tube (ETT).

After the arrival of patients in the OR and measurement of initial baseline core body temperature, patients in the passive warming group were covered with cotton blankets covering all body parts except the face and an arm required for the intravenous (IV) line. At the same time, forced air warming was immediately started in the patients from the active warming group under the patient's cotton blanket at 47˚C. An arm for IV access and a face were exposed. Patients in the active warming group were warmed for the time required to attach monitors and during the induction of anesthesia. Induction of anesthesia commenced after insertion of a standard 18 G IV line in the forearm or dorsum of the hand using a standard technique, 2mg/kg of 2% propofol and 0.5mg/kg of atracurium. After induction, the forced air warmer was switched off, but the patient remained covered with the cotton blanket as appropriate, according to the surgical site. Once surgical draping was completed, a forced air warmer was started, initiating intraoperative active warming. Forced air warmer temperature was adjusted according to measure intraoperative core body temperature: 45˚C when core body temperature was <36.5˚C, 40˚C when the core body temperature was 36.5-37.5˚C and was turned off when the core body temperature was >37.5˚C. The patients in the control group were induced using the same standard methods and were afterwards covered utterly other than the surgical site with surgical drapes. All patients undergoing the study were given 1000-1500ml of room temperature fluids intraoperatively.

After extubation, patients were shifted to PACU, covered with woolen blankets except for their faces. If postoperative hypothermia was observed, active warming was initiated in PACU in the same manner as intraoperatively.

Data was analyzed using IBM SPSS Statistics, version 27.0. The Mean ± SD of the quantitative variables (continuous data) was calculated. Qualitative variables (categorical variables) are presented as frequency and percentage. The two groups in the study were compared using the independent sample t-test, Mann-Whitney U test, and Fisher's exact test, as appropriate for the data analysis. A p-value of <0.05 was considered statistically significant.

Results

The Mean ± SD of age in the study was 36.95 ± 9.659. The male gender was 38.3%, and the female gender was 61.7% of the study population. Patient characteristics and demographic details are given in Table 1. The confounding variables, such as the ambient temperature of the operating room and post-anesthesia care unit (PACU), duration of anesthesia, type of procedure, ASA physical status, and initial baseline core body temperature, were also analyzed, and their results were comparable (Table I). The core body temperature at the end of surgery and the end of a thirty-minute stay in PACU were analyzed along with the postoperative shivering scale, as shown in Table II. The results observed demonstrated a significant difference in the incidence of both intraoperative and PACU hypothermia between the active warming group and control group (p-value <0.05); Table III.

Table I: Patient Characteristics and Baseline Variables.

Patient Characteristics and Baseline Variables		Active Warming Group (n=30)	Control Group (n=30)
Age (Mean ± SD) years		36.80±10.307	37.10 ± 9.14
Gender	Male n(%)	11(36.7)	12(40)
	Female n(%)	19(63.3)	18(60)
ASAPS	1 n(%)	11(36.7)	10(33.3)
	2 n(%)	13(43.3)	14(46.7)
	3 n(%)	6(20)	6(20)
Type of Procedure n(%)	Laparoscopic Surgery	17(56.7)	17(56.7)
	Open Abdominopelvic Surgery	5(15.7)	5(15.7)
	Orthopedic Surgery	3(10)	3(10)
	Head and Neck Surgery	2(6.7)	2(6.7)
	Spine Surgery	3(10)	3(10)
Duration of Anesthesia (Mean ± SD)		82.67±29.411	77.50±32.397
Ambient Temperature of OR (˚C) (Mean ± SD)		23.233±0.8277	23.29±0.9925
Initial Baseline Core Body Temperature (˚C) Mean ± SD		36.897±0.2498	36.693±0.3051
Ambient Temperature of PACU (˚C) (Mean ± SD)		25.88±0.3643	25.88±0.3764

Overall, 40% and 16% lower incidence of intraoperative and postoperative hypothermia respectively, is observed in the active warming group. The incidence of postoperative shivering was 20% in the active warming group and 16.9% in the control group (p-value 0.399), which was not statistically significant. Table IV shows the incidence of severity of hypothermia among the two groups. The incidence rate of mild hypothermia is significantly reduced in patients undergoing forced air warming (p-value = 0.015) but the incidence of moderate hypothermia in the active warming group is not statistically significant compared to the passive warming group as seen by the p-value of >0.05.

Table II: Intraoperative and Postoperative Outcome Variables.

Outcome Variables		Active Warming Group n=30	Control Group n=30
Last Intraoperative Core Body Temperature (˚C) Mean ± SD		36.8±0.51	36.1±0.49
Last PACU Core Body Temperature (˚C) Mean ± SD		36.7±0.45	36.3±0.47
Shivering Scale n(%)	0	24 (80)	25(83.3)
	1	2 (6.7)	4 (13.3)
	2	4 (13.3)	1 (3.3)
	3	0 (0)	0 (0)

Table III: Incidence of Intraoperative and Postoperative Hypothermia

Incidence of Hypothermia	Active Warming Group n=30	Control Group n=30	p-value
Normothermia (≥36.0˚C) n(%)	26 (86.7)	14 (46.7)	<0.001
Intraoperative Hypothermia (<36.0˚C) n(%)	4 (13.3)	16 (53.3)	<0.001
PACU Hypothermia (<36.0˚C) n(%)	1 (3.3)	6 (20)	<0.001
Postoperative Shivering Score 0/1/2/3	24/2/4/0	25/4/1/0	0.399

Table IV: Severity of Hypothermia.

Hypothermia Severity	Active Warming Group n=30	Control Group n=30	p-value
Mild (35.5-35.9˚C) n(%)	3 (10)	11 (36.7)	0.015
Moderate (35.0-35.4˚C) n(%)	1 (3.3)	5 (16.7)	0.090
Severe (<35.0˚C) n(%)	0 (0)	0 (0)	Not Applicable

Discussion

This study demonstrated that active warming using a forced air warmer resulted in higher core body temperature at the end of surgery compared to the passive warming group (36.8±0.51 vs 36.077±0.49). In different studies, active warming is more effective in preventing IPH. [12–14]

Yoo et al. [6] studied the role of peri-induction forced air warming with passive warming using cotton blankets in patients undergoing surgery longer than 2 hours.[6] This study showed a significant decrease in incidence rates of intraoperative hypothermia in the forced air warming group (p-value <.001, 19% in the active warming group and 57.1% in the control group). The incidence rate of postoperative hypothermia was also reduced compared to the control group (p-value = .013).[6] These results are consistence with the results of our study.

Other similar studies have been done by Horn et al. [15] and Perl et al. [16] Horn et al. [15] have compared the role of passive insulation and active warming with forced air skin surface warmers for various durations (10, 20 and 30 minutes) in patients undergoing surgery between 30 and 90 minutes under general anesthesia. The study concludes that a p-value of <0.00001 demonstrated a statistically significant difference between the pre-warmed and non-per-warmed groups. However, among the three groups of actively pre-warmed patients, insignificant results were obtained (p-value = 0.54) [15]

Akhtar et al. [17] have reported no significant difference between passive and active pre-warming of 60 minutes' duration. This can likely be attributed to the warming suit used in this study, which provided effective passive insulation compared to the cotton blankets used in our study. The use of cotton blankets likely caused a more significant redistribution of body heat in our study, as shown in previous studies.[15–17]

Various studies have been performed that compare different methods of active warming. Investigations have also been done that compare pre-warming (started in the preoperative holding area) with continuous intraoperative warming (started as soon as the patient is shifted into the OR), known as co-warming. One such particular study has compared the two methods in patients undergoing elective laparotomy lasting longer than 120 minutes under general anesthesia; Shenoy et al. [18] concluded in this study that actively warming the patient for longer than 60 minutes prior to surgery does not confer additional benefit when compared to co-warming (p-value =0.4). Different studies use different time durations of pre-warming ranging from 30 minutes to 120 minutes [19–22], and a couple of studies demonstrate that pre-warming for as little as 15 minutes can prevent hypothermia.[23,24] Previous studies have shown that intraoperative warming only without pre-warming is sufficient and adequate to prevent hypothermia in surgical patients.[25,26] Our study utilizes co-warming in the active warming group, but the literature is unclear if any added benefits are provided with pre-warming when compared to intraoperative warming alone. Vanni et al. [27] started active warming 5 minutes after induction of general anesthesia and found comparable results (incidence rates of normothermia and postoperative shivering) in patients undergoing both pre-warming and intraoperative warming.

Similar studies performed for patients undergoing surgery under neuraxial anesthesia have been conducted. One such study by Horn et al. [23] compared 15 minutes of forced air pre-warming in combination with intraoperative warming and passive insulation in patients undergoing elective cesarean section under epidural anesthesia. Core temperature measured with an infrared tympanic membrane thermometer recorded a significant decrease in maternal hypothermia, p-value <0.01, and a significant reduction in postoperative shivering in mothers, p-value <0.05 in the forced air warming group. Babies born to these mothers had better APGAR scores, elevated core body temperatures (37.1 ± 0.5˚C vs 36.2 ± 0.6˚C) and umbilical vein pH (7.32 ± 0.07 vs 7.23 ± 0.07). [23] These results are from other studies conducted in patients undergoing neuraxial anesthesia. [11,20]

The Mean ± SD of age in our study was 36.95 ± 9.659 (years). The study population included 38.3% of male and 61.7% of female patients. Our study showed a significant decrease in intraoperative and postoperative hypothermia in the active warming vs control groups (13.3% vs 53.3%, p-value <0.001 and 3.3% vs 20%, p-value <0.001 respectively). However, incidence rates of postoperative shivering were statistically insignificant in our study (p-value =0.399). The comparison of overall mild and moderate hypothermia shows a reduction in the active warming group vs the control group (10% vs 36.7% and 3.3% vs 16.7%, respectively). The incidence rate for severe hypothermia is 0% in both groups. These results align with various studies mentioned above. Our research demonstrates that active forced-air warming in patients undergoing surgery lasting longer than 30 minutes significantly reduces the incidence and severity of hypothermia during the intraoperative and immediate postoperative periods.

The major limitation of this study is the small sample size. Moreover, the study can be performed for surgeries with prolonged duration. It may provide better results since our study is performed for a mixture of short-duration procedures and major abdominopelvic surgeries.

Conclusion

This study demonstrated the benefits of active warming using forced air warmer in preventing inadvertent intraoperative hypothermia in patients undergoing procedures longer than 30 minutes under general anesthesia. It effectively reduces the incidence and severity of intraoperative and postoperative hypothermia.

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