Preoperative Risk Factors for Intraoperative Hypothermia in Surgeries under General Anesthesia

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ABSTRACT

Background: Surgery can have higher rates of morbidity and mortality due to intraoperative hypothermia. Consequently, an essential component of perioperative management is identifying its risk factors.

Objectives: To determine the frequency of and contributing factors to intraoperative hypothermia following operations performed under general anesthesia.

Methods: This is a prospective single observational study with 70 patients scheduled to have various surgeries under general anesthesia (GA). The following information was gathered and analyzed because it was thought to be a potential risk factor: baseline body temperature, age, sex, weight, height, comorbidities, and type of surgery. Systolic blood pressure, heart rate and axillary temperature were recorded before anesthesia was administered, at zero hour, thirty minutes, one hour, and at the end of surgery. According to their body temperatures, patients were split into two groups: hypothermic and normothermic patients.

Results: Thirty-two patients (45.71%) experienced hypothermia at the end of induction. Intraoperative hypothermia is dependently correlated with older age >40 years (OR= 5.4, 95% CI= 1.94-15.05, p= 0.018), lower body weight <80 kg (OR= 6.87, 95% CI=2.35-20.1, p 0.001), systolic blood pressure < 125 mmHg (OR= 6.5, 95% CI= 2.19-18.3, p= 0.022), and lower heart rate < 80 beats/min.

Conclusions: Under general anesthesia, intraoperative hypothermia still happens frequently during surgeries. Intraoperative hypothermia is dependently influenced by older age (> 40 years), body weight < 80 kg, preoperative heart rate <80 beats/min, and systolic blood pressure < 125 mmHg.

Keywords: Hypothermia, Intraoperative, General anesthesia, Risk factors.

Iraqi Medical Journal Vol. 71, No. 1&2, 2025; p. 29-38.

A core body temperature of less than 36°C is considered hypothermia and can be categorized as mild (35.0-35.9°C), moderate (34.0-34.9°C), or severe (≤33.9°C)[1,2]. Typically, behavioral and autonomic triggers help the peripheral and central nervous systems work together to regulate body temperature precisely[3,4]. However, factors present in the perioperative environment, such as general anesthesia (GA), regional anesthetic agents, and others, alter this mechanism[3,5]. In the postoperative period, hypothermia occurs more frequently, anywhere between 60% and 90% more frequently[4].

Due to the ambient operating room temperature, surgical exposure, the infusion and irrigation of unwarmed fluids, anesthesia, and other factors, the cause of hypothermia is most likely iatrogenic[6]. Hypothermia is a common side effect of both general and neuraxial anesthesia, especially in surgical patients who are not warmed up[7].

A higher American Society of Anesthesiology (ASA) physical status[2], older age[8], major or longer duration of anesthesia or surgery[8], preoperative body temperature[9,10], anesthetic technique, female gender, emergency surgery, and operating room temperature are all associated with postoperative hypothermia[11,12].

Intraoperative hypothermia may result in an extended hospital, post-anesthetic care unit, or intensive care unit stay[3], an increase in the risk of cardiovascular

complications, surgical site infections, postoperative blood transfusions, pressure ulcers, and decreased patient comfort[2,3,13,14]. These facts have motivated many anesthetists to work hard to keep patients' core temperatures normal during the perioperative period.

This study's goal is to look into the incidence and risk factors for intraoperative hypothermia following operations performed under GA.

Methods

This prospective observational study took place in the department of surgery at Al-Imammain Al-Kadhimiyain Medical City between May 2021 and April 2022. The Iraqi Board for Medical Specializations approved the study protocol. Each participant provided with verbal approval and written consent.

In the study, 70 patients between the ages of 18 and 60 who underwent various types of surgeries under general anesthesia were included. No matter the anesthetic method used, patients who underwent elective surgery lasting more than one hour and were admitted to the post-anesthesia cure unit (whether extubated or not) were included in the study.

Emergency cases, patients with a history of thyroid disease, malignant hyperthermia, malignant neuroleptic syndrome, patients who are preoperatively hyperthermic (core body temperature >37.5°C), higher American Society of Anesthesiology (ASA) physical status I and II, and those who have trouble getting access to a thermometer are all excluded from the study.

When the patients entered the operating room, they were put in beds with cotton blankets and monitored with noninvasive blood pressure, pulse oximetry, and baseline body temperature measurements. A thermometer was used to measure the body's surface temperature (Medicare infrared ear and forehead thermometer Model HW-1, China).

The thermometer was validated and calibrated in accordance with the manufacturer's instructions prior to taking the temperature. Operating room temperature seated to 22° C. Prior to induction, 0 hour, 30 minutes, 1 hour, and finally at the end of surgery, axillary temperature was recorded. A peripheral temperature of less than 35°C was considered hypothermia.

IBM SPSS version 25 was used to analyze the data (SPSS Inc., Chicago, Illinois, USA). For categorical data, the descriptive data were presented in number and percentage form; for continuous data, they were presented as mean and standard deviation (SD). Patients were divided into the hypothermia and normothermia groups based on axillary temperature.

The student's t-test was used to analyze continuous variables in the univariate analysis. Where appropriate, the Chi square or Fisher's exact test was used to analyze categorical variables. To identify the predictors of intraoperative hypothermia, all variables with $p < 0.01$ between the two groups in the univariate analysis were included in the multivariate logistic regression analysis. A two-sided p value of 0.05 or higher was deemed significant in each analysis.

Results

There were 70 patients enrolled in total for this study. The patients' average age was 38.21(±15.17) years, with a range of 18 - 60 years, and 65.71% of them were female. The average weight and height of the population were 164.3 cm and 79.61 kg, respectively. Appendectomy was the most frequently performed surgical procedure, accounting for 22.86% of cases, followed by hysterectomy (17.14%), ovarian cyst removal (14.14%), and anterior repair (14.29% each). Hernia, cholecystectomy, and varicocele surgeries are less frequent (5.71% each), (Table 1).

Table 1: Demographic characteristics of the study population.

Variables	Value
Age, years mean ± SD (range)	**38.21±15.17 (18-60)**
Gender no. (%)	
Male	**24(34.29%)**
Female	**46(65.71%)**
Weight, kg mean ± SD (range)	**79.61±14.13 (37-113)**
Height, cm mean ± SD (range)	**164.3±14.55 (71-187)**
Type of surgery no. (%)	
Appendectomy	**16(22.86%)**
Hysterectomy	**12(17.14%)**
Ovarian cyst	**10(14.29%)**
Anterior repair	**10(14.29%)**
Hernia	**4(5.71%)**
Cholecystectomy	**4(5.71%)**
Varicocele	**4(5.71%)**
Others	**10(14.29%)**

Prior to induction, mean systolic blood pressure (SBP) was 126.17 (±16.9) mmHg, while the average heart rate was 81.23 (±8.61) beats per minute and the average body temperature was 37.03 (±0.23)^{o}C. Body temperature decreased gradually throughout the surgical procedure, starting at 36.85 (±0.22)^{o}C after skin incision, 35.23 (±0.56)^{o}C after 30 minutes, 35.04 (±0.56)^{o}C after an hour, and finally 34.97 (±0.55)^{o}C at the end of surgery, (Table 2).

There was no baseline hypothermia in any of the patients. However, 32 patients (45.71%) had hypothermia at 30 minutes, one hour after induction, and at the end of induction of anesthesia, while the remaining patients (54.29%) were normothermic.

Intraoperative hypothermia was found to be significantly correlated with four different factors. The mean age of the hypothermic patients was 43.78±3.26 years, which was significantly older than the normothermic patients' mean age of 35.74±18.5 years. The difference between the body weight of hypothermic and normothermic patients (74.44±12.5 kg versus 83.92±14.21 kg) was significant. The mean SBP varied significantly between hypothermic and normothermic patients, measuring 132.55±14.3 mmHg and 118.6±16.9 mmHg, respectively. Finally yet importantly, there was a significant difference in HR between hypothermic and normothermic patients (74.5±6.31 beats/min versus 86.9±5.73 beats/min), (Table 3).

Table 2: Clinical Characteristics of the patients.

Variables	Value mean ± SD (range)
Systolic blood pressure, mmHg	126.17±16.9 (103-139)
Heart rate, beats/min	81.23±8.61 (62-97)
Temperature, ºC	
Before induction of anesthesia	37.03±0.23 (36.4-37.7)
0 hour after skin incision	36.85±0.22 (36.3-37.3)
30 minute after skin incision	35.23±0.56 (34.4-36.9)
1 hour after skin incision	35.04±0.56 (34.2-36.5)
At the end of operation	34.97±0.55 (34.1-35.6)

Table 3: Association of demographic and clinical factors with the hypothermia.

Variables	Normothermia (N=38)	Hypothermia (N=32)	p- value
Age, years mean ±SD	35.74±18.5	43.78±3.26	**0.026**
Sex **Male** **Female**	 12(31.58%) 26(68.42%)	 12(37.5%) 20(62.5%)	**0.603**
Weight, Kg mean ±SD	83.92±14.21	74.44±12.5	**0.005**
Height, cm mean ±SD	162.66±16.0	166.25±12.59	**0.307**
Type of surgery ***Appendectomy*** ***Hysterectomy*** ***Ovarian cyst*** ***Anterior repair*** ***Hernia*** ***Cholecystectomy*** ***Varicocele*** ***Others***	 11(28.95%) 3(7.89%) 5(13.16%) 6(15.79%) 1(2.63%) 4(10.53%) 5(13.16%) 3 (7.89%)	 5(15.62%) 9(28.13%) 5(15.62%) 4(12.5%) 3(9.37%) 0(0%) 5(15.62%) 1(3.12%)	**0.129**
Systolic blood pressure, mmHg mean ±SD	118.6±16.9	132.55±14.3	**<0.001**
Heart rate, beats/min mean ±SD	86.9±5.73	74.5±6.31	**<0.001**
Body temperature before induction mean ±SD	37.0±0.23	37.3±0.24	0.886

The data are presented as mean ±SD (range) or number (%).

A multivariate logistic regression model was used to determine the relative importance of each factor as well as the dependent factors linked to hypothermia. Using the appropriate cutoff value, the continuous variables were divided into binomial variables for this purpose. Table 4 displays the outcome. Intraoperative hypothermia is dependently correlated with older age >40 years (OR= 5.4, 95% CI= 1.94-15.05, p= 0.018), lower body weight 80 kg (OR= 6.87, 95% CI=2.35-20.1, p = 0.001), higher SBP < 125 mmHg (OR= 6.5, 95% CI= 2.19-18.3, p= 0.022), and lower HR 80 beats/min.

The relationship between body temperature at the end of surgery and other variables was investigated using Pearson's correlation. As shown in table 5 and figures 1 through 4, the findings showed a significant negative correlation between body temperature and age (r = -0.266, p = 0.026) and a significant positive correlation with body weight (r = 0.355, p = 0.005), SBP (r = 0.787, p <0.001) and heart rate (r = 0.723, p <0.001).

Table 4: Multivariate analysis.

Variables	Normothermia (N=38)	Hypothermia (N=32)	p-value	OR (95%CI)
Age, years			**0.018**	**1.0**
≤40	27(71.05%)	10(31.25%)		**5.4(1.94-15.05)**
>40	11(28.95%)	22(68.75%)		
Weight, kg			**<0.001**	**1.0**
≥80	25(65.79%)	7(21.87%)		**6.87(2.35-20.1)**
<80	13(43.21%)	25(78.13%)		
SBP, mmHg			**0.022**	**1.0**
≥125	31(81.57%)	13(40.62%)		**6.5(2.19-18.3)**
<125	7(18.42%)	19(59.38%)		
HR, beats/min			**0.007**	**1.0**
≥80	**35 (92.11%)**	**4 (12.5%)**		**8.67(6.18-13.28)**
<80	**3 (7.89%)**	**28 (87.5%)**		

Table 5: Correlation of body temperature with other variables.

Variables	Correlation coefficient	p-value
Age, years	**-0.266**	**0.026**
Gender	0.062	**0.609**
Weight, kg	**0.335**	**0.005**
Height, cm	-0.124	**0.307**
Systolic blood pressure, mmHg	**0.787**	**<0.001**
Heart rate, beats/min	**0.723**	**<0.001**

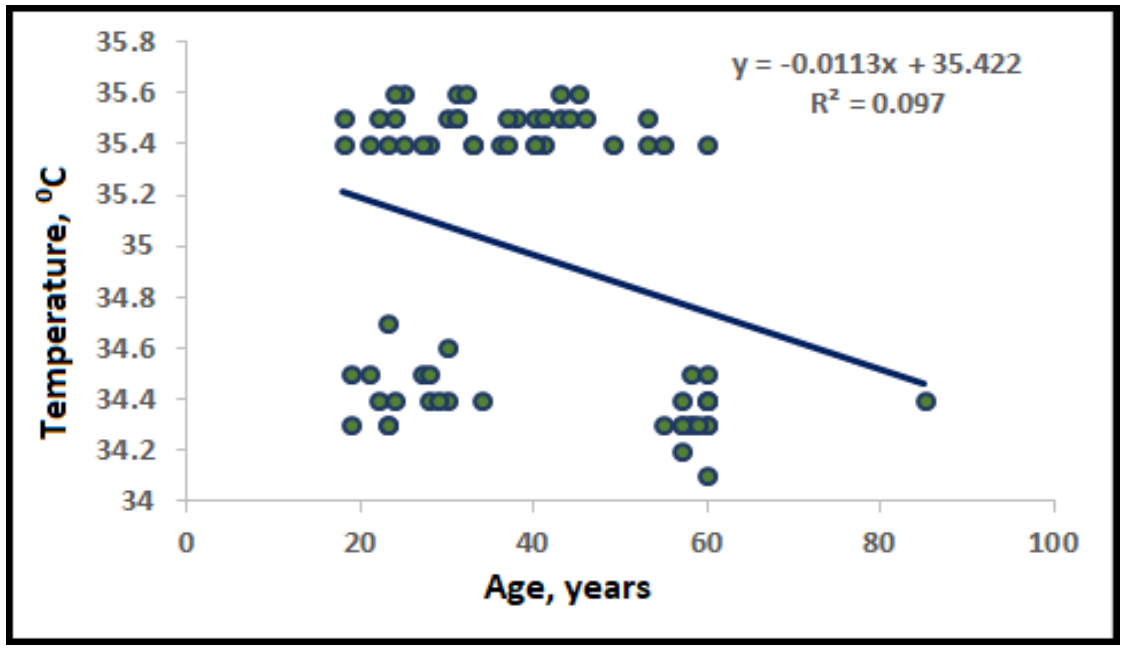

Figure 1: Scatter plot and regression line between age and body temperature.

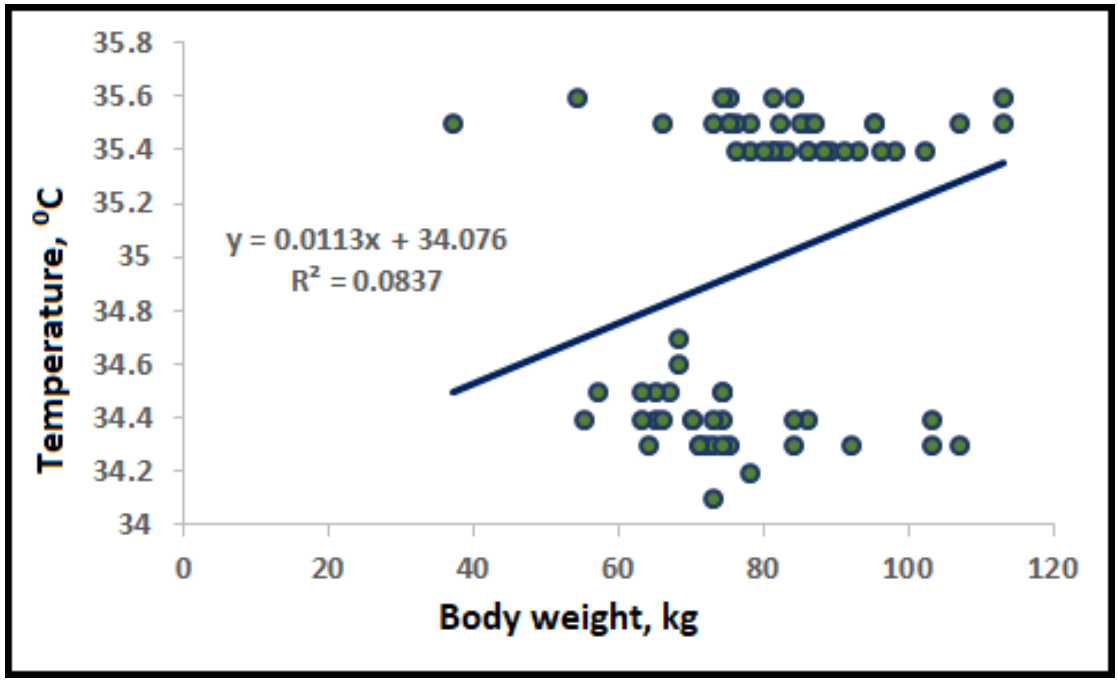

Figure 2: Scatter plot and regression line between body weight and body temperature.

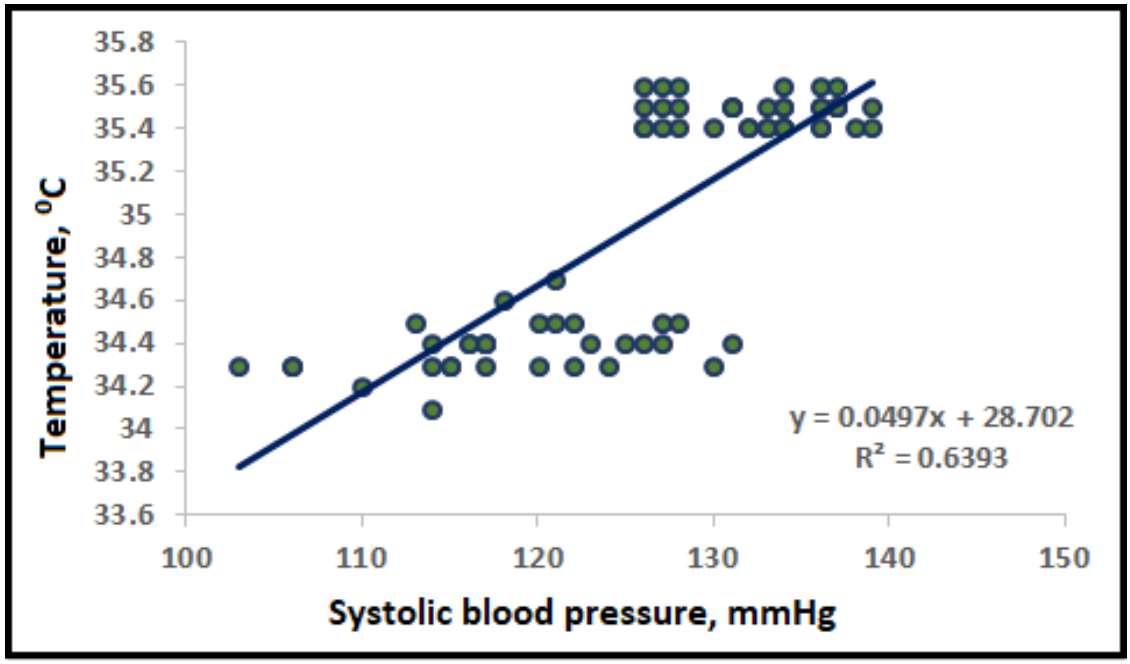

Figure 3: Scatter plot and regression line between SBP and body temperature.

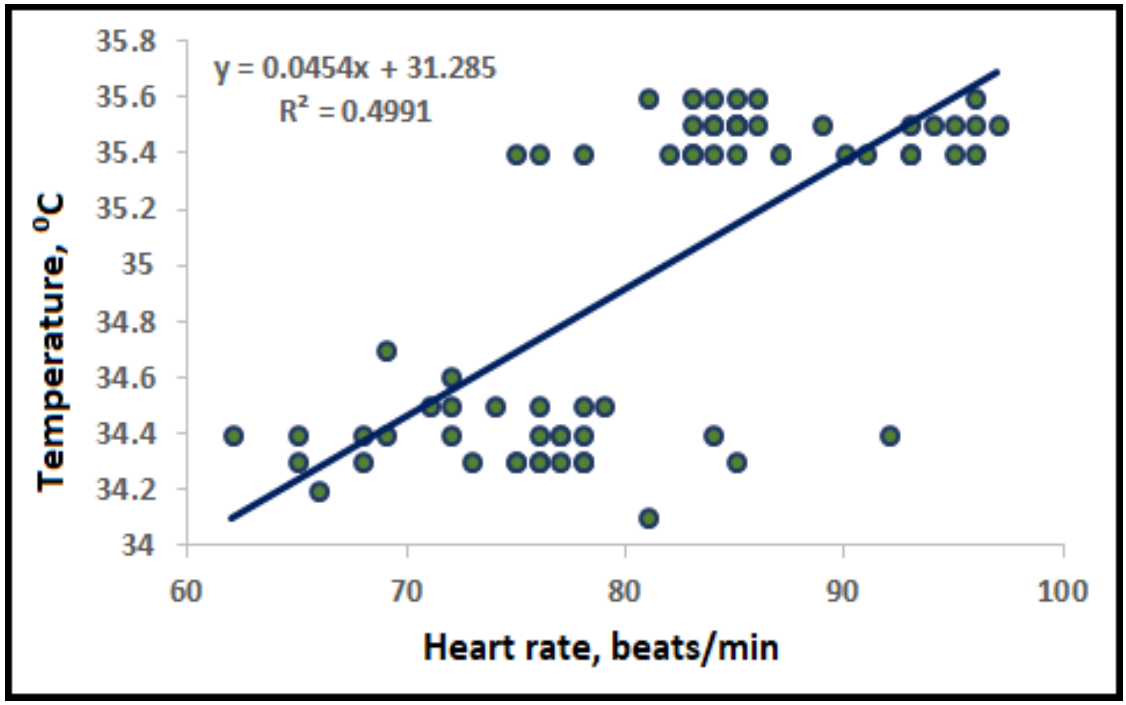

Figure 4: Scatter plot and regression line between heart rate and body temperature.

Discussion

The prevalence of intraoperative hypothermia in the current study was 45.71%. This rate is considered in the context of the global prevalence as shown by various studies[15,16]. Patients under GA who become hypothermic experience impaired thermoregulation, including inhibition of vasoconstriction and vasodilation, decreased metabolic rate, and heat loss from exposure to cold environments[17].

Several studies reported higher rates than ours, including 66%+ [23-25] and 80%+ [18,19]. Different studies revealed a lower rate of hypothermia (25-31%)[2,4,20-22]. It is interesting to note that only 4% of patients in an American study have postoperative hypothermia, which is a very low prevalence[23]. This variation among different studies could be attributed to several factors, the most important of which are variation in sample size, definition of hypothermia, site of measurement, thermometer type, type of operation and duration of surgery.

In the current study, intraoperative hypothermia is dependently influenced by older age >40 years, lower body weight <80 kg, higher SBP < 125 mmHg, and lower HR <80 beats/min. These results were in agreement with earlier studies. According to Yan et al., the likelihood of hypothermia increases with patient age[24]. They stated that the senior group (those over 60) had a higher than average prevalence of hypothermia at 33%. Billeter et al.[25] showed in their study that patients over 65 years of age have a 1.61 times higher risk of hypothermia. Age greater than 50 was significantly associated with postoperative hypothermia, according to multivariate logistic regression used to identify the dependent risk factors[2,9].

Many theories have been put forth to explain how aging affects body temperature. According to one theory, elderly patients may lack physiological thermoregulation coping mechanisms, have less subcutaneous tissue, and have less effective vasoconstriction and shivering, all of which contribute to hypothermia[2].

Another theory is that older people are less able to respond to heat stress, which increases their risk for hypothermia and its harmful effects. This is primarily due to inferior vasoconstriction ability, decreased muscle mass, and decreased ability to produce heat[26]. In addition, even in a non-anesthetized state, older patients have a weaker ability to effectively regulate and maintain a normal body temperature because they have less subcutaneous fat, lower resting muscle tone, a greater body surface area to body weight ratio, and a lower metabolic rate[24].

In the current study, low BMI was significantly linked to hypothermia. This is consistent with the findings of numerous earlier studies. A risk factor for postoperative hypothermia in 3132 Chinese patients undergoing various surgeries under GA was found to be a BMI ≥25[27]. According to numerous other studies, lower BMI is a well-known risk factor for perioperative hypothermia in patients under general anesthesia[28]. According to Chen et al., a higher BMI index was protective against hypothermia on the reversal[9].

High BMI may have a protective effect because the adipose tissues act as a heat-insulating buffer during the procedure. According to the gradient theory, which states that metabolic heat flows from the core to the periphery and then to the environment[29]. Lower BMI was confirmed as a risk factor for intraoperative hypothermia in patients undergoing robot-assisted gynecological surgery, as well as in other surgeries, like laparoscopic, video-assisted thoracoscopic, and orthopedic surgeries. Although a higher BMI does not necessarily mean a higher fat content, which serves as a buffer for maintaining body temperature during surgery, a lower BMI was confirmed as a risk factor[9,30].

Due to a higher vasoconstriction threshold in obese patients, early vasoconstriction occurs when the core temperature drops to maintain thermal balance, resulting in less redistribution[31]. Additionally, the degree of redistribution and drop in body temperature were inversely related to body surface area and fat percentage[28].

Low baseline HR (<80 beats/min) was a risk factor for intraoperative hypothermia in the current study. High preoperative heart rates were linked to a lower incidence of intraoperative hypothermia, according to research by Kim et al[13]. Preoperative heart rate greater than 80 beats per minute was shown to be protective against intraoperative hypothermia by Zangmo et al[18].

High levels of catecholamine secretion prior to surgery may be reflected in a high baseline HR, and an increase in plasma catecholamine levels may help to maintain thermoregulatory peripheral vasoconstriction[32]. The balance of sympathetic and parasympathetic activities controls HR, which is influenced by a number of factors including anxiety, psychological stress, and dehydration[33]. Additionally, a HR during anesthesia may raise the risk of hypothermia by raising cardiac output and encouraging redistribution[6].

Low baseline SBP (<125 mmHg) was found to be significantly linked to intraoperative hypothermia in the current study. In line with these findings, numerous studies across the globe[34-36].

One of the study's limitations is that axillary temperature was used to gauge varied depending on the type of surgery and the anesthesiologist using them, who enforces the standardization of anesthetic methods. Third, because the study only involved one center, it is best to proceed with caution when extrapolating its results.

In conclusion, intraoperative hypothermia continues to be a problem in surgeries performed under GA. As the surgery progressed, the core temperature tended to drop, and the incidence of hypothermia tended to rise. Older age (>40 years), body weight <80 kg, preoperative heart rate <80 beats per minute, and SBP <125 mmHg are dependent risk factors for intraoperative hypothermia.

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