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ORIGINAL ARTICLE

Postoperative Hypothermia in Patients Undergoing Major Abdominal Surgery: A Cohort Study

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ABSTRACT

Introduction: Up to 90% of patients undergoing surgery will present hypothermia in the perioperative period. However, no study has reported the occurrence of postoperative hypothermia, nor the variables associated with its occurrence only in patients undergoing major abdominal surgery.

Objective: To describe the proportion of patients undergoing major abdominal surgery who develop postoperative hypothermia, and the variables associated with its occurrence.

Material and Methods: We conducted a prospective cohort study in a tertiary care referral hospital in Mexico City to describe the incidence of perioperative hypothermia and factors associated with postoperative hypothermia. Potential variables associated with hypothermia were evaluated with logistic regression analysis.

Results: A total of 110 patients were included in the analysis; among them, 61% (n = 67) were women. The mean age was 56.7 years (SD: 16.3). The incidence of postoperative hypothermia in patients undergoing major abdominal surgery was 57.3%, while preoperative and intraoperative hypothermia occurred in 55.5% and 79.1%, respectively. An age over 60 years was the only variable associated with postoperative hypothermia after multivariable adjustment for sex, age, and time surgery (OR=18.4; 95% CI: 3.79-89.6; p<0.0001).

Conclusion: Increased age was the only variable associated with postoperative hypothermia in patients undergoing major abdominal surgery.

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Hipotermia posoperatoria en pacientes sometidos a cirugía abdominal mayor: un estudio de cohorte

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RESUMEN

Introducción: hasta el 90 % de los pacientes intervenidos quirúrgicamente presentan hipotermia en el perioperatorio. Sin embargo, no se ha reportado la aparición de hipotermia posoperatoria ni las variables asociadas a su a parición exclusivamente en los pacientes sometidos a una cirugía abdominal mayor.

Objetivo: describir la proporción de pacientes sometidos a cirugía abdominal mayor que desarrollan hipotermia posoperatoria y las variables asociadas a su ocurrencia.

Materiales y métodos: estudio de cohorte prospectivo en un hospital de referencia de tercer nivel en la Ciudad de México. Las variables asociadas con hipotermia posoperatoria se evaluaron mediante regresión logística.

Resultados: se incluyeron un total de 110 pacientes, y entre ellos el 61 % (n = 67) eran mujeres. La edad media fue de 56,7 años (DE: 16,3). La incidencia de hipotermia postoperatoria en pacientes sometidos a cirugía abdominal mayor fue del 57,3 %, mientras que la hipotermia preoperatoria e intraoperatoria se presentó en el 55,5 % y el 79,1 %, respectivamente. La edad mayor de 60 años fue la única variable asociada a hipotermia posoperatoria tras el ajuste multivariable por sexo, edad y tiempo de cirugía (OR = 18,4; IC 95 %: 3,79 - 89,6; $p < 0,0001$).

Conclusión: solo la edad se asoció con la presencia de hipotermia posoperatoria en pacientes sometidos a cirugía mayor abdominal.

INTRODUCTION

Up to 90% of patients undergoing surgery will present hypothermia in the perioperative period (1). To improve the patient care, the Standards and Practice Parameters Committee of the American Society of Anesthesiologists (ASA) states: "Every patient receiving anesthesia shall have temperature monitored when clinically significant changes in body temperature are intended, anticipated, or suspected" (2). Postoperative hypothermia is defined as a decrease in body temperature below 35°C within the first 24 hours after surgery (3).

Anesthesia and surgical procedures affect the thermoregulatory center, thereby contributing to adverse events during the perioperative period (4). The decrease in temperature affects processes going from drug metabolism to the tissue healing and immune protection during perioperative hypothermia, which increases morbidity and complications that may result in cardiovascular events, altered platelet activity, or postoperative infections (5).

As shown in Table 1, the occurrence of hypothermia can vary widely depending on the type of patients included in the study (5-12). Its occurrence has been associated with factors such as sex, type and duration of surgery, and age (13). However, no study has reported the occurrence of postoperative hypothermia and variables associated with its occurrence only in patients undergoing major abdominal surgery, who may have different risk factors and frequency of occurrence of postoperative hypothermia than patients undergoing other types of surgery.

Table 1. Representative studies conducted in the last 10 years, which have reported the occurrence and/or risk factors associated with perioperative hypothermia

Study	Type of surgery	Country	Hypothermia (%)	Identified Risk Factors
Li, *et al.* (2021)[6]	all surgeries	China	6.32	ASA>II, general anesthesia (vs. regional anesthesia) and lower preoperative body temperature
Karalapillai, *et al.* (2011)[7]	elective heart surgery	Australia and New Zealand	66	Not analyzed
Karalapillai, *et al.* (2013)[8]	Non-cardiac elective surgery	Australia and New Zealand	46	Not analyzed
Kleimeyer, *et al.* (2018)[5]	Orthopedic surgery	United States of America	72.5	Intraoperative hypothermia, lower preoperative body temperature, gender (female), lower body mass index, older age, reconstructive surgery, and hip or pelvic surgery
Akers, *et al.* (2019)[9]	Abdominal and orthopedic surgery	United States of America	2.3	Older age and type of surgery (abdominal)
Motamed, *et al.* (2021)[10]	Oncological surgery (breast)	France	21	Not analyzed
Tavares Mendonça, *et al.* (2019)[11]	all surgeries	Brazil	69.2	Older age, combined anesthesia, morphine, sufentanil, spinal anesthesia
Assunção Peixoto, *et al.* (2021)[12]	non-cardiac surgery	Brazil	69.8	Older age

Source: own creation

Considering the complications that can derive from hypothermia, determining the factors that can contribute to its development may lead to prevention strategies that ultimately increase patient safety. Therefore, the aim of this study was to describe the proportion of patients undergoing major abdominal surgery who develop postoperative hypothermia, as well as the variables associated with its occurrence in a tertiary care hospital.

METHODS

Study design

A prospective cohort study was conducted in patients undergoing major abdominal surgery between November 2021 and March 2022 in a tertiary care referral center in México City. The inclusion criteria were patients with an age over 18 years who underwent scheduled or emergency major abdominal surgery lasting more than 2 hours. Pregnant women, patients with neuromuscular diseases or with prolonged advanced life support, as well as those who did not give their consent to participate in the study, were not included. Patients who withdrew their consent at any time during the study were also excluded. The study was approved by the Ethics and Research Committee of "Centro Médico Nacional 20 de Noviembre ISSSTE" (approval number 459.2021) and all the enrolled patients signed a written informed consent form to participate in the study.

Data Collection

During the pre-anesthetic evaluation, patients who met the inclusion criteria were invited to participate in the study. After consenting to be enrolled, their baseline characteristics, surgical procedure data, and post-procedural data were collected. Clinical variables collected were sex, age, weight (in kilograms), body mass index (BMI), body temperature (°C), their physical status classification by the American Society of Anesthesiologists (ASA-PS, see below), and comorbidities (type-2 diabetes, hypertension, obesity, malnutrition, coronary artery disease, chronic kidney disease, peripheral venous disease, epilepsy, anxiety, illicit drug use, and current smoking). Data related to the surgical procedure were: type of surgery (urgent or elective), organ involved (kidney or urinary tract, liver and bile ducts or gallbladder, esophagus or stomach, small bowel, large bowel, exploratory laparotomy, or gynecological), duration of surgery (time in minutes from primary incision to wound closure), anesthetic technique (balanced general or combined [balanced general + neuraxial]), duration of anesthesia (time in minutes from drug induction until the patient woke up), and room temperature during surgery.

Body temperature was measured using an electronic axillary skin thermometer and was reported in Celsius degrees (°C) during the pre-anesthetic evaluation (preoperative), during surgery (intraoperative), and after surgery (postoperative). Patients were classified as hypothermic when they presented a body temperature equal to or lower than 35°C (14). Postoperative pain and hypoxemia were also recorded; it was classified according to room-air peripheral arterial oxygen saturation (SpO_2) as mild (SpO_2 = 86-90%), moderate (SpO_2 = 81-85%), severe (SpO_2 = 76-80%), or extreme (SpO_2 <70%) hypoxemia. The presence of pain was determined with the visual analog pain scale.

Patients were classified in stages 1 to 5 according to the 2020 ASA-PS classification (15) during the pre-anesthetic evaluation, considering ASA-PS 1 as normal healthy patient; ASA-PS 2, mild systemic disease; ASA-PS 3, severe systemic disease that is not life-threatening; ASA-PS 4, severe systemic disease that is a constant threat to life; and ASA-PS 5, moribund patient who is not expected to survive without the surgery.

Clinical evaluation of patients was based on the diagnosis of malnutrition, detection of postoperative hypoxemia and pain during the stay in the post-anesthesia care unit (PACU). Patients with

a BMI less than 18.5 were classified as having severe malnutrition according to the GLIM criteria for its diagnosis (10).

Outcome

The main outcome was the presence of postoperative hypothermia, defined as a body temperature below 35°C during PACU stay after surgery (14).

Sample size

Considering that the presence of variables under study could double the risk of hypothermia, the calculation was done considering a 0.5 probability for the presence of each variable in the study sample, with a statistical power of 80% (1-β = 0.80) and a type 1 error probability of 5% (α=0.05). The sample size obtained was 136 subjects. The following formula for estimating an odds ratio was applied:

$$\textit{Patients per group} = \frac{[Z\alpha\sqrt{[2 * P * (1-P)]} + Z\beta\sqrt{[P1 * (1-P1) + P2 * (1-P2)]}]^2}{(P1-P2)^2}$$

$$P2 = \frac{(P1 * OR)}{[1 + P1 * (OR-1)]}$$

Statistical analysis

Descriptive data are presented as mean and standard deviation for quantitative variables, and as frequency and percentage for qualitative variables. Comparisons between patients who presented hypothermia and normal temperature during PACU stay were made using the Student's t-Test for quantitative data and the Chi-square test or Fisher's exact test for qualitative data.

A repeated measures ANOVA (RM-ANOVA) model was performed to compare preoperative, intraoperative, and postoperative temperatures. The model is summarized in a scatter plot showing the mean and 95% confidence intervals (95% CI). Once the assumptions of sphericity were verified by the Greenhouse-Geisser test and the assumption of dependence of observations, the p value of the model was obtained. When a significant value was found, the Bonferroni post-hoc test was performed to identify whether there was a difference between the intraoperative and postoperative moments compared to the preoperative moment.

The evaluation of potential variables associated with hypothermia was carried out by means of logistic regression analysis to determine the effect of each variable on the development of postoperative hypothermia. The variables were included in each univariate model by the Enter method. Variables associated with postoperative hypothermia were included in a multivariable model adjusted by sex, age, and duration of surgery. The results are summarized by means of the regression coefficient, Odds Ratio (OR) and 95% CI.

The quantitative variables (weight, age, preoperative temperature, intraoperative temperature, room temperature, surgery time, and anesthetic time) were included in linear regression models to determine the decrease or increase for every °C for each increase of one unit in the independent variable. The results of the models are summarized in regression coefficients, standard error, and 95% CI.

The assumptions of each statistical model were verified by residual analysis. The value of $p<0.05$ was considered as statistically significant. All analyses were performed using SPSS v.21 Software. The RM-ANOVA graph was built with GraphPad Prism v. 9.0.3.

RESULTS

A total of 110 patients were included for the analysis; among them, 61% (*n* = 67) were women. The mean age was 56.7 years (SD = 16.3, range: 75), with the most frequent age range being adults over 60 years (43.6%). The most frequent comorbidities were smoking (59.1%), arterial hypertension (40.0%), and type-2 diabetes (24.5%). The organs most frequently involved in the surgical procedures were the kidney or urinary tract (21.8%), followed by the large bowel (14.5%) and the abdomen by exploratory laparotomy (14.5%). The average duration of the surgeries was longer than 4 hours (mean = 298 minutes, SD: 166.5, range: 480).

Most surgeries were elective (92.75%), performed by general balanced anesthetic techniques (95.5%), and most patients were in the ASA-PS III category (94.5%). Of the total number of patients in this category (n = 104), 58.2% were women. During recovery in the PACU, all patients presented some degree of hypoxemia, the majority (91.8%) being mild cases.

Hypothermia occurred in 61 patients (55.5%) prior to surgery (preoperative), while 87 (79.1%) presented intraoperative hypothermia, and 63 (57.3%) had postoperative hypothermia during PACU stay. Figure 1 shows the distribution of body temperature before, during and after surgery; it was lower after surgery than before surgery (p=0.009), but the temperature during surgery was lower than that observed after surgery (p=0.0002).

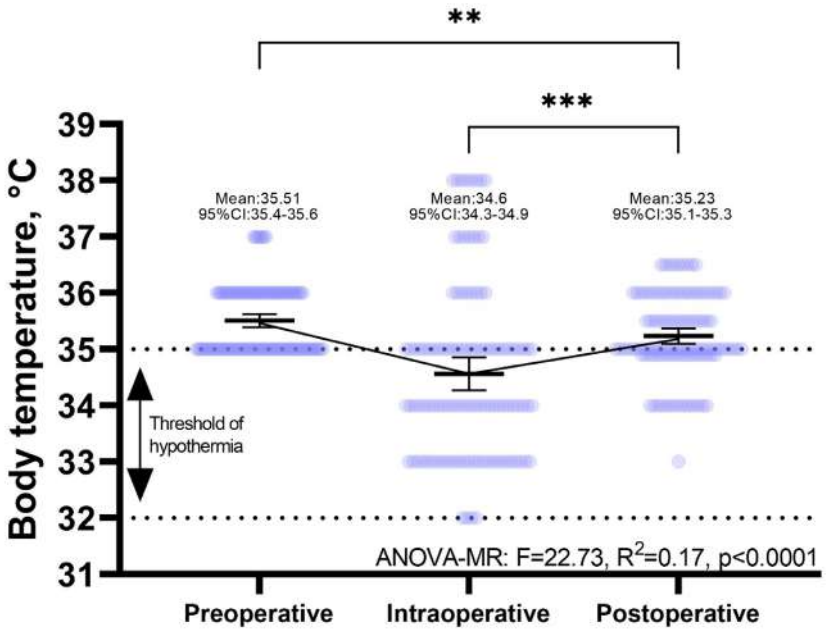

Figure 1. Comparison of body temperature before, during and after surgery
Data are presented as mean and 95% CI. Data compared by means of repeated measures ANOVA (ANOVA-MR) model.
**:p<0.01, ***:p<0.001
Source: own creation

Table 2 shows the comparisons of the main clinical and surgical characteristics and comorbidities, according to the occurrence of postoperative hypothermia or not during PACU stay; no significant differences were observed between them, except for age categories where there was a higher frequency in subjects older than 60 years.

Table 3 shows the results of the univariate logistic regression analysis to identify the factors associated with postoperative hypothermia. Only advanced age (age over 60 years) was associated with a higher risk of postoperative hypothermia (OR=4.20, 95%CI: 1.45-12.18, p=0.01). After multivariable adjustment for sex, age, and time surgery, advanced age remained as a risk factor for postoperative hypothermia (OR=18.4; 95% CI: 3.79-89.6; p<0.0001).

Table 2. Comparisons of characteristics among patients who presented postoperative hypothermia versus patients not experiencing that outcome

	Total sample	**Normal temperature**	**Hypothermia**	***p* value**
	***n* = 110**	***n* = 47**	***n* = 63**	
Sex, *n (%)*				
Women	67 (60.9)	29 (61.7)	38 (60.3)	0.3
Men	43 (39.1)	18 (38.3)	25 (39.7)	
Age, years	56.7 (16.3)	54.8 (1.9)	58.1 (2.31)	0.3
Age categories, *n (%)*				
≤30 years	4 (3.6)	0 (0.0)	4 (6.3)	0.4
31-40 years	18 (16.4)	7 (14.9)	11 (17.5)	
41-50 years	18 (16.4)	12 (25.5)	6 (9.5)	
51-60 years	22 (20.0)	15 (31.9)	7 (11.1)	
>60 years	48 (43.6)	13 (27.7)	35 (55.6)	
Weight, Kg	73.3 (16.4)	73.5 (2.3)	73.1 (2.12)	0.9
BMI classification, *n (%)*				
<25	47 (42.7)	20 (42.6)	27 (42.9)	0.8
25-29.9	39 (35.5)	16 (34.0)	23 (36.5)	
31-34.9	15 (13.6)	7 (14.9)	8 (12.7)	
≥35	9 (8.2)	4 (8.5)	5 (7.9)	
Comorbidities n (%)				
Type 2 Diabetes	27 (24.5)	10 (21.3)	17 (27.0)	0.5
Systemic arterial hypertension	44 (40.0)	21 (44.7)	23 (36.5)	0.4
Coronary artery disease	18 (16.4)	8 (17.0)	10 (15.9)	0.8
Obesity	24 (21.8)	11 (23.4)	13 (20.6)	0.7
Malnutrition	8 (7.3)	2 (4.3)	6 (9.5)	0.3
Chronic kidney disease	9 (8.2)	5 (10.6)	4 (6.3)	0.4

Table 2. Comparisons of characteristics among patients who presented postoperative hypothermia versus patients not experiencing that outcome

	Total sample	Normal temperature	Hypothermia	*p* value
	***n* = 110**	***n* = 47**	***n* = 63**	
Peripheral venous disease	12 (10.9)	5 (10.6)	7 (11.1)	0.9
Epilepsy	2 (1.8)	1 (2.1)	1 (1.6)	0.8
Anxiety	2 (1.8)	1 (2.1)	1 (1.6)	0.8
Illicit drug use	32 (29.1)	17 (36.2)	15 (23.8)	0.2
Smoker	65 (59.1)	32 (68.1)	33 (52.4)	0.09
ASA-PS, *n (%)*				
ASA-PS II	5 (4.5)	1 (2.1)	0 (0.0)	
ASA-PS III	104 (94.5)	45 (95.7)	4 (6.3)	
ASA-PS IV	1 (0.9)	1 (2.1)	59 (93.7)	
Urgent surgery, *n (%)*	8 (7.3)	2 (4.3)	6 (9.5)	0.3
Organ involved, *n (%)*				
Kidney / urinary tract	24 (21.8)	10 (21.3)	14 (22.2)	
Liver and bile ducts / gallbladder	15 (13.6)	9 (19.1)	6 (9.5)	
Esophagus / stomach	13 (11.8)	6 (12.8)	7 (11.1)	
Small bowel	5 (4.5)	3 (6.4)	2 (3.2)	
Large bowel	16 (14.5)	6 (12.8)	10 (15.9)	
Exploratory laparotomy	16 (14.5)	4 (8.5)	12 (19.0)	
Gynecological	9 (8.2)	4 (8.5)	5 (7.9)	
Other classification	12 (10.9)	5 (10.6)	7 (11.1)	
Time surgery, minutes	298.3 (166.5)	333.8 (26.0)	271.9 (19.31)	0.05
Time anesthesia, minutes	358.3 (166.5)	393.8 (26.0)	331.9 (19.31)	0.05
Combined anesthetic technique, *n (%)*	5 (4.5)	2 (4.3)	3 (4.8)	0.9
Ambient temperature, °C	24.2 (0.6)	24.2 (0.1)	24.2 (0.07)	0.8
Forced air warming, *n (%)*	38 (34.5)	18 (38.3)	20 (31.7)	0.5
Body temperature preoperative, °C	35.5 (0.6)	35.4 (0.1)	35.6 (0.08)	0.1
Body temperature intraoperative, °C	34.6 (1.5)	34.4 (0.2)	34.7 (0.21)	0.2
Preoperative hypothermia	61 (55.5)	29 (61.7)	32 (50.8)	0.3
Intraoperative hypothermia	87 (79.09)	39 (83.0)	48 (76.2)	0.4
Postoperative pain, *n (%)*	17 (15.5)	9 (19.1)	8 (12.7)	0.4

Table 2. Comparisons of characteristics among patients who presented postoperative hypothermia versus patients not experiencing that outcome

	Total sample	Normal temperature	Hypothermia	*p* value
	***n* = 110**	***n* = 47**	***n* = 63**	
Postoperative hypoxemia, n (%)				
Mild	101 (91.8)	41 (87.2)	60 (95.2)	0.09
Moderate	8 (7.3)	5 (10.6)	3 (4.8)	
Severe	1 (0.9)	1 (2.1)	0 (0.0)	

Data presented as media (standard error) or frequency (%)
Comparison between groups were made by Student t-test, Chi-square or Fisher's exact test
BMI: Body mass index, ASA-PS: American Society of Anesthesiologists physical status classification system
Source: Own creation

Table 3. Results of the logistic regression analysis for the identification of factors associated with the occurrence of postoperative hypothermia

	β	OR	95%CI	*p* value
Sex, Man	0.06	1.06	(0.49-2.30)	0.88
Age, years	0.01	1.01	(0.99-1.04)	0.29
Advanced age	1.44	4.20	(1.45-12.18)	0.01
Weight, Kg	0.00	1.00	(0.98-1.02)	0.90
BMI classification				
<25	0.06	1.06	(0.45-2.52)	0.89
25-29.9	-0.17	0.85	(0.26-2.72)	0.78
31-34.9	-0.08	0.93	(0.22-3.89)	0.92
≥35				
Comorbidities				
Type 2 Diabetes	0.31	1.37	(0.56-3.34)	0.49
Systemic arterial hypertension	-0.34	0.71	(0.33-1.54)	0.39
Coronary artery disease	-0.08	0.92	(0.33-2.54)	0.87
Obesity	-0.16	0.85	(0.34-2.11)	0.73
Malnutrition	0.86	2.37	(0.46-12.30)	0.30
Chronic kidney disease	-0.56	0.57	(0.14-2.25)	0.42
Peripheral venous disease	0.05	1.05	(0.31-3.54)	0.94
Epilepsy	-0.30	0.74	(0.05-12.18)	0.83
Anxiety	-0.30	0.74	(0.05-12.18)	0.83
Illicit drug use	-0.60	0.55	(0.24-1.27)	0.16
Smoker	-0.66	0.52	(0.23-1.13)	0.10
Urgent surgery	0.86	2.37	(0.46-12.30)	0.30

Table 3. Results of the logistic regression analysis for the identification of factors associated with the occurrence of postoperative hypothermia

Organ involved				
Kidney / Urinary tract	0.06	1.06	(0.42-2.65)	0.91
Liver and Bile ducts / gallbladder	-0.81	0.44	(0.15-1.35)	0.15
Esophagus / stomach	-0.16	0.85	(0.27-2.73)	0.79
Small bowel	-0.73	0.48	(0.08-3.00)	0.43
Large bowel	0.25	1.29	(0.43-3.84)	0.65
Exploratory laparotomy	0.93	2.53	(0.76-8.42)	0.13
Gynecological	-0.08	0.93	(0.24-3.66)	0.91
Other classification	0.05	1.05	(0.31-3.54)	0.94
Time surgery, minutes	-0.14	0.87	(0.76-1.00)	0.06
Time anesthesia, minutes	-0.14	0.87	(0.76-1.00)	0.06
Combined anesthetic technique	0.12	1.12	(0.18-7.02)	0.90
Ambient temperature, °C	-0.06	0.94	(0.50-1.76)	0.85
Forced air warming				
Body temperature preoperative, °C	0.50	1.65	(0.87-3.15)	0.13
Body temperature intraoperative, °C	0.15	1.17	(0.90-1.50)	0.24
Preoperative hypothermia	-0.45	0.64	(0.30-1.38)	0.26
Postoperative hypothermia	-0.42	0.66	(0.25-1.71)	0.39
Moderate or severe hypoxemia	-1.07	0.34	(0.08-1.44)	0.14

β: Regression coefficient, OR: Odds Ratio, 95%CI: 95% confidence interval
Source: own creation

Table 4. Linear regression analysis to identify the relationship of various risk factors with the decrease in post-surgical body temperature

	β0	SE of β0	β1	SE of β1	95%CI	*p* value
Age, years	35.823	0.248	-0.010	0.004	(-0.019 a -0.002)	0.01
Weight, Kg	34.974	0.321	0.004	0.004	(-0.005 a 0.012)	0.4
Ambient temperature, °C	34.219	2.828	0.042	0.117	(-0.190 a 0.273)	0.7
Body temperature preoperative, °C	40.098	4.028	-0.137	0.113	(-0.362 a 0.088)	0.2
Body temperature intraoperative, °C	35.765	1.580	-0.015	0.046	(-0.106 a 0.075)	0.7
Time surgery, minutes	35.098	0.144	0.027	0.025	(-0.023 a 0.077)	0.3
Time anesthesia, minutes	35.070	0.166	0.027	0.025	(-0.023 a 0.077)	0.3

β0: Regression constant, β1: Regression coefficient, SE: standard error, 95% CI: 95% confidence interval
Source: own creation

Table 4 shows the results of the linear regression analysis to determine the linear relationship of each of the quantitative variables with the change in body temperature after surgery. Only age was related to a decrease in temperature, considering that every one-year increase in individuals over 35.8 years lead to a decrease of 0.01 °C in the postoperative body temperature.

DISCUSSION

In this study, we sought to describe the proportion of patients subjected to major abdominal surgery who experience postoperative hypothermia, and to study potential variables associated with it. We found that the incidence of postoperative hypothermia in patients undergoing these surgeries was 57.3%, while preoperative and intraoperative hypothermia occurred in 55.5% and 79.1% individuals, respectively.

Perioperative hypothermia occurs in up to 90% of patients (1); we found that preoperative hypothermia occurred in 1 out of 2 patients, with very diverse causes ranging from environmental conditions, room temperature, measurement methods, intravenous solutions, and patient-specific diseases, among others (16,17). In the case of emergency surgeries, it was reported that two-thirds of patients present preoperative hypothermia (18) due to the severity of injury, wet clothing, low temperature in transport units, use of anesthesia and prolonged surgery. Preoperative hypothermia should be monitored every 15 minutes, and measures should be taken to normalize body temperature, as this condition is associated with more perioperative complications (19). We found that the occurrence of hypothermia was higher in the intraoperative period, which could be attributable to situations happening during surgery, such as the induction of anesthesia or blood loss.

The incidence of postoperative hypothermia varies among studies. A cross-sectional study performed in Mexico with 116 patients reported a similar proportion regarding ours (55%) (1). Likewise, Zhang *et al.* reported an incidence of 21.3% in a retrospective cohort study with a larger study population (20). Regarding advanced age as a risk factor, it was hypothesized that modifiable and non-modifiable risk factors are associated with the presentation of hypothermia in the immediate postoperative period in patients undergoing major surgery. However, only ages older than 60 years were found to be associated with hypothermia. This coincides with the literature reports, where it has been evidenced as a risk factor in studies of patients undergoing orthopedic surgery (5,9), abdominal surgery (9), and surgeries in general without distinguishing the anatomical site (6,11,12).

Differences in thermoregulatory mechanisms between younger and older adults have been documented (21). Underlying mechanisms include alteration of three of the major protective mechanisms against hypothermia: i) decreased sympathetic and vasomotor responses that attenuate cutaneous vasoconstriction; ii) decreased heat generation by metabolic activity, and iii) decreased cold perception (21).

Other studies have found that the anatomical site is associated with the presence of perioperative hypothermia, especially abdominal procedures when compared to surgeries of other sites (9). Therefore, there was special interest in studying whether there was any association between the occurrence of postoperative hypothermia and the specific abdominal site of surgery. However, none of the specific surgical sites or organs were found to be associated with postoperative hypothermia. Therefore, there could be common pathophysiological triggers for all abdominal surgeries that are not organ specific. In a study that compared the occurrence of perioperative hypothermia in patients undergoing colorectal surgery by open versus laparoscopic surgery, the occurrence of hypothermia was comparable to the rate reported in our study (67%), while it was more frequent in the open surgical approach than in the laparoscopic approach (71.23% vs. 63.16%, $p<0.001$), and the type of surgical approach did not behave as a risk factor after adjusting for confounding

variables (22).

Other factors such as comorbidities, body mass index, ASA-PS and sex were not associated with postoperative hypothermia in this study despite the fact that in other studies there has been an association (5,6). Notably, most patients in our study were ASA-PS III (94.5%), which limited our capacity to capture a broader perspective of what could be expected in patients under different ASA-PS categories. Although there is a possibility that these are not factors associated exclusively with postoperative hypothermia in patients undergoing major abdominal surgery, it is important to take into account that the sample size calculation for this study was made to detect variables that increased the risk of hypothermia by at least twice, so it is likely that larger sample sizes are required to detect smaller differences. Furthermore, we were unable to reach the final sample size calculated for the study due to administrative constraints, which may have resulted in our study being underpowered to detect those differences.

Our results of the incidence of hypothermia and age as a significant risk factor contribute to the existing literature by providing insights into a specific population of patients who underwent abdominal surgery. Our findings suggest that age is a crucial factor in assessing the risk of perioperative hypothermia, emphasizing the need for temperature monitoring in older adults. Current research identifies several risk factors for perioperative hypothermia, including operating room temperature, shock, type of surgery, and extremes of age (23). This underscores the importance of identifying potential predictors to mitigate the risk of adverse outcomes. Our research aligns with multiple studies that highlight the importance of temperature regulation to prevent complications like wound infections, coagulopathies, and myocardial injury, which predominantly affect the elderly and high-risk patients (24,25). For instance, it is demonstrated that hypothermia impairs platelet function, which increases blood loss by about 20%, thereby raising the need for transfusions (26).

Nevertheless, it should be considered that our findings are from a sample of 110 patients undergoing abdominal surgery lasting longer than 2 hours from a single tertiary care referral hospital, which may not be generalizable to populations undergoing surgery at different kind of hospitals. Although our results are consistent with other studies, a further limitation to the generalizability of our study is that we did not include pregnant women, patients under 18 years of age, or individuals with neuromuscular problems. Future research could include these and other populations for a comprehensive understanding of the risk factors and mechanisms that lead to hypothermia during surgery.

Furthermore, we only assessed forced air maneuvers as a potential intervention done to manage perioperative hypothermia. Other warming devices (23) were not assessed due to their empirical low use in that center but could have an important role in prevention and management of perioperative hypothermia. Likewise, variables such as drugs administered in the perioperative period (which could have a pathophysiological role in the triggering of hypothermia) were not collected (27).

It is important to acknowledge that in our study the temperature was measured with an axillar thermometer. While axillary temperature measurements are usually close to core temperature, they can deviate due to external factors and patient positioning (25). The most reliable monitoring sites are typically the esophagus, nasopharynx and the tympanic membrane (28,29). The tissue temperature varies considerably from region to region; thus, the selection of the measurement site can significantly influence the detection of hypothermia, potentially leading to an underestimation of its prevalence. This highlights the need for careful consideration in the selection of temperature measurements in clinical settings. Extensive research shows that the esophagus and nasopharynx are the best practical sites for temperature monitoring during general anesthesia, while oral and axillary temperature can be suitable alternatives for neuraxial anesthesia and postoperative care

(25). For future studies, employing other temperature monitoring sites could enhance the accuracy of detection of hypothermia and associated variables.

CONCLUSIONS

The incidence of postoperative hypothermia in patients undergoing major abdominal surgery was 57.3%, while preoperative and intraoperative hypothermia occurred in 55.5% and 79.1% individuals, respectively. Age over 60 years was associated with the presence of postoperative hypothermia. Prospective studies with a larger number of patients that include other types of surgery at different anatomical sites are required to continue characterizing the potential role of the anatomical site of surgery as a determinant of perioperative hypothermia.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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REFERENCES

1. De la Cajiga-León A, Aguirre-Ibarra CP, Álvarez-Reséndiz GE, Escobedo-Berumen L, Nápoles-Martínez AR, Labra-Nassar A, et al. Hipotermia postquirúrgica: incidencia en el Hospital Ángeles Lomas. Acta Med Grupo Angeles [Internet]. 2020;18(1):111–115. https://dx.doi.org/10.35366/92018

2. American Society of Anesthesiologists. Standards for Basic Anesthetic Monitoring [Internet]. 2020. Available from: https://www.asahq.org/standards-and-practice-parameters/standards-for-basic-anesthetic-monitoring

3. National Collaborating Centre for Nursing and Supportive Care. The Management of Inadvertent Perioperative Hypothermia in Adults [Internet]. London: Royal College of Nursing (UK); 2008. Available from: https://www.ncbi.nlm.nih.gov/books/NBK53797/

4. Kim D. Postoperative Hypothermia. Acute Crit Care [Internet]. 2019;34(1):79–80. Available From: https://pmc.ncbi.nlm.nih.gov/articles/PMC6849040/

5. Kleimeyer JP, Harris AHS, Sanford J, Maloney WJ, Kadry B, Bishop JA. Incidence and Risk Factors for Postoperative Hypothermia After Orthopaedic Surgery. J Am Acad Orthop Surg [Internet]. 2018;26(24):e497–503. https://doi.org/10.5435/JAAOS-D-16-00742

6. Li C, Zhao B, Li L, Na G, Lin C. Analysis of the Risk Factors for the Onset of Postoperative Hypothermia in the Postanesthesia Care Unit. J Perianesth Nurs [Internet]. 2021;36(3):238–242. https://doi.org/10.1016/j.jopan.2020.09.003

7. Karalapillai D, Story D, Hart GK, Bailey M, Pilcher D, Cooper DJ, et al. Postoperative hypothermia and patient outcomes after elective cardiac surgery. Anaesthesia [Internet]. 2011;66(9):780–784. https://doi.org/10.1111/j.1365-2044.2011.06784.x

8. Karalapillai D, Story D, Hart GK, Bailey M, Pilcher D, Schneider A, et al. Postoperative hypothermia and patient outcomes after major elective non-cardiac surgery. Anaesthesia [Internet]. 2013;68(6):605–611. https://doi.org/10.1111/anae.12129

9. Akers JL, Dupnick AC, Hillman EL, Bauer AG, Kinker LM, Hagedorn-Wonder A. Inadvertent

Perioperative Hypothermia Risks and Postoperative Complications: A Retrospective Study. AORN J [Internet]. 2019;109(6):741–747. https://doi.org/10.1002/aorn.12696

10. Motamed C, Weil G, Dridi C, Bourgain JL. Incidence of severe hypothermia and its impact on postoperative surgical complications and time delay to adjunct treatments in breast surgery cancer patients: A case-controlled study. J Clin Med [Internet]. 2021;10(16):3702. https://doi.org/10.3390/jcm10163702

11. Tavares-Mendonça F, Cabral-de Lucena M, Silva-Quirino R, Sousa-Govêia C, Nunes-Guimarães GM. Risk factors for postoperative hypothermia in the post-anesthetic care unit: a prospective prognostic pilot study. Braz J Anesth [Internet]. 2019;69(2):122–30. https://doi.org/10.1016/j.bjan.2018.10.001

12. De Assunção-Peixoto C, Guimarães -Ferreira MB, dos Santos-Felix MM, de Mares-Pereira CB, Cândido JV, et al. Factors contributing to intraoperative hypothermia in patients undergoing elective surgery. Perioper Care Oper Room Manag [Internet]. 2021;22:100150. https://doi.org/10.1016/j.pcorm.2020.100150

13. Sagiroglu G, Ozturk G, Baysal A, Turan F. Inadvertent Perioperative Hypothermia and Important Risk Factors during Major Abdominal Surgeries. J Coll Physicians Surg Pak [Internet]. 2020;30(2):123–128. https://doi.org/10.29271/jcpsp.2020.02.123

14. Duong H, Patel G. Hypothermia [Internet]. Treasure Island (FL): StatPearls Publishing; 2022 [cited 2023 Mar 13]. Available from: https://www.ncbi.nlm.nih.gov/books/NBK545239/

15. American Society of Anesthesiologists. Statement on ASA Physical Status Classification System [Internet]. 2020. Available from: https://www.asahq.org/standards-and-guidelines/asa-physical-status-classification-system

16. Demelash-Simegn G, Debas-Bayable S, Bantie-Fetene M. Prevention and management of perioperative hypothermia in adult elective surgical patients: A systematic review. Ann Med Surg (Lond) [Internet]. 2021;72:103059. https://doi.org/10.1016/j.amsu.2021.103059

17. Torossian A, Bräuer A, Höcker J, Bein B, Wulf H, Horn EP. Preventing inadvertent perioperative hypothermia. Dtsch Arztebl Int [Internet]. 2015;112(10):166-72. https://doi.org/10.3238/arztebl.2015.0166

18. Perlman R, Callum J, Laflamme C, Tien H, Nascimento B, Beckett A, et al. A recommended early goal-directed management guideline for the prevention of hypothermia-related transfusion, morbidity, and mortality in severely injured trauma patients. Crit Care [Internet]. 2016;20(1):107. https://doi.org/10.1186/s13054-016-1271-z

19. Haverkamp FJC, Giesbrecht GG, Tan ECTH. The prehospital management of hypothermia - An up-to-date overview. Injury [Internet]. 2018;49(2):149-164. https://doi.org/10.1016/j.injury.2017.11.001

20. Zhang H, Wang J, Zhu S, Li J. The prevalence of and predictors for perioperative hypothermia in postanaesthesia care unit. J Clin Nurs [Internet]. 2022;31(17–18):2584–2592. https://doi.org/10.1111/jocn.16080

21. Frank SM, Raja SN, Bulcao C, Goldstein DS. Age-related thermoregulatory differences during core cooling in humans. Am J Physiol Regul Integr Comp Physiol [Internet]. 2000;279(1):R349–R354. https://doi.org/10.1152/ajpregu.2000.279.1.R349

22. Cumin D, Fogarin J, Mitchell SJ, Windsor JA. Perioperative hypothermia in open and laparoscopic colorectal surgery. ANZ J Surg [Internet]. 2022;92(5):1125–1131. https://doi.org/10.1111/ans.17493

23. Chen HY, Su LJ, Wu HZ, Zou H, Yang R, Zhu YX. Risk factors for inadvertent intraoperative hypothermia in patients undergoing laparoscopic surgery: A prospective cohort study. PLoS One [Internet]. 2021;16(9):e0257816. https://doi.org/10.1371/journal.pone.0257816

24. Sessler DI. Complications and treatment of mild hypothermia. Anesthesiology [Internet].

2001;95(2):531-43. https://doi.org/10.1097/00000542-200108000-00040

25. Sessler DI. Perioperative Temperature Monitoring. Anesthesiology [Internet]. 2021;134(1):111-118. https://doi.org/10.1097/ALN.0000000000003481

26. Rajagopalan S, Mascha E, Na J, Sessler DI. The effects of mild perioperative hypothermia on blood loss and transfusion requirement. Anesthesiology [Internet]. 2008;108(1):71-77. https://doi.org/10.1097/01.anes.0000296719.73450.52

27. Rauch S, Miller C, Bräuer A, Wallner B, Bock M, Paal P. Perioperative hypothermia—a narrative review. Int J Environ Res Public Health [Internet]. 2021;18(16):8749. https://doi.org/10.3390/ijerph18168749

28. Sessler DI. Perioperative thermoregulation and heat balance. Lancet [Internet]. 2016;387(10038):2655-2664. https://doi.org/10.1016/S0140-6736(15)00981-2

29. Lenhardt R. Monitoring and thermal management. Best Pract Res Clin Anaesthesiol [Internet]. 2003;17(4):569–581. https://doi.org/10.1016/s1521-6896(03)00048-x