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REVIEW ARTICLE

Perioperative hypothermia: a systematic review

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Abstract

Temperature is a vital sign that is closely regulated by the hypothalamus. Perioperative hypothermia is a common event; as peripheral heat redistribution occurs, thermoregulation is altered by anesthesia and exposure to a cold environment (operating room). Hypothermia is defined as core body temperature below 36°C. The aim of this systematic review was to analyze the main risk factors and complications of perioperative hypothermia and, at the same time, find out which warming method is most useful in the perioperative period. Of the 20 articles that were analyzed, 17 of them indicate that the patients present hypothermia in the perioperative period, with a range of mean temperatures ranging from 32.8[9] to < 36.0°C; three of them mention that the mean temperature ranges ≥ 36.0°C. The mean complications associated with hypothermia are shivering and thermal discomfort. Perioperative temperature is still one of the least commonly monitored vital parameters during anesthesia and surgery. A combined approach through active and passive warming measures is the key to preventing its complications.

Keywords: *Hypothermia. Perioperative. Complications of hypothermia. Management of hypothermia.*

Introduction

Temperature is a vital sign that is closely regulated by the hypothalamus between the limits that go from 36°C to 37.5°C. In a conscious individual, thermoregulation is given by an afferent pathway, central regulation, and an efferent pathway. The efferent pathway gives us responses in the individual's behavior change (shelter) and an autonomic response. Behavior regulation is the strongest mechanism, and this requires the individual to be aware of the perception of body temperature[1,2]. The main mechanism of the hypothalamus to regulate the hypothermic effect is described in Fig. 1. Thermoregulation occurs through the muscles through involuntary tremors. At the same time, hypothalamus can produce peripherical vasoconstriction and finally, the hypophysis produces the peak of ACTH than increases metabolism through suprarenal epinephrin (Fig. 1).

Perioperative hypothermia is a common event, as peripheral heat redistribution occurs, thermoregulation altered by anesthesia, and exposure to a cold environment (operating room)[1].

Hypothermia is defined as core body temperature below 36°C. It can be classified as follows: mild (34°-36°C), moderate (34°-32°C), and severe (<32°C). The main forms of core temperature measurement are the pulmonary artery, esophageal, nasopharynx, and tympanic membrane, and peripheral temperature is axillary and forehead skin[1,3].

The hypothermia that occurs during generalized anesthesia follows different phases, and these are the different phases[2,4]:

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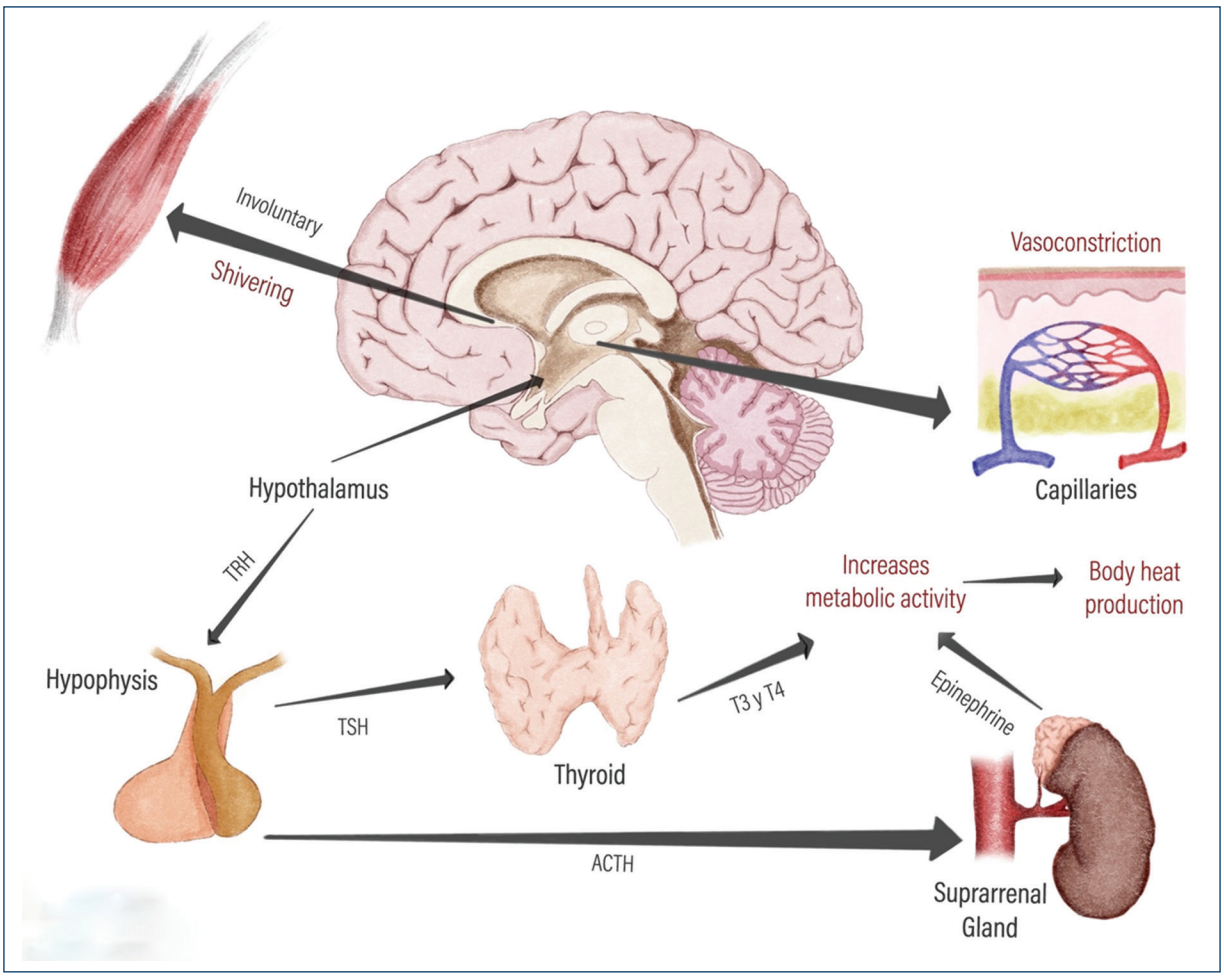

Figure 1. This image is showed several mechanisms of hypothalamus to counterbalance the hypothermia. There are two principal mechanisms; increase the metabolism (T3, T4, norepinephrine and shivering) and decreasing the body heat (vasoconstriction).
TRH = Thyrotrophin Release Hormone, TSH = Thyroid Stimulation Hormone, T3 = Triiodothyronine, T4 = Thyroxine.

- Phase I - *Redistribution*: gradual linear decrease that occurs within the 1st h. Circulatory redistribution (1-3°C)[2,4].
- Phase II - *Heat loss*: heat is transferred from the hottest periphery to the environment. Understood between 2-4 h. Metabolic overwhelmed[2,4].
- Phase III - *Plateau*: thermal homeostasis begins after 3-4 h once the core temperature is 33-35°C[2,4].

Perioperative hypothermia leads to several complications, among which are cardiac alterations, infection, coagulation alterations, tremors, delayed healing, and longer time in the recovery area[1,2,5].

Material and methods

A systematic review of the literature was carried out using the following methodology. The PubMed, Google Scholar, and Cochrane Library databases were searched for the open terms *perioperative hypothermia, accidental hypothermia, post-operative hypothermia*, and the MeSH term (perioperative hypothermia AND anesthesia). Articles were searched for a period from 1980 to the present. Articles such as systematic reviews, meta-analyses, and clinical trials were investigated. The following inclusion criteria are spanish and English language, which included anesthetic procedures in humans, which refers to temperature figures in the perioperative period, which included the anesthetic technique, and which included perioperative complications. Duplicate articles or articles that, although mentioned, did not meet the inclusion criteria were excluded from the study. The articles excluded were those that discussed hypothermia in cardiac surgeries, surgeries in which hypothermia was induced, and studies that were not found in their complete online

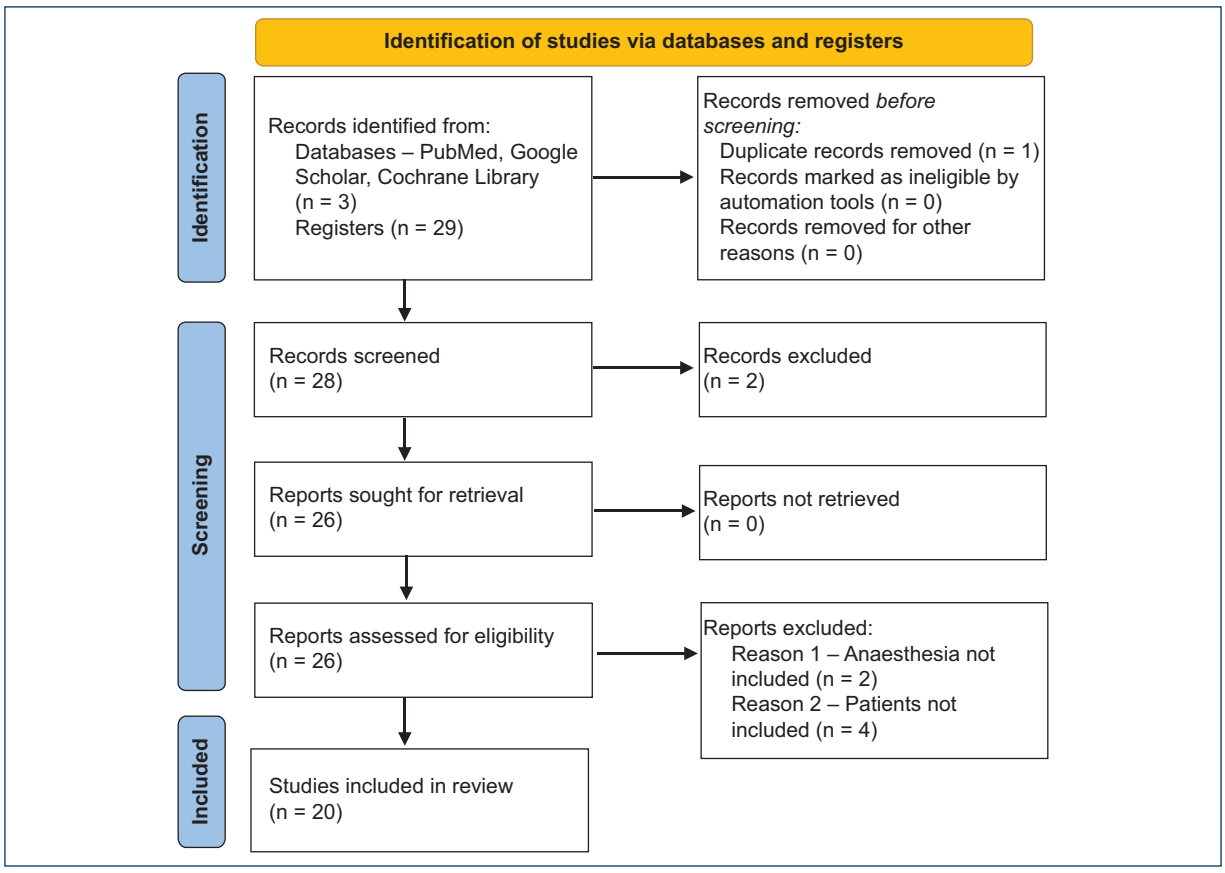

Figure 2. Flow chart for selection of studies using PRISMA flow diagram.

version. All articles were reviewed, and duplicates were removed (Fig. 2).

Results

Of the 20 articles that were analyzed, 17 of them indicate that the patients present hypothermia in the perioperative period, with a range of mean temperatures ranging from 32.8 to < 36.0°C; three of them mention that the mean temperature ranges ≥ 36.0°C[6-8].

The main complications associated with hypothermia are shivering and thermal discomfort. Cardiovascular alterations are also mentioned in three of the articles[9-11], and in four of them, various alterations are mentioned, such as increased infections, coagulopathies, and an increase in mortality[11-13]. Five articles do not report adverse events[6,8,14-18].

Four types of management for perioperative hypothermia have been reported: amino acid infusion[19], fluid prewarming[6], forced-air pump warming[6,7,20-22], swaddling[20-22], and increase in operating room temperature[9]. Of these types of management, the one that showed the best result and significance with respect to it was active heating with forced-air pumps (Table 1)[23-25].

Discussion

Perioperative hypothermia can be triggered by different risk factors, which can be divided into patient-related, anesthesia-related, surgery-related, environmental, and others[26] (Table 2).

Perioperative hypothermia is a problem that is often not given due importance, since, by not managing it, patients both intraoperatively and postoperatively leave with low body temperatures, and it has been seen that with hypothermia complications ranging from patient discomfort to serious ones that could compromise the patient's life, such as cardiovascular complications.

Core body temperature versus peripheral body temperature

Core body temperature (head, deep thorax abdominal) is normally around 37°C. The peripheral is typically 2°-4°C cooler than the central[3,4]. This gradient is maintained by thermoregulation given by vasoconstriction. Thermoregulation is the mechanism by which the

Table 1. This table shows the references of twenty authors. Number of patients in the sample, the mean of hypothermia, complications, management, and bias

Year	Title	Patients (n)	Anethetic technique	Mean Temperature ($\bar{X}$/Stardar deviation)	Complications	Observations	Biases
1981	Postoperative Hypothermia in Adults: Relationship of Age, Anesthesia, and Shivering to Rewarming[23]	198	Regional anesthesia: Subarachnoid block or with T 10 level or superior. General anesthesia	PACU arrival temperature: young 35.7 ± 0.06; elderly: 35.4 ± 0.11, general anesthesia: 35.5 ± 0.06; regional: 35.6 ± 0.14 PACU discharge temperature: young: 36.4 ± 0.04; elderly; 36.1 ± 0.9; general anesthesia: 36.4 ± 0.04; regional: 36.2 ± 0.12	Shivering	A tendency to hypothermia was show in older patients, compared to younger adults. Temperature difference admitted to the PACU (young vs adults - p = < 0.05), duration of hypothermia (young vs adults and general vs regional anesthesia - p = < 0.05), temperature increase in the 1st h (general vs regional anesthesia - p = < 0.05) and recovery time (general vs regional anesthesia - p = < 0.05); χ^2	It is a study performed in the eighties. In general anesthesia, the gases used ar currently out of use, which transposing it to the present could vary the results.
1995	Postoperative hemodynamic and thermoregulatory consequences of intraoperative core hypothermia[10]	74	General anesthesia, neuromuscular block	Normpthermic group: 37 ± 0.3; Hypothermic group: 34.4 ± 0.4	Shivering, thermal discomfort, peripheral vasoconstriction	It is a study that evaluates the effects of hypothermia on heart rate and blood pressure (without changes). Difference in core body temperature at the end of surgery (p = < 0.01).	It is only focused on one type of electivbe surgery, which is colon surgery. The anesthetics currently used no longer in use. The sample number of hypothermic patients was lower.
1996	Preoperative infusion of amino acids prevents postoperative hypothermia[19]	24	General anesthesia	Group A: 37.1ºC, Group B: 36.4ºC, Group C: 35.9ºC	Shivering	Group A: Adm. 1h before anesthesia, Group B: 2h before anesthesia, Group C: Adm. Saline solution. Amino acid infusion counteracts the hypothermic effect of anesthesia through preoperative heat buildup and delayed metabolic simulation. Tº 1h before group A (p = 0.001), 1 and 2 h before group B (p = 0.001) and decrease in Tº group C post-anesthesia (p = 0.05). Increased post-anesthesia O2 uptake, group A (p = 0.001)	It was performed on females patients who underwent hysterectomy for menorrhagia. A very small number of patients.

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Table 1. This table shows the references of twenty authors. Number of patients in the sample, the mean of hypothermia, complications, management, and bias *(continued)*

Year	Title	Patients (n)	Anethetic technique	Mean Temperature ($\bar{X}$/Stardar deviation)	Complications	Observations	Biases
1997	Mild Intraoperative Hypothermia Prolongs Postanesthesic Recovery[27]	150	General anesthesia	Intraoperative final temperature: Hypothermic group: 34.8 ± 0.6, Normothermic group: 36.7 ± 0.6	Shivering	2º of hypothermia, delays discharge fron the PACU by approximately 40 minutes when normothermia is not used as a criteria (36.0ºC) and when normothermia is used as a discharge criteria, it is delayed by approximately 90 min; core body temperature difference at the end of surgery (p = < 0.001); X^2 = 2, §	The anesthetics used in the trial ar currently out of use and one of the discharge criteria (Kroulik score) is still out of use.
2000	Age-Related Thermoregulatory Differences in a Warm Operating Room Enviroment (Approximately 26ºC)[9]	40	General anesthesia	PUCA arrival: Young (36.7ºC ± 0.1); Elderly (36.4ºC ± 0.1); after prewarming only 4 patients showed < 36.0ºC (3 elderly, 1 young) and 1 patient < 35.5ºC (elderly)	Shivering (40% young and 10% elderly) and peripheral vasoconstriction	It concludes that increasing the operating room temperature to 26ºC decreases the incidence of low hypothermia in both groups (young and adults). Postoperative shivering (p = 0.06); X^2	The sample size is small and only surgical speciality and one type of anesthesia.
2010	Incidence of Postoperative Hypothermia and the Relationship to Clinical Variables[17]	287	General anesthesia, regional anesthesia, combined anesthesia and MAC sedation.	Tº $\bar{X}$ postoperative: 36.8ºC, only 4% showed Tº < 36.0ºC	Not mentioned	It only seeks to see the percentage of incidence of hypothermia in the PACU (4% of the sample size)	As a limitation of the study is that the way in which body temperature was measured is not montined, and it does not have statistical tables.
2013	Postoperative hypothermia and patient outcomes after elective non-cardiac surgery[12]	50689	No mentioned	Highest temperature recorded: 36.9ºC ± 0.003; Lowest temperature: 35.5ºC ± 0.02	Increase in mortality	Age (p = 0.001), male sex (p = 0.001), APACHE III corrected (p = 0.001), transitory and persistent hypothermia vs. normothermia (p = 0.001), type of hospital (p = 0.001), surgical speciality (p = 0.001) and controlled ventilation (p = 0.001); **,***	The type of anesthesia required by each patient is not mentioned. Only the highest and lowest temperatures recorded in the postoperative period in a period of 24 h were obtained. Only patients in the ICU are taken into account in the analysis.
2013	Manejo de la temperatura en el preoperatorio y frecuencia de hipotermia inadvertida en un hospital general[15]	167	General anesthesia, neuraxial anesthesia, combined anesthesia and sedation.	$\bar{X}$ temperature of 35.6ºC ± 0.23	Not mentioned	Significant data: Age 65 years (p = 0.012), BMI (p = 0.018), female sex (0.029), difference in body temperatures (p = <0.01), ASA grade (p = <0.02) **	Complications associated with postoperative hypothermia are not mentioned. The form of measurement of body temperature was peripheral (skin of the forehead).

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Table 1. This table shows the references of twenty authors. Number of patients in the sample, the mean of hypothermia, complications, management, and bias *(continued)*

Year	Title	Patients (n)	Anethetic technique	Mean Temperature ($\bar{X}$/Stardar deviation)	Complications	Observations	Biases
2014	Efficacy of a novel prewarming system in the prevention of preoperative hypothermia. A prospective, randomized, multicenter study[20]	90	No mentioned	Whit active prewarmimg: 36.6°C ± 0.4 Passive prewarming: 35.9°C ± 0.3 Without prewarming: 35.9°C ± 0.6	Shivering	Differences in body temperature between the three groups, primarily between the active warming group versus the control group (p = < 0.05)	The type of anesthesia required by each patients is not mentioned.
2014	Survery on Posoperative Hypotermia Incidence in Operating Theatres of Kocaeli University[25]	564	General anesthesia, neuraxial anesthesia and peripheral nerve block.	PUCA arrival $\bar{X}$ 34.3 ± 0.5	Shivering and delayed postoperative recovery	Significant data: age (41.4 ± 20.5 p = 0.001), type of anesthesia (p = 0.001), fluid balance (0.001), surgery time (p = 0.001), recovery period (p = 0.001) and shivering (0.002)	Is taken as hypothermia temperature < 35°C
2018	Incidence and Risk Factor of Posoperative Hypotermia After Orthopaedic Surgery[8]	6950	General anesthesia and regional anesthesia.	Preoperative $\bar{X}$ 36.6°C ± 0.24; Postoperative. $\bar{X}$ 36.4°C ± 0.51	Not mentioned	Significant data: age (p = 0.004), male sex (p = 0.006), body mass index (p = 0.000), intraoperative hypothermia (p = 0.000), preoperative hypothermia (p = 0.007), reconstructive surgery (p = 0.001), hip and pelvis surgey (p = <0.000), **	The article is based only on orthopedic surgeries.
2018	Risk factors posoperative hypotermia in thepost-anesthetic care unit: a prospective pronostic pilot study[18]	70	General anesthesia, regional anesthesia and combined anesthesia.	OR: arrival 36.3°C ± 0.5 and discharge 35.6°C ± 0.55; UCPA: arrival 35.6°C ± 0.57 and discharge 36.0°C ± 0.59	Not mentioned	It was show that more than a half of the admitted patients presented hypothermia. Significant data: age (< 60 years and > 60 years; p = <0.001), ASDA grade (p = 0.006), arterial hipertension (p = <0.001), type of anesthesia (p = 0.004), warming in the OR (p = 0.008), fluids warming in the OR (p = 0.001); + , X^2	The sample size is small and complications are not mentioned. Surgeries are performed primarily in patients < 60 years with a high predominance in the speciality of Gynecology.

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Table 1. This table shows the references of twenty authors. Number of patients in the sample, the mean of hypothermia, complications, management, and bias *(continued)*

Year	Title	Patients (n)	Anethetic technique	Mean Temperature ($\bar{X}$/Stardar deviation)	Complications	Observations	Biases
2018	Effect of preoperative warming on intraoperative hypothermia: a randomized-controlled trial[6]	200	General anesthesia	Preoperative: Control group (36.8ºC) - Prewarming group (36.9ºC); Intraoperative: Control group (36.0ºC) - Prewarming group (36.3ºC); Postoperative: Control group (36.0ºC) - Prewarming group (36.4ºC)	Not mentioned	Intraopetaive hypothermia 60 minutes ($p \leq 0.001$), Postoperative ($p \leq 0.001$). Risk factors surgery 2.5 h ($p = 0.002$), protective factor use of crystalloids pre-warmed to 37°C ($p = 0.014$); §, X^2	The temperature was measured peripherally, leading to biases related to a core boby temperature measurement.
2019	Effect of the ASPAN Guideline on Perioperative Hypothermia Among Patiens with Upper Extremity Surgery Under General Anesthesia: A Randomized Controlled Trial[21]	54	General anesthesia	Control group (blankets): preoperative: 36.68 ± 0.22; posoperative 35.81 ± 0.51. Experimental group (active warming): preoperative: 36.77 ± 0.30; posoperative: 36.92 ± 0.57	Shivering, thermal discomfort.	It was show: differences in body temperture ($p = < 0.001$), shivering ($p = 0.012$), thermal discomfort ($p = < 0.001$), thermal comfort ($p = < 0.001$); X^2	It is limited by the number of patients and only one type of anesthesia was used.
2019	Inadvertent Perioperative Hypothermia Risks and Postoperative Complications: A Retrospective Study[13]	298	General anesthesia and spinal block	First measurement $\bar{X}$ = 35.3 °C ± 0.8, and lowest temperature recorded was < 32.8ºC	Low hemoglobin and hematocrit levels, bloood transfusion, sepsis, pneumonia and increase in mortality	Hypotermic patients (n = 7; 100%) showed hemoglobin and hematocrit levels ($p = 0.0019$ --> Required blood transfusion. Age < 70 years ($\bar{X}$ ± 72.9 years - $p = 0.02$), type surgery ($p = 0.004$), +	General anesthesia was the most used type (98.7%), which could influence the results. Also it is not mentioned how the temperature was measured.
2020	The Effect of Active Warming on Postoperative Hypothermia on Body Temperature and Thermal Comfort: A Randomized Controlled Trial[22]	64	General anesthesia	Temperature one day before: 36.7 ± 0.69. Euthermia (37 l c) active warming $\bar{X}$ = 330 minutes, passive warming $\bar{X}$ = 555 minutes.	Shivering and thermal discomfort.	Active warming time vs passive warming ($p = 0.01$), shivering duration ($p = 0.05$), perception of thermal comfort ($p = 0.05$); +	The perception of thermal comfort is subjective, so this can bias a results. Just focus on warm up. The temperature measurement was made one day before and only takes into account the warming time in minutes.

(Continues)

Table 1. This table shows the references of twenty authors. Number of patients in the sample, the mean of hypothermia, complications, management, and bias *(continued)*

Year	Title	Patients (n)	Anethetic technique	Mean Temperature ($\bar{X}$/Stardar deviation)	Complications	Observations	Biases
2021	Efficacy of active forced air warming during induction of anesthesia to prevent inadvertent perioperative hypothermia in intraoperative warming patients[6]	130	General anesthesia	Preoperative warming group : $\bar{X}$ 36.94ºC ± 0.66; Control group. : $\bar{X}$ 36.58ºC ± 0.70 (p = 0.004)	Shivering and thermal discomfort.	A decrease in hypothermia was observed in patients who received peri-induction warming, compared to the control group. Duration of perioperative warming (20.2 ± 8.7 min - p = <0.0001), duration of the period without warming (p = <0.001), severity of hypothermia (p = <0.001), intraoperative hypothermia (p = <0.001); *, **	It is limited since only focuses on warming the patient during the intraoperative period, in surgeries lasting more than 120 minutes.
2021	Incidence of postoperative hypothermia and risk factors in adults undergoing orthopedic surgery under brachial plexus block: A retrospective cohort study[16]	660	Brachial plexus block	Tympanic temperaturte < 36ºC at PUCA. Arrival Whith $\bar{X}$ of 35.7ºC	Not mentioned	Type of surgery (shoulder arthroscopy - p = <0.001), surgery time (p = 0.002), fluid administration (p = 0.035), midazolam + dexmetomidine (p = 0.001), fentanyl (p = 0.022), patient alcoholic (p = 0.029) and baseline body temperature (p = 0.002); *	Only one type of anesthesia mentioned, specifically the brachial plexus block in orthopedic surgeries.
2021	Postoperative hypothermia following non-cardiac high-risk surgery: A prospective study of temporal petterns and risk factors[11]	738	General anesthesia, neuraxial anesthesia and combined anesthesia	Core body temperature < 36ºC in 64% and < 36ºC in 19%	Primarly: infectio and coagulopathy. Others: cardiovascular, renal, and gastrointestinal	Age (< 50 years, > 70 years - p = <0.001), surgery time (p = <0.001), adbominal surgery (p = < 0.001), Comorbiidities (coronary insufficiency, SAH - p = < 0.001); *,**	The study was performed in the ICU, which could vary the temperature measurement method. And it was patients who had major non-cardiac surgery. Over 18 years. Temperature measurement with different devices (axillary, tympanic and esophageal).
2021	Analysis of the Risk Factors for the Onset of Postoperative Hypothermia in the Post anesthesia Care Unit[14]	2880	General anesthesia, epidural anesthesia, local anesthesia and total intravenous anesthesia	Hypothetic group: 35.79 ± 0.46 C Non hypothermic group: 36.75 ± 0.44 C	Not mentioned	Contributing factors: patient age (p = 0.01), type of anethesia (p = 0.027), ASA grade (p = 0.038), surgery time (p = 0.01), intraoperative fluid volume (p = 0.01), epidural anesthesia (p = 0.033), preoperative hypothermia (p = 0.003).	In the present study, the complications that occur in a patient with hypothermia are not explored.

ASA: American Society of Anesthesiologists; PACU: Postanesthetic Care Unit; ICU: Intensive Care Unit; SAH: Systemic Arterial Hypertension; BMI: Body Mass Index; OR: Operating Room; * Multivariate regression; ** Univariate regression; *** Linear regression; + Fisher's exact test; ǂ T-Student; § Wilcoxon test; $\chi 2$ Chi-square; $\bar{X}$ Mean; ϕ Mann-Whitney U test; Θ ANOVA.

Table 2. Risk factors for perioperative hypothermia

Risk factors source	Risk factors
Related to the patient	Female gender, of legal age, low BMI, ASA score between II and IV, diabetes mellitus, risk of cardiac complications, SBP < 140 mmHg.
Related to anesthesia	Combined or regional anesthesia, prolonged duration of anesthesia, level of spinal block.
Related to surgery	Pre-operative hypothermia, prolonged pre-operative fasting, major or intermediate surgery, size of surgical incision, long duration of surgery.
Environmental	Operating room temperature < 21°C, minimal patient coverage during surgery
Others	Infusion of cold IV fluids, use of cold irrigation solutions, blood transfusion, blood loss.

BMI: body mass index; ASA: American Society of Anesthesiologists; SBP: systolic blood pressure; IV: intravenous[28].

Table 3. Types of warming[28]

Active warming	Passive warming
Forced air or convective warm air transfer, heated intravenous fluids, heated fluid irrigation, warming and humidifying air (anesthesia).	Place warm blankets, remove any wet clothing, cover the person with dry clothing, and protect them from the cold wind (air conditioning), infusion of amino acids (1 h or 2 h before surgery).

hypothalamus regulates body temperature at a stable level. Thermoregulation is the basis of multiple signals coming from each nearby tissue[27]. Processing of thermal information occurs in three phases: afferent input, central regulation, and efferent responses[4].

Thermoregulation and complications

The human body has different methods to maintain core temperature. This requires sufficient intravascular volume and cardiovascular function, as the body must be able to transport rising internal heat to its surface for release. That is why older people are at increased risk of thermoregulation disorders due to a generally decreased intravascular volume and decreased cardiac function[4].

The main complications that occur in patients with hypothermia are hypothermic cardiac arrest, cardiac arrhythmias, coagulopathies, tremors, increased blood loss and increased need for blood transfusion, delayed healing, altered pharmacodynamics, and prolonged hospital stay[28].

Medulla oblongata reactivity decreases when body temperature falls below 34°C. Colder blood affects the sinoatrial node, atrioventricular node, and bundle of His and Purkinje fibers, leading to slow heart rate (bradycardia). This bradyarrhythmia can lead to a blockage.

The respiratory system is inhibited, leading to an increase in lung dead space, which causes the pooling of blood in the lungs. The oxygen dissociation curve shifts to the left and the affinity of hemoglobin for oxygen increases[5,28].

Cerebral circulation decreases by 6-10% for every 1°C that decreases in body temperature. Therefore, they lead to a deterioration of consciousness and rational thought when the temperature falls below 35°C[25].

Enzymatic coagulation reactions are affected by hypothermia since a correct pH and temperature are required for their proper functioning. A small drop in body temperature causes platelet dysfunction and clot formation. Bleeding time is longer while the lower the body temperature decreases[2,5,28]. The function of the coagulation system is reduced by 10% for every 1°C drop in body temperature[28].

Cardiac arrhythmia (sinus bradycardia, atrioventricular block, ventricular arrhythmia, and prolonged PR interval) is commonly seen on ECG in hypothermic patients. Included in these abnormalities in the ECG are the *Osborn wave*, also known as the *camel-hump sign*, (J wave or elevation of J point)[28]. Which is the elevation of the J point. This elevation is associated with hypoventilation and respiratory acidosis. Once the rise in body temperature begins, the J wave disappears[2,28].

Preventive measures

There are preventive measures for the appearance of hypothermia, which, for an easier understanding, we will divide into two. First, the passive warming measures and second, the active warming measures (Table 3).

Suggestions

To prevent perioperative hypothermia, it is necessary to make use of the tools and measures that are available. Those that have shown a better impact on the patient's body temperature, both pre-operative, intraoperative, and post-operative, are the previously mentioned active warming measures. The most relevant are

the following: use of forced air machines, thermal blankets, and heated intravenous fluids.

In a 2015 systematic review, it was shown that warmed intravenous fluids showed higher temperatures from the moment of anesthetic induction, with a mean at 60 min of 0.51°C higher (95% confidence interval [CI], 0.33-0.69) and at term and admission to the post-anesthesia care unit, with a mean of 0.63°C higher (95% CI, 0.28-0.98) than the control group[29].

In a 1996 clinical trial, it was found that the infusion of amino acids in the pre-operative period (1 or 2 h before the surgery) stimulates an increase in energy expenditure, thus preventing hypothermia induced by anesthesia to some degree[19].

Conclusions

Perioperative temperature is still one of the least commonly monitored vital parameters during anesthesia and surgery. With the results obtained, the main complications observed are: in cardiovascular impairment, shivering, thermal discomfort, coagulopathies, increased surgical site infections, and increased mortality. Temperature management in the pre-, intra-, and post-operative period is crucial to diminish the risks of perioperative hypothermia. A combined approach through active and passive warming measures is the key to preventing its complications.

Limitations

The limitations of our study include the type of secondary research, the small sample sizes, and the lack of information with respect to the fact that some studies did not mention the type of anesthesia used, types of surgery used, the lack of statistical analysis, and also lack of methodology in measuring body temperature.

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Conflicts of interest

The authors declare no conflicts of interest.

Ethical disclosures

Protection of human and animal subjects. The authors declare that no experiments were performed on humans or animals for this study.

Confidentiality of data. The authors declare that no patient data appear in this article.

Right to privacy and informed consent. The authors declare that no patient data appear in this article.

Use of artificial intelligence for generating text. The authors declare that they have not used any type of generative artificial intelligence for the writing of this manuscript nor for the creation of images, graphics, tables, or their corresponding captions.

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