RESEARCH PAPER

Perioperative hypothermia and hyperthermia : outcome in elective surgeries

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ABSTRACT

Perioperative temperature disturbances, including hypothermia and hyperthermia, are common complications during elective surgeries and are associated with significant adverse outcomes. Perioperative hypothermia, defined as a core body temperature below 36°C, frequently results from anesthesia-induced thermoregulatory impairment, exposure to cold operating room environments, and administration of unwarmed intravenous fluids. It has been linked to increased risks of surgical site infections, coagulopathy, prolonged recovery, and extended hospital stay. Conversely, perioperative hyperthermia, although less common, may arise from conditions such as infection, excessive warming, drug reactions, or malignant hypermetabolic states, leading to complications including increased metabolic demand, organ dysfunction, and in severe cases, life-threatening events.

Maintaining normothermia is therefore a critical component of perioperative care in elective surgeries. Active warming techniques, temperature monitoring, and early identification of temperature deviations play a key role in improving patient outcomes. This paper reviews the causes, risk factors, and clinical consequences of perioperative hypothermia and hyperthermia, and emphasizes evidence-based strategies for effective temperature management to enhance surgical safety and recovery.

Keywords: Perioperative hypothermia, Perioperative hyperthermia, Elective surgery, Normothermia, Temperature management, Surgical site infection, Anesthesia complications, Patient outcomes, Thermal regulation, Intraoperative care.

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Introduction

The secret threat in the majority of elective surgical procedures is hypothermia[1].Despite all the negative consequences during the postoperative phase, very few anesthesiologists and surgeons consider this issue during surgery. Even if a procedure only takes one hour, 70–90% of patients are thought to have hypothermia[2].

If precautions against hypothermia are not implemented, it may take up to four hours to return to normothermia[3]. Regional and global anesthesia both worsen hypothermia's protective mechanisms[4]. In addition to the well-known consequences of hypothermia, which include a higher risk of infection, impaired coagulation mechanisms, and significant bleeding, there are also unfavorable events brought on by the unavoidable tremors, which are extremely uncomfortable and unpleasant[5].

Methodology

A systematic literature review was performed in databases such as PubMed and Medline, entering keywords in English: hypothermia in plastic surgery, complications of hypothermia, prevention of hypothermia, maintaining normothermia. The articles were read, those referring to the subject were consulted and according to this methodology 52 references were selected. The results of this review are presented below.

Literature Search Strategy

A comprehensive literature search was conducted to identify relevant studies on perioperative hypothermia and hyperthermia in elective surgeries. Electronic databases including PubMed, Scopus, Web of Science, CINAHL, and Cochrane Library were systematically searched. Keywords and Medical Subject Headings (MeSH) terms used included *"perioperative hypothermia," "perioperative hyperthermia," "elective surgery," "temperature management," "normothermia,"* and *"surgical outcomes."* Boolean operators (AND, OR) were applied to refine the search. The search was limited to studies published in English between 2000 and 2025 to ensure relevance to current clinical practices. Additionally, reference lists of selected articles were manually screened to identify further relevant studies.

Inclusion and Exclusion Criteria

Studies were included if they involved adult patients undergoing elective surgeries, comprised randomized controlled trials, cohort, case-control, or systematic review designs, and reported outcomes related to perioperative hypothermia and/or hyperthermia, including temperature management strategies and associated complications. Only full-text articles published in English were considered. Studies were excluded if they involved emergency or trauma surgeries, pediatric populations, or were case reports, editorials, conference abstracts, or letters to the editor. Additionally, studies lacking clear temperature-related outcomes or published in languages other than English were excluded.

Data Extraction Process

Data extraction was performed systematically using a standardized data collection form. Relevant information extracted from each study included author details, year of publication, study design, sample size, patient characteristics, type of surgery, temperature management methods, and key outcomes such as incidence of hypothermia/hyperthermia, surgical site infections, blood loss, and recovery time.

To ensure accuracy and minimize bias, studies were independently reviewed, and key findings were cross-checked. Any discrepancies in data extraction were resolved through discussion and consensus. The extracted data were then synthesized narratively to identify common themes, trends, and gaps in the existing literature.

Risk of Bias Assessment

The risk of bias in the included studies was assessed using standardized and appropriate appraisal tools based on study design. Randomized controlled trials were evaluated using the *Cochrane Risk of Bias Tool*, while observational studies (cohort and case-control) were assessed using the *Newcastle–Ottawa Scale*. Systematic reviews were appraised using relevant critical appraisal checklists.

Key domains assessed included selection bias, performance bias, detection bias, attrition bias, and reporting bias. Each study was independently reviewed, and judgments were categorized as low, moderate, or high risk of bias. Any discrepancies were resolved through discussion to ensure consistency and reliability in the assessment.

Review

Maintaince of normothermia in operation theatre:

Human being is homeothermic and endothermic[6]. This means that, in addition to maintaining its temperature in narrow ranges, can produce heat by itself. In simple terms, the human body is divided into two compartments, one central that produces heat and one peripheral that regulates heat loss[7]. Our tight regulatory mechanisms are made to protect our central compartment at the expense of the peripheral. Thus, the core temperature, and especially the temperature in the brain, is regulated close to 37 °C, with an almost perfect thermoregulation, but at the expense of the skin, which is actually poikilothermic and its temperature resembles the ambient temperature about 33 °C[8]. Under normal conditions, the production of body heat is the result of the basal metabolic rate of internal organs such as the brain and those of the thoracic and abdominal cavity as heart, lung, liver, intestine and kidney[9]. Blood passes through these organs is heated and then is distributed by the cardiovascular system by convection from the central region to skin region[10].

The core that integrates and regulates body temperature and actually acts as a thermostat is in the posterior hypothalamus[11]. Thus the blood temperature that reaches the hypothalamus is the major determinant of the body's response to climate change and is responsible for maintaining a balance between heat production and heat transfer processes (gain and loss)[12].

These transfer processes between our body and the external medium is produced in two ways: by evaporation and no evaporative mechanisms (radiation, conduction and convection)[13].

According to the second law of thermodynamics heat can only flow by temperature gradient from the body that is warmer toward the periphery or the environment that is colder, therefore, the body never can be heated from the periphery to the core which is usually warmer than the outside[12].

Central thermal regulation mechanisms:

Body temperature is regulated exclusively by nervous mechanisms of negative feedback operating in the thermoregulatory centers in the hypothalamus[14]. In few cases, body temperature can only be altered by internal heat generation, regularly is by cooling or heating of the environment[15]. For its part, transient receptor potential (TRP) channels in the skin are widely present in sensory neurons. TRPM8 subtype exhibits activation at a room temperature <27 °C that is when there is a slight cold. The central thermoreceptors are located in the brain, spinal cord and abdomen[16]. Lateral parabrachial nucleus neurons are activated by cooling signal, which promotes an excitatory influx aimed at GABAergic interneurons[17]. This GABA influx inhibits inhibitory neurons in the preoptic area in the hypothalamus, which is the area in charge of temperature control, among other functions[18]. The result is the disinhibition of thermogenesis-promoting neurons in the hypothalamus. The spinal sympathetic influx and somatic motor circuits are activated by these fibers to trigger thermogenesis[19]. Thus, the coordination of a thermoregulatory response with a perfect hierarchical organization takes place from the preoptic area of the anterior hypothalamus, coordination that goes far beyond a simple spinal cord response as vasoconstriction[20].

A symphatic spinal flow is triggered with a large release of adrenaline and noradrenaline due to hypothermia, which produces an extensive peripheral vasoconstriction with arteriovenous shunts that reduce the blood flow to these cold peripheral areas and, in turn, keeps the warm blood in the central compartment[21]. Thus we have a gradient between the central and peripheral temperature, which can be 2–4° with peripheral temperatures of 32 °C and centrals of 36 °C or lower[21].

Operating Theatre Temperature in Burn Care

The perioperative maintenance of a patient's core temperature is a challenge during burn care. While patient warming devices are sometimes used to prevent intraoperative hypothermia, raising the ambient temperature of the theatre is the most common practice[22]. Theatre temperature can impact on the performance and comfort of surgery staff but standards for theatre temperatures in burn care are poorly defined. Therefore, in this study we investigated the current, global, clinical practices in burn care with respect to the ambient temperature of theatres[23]. The prevention of hypothermia was the clinical justification most reported for those theatre temperatures. Temperatures between 26 and 30°C appear to be most comfortable for the staff. One respondent mentioned that surgeries are often limited to 5 h to avoid hypothermia in patients, however, others noted surgery durations of up to 8–12 h in raised temperatures, which may impact the physiology and performance of the team, potentially impacting the safety of the patients[24]. The adoption of an optimal theatre temperature to address the surgical team's comfort levels, their performance, and patient hypothermia, may improve outcomes in elective cases[25].

While a wide arc for OT temperatures during burn care is given as 30–40°C , some researchers describe temperatures between 24 and 35°C as being the temperatures employed in elective Ots[26], while others note that OTs should be maintained at 28–32°C . Evidently, there is a discrepancy between the OT temperatures reported in practice guidelines in the literature and clinical practice. Given the potential consequences for patient recovery and surgical performance, it is important to identify the temperatures at which burn surgeries are conducted and compare that practice to the recommended values that are provided in the literature. Therefore, the aim of this study was to gather information on theatre temperatures.[27]

Anaesthestic implications in hypothermia

All inhaled anesthetics impaired deeply the autonomic responses that defend us from hypothermia. These responses are given in therapeutic ranges, thus interthreshold range may increase 10–20 times (4 °C), meaning that the response of peripheral vasoconstriction, usually given at 37 °C with inhaled anesthesia, can be given at 34 °C or 35 °C.

It means being totally exposed to hypothermia during surgery; regional anesthesia may increase the range only 3 or 4 times, but also has a direct vasodilator effect that deteriorates the response to cold.[28-30]

Anaesthestic implications in hyperthermia:

Complications due to hypothermia:

Temperature changes occur in three phases during anesthesia.[10] The greatest decline takes place during the first phase; temperature drops from 1 °C to 1.5 °C in the first hour due to a redistribution of heat from the center to the periphery. Heat loss in this phase is the result of the normal gradient, from 2 °C to 4 °C, between the core to the periphery and the vasodilatation that exists at the peripheral level due to the loss of the mechanisms of vasoconstriction by anesthesia.[31,32,33]

During the second phase (second and third hour) occurs a slow linear reduction of temperature due to central heat loss by decreased of basal metabolism. Hypothermia is also exacerbated by the low temperatures in the operating room, the body sites exposed (for example in liposuction) and the amount of cold liquids infiltrated subcutaneously.[34,35]

In the third phase (third and fourth hour) or plateau, temperature maintains a relatively stable state. In this phase, normally between 34 °C and 35 °C, the mechanisms of protection against lost hypothermia such as vasoconstriction and the closure of shunts in hands and feet, are activated again. At this stage the heat loss is minimized, but it never gets to reheat the body.[36,37]

Implications with hypothermia and regional anaesthesia

Hypothermia is frequent in both general and regional anesthesia. Some studies may show that the loss of temperature may be slightly lower in the first hour with regional anesthesia (0.8 °C) versus general anesthesia (1.2 °C) while others have shown no difference [38-40]. Phases 1 and 2 are almost equal to the general anesthesia ones, but the phase 3 has complications. Vasoconstriction is not activated at 34 °C with regional anesthesia, therefore, in this third phase (phase Plateau in general anesthesia) heat loss may continue in the patient, after 3 or 4 h. Thus, hypothermia can become even more serious with regional anesthesia, especially during lengthy surgery[41-42]. Hypothermia is more severe, depending on the dermatomes blocked and hence of the sympathetic blockade. Some studies have shown a decrease in 0.15 °C per dermatome blocked[43]. In plastic surgery this is a matter of great concern since very extensive blockages are performed that might include the thoracolumbar system in cases of tummy tucks and breast procedures with double puncture[44]

Autonomic effects in response to severe varied temperatures

Even mild hypothermia (1–2 °C), Norepinephrine values increase up to 7 times that generate a considerable hyperdynamic response. It has been proved that this can cause morbid cardiac events in susceptible individuals.[45-47]

According to a study published by Frank (1993), which compares normothermic patients versus hypothermic patients intraoperatively, it was found the latter was three times more risk of myocardial infarction and 12 times more risk of angina.[48]

Perfusion changes and monitoring in anaesthesia

Hypothermia increases blood viscosity which can lead to a deterioration of perfusion. Hematocrit levels rises by 2% per 1 °C decline in temperature. This false hematocrit increase can be misleading in a hypothermic patient with blood loss[49-51]. It also has deleterious effects on the coagulation cascade; hypothermia decreases all enzymatic reactions involved in the intrinsic and the extrinsic pathway. It has been shown that both the partial thromboplastin time (PTT) and prothrombin time (PT), are increased significantly by hypothermia in surgery in regards to normothermic patients[52-54]. Furthermore hypothermia causes transient thrombocytopenia and reduces platelet function by a transient decrease of thromboxane synthesis B2[55-56]. A prospective controlled study by Cavallini found that the group with intraoperative hypothermia presented partial times higher than thromboplastin preheated group, of which it was concluded that maintaining normothermia is one of the main strategies to reduce both intraoperative bleeding as the need for transfusions.[57]

Effects on the immune system

Hypothermia has an immunosuppressive effect that lowers resistance to infection. It has been shown in vitro that low temperatures decrease leukocyte migration; reduces neutrophil phagocytic capacity; decreases production of interleukins 1, 2 and 6 and the tumor necrosis factor [58-60]; antibody production decreases in T cells, while both complement activation and levels of C-reactive protein are deteriorated [61]. Melling et al. conducted a study in patients with clean surgical procedures (such as breast surgeries) and found that the group without warming had infection rates much higher than groups that underwent prewarming (15% vs 6% and 4%).[62]

Hypothermia monitoring and critical identification:

The tympanic membrane, nasopharynx, esophagus and the distal pulmonary artery are the most accurate sites to monitor core temperature.[63,64]

Hypothermia is defined as a body core temperature below 36 °C and classified as mild (36–32 °C), moderate (28–31.9 °C) and severe (less than 28 °C). However, Kirkpatrick,[34] has classified hypothermia in four phases, making a division of the mild phase; one of 36–34 °C and other of 34–32 °C.[65]

effective measures, but also less implemented due to the discomfort for the entire surgical team is to maintain operating room temperatures above 22 °C, but this has been little used in practice.[66]

Effect of warmers in Operation theatres:

Although hot water mattresses have been widely used for decades and are considered as the classic heating system in surgery, actually their effectiveness is limited: the back is just a portion of the total body surface area and 90% of core heat is lost from the previous area of the body. In addition hot water mattresses have been associated with burned areas in pressure zones. [67]

Infusing warm intravenous fluids

It is known that 1 l of saline solution intravenously infused at room temperature decreases the temperature in adults 0.25 °C[68]. However, this is not the main cause of heat loss in plastic surgery patients in which the liquid handling is conservative, although some studies have shown that patients, who were infused with heating systems IV such as Hotline, could have some thermal benefit compared to those without any measure of thermal protection liquid. Heaters should be an alternative only if IV fluids exceed 2 l per hour as in the case of resuscitation or emergency surgery.[49,63]

Summary of the review :

Our goal is to avoid the patient temperature drops below 36 °C. For this, the first step is a continuous monitoring of the core temperature during surgery. To achieve this aim the three most important measures are in order prewarmed the patient with forced air blankets for 1 h before surgery, prewarmed of infiltration liquid at 37 °C in the case of plastic surgery and maintenance air conditioning in operating rooms above 22 °C. All these measures are preventive, easy to implement and economic. Finally, it is important to highlight the need of specific studies about the temperature in the different specialties.

Electric blankets, beds, forced-air warming or convective air-warming transfer, and the heating of irrigation and IV fluids are examples of active warming systems. All of the aforementioned provide the patient with the right amount of heat without requiring external electricity. Perlman et al. demonstrate the effectiveness and ease of use of both passive and active external methods for moderate hypothermia. For moderate hypothermia, humidified gasses, warming blankets, and radiant heaters work well. Patients with severe hypothermia are especially advised to rewarm. According to this systematic review, individuals who get systemic warming have lower rates of perioperative blood loss, shivering, and postoperative wound infection compared to those who do not.

Conclusions

The ambient temperature of the operating room is the most significant factor in determining intraoperative heat loss. Compared to room temperature fluids and any colloid fluid, warm intravenous fluids seem to keep patients warmer during surgery. The optimal temperature in the operating room (23 °C for adults and 26 °C for newborns) is the most important element that determines cutaneous losses through radiation, convection, and evaporation since the amount of heat lost through the skin is proportional to the exposed body surface. Cutaneous warming can be achieved by either passive or active warming, although passive insulation is the simplest approach, even though it is insufficient on its own. To be effective, it should be used in conjunction with cotton blankets, surgical drapes, plastic sheets, and sleeping bags. Preventing hypothermia allows a safer surgery and a more pleasant postoperative recovery. Prevention measures result in great benefits such as reducing the rate of infections, improvement in cicatrization, less blood loss, less need of transfusion and a fast and pleasant wake up after anesthesia.

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Author(s)	Year	Study Type	Population/Country	Sample Size (N)	Intervention/Focus	Key Outcome	Complications/ Notes
Leopold H J Eberhart	2005	Original Article	USA	1849	Shivering risk factors	Identified predictors	Increased O2 demand
Ko-Eun Choi	2017	Systematic Review	Korea	40 studies	Antishivering protocols	Variable efficacy	Lack of standardization
Park Sea Mi	2012	Meta-analysis	USA	2000+	Drug comparison	Meperidine effective	Sedation, nausea
AW Crossley	1992	Review Article	UK	NA	Shivering mechanism	Multifactorial causes	Patient discomfort
Jeffrey L Apfelbaum	2013	Review/Guideline	USA	NA	Post-op care	Normothermia important	Reduced complications
Sung Hee Chung	2012	Original Article (RCT)	Korea	100	Prewarming	Reduced hypothermia	Improved comfort
Hiroshi Hoshijima	2016	Meta-analysis	Japan	1500+	Opioid effects	Remifentanil ↑ shivering	Drug variability
Caruselli M.	2018	Review Article	Italy	NA	Shivering overview	Preventable condition	Needs multimodal care
Destaw B	2020	Original Article	Ethiopia	60	Dexamethasone vs pethidine	Equal efficacy	Steroid safer
Ibrahim IT	2014	Randomized Controlled Trial	Egypt	120	Magnesium sulfate	Reduced shivering	Stable vitals
Bhatnagar S	2001	Original Article (RCT)	India	90	Tramadol vs pethidine	Tramadol effective	Less respiratory depression
Doufas AG	2003	Original Article	USA	60	Dexmedetomidine combo	Synergistic effect	Lower shivering threshold

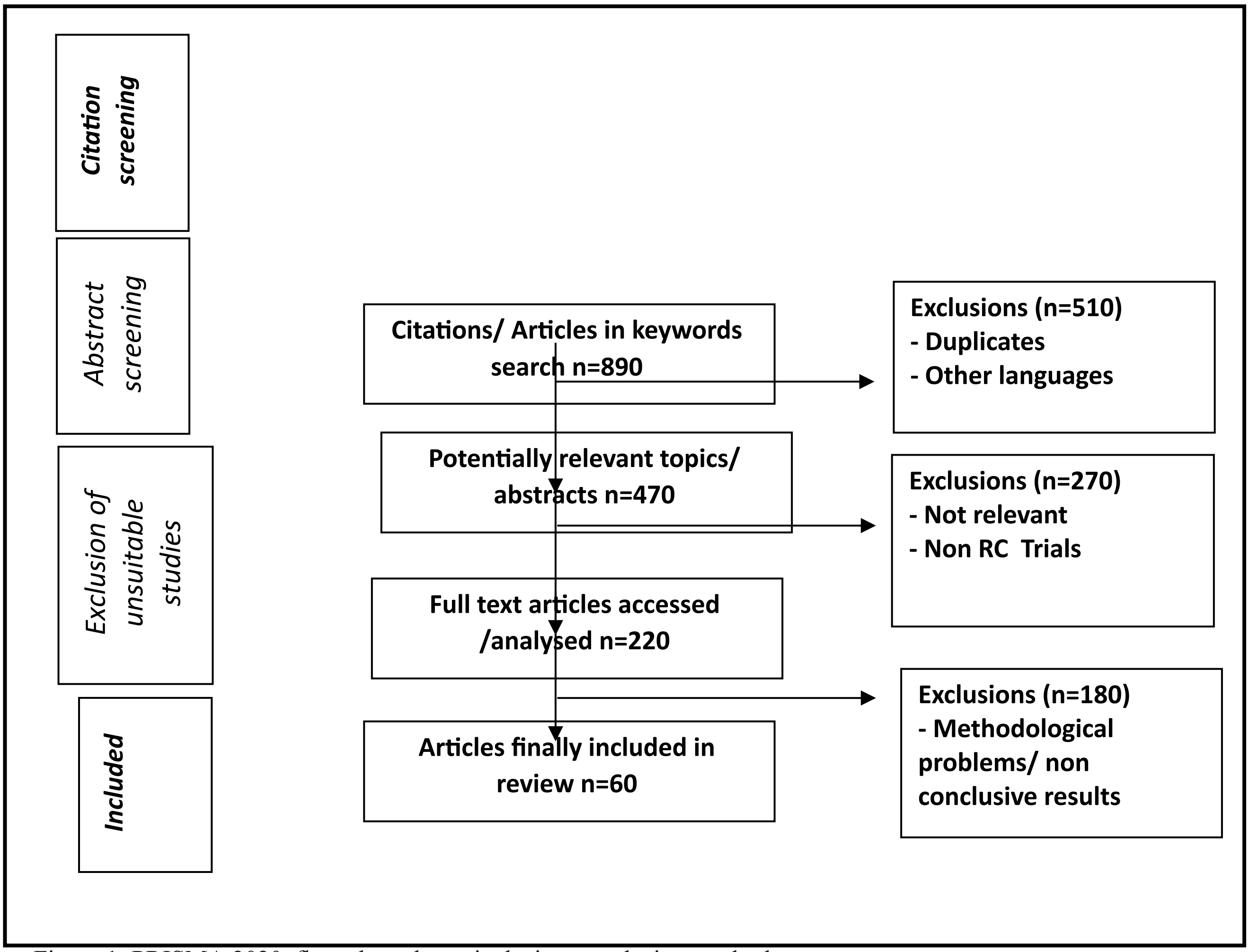

Figure 1: PRISMA 2020, flow chart shows inclusions, exclusions and relevance.