



*Review article*

# Inadvertent Perioperative Hypothermia: A Literature Review of an Old Overlooked Problem

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## SUMMARY

**Inadvertent perioperative hypothermia is a common anesthesia-related complication in patients undergoing surgery. This could possibly lead to several clinical consequences, which adversely affect the surgery outcome, particularly in high risk patient. The combination of anesthetic drugs and cold operating room environment are among the most common predisposing factors of perioperative hypothermia. The aim of this comprehensive literature review is to describe the importance, monitoring techniques, potential complications, appropriate pharmacologic interventions and modalities to manage perioperative hypothermia.**

***Key words:* perioperative hypothermia, thermoregulation, surgery, complication**

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## INTRODUCTION

Inadvertent perioperative hypothermia (PH) is defined as a body temperature lower than 36° C (1-3), and can be observed in 50%-90% of all the patients undergoing surgical procedures in operating room and postanesthetic care unit (PACU) (4-6). As PH potentially causes numerous adverse effects, its prevention may reduce associated morbidity, length of hospital stay, and healthcare costs (7).

Similar to many physiologic control systems, thermoregulation uses negative and positive feedback in the brain to minimize temperature perturbations (1, 2). Core body temperature is usually maintained near 37°C by thermoregulatory system. This homeostasis is achieved by vasoconstriction, vasodilatation, shivering, and sweating, as thermoregulatory defense mechanisms (8). Thermoregulation is usually impaired during general anesthesia (GA) (9). The severity of impairment is dose-dependant, frequently leading to PH in most surgical procedures, lasting more than 1 hour (8, 10).

Anesthetic-induced impairment of thermoregulation (AIIT) results in core-to-peripheral body heat redistribution that consequently leads to PH. It means that the combination of AIIT and exposure to a cool environment of the operating theatre may cause hypothermia in most patients (11). The severity of hypothermia varies in different surgical procedures (12). PH usually occurs in three phases. During the first phase, a fast reduction in core temperature after anesthetic induction happens, mostly due to heat redistribution from core to the body surface. In the second phase, a slower reduction in the core temperature ensues (11). Finally, a core temperature plateau is reached, remaining constant till the end of surgery. The plateau happens passively, or results from the re-emergence of thermoregulatory mechanism in hypothermic patients (13).

The aim of this comprehensive literature review is to describe the importance, monitoring techniques, potential complications, the appropriate pharmacologic interventions and modalities to manage perioperative hypothermia.

## METHODS

A search of the relevant literature was performed within international databases including Scopus, PubMed/Medline, Science Direct using the following search terms or their combinations:

"hypothermia", "perioperative hypothermia", "thermoregulation", "anesthesia", "perioperative", "shivering", "temperature", "warming", "surgery", "operation" and "postoperative complication". These keywords were identified before initiating the search. A hand search of article references was done to ensure thoroughness of the search. Being limiting to the English language, without any time restriction, all articles containing the selected keywords in the title, abstract and text were included and evaluated.

## FINDINGS

### Adverse effects of perioperative hypothermia

PH may lead to some postoperative complications (14), including drug metabolism impairment, prolonged recovery from anesthesia, high plasma catecholamine concentration, cardiac morbidity, coagulopathy, impaired wound healing, wound infections, postoperative shivering, systemic and pulmonary vasoconstriction, increased arterial blood pressure, sympathetic hyperactivation, variations in serum potassium levels, impaired function of neutrophils and macrophages, and decreased partial oxygen pressure (1, 6, 8, 13, 15-17).

Shivering, as a common complication of PH, increases the total body oxygen consumption, due to the increase in the metabolic rate by 400% to 500%, that could be detrimental to high risk patients (1). A study by Karalapillai et al. showed that after major elective non-cardiac surgery, 46% of patients developed postoperative hypothermia. The transient hypothermia (temperature <36°C corrected within 24h), and persistent hypothermia (hypothermia not corrected within 24h) were not associated with increased hospital mortality (5). The incidence of perioperative myocardial ischemia and dysrhythmia were more prevalent in hypothermic patients as compared to normothermic patients (18). Hypothermia could alter the enzymatic reactions velocity, coagulation cascade, and platelet function, thus increasing the demand for red-cell transfusion (11, 18).

It has been reported that mild hypothermia is associated with increased blood loss during surgery (11, 19). Also, it has been revealed that mild PH increased the risk of wound infection, as well as delaying wound healing (20). A study by Hasankhani et al. demonstrated that postoperative mean arterial blood pressure was

significantly increased in the hypothermia group, as compared to normothermia group (17).

### Management of perioperative hypothermia

Preserving perioperative normothermia is crucial for preventing inadvertent HP, as well as its complications. This makes the patients feel more comfortable, increases their satisfaction, and decreases the patients' hospital stay in the PACU(1). The anesthesiology and surgical team (surgeons, preoperative nurses, circulating nurses, scrub persons, and PACU nurses) can use modalities to reduce hypothermia complications.

The American Society of Peri-Anesthesia Nurses introduced the first guideline for PH prevention (1). It provides direction for assessment and interventions during pre-, intra-, and postoperative phases. However, this guideline does not sufficiently provide pre-, and post-operative care. American Association of Nurse Anesthetists' guidelines recommend monitoring of body temperature during local, regional, and general surgical procedures. Similarly, the American Society of Anesthesiologists recommends constant evaluation of body temperature when clinically significant changes in body temperature are intended, anticipated, or suspected (1, 21). In patients undergoing major surgeries or GA longer than 30 minutes, the body temperature should be measured as a standard practice (9, 22).

Many different methods and sites are used to measure the body temperature perioperatively (23). Perioperative temperature monitoring devices vary by transducer type and the monitored site (15). Evidence shows that in noninvasive temperature monitoring, the oral route is the most reliable approach, but suffers from numerous limitations in the intraoperative phase. Infrared ear temperature measurement is inaccurate. Axillary route is the safest approach, and is helpful in patients who cannot have oral temperature readings. The accuracy and precision of axillary site is less than that of other sites. Intraoperatively, acceptable, less-invasive temperature monitoring sites are the nasopharynx, esophagus, and urinary bladder (24). Monitoring of core temperature, among other vital signs, is advisable to detect temperature changes, thus preventing or correcting hypothermia (10). Constant intraoperative core temperature monitoring is recommended in all cases in which operations last longer than 30 minutes. The clinical setting, as well as the procedure used in surgery, determines how the core temperature should be monitored (25).

There are some methods to manage perioperative hypothermia (PH):

**Passive insulation:** Cotton blankets, surgical drapes, plastic sheeting, and reflective composites are available as the thermal insulators in most operating rooms (ORs). Having similar clinical benefits, these can reduce heat loss by approximately 30% (11). Warmed cotton blankets do not affect core temperature and duration of hypothermia, whereas, they decrease radiation of heat. It is essential to keep the warming blanket dry, as the irrigation fluid may easily make it wet. Patients wearing warming gown are more likely to report normal body temperatures, and less likely to ask for additional blankets (13). Heat loss through the skin can be reduced by passive insulation, but most patients need active warming to save normal temperature (26).

**Pre-warmed intravenous (IV) fluids:** Intraoperative administration of warm IV fluids may reduce PH, postoperative shivering, and recovery time (17). The infusion of about 600–700 ml of pre-warmed fluids (41°C) may preserve perioperative normothermia, and decrease the incidence of postoperative shivering (3). Infusion of warm IV fluids, faster than one liter per hour, would be effective in such cases. Large volumes of fluids must be warmed to body temperature before infusion in order to avoid heat loss as well (27).

**Forced-air warming:** Evidence shows that patients who enter ORs with temperatures lower than 21° C became hypothermic (28); thus ORs need to be actively warmed. Use of forced-air warming, as one of several techniques to prevent inadvertent PH, has been recommended for this purpose. Using this method to maintain the temperature in normal ranges has been shown to be cost-effective and efficient. External warming enhances local blood flow, which in turn, increases oxygenation at cellular level. Moreover, warming may increase metabolism and cellular proliferation. Safe application of forced-air warming devices requires selection of the right device, following the manufacturer's recommendations, evaluation of patients' risks, and protecting them from burn injuries.

**Pharmalogical management of shivering:** Shivering sometimes needs pharmacologic treatment, including: pethidine, clonidine, and magnesium sulfate (9). Presence of pain and shivering in postoperative patients justifies the administration of opioids as the first choice in treating shivering. Among opioids, pharmacologic effect of pethidine is unique in increasing the shivering threshold (18). Shivering may be treated by IV administration of pethidine (50 mg within 5 minutes) in almost 90% of postoperative patients. However,

pancuronium acts better than pethidine in treating postoperative shivering among patients undergone cardiac surgery, because it returns oxygen consumption to the baseline more efficiently. Given intravenously, clonidine as a centrally acting agent is effective in shivering. Premedication with oral clonidine produces less shivering in surgical patients (29). Moreover, there is evidence claiming that amino acid infusion during GA may stimulate energy expenditure as a useful and safe method in prevention of perioperative hypothermia (30). Also, it has been shown that ketamine, doxapram and meperidine have similar effect in preventing the postoperative shivering (27).

## DISCUSSION

PH is a common complication of anesthesia. Evidence shows that perioperative hypothermia may increase the risk of infection, bleeding, and dysrhythmia, deserving more attention as a serious risk factor. According to previous studies, temperature should continuously be monitored perioperatively in major

surgeries (24, 29). Forced air warming, as well as covers, may effectively reduce shivering and hypothermia risks, before, during, and after surgery (31).

Using warmed forced-air devices pre- and/or intra-operatively is efficient in minimizing the redistribution hypothermia following induction, whereas intraoperative usage of warmed IV fluids may help in reducing the risk of fluid-induced hypothermia, thereby improving normothermia(32). If the period of anaesthesia is longer than 60 minutes, active warming should be applied. Warming of irrigation fluids could be used as a complementary therapy (27).

In conclusion, perioperative hypothermia has been one of clinicians' concerns in the past decades worldwide. Although some influencing factors and their modalities have been discussed in the literature, reports show that it has not been sufficiently managed up to now, and healthcare systems still suffer from associated financial losses and clinical complications. It seems that future researches must answer the question why this problem still persists.

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## Neželjena perioperativna hipotermija: pregled literature o starom problemu koje se često zanemaruje

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### SAŽETAK

Neplanirana perioperativna hipotermija je česta komplikacija u anesteziji tokom hirurških intervencija. Ona može da dovede do brojnih kliničkih posledica koje negativno utiču na ishod hirurških intervencija, naročito kod visoko rizičnih bolesnika. Kombinacija anestezioloških lekova i hladne operacione sale je među najčešćim predisponirajućim faktorima perioperativne hipotermije. Cilj ovog pregleda literature bio je da prikaže značaj, monitoring tehnike, potencijalne komplikacije, adekvatne farmakološke intervencije i načine za saniranje perioperativne hipotermije.

*Ključne reči:* perioperativna hipotermija, termoregulacija, hirurgija, komplikacija