Perioperative hypothermia in the high-risk surgical patient

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Perioperative hypothermia is common in high-risk surgical patients. Anaesthesia impairs central thermoregulation, allowing re-distribution of body heat. Cool ambient temperatures and high-volume fluid administration accelerate loss of heat to the environment. Randomized, controlled trials have proven that mild hypothermia increases the incidence of wound infection and prolongs hospitalization, increases the incidence of morbid cardiac events and ventricular tachycardia, and impairs coagulation. Other complications include enhanced anaesthetic drugs effects, prolonged recovery room stays, shivering, and impaired immune function. There is compelling animal evidence for cerebral protection by mild hypothermia. However, evidence for protection in surgical patients is not yet available. The most effective means of preventing perioperative hypothermia is active pre-warming. High ambient temperatures, warmed intravenous fluids and active cutaneous warming are useful intra-operatively, while active cutaneous warming and intravenous pethidine abolish post-operative shivering. Proper thermal management may reduce complications and improve the outcome in high-risk surgical patients.

Key words: anaesthesia: general, epidural, spinal; thermoregulation; complications: myocardial ischaemia, wound infection, coagulopathy; economics: recovery room; forced-air warming; fluid warming; shivering.

Inadvertent perioperative hypothermia should be avoided in high-risk surgical patients. While those at risk of cerebral ischaemia may benefit from deliberate induction of mild hypothermia1–3, the majority of patients will be at risk for complications that may adversely affect their outcome.4 Clinicians treating high-risk surgical patients must evaluate the risks and benefits of mild hypothermia in each patient and institute appropriate thermal care. In this chapter, we briefly review the aetiology of
hypothermia in surgical patients, outline the consequences of hypothermia, and discuss strategies to prevent and treat hypothermia in high-risk patients.

AETIOLOGY OF PERIOPERATIVE HYPOTHERMIA

Both general anaesthesia and major regional anaesthesia profoundly disturb thermoregulation, allowing significant core hypothermia to develop. For a comprehensive summary of this subject readers are referred to a recent review.5

General anaesthesia

General anaesthesia disturbs central thermoregulation. This disturbance is mainly evidenced by profound inhibition of arterio-venous shunt vasoconstriction, non-shivering thermogenesis, and shivering, although sweating and vasodilation may also be inhibited. Thermoregulatory responses to decreases in core temperature are not triggered until 2–3 °C of hypothermia (core body temperature of 35–34 °C) has developed during typical general anaesthesia.5

At induction of general anaesthesia, loss of thermoregulatory control leads to loss of tonic thermoregulatory vasoconstriction: arterio-venous shunts dilate, and core-to-peripheral re-distribution of body heat occurs.6 Core temperature typically decreases \( \approx 1 \, ^\circ \text{C} \) within 30 minutes of induction because of re-distribution. Heat production decreases 5%/°C in the absence of shivering7, and heat loss increases owing to exposure of skin and organs to the cold operating-room environment. Volatile surgical preparation, cold intravenous fluids, and dry inhaled gases also contribute to heat loss. When vasoconstriction is triggered, at \( \approx 34 \, ^\circ \text{C} \), core temperature stabilizes. However, heat loss may continue from the peripheral compartment.8 This heat debt will need to be replaced during recovery from anaesthesia, usually by shivering.

Practice points

- identify patients at particular risk of complications from mild hypothermia
- pre-warming is the best way to prevent re-distribution hypothermia
- cover and warm as much of the skin surface as possible during surgery
- prevent or treat post-operative shivering with active cutaneous warming or pethidine

Research agenda

- does hypothermia predispose patients to deep venous thrombosis?
- does impairment of immune function by hypothermia predisposed patients to infections at sites other than the surgical wound, such as pneumonia?
- does mild hypothermia provide cerebral protection in surgical patients at risk of cerebral ischaemia?
- is prevention or treatment of perioperative hypothermia cost-effective in a variety of surgical patients?
Regional anaesthesia

Hypothermia is common during major regional anaesthesia because spinal and epidural anaesthesia affect central thermoregulatory control. The apparent increase in lower-body skin temperature associated with onset of the block results in more hypothermia being tolerated before thermoregulatory responses are triggered. This is an appropriate consequence of an apparent increase in lower-body temperature because skin-surface warming normally decreases the core temperature, triggering cold-defences. A further difficulty is that loss of sympathetic nervous system function in the blocked area means that responses are initiated only in unblocked areas. Because patients feel warm and therefore do not complain of feeling cold, and because body temperature is still rarely monitored during regional anaesthesia, a fair degree of hypothermia may develop in these patients without being noticed by the anaesthetist.

The onset of neuraxial anaesthesia provokes re-distribution of body heat in the affected area. The second phase of hypothermia during regional anaesthesia results from heat loss exceeding heat production. However, core temperature rarely stabilizes during regional anaesthesia because vasoconstriction is prevented, or at least impaired, in the legs.

Combined general and epidural blockade is frequently employed in high-risk surgical patients. However, impairment of central thermoregulation coupled with an inability to recruit thermoregulatory responses in the legs may result in more profound hypothermia than when either technique is used alone. Thermoregulatory impairment by both general anaesthesia and major regional anaesthesia is more profound in the elderly.

THE CONSEQUENCES OF MILD PERIOPERATIVE HYPOTHERMIA

Evidence is mounting, from large randomized trials in high-risk patients, that mild perioperative hypothermia adversely affects outcome from surgery. In contrast, while the animal evidence for cerebral protection by mild hypothermia is compelling, and there is considerable interest in mild hypothermia for reducing brain injury after stroke and aneurysmal subarachnoid haemorrhage, evidence from human trials is

![Figure 1](image-url)
not yet available to support the use of mild hypothermia for cerebral protection during surgery. In contrast, mild hypothermia has proven protective after cardiopulmonary arrest.20,21 Potential risks and benefits of mild hypothermia are discussed in more detail below. One that is not life-threatening, but nonetheless disliked by patients, is thermal discomfort, which can persist for hours (Figure 1).

**Risks of mild perioperative hypothermia**

**Increased cardiac morbidity**

Coronary artery disease is common in elderly patients presenting for major non-cardiac surgery, particularly vascular and thoracic surgery. Even mild core hypothermia may lead to increased circulating catecholamine levels, leading to tachycardia, hypertension, systemic vasoconstriction, and an imbalance between myocardial oxygen supply and demand.22,23 The resulting cardiac morbidity and mortality may seriously prejudice recovery in these patients. Evidence to support this hypothesis was provided by Frank et al.16 These authors conducted a randomized, controlled trial in 300 high-risk patients to determine whether mild perioperative hypothermia increased the incidence of morbid cardiac events. Patients were randomized to routine thermal care or active warming. Perioperative myocardial ischaemia and ventricular tachycardia were more prevalent in hypothermic patients than in normothermic patients. Frank et al concluded that the maintenance of normothermia is associated with a reduced incidence of morbid cardiac events in the perioperative period (Table 1).

**Coagulopathy**

Hypothermia reduces the velocity of enzymatic reactions, and those associated with the coagulation cascade and platelet function are no exception.24,25 In fact, there is an increased requirement for red-cell transfusion during surgery in hypothermic patients undergoing colo-rectal26 or hip replacement surgery. Schmied et al27 retrospectively evaluated the effect of active patient warming, red-cell scavenging and haemodilution on transfusion requirement during joint replacement surgery. They reported that all three strategies contributed significantly to the decreased transfusion requirement over the study period. High-risk surgical patients often have numerous factors predisposing them to coagulopathy (e.g. massive transfusion, trauma, liver dysfunction). A subsequent study demonstrated that a decrease in core body temperature of only 0.5 °C was also associated with increased blood loss.28 In contrast, another study was

<table>
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<th>Table 1. Perioperative hypothermia and surgical wound infection.</th>
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<tr>
<td><strong>Normothermia (36.6 ± 0.5 °C)</strong></td>
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<tr>
<td>Number of patients</td>
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<tr>
<td>Blood transfusion (units)</td>
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<tr>
<td>Number of wound infections</td>
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<tr>
<td>Sutures removed (days)</td>
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<td>Duration in hospital (days)</td>
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*Significantly different from normothermic patients. Data are presented as means ± SDs or numbers.
unable to demonstrate increased blood loss. As perioperative bleeding may result in major morbidity and mortality, prevention and treatment of hypothermia are important.

Wound complications

Many factors conspire to establish wound infections in high-risk surgical patients. Organ or subcutaneous hypoperfusion and hypoxaemia—from haemodynamic instability, systemic hypoxaemia, and stress- or hypothermia-induced vasoconstriction—creates an environment in which contaminating bacteria thrive. In addition, immune responses are impaired by illness, anaesthesia and hypothermia. Efficient wound healing also depends on adequate perfusion, oxygenation, and immune function. Wound dehiscence—and particularly anastomotic breakdown—can contribute significantly to perioperative morbidity and mortality.

Kurz et al. reported the results of a randomized, double-blind trial on the effect of mild perioperative hypothermia on the incidence of wound infection and delayed wound healing. Two hundred patients undergoing major colo-rectal surgery were randomly assigned to routine thermal care or active warming. Wound infections and delayed removal of sutures were more common in hypothermic than in normothermic patients, and hospital stay was increased by 20%. Thus, maintaining normothermia is likely to improve the outcome following colo-rectal surgery (Table 2). That mild hypothermia is associated with surgical wound infections has since been confirmed by an independent group.

Immune function

Immune responses are impaired by mild hypothermia. For example, mild hypothermia was reported to impair neutrophil oxidative killing in one patient study and to suppress lymphocyte activation and production of cytokines in another. As mentioned above, prevention of mild hypothermia decreases the incidence of wound infection following colo-rectal surgery. However, there is no evidence from human studies that the prevention of hypothermia reduces the risk of other perioperative infections such as pneumonia. The results of such a trial would be of great interest as respiratory infections are common in high-risk surgical patients and may have devastating consequences.

<table>
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<th>Table 2. Perioperative hypothermia and morbid cardiac events.</th>
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<td>Number of patients (n)</td>
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<td>Ventricular tachycardia (%)</td>
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<td>Morbid cardiac eventb (%)</td>
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a Significantly different from normothermic patients.
b Morbid cardiac events included unstable angina, myocardial ischaemia, myocardial infarction and cardiac arrest.

Enhanced drug effects

The potency of anaesthetic agents is augmented by hypothermia. Most studies report a $5\%/\text{C} \approx 28\%$ decrease in volatile anaesthetic requirement. In addition, hypothermia alters the distribution and metabolism of anaesthetic drugs. Propofol blood concentrations are $\approx 28\%$ greater at a core body temperature of $34\ ^\circ\text{C}$ than of $37\ ^\circ\text{C}$ because of alterations in intercompartmental distribution. The duration of action of vecuronium is more than doubled by $3\ ^\circ\text{C}$ of hypothermia, probably due to a pharmacokinetic mechanism. Similarly, the duration of action of atracurium increases $60\%$ at $34\ ^\circ\text{C}$. Disturbed drug pharmacokinetics and pharmacodynamics in hypothermic patients must therefore be considered if relative overdose and prolonged recovery from anaesthesia is to be avoided.

Prolonged recovery from anaesthesia

Both medical and economic incentives exist to promote rapid recovery from anaesthesia in high-risk surgical patients. A clear answer to the question 'Does hypothermia prolong recovery?' was not previously forthcoming because existing studies were limited by lack of randomization and blinding. However, Lenhardt et al reported the results of a randomized, blinded study in 150 patients presenting for major surgery. Recovery was significantly delayed in hypothermic patients compared to normothermic patients ($94 \pm 65$ versus $53 \pm 36$ minutes), even when core normothermia was not included as a discharge criterion. These results suggest that maintenance of core normothermia might reduce recovery room costs. Confirmation of this hypothesis awaited a formal pharmaco-economic analysis. Fleisher et al conducted a randomized, blinded trial in which 100 patients were allocated to either forced-air warming or routine thermal care. Post-surgical core temperatures were $1.5\ ^\circ\text{C}$ less in the routine thermal care group. The time from completion of surgery until extubation was significantly less in the normothermic group, although recovery rooms lengths of stay were similar. Net savings of US$15 were calculated if costs were fixed, or US$29 if costs were variable.

Shivering

Shivering is rarely seen in anaesthetized patients because thermoregulatory cold-defences are profoundly inhibited by general anaesthesia. However, as hypothermic patients recover from anaesthesia, shivering is triggered to compensate for the substantial intra-operative heat debt and to increase core temperature. The most important consequences of shivering are extreme discomfort and impairment of monitoring in high-risk surgical patients. Shivering increases metabolic rate, and may lead to imbalances between oxygen supply and demand. However, elderly or debilitated patients shiver less effectively than younger patients and so it is unlikely that shivering itself actually causes adverse outcomes. Nevertheless, shivering should be prevented simply because it is uncomfortable for patients.

Re-distribution of body heat and enhanced heat loss to the environment often produces hypothermia sufficient to trigger shivering in patients under spinal or epidural anaesthesia, even though neuraxial anaesthesia decreases the shivering threshold. Vigorous shivering may disrupt the operation and, during Caesarean delivery, prevent the mother from holding her baby. Shivering during regional anaesthesia is not particularly effective at increasing core temperature because upper body muscles fail to
compensate for lower-body paralysis. Operating conditions and patient comfort will be enhanced if shivering is prevented.

**Venous stasis**

Deep venous thrombosis is a common and serious development in post-operative patients. Vasoconstriction may facilitate thrombosis by producing venous stasis and hypoxia. Tayefeh et al reported that vasodilation increases venous oxygen saturation and shunt flow in awake and anaesthetized volunteers. The corollary is that thermoregulatory vasoconstriction may promote deep venous thrombosis. This hypothesis awaits confirmation by a suitably designed clinical trial.

The benefits of mild perioperative hypothermia

**Cerebral protection**

The brain is at risk of ischaemia during a variety of surgical procedures, including neurosurgery, carotid endarterectomy and cardiopulmonary bypass. In addition, haemodynamically unstable patients are at risk of cerebral hypoperfusion. The outcome from cerebral ischaemic events can be devastating. This explains the intense interest in the use of mild hypothermia for cerebral protection.

The animal evidence for cerebral protection by mild hypothermia is compelling. Some human studies support the use of moderate hypothermia in severe head injury. For example, Marion et al reported that induction of moderate hypothermia for 24 hours in patients with Glasgow Coma Scores of 5–7 hastened neurological recovery and may have improved outcome. However, Hartung and Cottrell have questioned the statistical validity of this post hoc sub-group analysis. Furthermore, the largest (and best) prospective randomized evaluation of hypothermia for head trauma failed to identify a benefit. While there is considerable interest in mild hypothermia to reduce brain injury after stroke and aneurysmal subarachnoid haemorrhage, no sufficiently large, prospective randomized trials in humans support this therapy.

No human trials currently published support the use of mild hypothermia during surgery. Hindman et al published the results of a randomized pilot study in patients presenting for cerebral artery aneurysm clipping. There were trends towards improved outcomes in patients with acute subarachnoid haemorrhage and no suggestion that inducing hypothermia adversely altered the outcome. These authors are completing a large, randomized trial in patients with aneurysmal rupture (IHAST-II), which may provide the answer to this tantalizing question.

**Myocardial preservation**

Most of the myocardial oxygen consumption relates to electromechanical activity. Mild hypothermia increases the incidence of morbidity cardiac events in the beating heart. Once contraction has been halted by cardioplegia, though, hypothermia provides only modest additional protection. Myocardial hypothermia is often induced independent of systemic temperature, and during re-perfusion myocardial normothermia is readily restored. Protection may therefore be provided to the heart without exposing the patient to the risks of systemic hypothermia. There is also convincing animal evidence that mild hypothermia provides protection in the context of acute myocardial
infarction. A large human trial of endovascular cooling for acute myocardial infarction has been completed, but the results have yet to be released.

Other benefits

Malignant hyperpyrexia is more difficult to trigger in hypothermic swine than normothermic swine, and the severity of the syndrome is less severe if triggered in the hypothermic swine. The induction of core hypothermia may also be beneficial in patients with adult respiratory distress syndrome.

PREVENTION AND TREATMENT OF MILD PERIOPERATIVE HYPOTHERMIA

The risk–benefit analysis in high-risk surgical patients usually favours maintenance of core normothermia in the perioperative period, and randomized controlled trials have proven that maintenance of normothermia can reduce the complications of hypothermia. The most effective means of maintaining normothermia is prevention, by pre-warming. Without pre-warming, a period of hypothermia is typical even if active warming is instituted after induction of anaesthesia.

Prevention of re-distribution hypothermia

Re-distribution after induction of anaesthesia is the most important cause of perioperative hypothermia. Re-distribution accounts for 81% of the decrease in core temperature in the first hour after induction and 43% in the subsequent 2 hours. The extent of re-distribution is proportional to the gradient between the core and peripheral compartments. Several factors influence this gradient, including ambient temperature, degree of adiposity and concurrent medications. The extent to which re-distribution will decrease core temperature in individual patients is thus difficult to predict.

Re-distribution hypothermia is difficult to treat. However, pre-warming prevents re-distribution hypothermia during general anaesthesia or regional anaesthesia. Pre-warming increases the heat content of the peripheral thermal compartment, reducing the gradient for re-distribution. One hour of active cutaneous warming with a forced-air warmer set on ‘high’ (∼43 °C) transfers sufficient heat to counteract the effects of re-distribution. Core temperature is usually not increased, although sweating and thermal discomfort may occur with prolonged warming. Pre-warming may be particularly cost-effective in high-risk patients having extensive surgery.

Another means of increasing the heat content of the peripheral thermal compartment is to administer vasodilators before anaesthesia (pre-dilation). Increased perfusion of the peripheral compartment increases its heat content and decreases the gradient for re-distribution. Nifedipine, 20 mg given orally 12 hours before surgery and 10 mg sublingually 1 hour prior to induction, prevented re-distribution hypothermia in surgical patients. The key element of this method is to give vasodilating medications well in advance of surgery so that the thermoregulatory system has sufficient time to increase peripheral tissue temperature without risking core hypothermia.

Obese patients essentially pre-warm themselves by pre-dilation, accounting for their reduced incidence of perioperative hypothermia. Increased heat production in obese
patients, along with excellent insulation by fat, means that obese patients are vasodilated for much of the time, thereby reducing the gradient for re-distribution.

**Intra-operative warming**

**Cutaneous warming**

A sufficiently high ambient temperature will maintain or re-establish core normothermia during anaesthesia. However, operating room personnel cannot usually tolerate the high ambient temperatures required (>23 °C). Furthermore, thermal discomfort impairs cognitive performance. Consequently, additional strategies need to be employed. A variety of passive and active warming devices is available for this purpose.

Passive coverings are effective and relatively inexpensive. The most important principle is to cover as much of the skin surface as possible. Different types of passive coverings, such as sheets, blankets, drapes and ‘space blankets’ perform similarly, each reducing heat loss by ≈30%. Three blankets reduce heat loss only 18% more than one blanket (Figure 2). Warming the blankets makes them more comfortable for patients but is inefficient because the additional heat transfer is trivial.

Active warming devices are more effective than passive coverings at transferring heat and can, over time, reverse the hypothermia that has developed due to redistribution. Once again, the total surface area covered by the device is critical. Devices are more efficient when positioned on top of the patient, rather than underneath, because little heat is lost from the back to the operating table.

When used intra-operatively, forced-air warming devices increase core temperature by about 0.75 °C/hour. Circulating-water blankets are effective when positioned above patients but are nearly ineffective when placed underneath. Electric blankets are also effective. Cutaneous warming remains effective when thermoregulatory vasoconstriction has been triggered. Peripheral non-shunt vasodilation induced by anaesthetic agents allows intercompartmental transfer of heat—which facilitates transfer of applied heat from the skin surface to the core thermal compartment.

![Figure 2](image.png)

**Figure 2.** A single cotton blanket reduces heat loss by 30%. However, adding two additional blankets reduces heat loss to only 50%. Reproduced from Sessler DI and Schroeder M (1993, *Anesthesia and Analgesia* 77(1): 73–77; Heat loss in humans covered with cotton hospital blankets) with permission.
Intravenous fluid warming

Room-temperature intravenous fluids can contribute substantially to heat loss during surgery. One litre of room-temperature crystalloid decreases mean-body temperature by \( \approx 0.25 \ degrees \ C \). However, core temperature transiently decreases at least twice that much because re-distribution to peripheral tissues is a relatively slow process. High-volume fluid resuscitation often occurs in patients who have other major risk factors for hypothermia such as major trauma or extensive surgery. Fluid-warming devices should therefore be used if more than \( \approx 2 \) litres of fluid are transfused within 1 hour. When lesser volumes are given, warming is not required unless core normothermia cannot otherwise be maintained.

Heating airway gases

Various means of heating and humidifying airway gases have been advocated for the prevention of heat loss during surgery. Most are effective at retaining heat and moisture in the airway. However, heat loss across the airway is trivial compared to other routes of heat loss during surgery (less than 5% of basal metabolic rate). Consequently, heating and humidifying airway gases has minimal impact on body temperature.

Post-operative warming

In the care of the high-risk surgical patient, anaesthetists should aim to prevent hypothermia or restore normothermia before emergence from anaesthesia because post-operative hypothermia and shivering are detrimental to patient outcome. However, patients who are hypothermic at the end of surgery will require treatment.

Unfortunately, active post-operative warming is relatively inefficient because anaesthetic-induced direct vasodilation no longer facilitates peripheral-to-core transfer of body heat. Smith et al compared forced-air warming with passive coverings during and after knee arthroscopy. Active warming reduced the duration but not the incidence of shivering, and did not reduce the duration of recovery room stay. Similarly, Villamaria et al compared forced-air warming with passive coverings in patients after coronary artery bypass surgery and found no difference between the two groups. In contrast, Pathi et al demonstrated a difference between active warming (with a forced-air warmer or an electric blanket) and passive coverings, and Plattner et al reported that forced-air warming increased core temperature more than passive covers in hypothermic post-operative patients. Differences in heat debt and anaesthetic technique may account for these apparently divergent results.

Prevention and treatment of shivering

As mentioned above, shivering can be uncomfortable for patients and comes at a substantial metabolic cost. Generally, shivering should be prevented by maintaining normothermia. But if that isn’t possible in particular cases, shivering should be effectively treated.

Active cutaneous warming is effective at abolishing shivering, long before enough heat is transferred to increase core temperature above the shivering threshold. The explanation for this phenomenon is that the skin is an important source of thermal information, contributing roughly 20% to afferent thermal input. There is an inverse
relationship between skin temperature and the core temperature triggering shivering.\(^9\)

Therefore, increasing skin temperature decreases the shivering threshold and terminates shivering. In patients recovering from general anaesthesia, as much of the skin surface as possible should be warmed. In patients recovering from epidural or spinal anaesthesia, only sentient skin needs to be warmed to abolish shivering. However, more extensive warming will facilitate restoration of normothermia. A limitation of cutaneous warming is that it can compensate for only a modest degree of hypothermia. For example, a 5 °C increase in mean skin temperature will treat only shivering that is induced by core hypothermia within 1 °C of the shivering threshold. Even the best generally available, non-invasive warming system, forced-air, increases mean skin temperature only about 3 °C.

Most anaesthetic agents produce a dose-dependent reduction in the shivering threshold. This explains why patients shiver in the recovery room even though there has been no significant change in their core temperature. Therefore, any anaesthetic agent that decreases the shivering threshold will effectively abolish shivering. Agents proven to be effective are numerous\(^{45}\) and include pethidine (meperidine)\(^{75}\), alfentanil\(^{76}\), sufentanil\(^{77}\), clonidine\(^{78}\), ketanserin\(^{78}\) and physostigmine.\(^{79}\)

Opioid analgesics are often the first choice for the treatment of shivering because pain often co-exists with shivering in post-operative patients, and because opioids are relatively non-sedating. Pethidine is more effective than the other opioids because it causes a disproportionate reduction in the shivering threshold.\(^{75}\) Pethidine’s special anti-shivering action may result from its action at many different receptor sites\(^{45}\), but does not appear to result from stimulation of kappa opioid receptors or a central anti-cholinergic action.\(^{80}\) Shivering during epidural or spinal anaesthesia can be treated with systemic opioids, or epidural or spinal opioids.\(^{81}\)

**SUMMARY**

General and major regional anaesthesia impair central thermoregulation, allowing substantial hypothermia to develop during surgery. The principal initial cause of hypothermia is core-to-peripheral re-distribution of body heat. This is followed by a slower, linear decrease in core temperature that results from heat loss to the environment exceeding metabolic heat production. Perioperative hypothermia contributes significantly to post-operative morbidity and mortality by increasing the incidence of wound infection and prolonging hospitalization, increasing the risk of morbid cardiac events and ventricular tachycardia, and increasing the need for blood transfusion through impairment of coagulation. Cerebral protection by mild hypothermia, which is proven in animals, awaits confirmation in surgical patients.

Pre-warming is the most effective means of preventing mild perioperative hypothermia. During surgery, active cutaneous warming, fluid warming, and high ambient temperatures are useful. If hypothermia is not prevented intra-operatively, shivering is common in the recovery room. Shivering is distressing for patients and should be treated. Active cutaneous warming and intravenous opioids, especially pethidine, can abolish shivering. The cost-effectiveness of perioperative warming has not been established across the range of surgical procedures. Nevertheless, proper thermal management has the potential to improve the outcome for high-risk surgical patients.
REFERENCES


Perioperative hypothermia in high-risk surgical patients


