

INADVERTENT PERIOPERATIVE HYPOTHERMIA

Definition

Hypothermia is the state where the core body temperature has dropped below 36 degrees centigrade, irrespective of the cause.

The Problem

There is a general lack of appreciation for the incidence and effects of perioperative hypothermia. As such, perioperative hypothermia is underdiagnosed and poorly managed.

Physiological changes due to hypothermia may be severe and affect patient outcome. Perioperative hypothermia is detectable and generally preventable.

More than 90% of surgical patients experience hypothermia perioperatively, with at least a one degree drop in their core temperature intra-operatively. Core temperature usually decreases 1°C during the first 30 to 40 minutes of general anaesthesia due to redistribution of heat. After this period, rapid heat loss may occur due to a host of factors.

Physiological Effects of Hypothermia (in awake patients)

The degree of hypothermia can be classified as follows:

Mild	32 – 35 degrees centigrade
Moderate	30 – 32 degrees centigrade
Severe	below 30 degrees centigrade

In Mild Hypothermia

The body seeks to diminish peripheral heat loss and preserve body temperature by peripheral vasoconstriction, resulting in the skin becoming cold and mottled.

The blood pressure and pulse increase in order to circulate blood to the extremities, and cardiac output is increased by 400% - 500%, this extra effort may result in cardiac arrhythmia.

Respiration and oxygen consumption are increased, leading to shivering. A shivering patient requires supplemental oxygen.

The suppression of anti-diuretic hormone (adreno-corticotrophic hormone) induces a cold diuresis and dehydration occurs within two hours.

Liver function is reduced, leading to impaired drug metabolism.

In Moderate Hypothermia

The cardiac output falls and the pulse slows and the level of consciousness is decreased, because the heart is unable to maintain the extra effort needed to force blood around a cold body.

Respiration slows as oxygen consumption falls and the respiratory centre becomes depressed. The blood vessels dilate and cause further heat loss.

Insulin levels are increased, and this causes hypoglycaemia.

The patient becomes more agitated and shivering decreases.

Kidney perfusion is reduced and leads to inefficient excretion of drugs.

In Severe Hypothermia

All symptoms become exaggerated, the patient loses consciousness and becomes increasingly acidotic due to anaerobic metabolism.

This results in the production of lactic acid rather than carbon dioxide.

Liver function is diminished and the skin becomes oedematous.

Intra-Operative Heat Loss

Risk factors are:

Age – the very young and the elderly being especially vulnerable

Disease state - Risk of heat loss increases with an increasing degree of systemic disease. Burn patients are also at increased risk, as well as patients with small body mass, impaired muscle mass, circulatory compromise, muscle atrophy, or thyroid disease

General Anaesthesia causes the following problems:-

- Thermoregulation impaired by depression of the thermoregulation centre.
- Inhalation of unheated non-humidified gases, leading to heat loss by evaporation. Volatile agents cause vasodilatation leading to increased heat loss.
- Skeletal muscle relaxants prevent reactive shivering.
- Certain drugs used frequently in anaesthesia impair thermoregulation.
- Pre-operative fasting reduces the ability to produce energy and heat from food.
- Administration of cool intravenous fluids and blood.

Environment

- Transfer to theatre along cold corridors in a thin gown.
- Exposure in anaesthetic room for monitoring.
- Exposure for surgery in a cool theatre.
- Anaesthesia causes poikilothermia (body temperature fluctuates according to environment).
- Theatre ventilation and air changes increase heat loss by convection.

Surgery

- Large areas of body exposed.
- Cool lotions used in preparing skin for surgery.
- Wet and thin drapes.
- Types of surgery (heat loss increased by 70% in abdominal surgery)
- Opening of body cavities hastens heat loss. Peritoneal lavage with cool fluids.

Methods of Preventing Inadvertent Hypothermia

- Increase the knowledge and awareness of staff.
- The theatre temperature should be above 24 degree centigrade and this will ensure that the patients will remain normothermic.

- Monitor temperature of patient carefully throughout surgery.
- Reduce patient exposure.
- To take the base-line temperature of the peri-operative patient when possible.
- Use a warming mattress on the theatre table.
- Prepare skin using room temperature fluid.
- Use several layers of drapes.
- Cover the head of the peri-operative patient with a theatre hat to retain body heat.

- Use warming blankets and Bair Huggers.
- Use warming coil for administration of all administration of all volatile gases.
- Transfer patients to pre-warmed beds.

Complications of Inadvertent Hypothermia

Perioperative hypothermia may result in serious complications affecting the outcome of the patient in terms of morbidity and mortality.

Cardiac Events

Two thermoregulatory responses to hypothermia may have detrimental cardiovascular effects. The first response is sympathetically mediated vasoconstriction, which increases arterial blood pressure. The second is shivering, which increases metabolic demands. High-risk surgical patients with a core temperature of less than 35°C have a two- to threefold increased incidence of early postoperative myocardial ischemia, independent of age and anesthetic technique. Patients who are aggressively

warmed during surgery have been shown to experience a decreased incidence of postoperative cardiac morbidity.

Coagulation and Need for Transfusion

Hypothermia significantly impairs the coagulation system through three mechanisms: platelet function, the coagulation cascade, and fibrinolysis. Platelet numbers remain normal during mild hypothermia, but their function is impaired because of inhibition of the formation of the initial platelet plug. The function of enzymes in the coagulation cascade is slowed by hypothermia. Studies suggest that fibrinolysis is enhanced by hypothermia, impairing clot formation.

A metaanalysis of study results from randomized controlled trials indicated that even mild hypothermia (less than 1°C) significantly increases blood loss by approximately 16% and increases the risk of requiring a transfusion by approximately 22%.

Wound Infection and Healing

Hypothermia may contribute to postoperative wound infection by directly impairing immune function and by triggering vasoconstriction, which decreases cutaneous blood flow and reduces the oxygen delivery to tissues. A randomized controlled study demonstrated that patients with a drop of average core temperature of approximately 2°C were three times more likely to develop surgical site infections. This effect was thought to be due to decreased macrophage function and decreased tissue oxygen tension, the latter of which is related to decreased tissue perfusion. The same study found that hypothermia contributed to delay in the time thought appropriate to remove sutures. Hospitalizations in hypothermic patients were demonstrated to be 20% longer than those of normothermic patients.

Pharmacokinetics and Pharmacodynamics

Perioperative hypothermia affects the metabolism of drugs because the enzymes that moderate organ function and metabolize duration of action drugs are highly temperature sensitive. Hypothermia lengthens the duration of action of muscle relaxants, although the pharmacodynamics of vecuronium has been found to be unaffected by mild hypothermia. Mild hypothermia alters propofol pharmacokinetics and during a constant infusion of propofol, the plasma concentration is approximately 30% greater than normal when individuals are 3°C hypothermic.

Hypothermia alters the pharmacodynamics of volatile anesthetics. The solubility of inhaled anesthetics is increased with hypothermia; consequently, at a steady-state plasma partial pressure, body anesthetic content increases. Inhaled anesthetic potency is related to partial pressure, not concentration, and remains unaffected. The increased solubility of volatile anesthetics and increased duration of the action of muscle relaxants suggests that hypothermia may delay emergence and recovery from general anesthesia.

Core Temperature Monitoring

Some risk factors for inadvertent perioperative hypothermia, such as age or body mass, may not be changed or avoided. Consequently, monitoring of core temperature and prevention of hypothermia are indispensable in preventing the complications associated with inadvertent perioperative hypothermia.

When to Measure

Core temperature usually decreases 1°C during the first 30 to 40 minutes of anesthesia induction due to initial core-to-peripheral redistribution of body heat. Monitoring core temperature alerts the provider to the need for preventative and corrective action.

Recommendations for perioperative temperature measurement:

1. Patients given general anesthesia and expected to undergo procedures exceeding 30 minutes and during regional anesthesia when changes are anticipated or suspected
2. In all patients when clinically significant changes in body temperature are intended, anticipated or expected.
3. All pediatric patients receiving general anesthesia
4. Any major procedure performed under regional anesthesia
5. All operations where major fluid shifts and/or haemorrhage are anticipated
6. Trauma or other cases where the patient is already hypothermic
7. Cold ambient temperatures

How to Measure Temperature Perioperatively

Core temperature may be monitored during general anesthesia in the pulmonary artery, nasopharynx, tympanic membrane, and distal esophagus, which are all sites that are reliable and accessible during surgery.

- Pulmonary artery catheters measure central blood temperature, and is considered the gold standard.
- Nasopharyngeal and distal esophageal temperature is accurate and is most commonly used.
- Tympanic temperature is often the preferred method in the preoperative and perioperative areas. The tympanic membrane is close to the carotid artery and hypothalamus and is a noninvasive and accurate measure of core temperature.

If the above-mentioned core temperature sites cannot be used in a particular clinical setting, the bladder, rectum, axilla, and skin may be used.

Methods of Preventing Hypothermia

To prevent hypothermia, temperature is maintained by balancing heat loss with heat gain, either from the body's own internal metabolic heat production or from an external source of heat.

Cutaneous Warming

Room temperature is the most critical factor in preventing perioperative heat loss from the patient because it determines the rate at which heat is lost by radiation and convection from the skin and by evaporation from within surgical incisions. Increasing the ambient OR temperature to 26°C reduces the incidence of core hypothermia in younger and older patient populations, but most OR personnel find this temperature uncomfortably warm.

Recommended theatre ambient temperature is 22-24°C, with an absolute minimum of 20°C.

It is accepted that 90% of metabolic heat is lost through the skin, thus it is imperative to prevent cutaneous heat loss through passive insulation and the use of active cutaneous warming systems.

Passive Insulation

Passive insulators are readily available and include cotton blankets, surgical drapes, plastic sheeting, and reflective space blankets. A study found that a single layer of each type of insulator may reduce heat loss by 30% with no differences noted among the insulation types. The addition of layers of insulating material increases efficacy, but the efficacy of passive insulators is directly proportional to the covered surface area.

Active Cutaneous Warming Systems

Active skin warming systems include the following:

Forced-air warming blankets (eg Bair-Huggers) are highly effective and may maintain normothermia even during extended operations.

Resistive heating (electric blanket) has been found to be as effective as forced-air heating.

Other Warming Methods

- Warming of IV fluids and blood is indicated, especially when more than two liters of fluid per hour are administered to an adult.
- Warming of irrigation fluids to decrease intraoperative heat loss especially during open cavity surgery.
- Pre-warming of patients prior to induction of anesthesia, including warming of patients in the wards and maintaining this throughout transfer to the OR. This prevents the rate of rapid redistribution of heat in the first 30min of anaesthesia and also reduces subsequent heat loss. It also reduces postoperative shivering in procedures lasting three hours or longer.

Interventions

Measures to prevent inadvertent hypothermia include the following:

- Prewarming patients
- Increasing ambient room temperature (minimum 20° to 24°C)
- Increasing ambient room temperature to higher than 26°C for neonates
- Increasing ambient temperature to greater than 28°C for patients with severe trauma or extensive burns
- Minimization of skin exposure by covering parts of the body not involved in the surgical procedure
- Passive insulation
- Forced-air warming
- Warming IV fluids and irrigation fluids to body temperature
- Warming and humidifying inspired gases
- Continuous monitoring of intraoperative temperatures in infants, neonates, severe trauma patients and patients with extensive burns

Postoperative Period

- Assess patients' temperature on admission to PACU/Recovery area
- If normothermic, assess the patient's temperature before discharge from the PACU or as ordered.
- If hypothermic, implement active warming strategies and monitor serial temperatures at least every 30 minutes until patient becomes normothermic.
- Do not allow discharge from PACU/Recovery area if the patient has any signs and symptoms of hypothermia, especially shivering.

Barriers to effective implementation of practice to prevent hypothermia:

1. High staff turnover
2. Lack of evidence-based guidelines
3. Surgeon resistance, because the benefits of warming are not immediately apparent and the comfort of operating theatre staff is considered more important than potential patient benefit.
4. Ignorance of operating staff to the deleterious effects of perioperative hypothermia.

Conclusion

Perioperative hypothermia occurs very frequently and has deleterious effects on patient outcome. The literature shows that maintaining perioperative normothermia reduces complications and improves outcome in patients at risk.

Perioperative temperature monitoring and active warming interventions allow prevention of perioperative hypothermia to be an obtainable goal.