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Avoiding inadvertent peri-operative hypothermia

The body’s thermoregulatory mechanisms usually maintain body temperature between 36.5°C and 37.5°C. However, patients undergoing anaesthesia and surgery encounter situations that cause core temperature to fall. If a surgical patient’s core temperature falls below 36°C during the peri-operative journey, it is classed as inadvertent peri-operative hypothermia (IPH). It occurs in around 20% of patients (Harper et al, 2008) and can be caused by two factors that reduce core temperature in surgical patients: impaired thermoregulation caused by anaesthesia and exposure to a cold environment.

Anaesthesia-impaired thermoregulation
Anaesthesia can impair temperature regulation by inhibiting sweating, vasoconstriction and shivering. The administration of anaesthesia leads to an initial rapid decrease in core temperature as vasoconstriction is restricted and core heat flows to the periphery where it might be lost to the environment. This redistribution of heat can cause a reduction in core temperature of up to 1.5°C during the first hour of anaesthesia. This initial rapid reduction is followed by a slow reduction in core temperature, caused by heat loss exceeding heat production, which stabilises after around four hours of administration of anaesthesia (Sessler and Kurz, 2007).

Exposure to a cold environment
Surgical patients are exposed to cold environments throughout surgery. For example, low ambient temperatures in the operating room are a concern for patients whose internal organs are exposed or whose clothing has been removed. With the exception of paediatric and burns theatres, operating room temperatures are usually set at 21-23°C to provide comfortable working conditions for the surgical team (Hart et al, 2011). This low ambient temperature can fall further due to wind chill from laminar air flow systems. Additional cooling results from fluids used to clean wound sites, irrigate or wash out wounds, deliver drugs or maintain fluid volume (Diaz and Becker, 2010).

Complications and interventions
Inadvertent peri-operative hypothermia is associated with numerous serious patient complications (Box 1), but can be avoided through thermal insulation and active warming. Thermal insulation aims to prevent heat loss and active warming is the

5 key points

1. Up to 40% of surgical patients experience hypothermia
2. Hypothermia is associated with impaired thermoregulation caused by anaesthesia and exposure to a cold environment
3. Hypothermia increases the risk of complications including cardiac events and surgical site infections
4. Symptoms can be reduced through active warming
5. Warming patients pre-operatively can help maintain body temperature
process of transferring heat to the patient. Insulation from space blankets or sheets made of cotton or plastic reduces heat loss by around 30%, although adding more sheets makes little difference (Sessler, 1993), while fluids can be warmed to minimise heat loss. Endotracheal warming systems can also be used, but since only a small amount of heat is lost through respiration this will have a minimal effect (Hynson and Sessler, 1992). Although preventing heat loss is important, insulation alone will not maintain normothermia in surgical patients. Therefore active warming should be implemented.

Active warming devices deliver heat to the patient’s skin through one of three processes:

- Convection (circulating warm air);
- Conduction (contact with a warm surface);
- Radiant heat (waves from a heat source).

Each approach has its advantages and disadvantages.

**Convection**

Forced-air warming devices, such as Bair Hugger, Bair Paws and Warm Touch, surround patients with circulating warm air. These devices comprise a warming air unit with a blower attached via a hose to a disposable gown or blanket. The gown or blanket is punctured on one side with a series of tiny holes that direct a current of warm, filtered air over the patient, which can be regulated at a constant degree of heat. Since they are disposable, the blankets do not require cleaning or maintenance, although filters in the warming unit need to be changed according to the manufacturer’s instructions.

There is concern, mainly among orthopaedic surgeons, that the air flow from the blower creates turbulence and eddies in the laminar air flow field, which direct unclean air from the floor towards the surgical site (Dasari et al, 2012). Studies testing forced air warming in laminar flow systems found mixed results regarding particle counts at the operating site (Legg and Hamer, 2013; Sessler et al, 2011). A summary review of 10 studies found forced air warming contaminates ultra-clean air ventilation but found no link to increased risk of surgical site infection (Wood et al, 2014). However, the review was not systematic and did not include high-quality randomised controlled trials.

**Conduction**

Resistive heating products provide a warm contact surface area. A low voltage, similar to that required to power a light bulb, passes through a semi-conductive polymer inside a mattress or blanket, where it is converted into heat and distributed uniformly. These products do not contain heating elements and therefore do not have localised ‘hot spots’. Some resistive heating mattresses also have pressure-relieving properties. This prevents occlusion of small blood vessels in areas of high pressure due to the weight of the patient, causing blood vessels to remain patent and blood to circulate and distribute heat.

These warming mattresses and blankets are not disposable. They must be cleaned after each use and may require storage and maintenance. Examples of resistive-polymer warmers are Inditherm, MedWarm, Hot Dog and Geratherm.

Circulatory warming systems, such as water-filled mattresses are rarely used. Placed underneath patients, they do not transfer large amounts of heat because heat loss from the back is minimal (Sessler and Kurz, 2007). They are associated with localised heat injuries or ‘hot spots’ due to compression of the tissues by the patient’s weight (Wood et al, 2014).

**Radiant heat**

Radiant heat sources, such as SunTouch, are more likely to be used during surgery for neonates or young children than adults. Studies suggest they are as effective as forced air warming (Wong et al, 2004), but can be uncomfortable for staff as they raise the ambient temperature.

**Which method is most effective?**

A systematic review including 19 randomised controlled trials, with 1,785 surgical patients, found active warming reduced hypothermia (Sajid et al, 2009). Numerous studies have been undertaken to identify whether one warming system is more effective than another. A recent systematic review of the prevention of perioperative hypothermia (IPH) – which included 29 trials and 1,875 patients – found forced air warming was more effective than circulating water mattresses but there was no difference in surgical patients, found active warming...
between forced air warming, resistive heating or radiant warming (Nieh and Su, 2016). However, regardless of which active warming system is used, anecdotal opinion suggests the most effective approach to intra-operative warming is to use a mattress underneath a patient combined with a blanket on top, providing maximum surface contact.

Pre-operative warming

Until recently, patient warming focused on the intra-operative phase, with warming devices being applied once the patient had been anaesthetised and transferred to the operating table. However, evidence shows this is too late in the patient journey and patients are already hypothermic at this stage due to the rapid drop in temperature caused by the anaesthetic (Sessler and Kurz, 2007). Even with a warming device in place, it can take up to two hours for a patient’s temperature to increase to 36°C (Sessler and Kurz, 2007).

Warming patients pre-operatively has been shown to act as a buffer, protecting the patient from the rapid decrease in core temperature caused by the anaesthetic (Hynson and Sessler, 1992).

While the temperature of pre-warmed patients will fall on induction of anaesthesia, the fall will not be as great as in those who do not receive pre-warming. A systematic review, including 14 randomised controlled trials, suggested hypothermia was reduced among patients who were warmed pre-operatively (de Brito Poveda et al, 2013). Clinical benefits have also been proven. For example, a randomised trial found the rate of surgical site infection reduced from 14% to 5% when pre-operative warming was implemented (Melling et al, 2001).

A study to identify the optimum duration of pre-operative or pre-induction warming found it to be just 15 minutes (Horn et al, 2012), which could easily be carried out in theatre reception bays.

If we use data from existing studies, we can construct a scenario that shows the potential cost-effectiveness of pre-operative warming. For example:

- A study in Scotland found the rate of surgical site infection (SSI) for breast surgery to be 9% (Reilly et al, 2006).
- Melling et al (2001) found that pre-operative warming reduced SSI rates among patients having breast surgery by 64% (14% down to 5%);
- Tanner et al (2011) found the cost of treating a breast surgical infection was £1,000, while the cost of a pre-operative warming gown was £15.

In a large operating department, where 400 patients receive breast surgery each year, the annual cost of implementing pre-operative warming is £6,000 but the subsequent reduction in SSIs would save £24,000. There would also be savings made from the reduction in other complications caused by hypothermia, including cardiac events and longer recovery times.

Conclusion

Inadvertent peri-operative hypothermia is a common condition among surgical patients, and causes a range of serious complications, but it can be prevented through active warming in the pre-operative and intra-operative phases.

References


