Inadvertant hypothermia and active warming for surgical patients

Inadvertant hypothermia is common among surgical patients and can result in serious complications. This article describes active warming systems which can be used preoperatively and intraoperatively to prevent hypothermia and maintain normothermia (normal body temperature).

Inadvertent perioperative hypothermia

During the perioperative period, patients are susceptible to heat loss with core body temperatures dropping below 36°C. This is known as inadvertent perioperative hypothermia (IPH) and is relatively common with an estimated incidence of 40–60% among surgical patients (Flores-Maldonado et al, 2001). Preoperative patients are susceptible to heat loss as they may be malnourished, stressed, and exposed to cold environments, such as draughty corridors on their way to the theatre suite. Additional heat can be lost in the operating theatre where the cool ambient temperature is further reduced by wind chill from laminar air flow systems, evaporation from surgical incision sites, and the use of cold fluids such as skin preparation solutions, washouts, irrigation and IV solutions. Most importantly, general anaesthesia prevents autonomic responses to hypothermia; vasoconstriction to minimize heat loss from core to periphery and shivering to increase the metabolic rate and generate heat. Patients having regional anaesthesia are also vulnerable as some sedatives and analgesics can impair temperature regulation responses (Pennsylvania Patient Safety Advisory (PPSA), 2008).

Complications

Hypothermia is a serious concern for patients undergoing surgery as it associated with increased mortality and serious complications. Two studies with 260 and 560 patients found mortality rates among normothermic patients of 1.5% and 2.7% compared with 12% and 6% among hypothermic patients (Bush et al, 1995; Mahoney and Odom, 1999). The same studies also found double the incidence of myocardial infarctions among hypothermic patients. Hypothermia has been shown to increase the risk of surgical site infections (SSI) which are distressing for patients and can cost the NHS around £10 000 to treat (Tanner et al, 2009). Studies by Flores-Maldonado et al (2001) and Kurz et al (1996) found SSI rates of 11.5% and 18% among hypothermic patients compared with 1.9% and 5% among normothermic patients. Other significant complications result in reduced platelet function, increased intraoperative blood loss, reduced drug metabolism and decreased collagen synthesis, which affects wound healing (PPSA, 2008). Hypothermia also lengthens the patient's recovery from anaesthesia and surgery, resulting in increased lengths of stay in the recovery and intensive care units, as well as lengthening the patient's overall hospital stay (Bush, 1995; Kurz, 1996; Mahoney and Odom, 1999).

NICE Guidelines

Comprehensive guidelines to prevent IPH are published by the National Institute for Health and Clinical Excellence (NICE) (2008). Perhaps the most notable recommendation for the preoperative phase is that patients on the ward who are hypothermic or considered to be high risk, should have active warming implemented and this should be maintained throughout the perioperative phase. Interestingly, high risk patients are identified as patients who have two of the following criteria:

- American Society of Anesthesiologists (ASA) grade II–V
- Temperature <36°C
- Undergoing combined general and regional anaesthetic
- Undergoing intermediate or major surgery
- At risk of cardiovascular complications.

These criteria would seem to be applicable to a large number of surgical patients. The guidelines state that induction of anaesthesia should not commence if the patient's temperature is less than 36°C and non-compliance with this guideline should be considered a critical incident. In the operative phase, patients having anaesthesia for longer than 30 minutes should receive active warming. This is an interesting recommendation as it transfers the emphasis away from the traditionally accepted 30 minutes of surgery to focus on the length of anaesthesia.

Preoperative and intraoperative heat loss

Audits show that patients lose most heat in the first hour of anaesthesia (Scott and Buckland, 2006) and warming devices spend this time rewarming patients rather than maintaining normothermia. However, many patients are already cold when they arrive in the anaesthetic room. This further exacerbates the drop in temperature during the first hour of anaesthesia, adding even more time to the rewarming period before normothermia is achieved. To ensure that patients are in an optimal position (ie. warm) at the start of anaesthesia, there is an impetus to implement preoperative warming. With preoperative warming, patients are warmed while they are on the ward, being transferred to theatre, or waiting in theatre reception suites. There are a number of emerging studies examining the benefits of preoperative warming. One randomized trial published in the *Lancet* found preoperative warming significantly more effective than traditional intraoperative warming among breast surgery patients in reducing SSIs (Melling et al, 2001).

Warming devices

Active patient warming devices usually transfer heat to the patient through a blanket, gown, or pads, using either convection or conduction. With a convective system, a warm air blower is attached to a blanket or gown which has small holes in the underside. The holes allow warm air to flow over the patient. This method has been shown to be effective in warming patients (NICE, 2008). A forced air warming system can cover most of the body surface area (up to around 64%) and protects vulnerable pressure points (Taguchi et al, 2004). To be effective, forced air warming systems must be in touch with the patient's skin and not placed on top of the patient's hospital gown. Most forced air warming blankets or gowns are disposable.

Conductive systems transfer heat directly to the patient through contact with warm blankets or pads. Some systems use heated water circulating inside pads which wrap around the patient. These have been shown to be less effective than other methods (Bräuer et al, 2004). The latest technology involves conductive polymers or fabrics inside mattresses or blankets. Studies of conductive polymer warming systems have found them to be effective (Kimberger et al, 2008). An advantage of conductive polymers is that they do not contain heating elements so the heat is dispersed evenly throughout the blanket with no hot or cold spots. These systems are predominantly reuseable and only require low voltage to run, though of course they need to be cleaned between patient use.

The NICE guidelines for IPH prevention published in 2008 recommend forced air warming as the most effective method of active patient warming. However, guidance from NICE medical technologies team currently under consultation recommends conductive polymer warming as an equal alternative to forced air warming (NICE, 2011).

It is worth noting that the majority of heat is lost from the top side of the patient as heat loss from the underside is restricted by the table, and therefore, warming devices should be placed on the top of the patient. Additionally, warming blankets should aim to cover as much of the patient as possible, though exploratory work is being conducted with localized warming systems. The cost of implementing warming systems is easily offset by the savings in treating the complications of intraoperative hypothermia. BJN

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Professor Judith Tanner
De Montfort University, Leicester