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Peri-operative hypothermia: implications for practice

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Abstract

This article explores whether there are adverse surgical outcomes for patients who experience hypothermia in the peri-operative period. Findings of this literature review highlight the need to establish a standard definition of hypothermia. Furthermore, the literature supports the full implementation of the National Institute for Health and Care Excellence guidance on *The Management of Inadvertent Perioperative Hypothermia in Adults*. A total of 18 studies were critically appraised to determine their rigour, reliability and validity. A discussion of the findings from the studies has taken into account the inferences drawn from the appraisal. Evaluation of the quality of the evidence has been used to evaluate which findings could apply to clinical practice. While there were variations in study quality, the evidence supports developing an effective strategy for preventing hypothermia in the peri-operative period.

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TEMPERATURE REGULATION IN the peri-operative period involves maintaining a core body temperature above 36°C. This has been shown to be beneficial in preventing surgical site infection (National Institute for Health and Clinical Excellence (NICE) 2008), peri-operative coagulopathy, myocardial ischaemia (Carpenter and Baysinger 2012) and blood loss, as well as reducing length of recovery and hospital stay (Harper *et al* 2003). The Association of Anaesthetists of Great Britain and Ireland define hypothermia as a core temperature below 36°C (Johnston *et al* 2012). Although there does not appear to be consensus on a threshold for hypothermia, a core temperature below 36°C has generally been accepted in the literature (Kiekkas and Karga 2005, Scott and Buckland 2006, AORN Recommended Practices Committee 2007, Kurz 2008, NICE 2008).

Anaesthetic-induced impairment of thermoregulation, heat redistribution and evaporative heat loss from open body cavities contribute to peri-operative hypothermia (MacFie *et al* 2005). Peri-operative hypothermia puts surgical patients at increased risk of adverse outcomes and prolonged hospital stay, ultimately increasing the cost of care (Kurz *et al* 1996, Kurz 2001, Kongsayreepong *et al* 2003, Putzu *et al* 2007, Berry *et al* 2008). Kurz *et al* (1996) suggested that hypothermia can lead to an increase in blood loss and the need for blood transfusion during surgery, impair immune function and promote surgical wound infection. Furthermore, it has been reported that 70% of all surgical patients experience some degree of hypothermia (Scott and Buckland 2006). Scott and Buckland (2006) suggested that this is a contributing factor in prolonged post-anaesthetic care unit stays, delayed wound healing and increased infection rates.

Peri-operative hypothermia leads to increased blood pressure, heart rate and plasma catecholamine concentration, which may increase the risk of cardiac complications and bleeding (Doufas 2003, Leslie and Sessler 2003, Pestel and Kurz 2005, Hasankhani *et al* 2007, Kurz 2008, NICE 2008, Weirich 2008, Burger and Fitzpatrick 2009). The Royal College of Anaesthetists (2012) acknowledged that inadvertent peri-operative hypothermia is preventable if frequent temperature monitoring and early warming therapy interventions are employed. Therefore, hypothermia is not an inevitable consequence of surgery.

NICE (2008) defined inadvertent peri-operative hypothermia as 'a common but preventable complication of perioperative procedures, which is associated with poor outcomes for patients'. The American Society of PeriAnesthesia Nurses produced guidelines that recommend a systematic approach to maintaining normothermia in surgical patients, using active and passive warming techniques (Berry *et al* 2008).

There is some evidence to suggest that pre-warming patients before surgery can contribute to normothermia (NICE 2008), although its guidance does not specifically recommend clinical pre-warming of patients. Instead, it recommends that the patient's temperature should be measured and recorded regularly so that inadvertent peri-operative hypothermia can be identified and treated. It also recommends that if a patient's core temperature falls below 36°C in the peri-operative period, then a forced air warming device should be used (NICE 2008).

Literature review

A literature review was conducted to identify whether there are adverse surgical outcomes for patients who experience hypothermia in the peri-operative period. It is not possible to present the full critique of the retrieved literature in this article. However, the following discussion takes into account the inferences drawn from the critical appraisal.

Search strategy

Several databases were searched to identify relevant literature. These were: the British Nursing Index (BNI), Embase, Medline, Database of Abstracts of Reviews of Effects (DARE), Cochrane Database of Systematic Reviews, Cumulative Index to Nursing and Allied Health Literature (CINAHL) and Evidence Based Medicine Reviews (EBMR). The use of a predefined search strategy, using a combination of medical subject headings terms, enabled exploration of keywords with the inclusion of Boolean operators 'and' and 'not'. Studies that were already known to the authors were viewed initially to identify potential differences in spelling and synonyms. By cross-referencing the search findings, 18 studies fulfilling all of the inclusion and exclusion criteria were retrieved for further analysis. Table 1 provides an overview of the search strategy.

Definition of hypothermia

Numerous attempts to define hypothermia are evident in the available literature. Enwright and Plowes (1999) and Keane (2000) defined hypothermia as a core body temperature of less than 35°C. This has been further categorised into three phases – mild, moderate and severe – as recognised by the American College of Surgeons (2012). As previously stated, hypothermia has also been defined as a core temperature of less than 36°C (Buggy and Crossley 2000, Kabbara *et al* 2002, Ayres 2004, Scott and Buckland 2006, Wagner

TABLE 1

Search strategy

Key terms	Exclusions	Medical subject headings	Limitations	Databases
Hypothermia Prevention Normothermia Peri-operative Warming Temperature Surgery Patient care Research Inadvertent Not planned Not intentional Prevention Adult	Paediatric Pregnant women Pregnancy Caesarean section Planned hypothermia Therapeutic hypothermia Advertent hypothermia Induced hypothermia Cardiac surgery Local anaesthesia Temperature measuring devices Patients with impaired temperature management	Adverse effects Complications Peri-operative care Heating Prevention and control Therapy Risk factors	Time frame 2003-2012 English language Research Randomised controlled trials Clinical trials Adults	Cochrane Database of Systematic Reviews Medline Cumulative Index to Nursing and Allied Health Literature British Nursing Index Embase Database of Abstracts of Reviews of Effects Evidence Based Medicine Reviews

et al 2006, Nunney 2008). Clinical guidelines for the prevention of unplanned peri-operative hypothermia tend to be based on a standard definition of a core temperature of less than 36°C (Berry *et al* 2008, NICE 2008), which reflects the definition that has been adopted informally in many peri-operative settings.

Definitions of hypothermia varied in the literature. While studies undertaken predominantly in the UK used the standard definition of a core temperature of less than 36°C (Scott and Buckland 2006, Wong *et al* 2007, Andrzejowski *et al* 2008, NICE 2008, Nunney 2008), studies in the United States focused on a core temperature of less than 35°C as determining hypothermia (Agrawal *et al* 2003, Alfonsi *et al* 2003, Janczyk *et al* 2004). Only Gallagher *et al* (2003) defined a core temperature of less than 35.5°C as an indicator to determine peri-operative hypothermia. Two studies discussed the normal physiological responses to hypothermia, but made no attempt to determine a baseline definition for hypothermia (Kumar *et al* 2005, Putzu *et al* 2007). It is important to note that direct comparison of the results between studies is potentially misleading because of variations in the definition of hypothermia. While there is no obvious justification for these differences, there is a need to establish a standard definition of hypothermia for use in practice.

In defining hypothermia, Agrawal *et al* (2003) did not explain why their definition of clinically significant hypothermia was less than 35°C, even though they claimed it was based on the American Society of Anesthesiologists definition of hypothermia as a core temperature of less than 36°C. Making comparisons between Agrawal et al (2003) and Kongsayreepong *et al*'s (2003) study may be misleading. For example, patients who would have been considered as having hypothermia in Kongsayreepong *et al*'s (2003) study were not considered hypothermic in the Agrawal *et al* (2003) study. Kongsayreepong *et al*'s (2003) findings indicated that a core temperature of less than 35°C was a significant predictor for prolonged stay in the surgical intensive care unit. On the whole, both studies concurred that a core temperature of less than 35°C was a significant risk factor for prolonged recovery.

The rigorous methodology in Abelha *et al*'s (2005) and Agrawal *et al*'s (2003) studies increases confidence in the ability to use this evidence to inform practice. The studies support a definition of hypothermia as 36°C and may be used as a basis for making recommendations in clinical practice. However, although Kongsayreepong *et al* (2003) defined hypothermia as less than 36°C, the authors also recorded the incidence of core temperatures below 35.5°C and 35°C.

Predictors for and consequences of hypothermia

Evidence from the literature review focused on various surgical outcomes as either predictors for or resulting from inadvertent peri-operative hypothermia. Hypothermia was found to be associated with adverse post-operative outcomes (Kurz *et al* 1996, Kongsayreepong *et al* 2003, Berry *et al* 2008). It is important to explore these outcomes to make a decision on how best to minimise hypothermia in the peri-operative period. Furthermore, any initiative to maintain peri-operative normothermia in practice will be reinforced by an understanding of the predictors for and consequences of hypothermia.

Ambient room temperature

In spite of ambient operating room temperature having been identified as a predictor for hypothermia in anaesthetised patients (Kongsayreepong *et al* 2003, Abelha *et al* 2005, NICE 2008), its influence on core body temperature was not addressed in the majority of studies. Vanni *et al* (2003) acknowledged low ambient temperature in theatre as being a limitation of their study. Ambient theatre temperature was not always discussed in the studies, but if researchers stated that they attempted to control for baseline characteristics, it is assumed that the ambient theatre temperature in these studies was the same for each patient. Any difference in ambient theatre temperature between participants could have influenced patient temperature. Based on appraisal of the literature, it is not possible to focus on ambient operating room temperature as a basis for determining practice.

Pre-operative temperature

Two studies found that higher pre-operative body temperature had a significant role in preventing peri-operative hypothermia (Kongsayreepong *et al* 2003, Abelha *et al* 2005). Conversely, one large randomised controlled trial (Melling *et al* 2001) found no significant difference between the incidence of peri-operative hypothermia in patients who were either pre-warmed locally or systemically. There was, however, a significant decrease in the incidence of post-operative wound infection in patients who were warmed. While Agrawal *et al* (2003) concluded that warming appeared to protect against hypothermia, the incidence of hypothermia

in their study was not significantly different between non-warmed and warmed patients. However, less of the body's surface area is exposed during head and neck surgery than in other types of surgery, therefore patients in Agrawal *et al*'s (2003) study who underwent such surgery may not have experienced as much heat loss as patients undergoing other types of surgery.

Although the results of Kongsayreepong *et al*'s (2003) study support efforts to increase body temperature before surgery, there are concerns about the study's validity. Patients who received forced air warming – a common method of intra-operative warming – were assessed by univariate analysis, but were not included in the multivariate analysis. By using univariate analysis the warming was only assessed against one variable rather than taking into account others. Also, while the results were statistically significant, the wide confidence intervals suggest that the sample size in this study may have been too small to make any generalised conclusions. Kongsayreepong *et al* (2003) suggested that if the body temperature is recorded pre-operatively it is possible to predict those at risk of hypothermia and begin active warming. Unlike Kongsayreepong *et al* (2003), Abelha *et al* (2005) took the use of warming devices into account in their multivariate analysis. Both of these studies were included in the NICE (2008) guidance and the guideline development group meta-analysis found that despite differences in the definition used for hypothermia, the findings of these studies were similar.

Recording core body temperature pre-operatively does appear to be a cost-effective way to predict peri-operative normothemia. The NICE (2008) consensus was that patients with a temperature of less than 36°C should not be operated on until this is raised, unless in an emergency. However, the guidelines did not specify to what extent temperature should be raised.

The effects of extending the period of warming to include the intra and post-operative periods was also discussed in the literature (Alfonsi *et al* 2003, Vanni *et al* 2003, 2007, Wong *et al* 2007). While it might be argued that intra-operative warming is an effective strategy to prevent peri-operative hypothermia, the usefulness of this in patients who arrive in the operating theatre with hypothermia is questionable. Heat that is applied to the skin surface of patients who are already cold takes some time before it reaches the core thermal compartment (Vanni *et al* 2003).

Despite the reported benefits of pre-operative forced air warming (Vanni *et al* 2003, 2007, Scott and Buckland 2006, Andrzejowski *et al* 2008, NICE 2008), there is still wide variation in its routine use for patients at risk of developing peri-operative hypothermia. Pre-emptive warming is effective and can increase core temperature rapidly (Vanni *et al* 2003, 2007); however, Andrzejowski *et al* (2008) suggested that pre-operative skin warming, while reducing the effects of the redistribution of heat from the body's peripheries to the core, did not elevate pre-operative core temperature significantly.

Although the quality of evidence was variable, the results of the studies discussed in this section would support an initiative involving pre-operative warming of patients to reduce the potential for inadvertent peri-operative hypothermia.

Age

While studies have demonstrated that older patients are at increased risk of hypothermia during surgery (Scott and Buckland 2006, Berry *et al* 2008, NICE 2008), Kongsayreepong *et al* (2003) demonstrated that after adjusting for variables such as age, type of surgery and type of anaesthesia, the risk in patients older than 70 years was not statistically significant. In comparing differences in mean appropriate length of stay in a post-anaesthetic care unit between patients with hypothermia and normothermia, Kiekkas *et al* (2005) reported a statistically significant correlation for patients aged under 60 years, but no difference in patients older than 60 years ($P = 0.128$). However, this may have been because more patients under 60 years were included in the study.

Agrawal *et al* (2003) concluded that there was a significant correlation between age and body mass and the final core temperature, and while the quality of this study was reasonable, one limitation in the methodology was the small sample size and resulting wide confidence intervals.

In analysing the included randomised controlled trials and cohort studies, it appears that the importance of age as a risk factor is not conclusive. However, based on the conclusions of some studies (Scott and Buckland 2006, NICE 2008), it could be argued that age may be a risk factor for hypothermia during surgery and, therefore, should be taken into account when making recommendations for practice.

Type of anaesthesia and surgery

Abelha *et al* (2005) demonstrated that the magnitude of surgery was a significant, independent predictor for hypothermia. Kongsayreepong *et al* (2003) correlated shorter operating time with patients being warmer. This suggests that patients undergoing longer procedures may be at increased risk of developing hypothermia.

The NICE (2008) guidelines included combined regional and general anaesthesia as a risk factor for hypothermia. However, only Kongsayreepong *et al* (2003) studied this relationship. Kongsayreepong *et al* (2003) found a statistically significant effect for the incidence of hypothermia when regional and general anaesthesia were combined, but the confidence intervals were wide, suggesting that the sample was too small to generate reliable findings. Although evidence related to combined regional and general anaesthesia remains insufficient, it should not be ruled out and should be considered in the maintenance of peri-operative normothermia.

Wound infection

While wound infection as a surgical outcome of peri-operative hypothermia was discussed (Abelha *et al* 2005, Kumar *et al* 2005, Scott and Buckland 2006, NICE 2008), only Wong *et al* (2007) included it as an outcome measure. Wong *et al* (2007) concluded that warming patients two hours before and after surgery reduced the incidence of surgical site infection. These findings are reflected in Scott and Buckland's (2006) study and NICE (2008) guidance.

Blood loss

Previous studies have suggested that maintenance of normothermia markedly reduces blood loss (Schmied *et al* 1996, 1998, Winkler *et al* 2000). One high-quality systematic review (Scott and Buckland 2006), two systematic reviews of reasonable quality (Kumar *et al* 2005, Rajagopalan *et al* 2008) and one high-quality randomised controlled trial (Wong *et al* 2007) addressed blood loss as a consequence of peri-operative hypothermia. As there are risks associated with blood loss and subsequent blood transfusion (Scott and Buckland 2006), preventing inadvertent peri-operative hypothermia would be of benefit to surgical patients.

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Mortality

Two cohort studies (Janczyk *et al* 2004, Abelha *et al* 2005) explored mortality as an outcome measure, and this was discussed further in some systematic reviews (Kumar *et al* 2005, Scott and Buckland 2006). There was no link between peri-operative hypothermia and mortality in Abelha *et al*'s (2005) study, however mortality was not a primary outcome in this trial so this finding should be treated with caution. While the adverse effects of hypothermia during elective repair of ruptured aortic aneurysms have been addressed (Kahn *et al* 1994, Bush *et al* 1995, Elmore *et al* 1998), only Janczyk *et al* (2004) focused on mortality as an outcome measure. Low intra-operative core body temperature (below 36°C) demonstrated a statistically significant inverse correlation with mortality ($P < 0.001$), but the high risk of bias in Janczyk *et al*'s (2004) study and the inability to generalise this to the wider surgical population makes it difficult to establish a reliable link. The evidence relating to the link between mortality and peri-operative hypothermia is insufficient to make any recommendation for practice.

Conclusion

Despite differences in the methodological quality of the studies included in the literature review, there are common findings in relation to the maintenance of peri-operative normothermia and improved outcome for surgical patients. Evidence demonstrates the need to establish a standard definition of hypothermia. Nurses also need to be aware of the implications of hypothermia for surgical patients. At-risk patients need to be identified at pre-operative assessment. Precautionary measures can go some way to reduce heat loss and minimise the risk of associated complications. While pre-warming has been shown to contribute to the maintenance of normothermia, only forced air warming devices have proved to be beneficial. There is scope for further research on the benefits of pre-warming as this may be key to maintaining normothermia in surgical patients **NS**

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