Maintenance of Perioperative Normothermia during Obstetric Surgery

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Abstract

In recent years prevention of perioperative hypothermia has become routine practice. However, we do not seem to follow the same practice in our obstetric surgical patients. This paper examines the evidence regarding the impact of perioperative hypothermia in this patient group and reviews the various warming methods available, the current guidelines and methods to monitor temperature. The National Institute for Health and Care Excellence (NICE) defines hypothermia as a core temperature of under 36°C.

Literature Search Strategy

A search of the literature was conducted using MEDLINE OVID, Google and Google Scholar. The following keywords were used in various combinations: *Caesarean, Cesarean, Perioperative, Intraoperative, Preoperative, Normothermia, Hypothermia, Warming, Warming mattress, Warming blanket, Spinal, Obstetric, Newborn, NICE, Perineal tear, Retained products, Retained placenta, Haemorrhage, Instrumental delivery*. References within the papers retrieved were also reviewed for any further resources.

Introduction

Women undergoing obstetric surgery, in particular caesarean section (CS), are vulnerable to perioperative hypothermia due to the propensity for CS to be performed under central neuraxial anaesthesia, with a potential for blood and fluid loss, and vasodilation.

Hypothermia causes shivering which can increase the metabolic rate by up to five times the basal rate[1], increasing oxygen demand and energy requirements. Adrenergic activation also contributes to this[2]. Perioperative hypothermia in the non-obstetric population is known to result in an increased incidence of ischaemic cardiac events [3, 4] due to this mismatch between oxygen supply and demand in patients with cardiac risk factors. Perioperative hypothermia is associated with an increased rate of culture-positive surgical site infection by a factor of three and increased duration of hospitalisation[5]. The mechanisms for this are thought to be impairment of neutrophil function and induced vasoconstriction at the wound site. It has been shown to decrease coagulation ability leading to increased blood loss and transfusions during total hip arthroplasty[6-8]. It also increases the duration of post-anaesthesia recovery[9].

The Obstetric Surgical Population

The obstetric surgical population is relatively young and rarely has underlying cardiac disease. Therefore inadvertent perioperative hypothermia is unlikely to result to the same degree of increased risk of cardiac events as in the patient population discussed above. However many of these other problems would also be expected in patients undergoing CS but studies in this specific population are not numerous.

In one small randomised control trial (RCT) of 45 patients undergoing elective CS with spinal anaesthesia pre-operative forced-air warming and warmed fluid prevented hypothermia and shivering[10]. A recently-published RCT[11] of 116 women booked for elective CS showed that use of a resistive warming mattress reduced the incidence of inadvertent perioperative hypothermia and attenuated the fall in haemoglobin. The authors therefore recommended that the use of a resistive warming mattress should be considered during CS.

Hypothermia is a major cause of morbidity and mortality in neonates[12]. There is evidence to suggest that perioperative forced-air warming of women undergoing CS with epidural anaesthesia

prevents maternal and foetal hypothermia, reduces maternal shivering, and improves umbilical vein pH[13]. Active forced-air warming of mothers and newborns immediately after caesarean delivery, during skin-to-skin bonding on the mother's chest, reduces the incidence of infant and maternal hypothermia and maternal shivering, and increases maternal comfort[14].

In one published audit the rate of postoperative hypothermia in unwarmed women who underwent CS under spinal anaesthesia was as high as 80%, leading the authors to suggest that it is "probably unacceptable that patients do not receive intra-operative warming"[15].

In cases where significant blood loss is expected such as when placenta accreta is diagnosed or suspected preoperatively, perioperative warming needs to be instituted in an attempt to prevent adverse effects on coagulation, such as decreasing synthesis of acute phase proteins and clotting factors, slowing down the coagulation cascade, prolonging clotting time and decreasing citrate metabolism. Every 1ºC drop causes a 10% reduction in coagulation activity[16].

Warming Methods

In the UK the common available modalities of perioperative warming are warming blankets, forced-air warmers, IV fluid warmers and warming mattresses.

Pre-warming patients reduces redistribution hypothermia and has been suggested as an effective strategy for maintaining intraoperative normothermia[17]. However a small RCT[18] of 30 healthy patients undergoing elective CS under spinal anaesthesia showed no significant benefit in the use of intraoperative lower body forced-air warming in preventing hypothermia or shivering. A RCT[19] of 75 patients conducted in a London hospital showed that warming intravenous fluids mitigates the decrease in maternal temperature during elective CS under combined spinal-epidural anaesthesia and improved thermal comfort, but did not affect shivering. The authors recommended that intravenous fluids should be warmed routinely in elective CS, especially for cases of expected long duration, but the use of pre-warmed fluids is as efficient as and cheaper than using a Hotline fluid warmer. However, others have found that on its own the use of warmed IV fluids was ineffective in preventing or treating hypothermia but did prevent fluid-induced hypothermia due to infusion of large volumes of fluid[17], which is relevant during CS. Another RCT[20] conducted in two acute care hospitals in central Canada showed that in their 62 patients undergoing CS under spinal anaesthesia, warmed cotton blankets performed just as well as intraoperative forced-air warming in terms of oral temperature, shivering, pain scores and newborn temperature. However, the perceived thermal comfort was better in the forced-air warmer group.

Forced-air warming has an excellent safety record but there have been anecdotal cases of thermal burns in infants, one aged four months and the other six weeks[21]. In a small study involving seven volunteers the second hour of forced-air pre-warming caused half to sweat[22]. In rare cases faulty thermal mattresses have resulted in thermal burns in paediatric patients[23].

Guidelines

NICE has issued guidelines[24] relating to perioperative core temperature maintenance, suggesting:

"**Preoperative phase**:

If the patient's temperature is below 36.0°C:

• forced air warming should be started preoperatively on the ward or in the emergency department (unless there is a need to expedite surgery because of clinical urgency, for example bleeding or critical limb ischaemia).

• forced air warming should be maintained throughout the intraoperative phase.

Intraoperative phase:

• The patient's temperature should be measured and documented before induction of anaesthesia and then every 30 minutes until the end of surgery.

• Induction of anaesthesia should not begin unless the patient's temperature is 36.0°C or above (unless there is a need to expedite surgery because of clinical urgency, for example bleeding or critical limb ischaemia).

Intravenous fluids (500 ml or more) and blood products should be warmed to 37°C using a fluid warming device.

• Patients who are at higher risk of inadvertent perioperative hypothermia and who are having anaesthesia for less than 30 minutes should be warmed intraoperatively from induction of anaesthesia using a forced air warming device.

• All patients who are having anaesthesia for longer than 30 minutes should be warmed intraoperatively from induction of anaesthesia using a forced air warming device.

Postoperative phase:

• The patient's temperature should be measured and documented on admission to the recovery room and then every 15 minutes.

• Ward transfer should not be arranged unless the patient's temperature is 36.0°C or above.

• If the patient's temperature is below 36.0°C, they should be actively warmed using forced air warming until they are discharged from the recovery room or until they are comfortably warm."

NICE also later published guidance[25] regarding the use of the inditherm patient warming mattress, stating that:

"The case for adopting the Inditherm patient warming mattress in the NHS is supported by the evidence. The clinical evidence suggests that the effectiveness of the Inditherm patient warming mattress in maintaining patient core body temperature above 36°C is similar to that of forced-air warming, and that the Inditherm mattress may have practical advantages.

The Inditherm patient warming mattress should be considered for use in patients undergoing operations that carry a risk of inadvertent hypothermia.

The annual cost saving when the Inditherm patient warming system is compared with forced-air warming is estimated to be £9800 per operating theatre (assuming that all eligible patients are warmed). This is based on an annual cost of £1300 for an Inditherm patient warming system comprising one full-length and one half-length mattress, two blankets and three controllers, and including maintenance costs."

Temperature Measurement

Effective perioperative management requires a robust means of measuring temperature. Ideally the selected method should be able to measure core temperature to the nearest 0.5°C, the minimum difference shown to affect blood loss[26-28].

Sites commonly used for measurement of temperature are skin, tympanic membrane, bladder, oesophagus, nasopharynx, pulmonary artery, and jugular bulb. Nasopharyngeal, oesophageal and urinary bladder are potentially accurate measurement sites. Less accurate sites include tympanic, rectal, and deep tissue thermometry[26]. Many of these are impractical and inappropriate in the usually-awake obstetric surgical patient. Tympanic thermometers and skin temperature thermometers are often used in this population due to ease of accessibility. Whether using infrared or thermocouple systems tympanic thermometers have been shown to be difficult to place correctly[28]. For the thermocouple type accuracy is decreased by air currents[28,29], is affected by changes in skin temperature on the head and face[30], the response to temperature change is delayed by cerumen or dried blood in the auditory canal[29] and rarely placement may perforate the tympanic membrane[30,26]. The least accurate location to measure temperature is the skin as it is subject to peripheral vasoconstriction[29] and can have 2˚C difference from core[28,26].

An underappreciated fact is that tympanic thermometers have various modes, usually, ear, oral, core and rectal. The reading is not reflective of the core temperature unless the mode on the thermometer reads "core." A commonly used tympanic thermometer, and the one used in our institution, is the Covidien Genius 2 and it seems to be set by default to the "ear" setting. On page four of its instruction manual it is stated that core temperature is 1.04°C higher than the "ear" temperature, and if it is set to "core" this adjustment is made automatically to the measured tympanic temperature to display a core temperature equivalent[31]. Appreciation of this is vital in avoiding "comparing apples and oranges" and resulting in the over-diagnosis of hypothermia, defined by NICE as a "core" temperature below 36°C, and therefore avoiding unnecessarily and inappropriately warming patients.

Conclusion

No evidence exists in the literature pertaining specifically to obstetric surgical procedures other than CS but the NICE guidelines, supporting maintenance of perioperative normothermia, were written to apply to all types of surgery. There is growing evidence specific to CS suggesting that we should be warming patients if their perioperative core temperature falls below 36°C. The best combination of warming methods within the obstetric population is unclear. NICE says:

"When using any device to measure patient temperature, healthcare professionals should:

• be aware of, and carry out, any adjustments that need to be made in order to obtain an estimate of core temperature from that recorded at the site of measurement.

• be aware of any such adjustments that are made automatically by the device used." [24] It should be appreciated that temperature measurement at the skin can be very inaccurate.

Limitations

NICE has stated in their full guideline document that the evidence for their individual recommendations, discussed in this review, range from "acceptable" to "good." However, it seems that none of these recommendations are based on level 1a evidence.

Declaration

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References

[1] Eyolfson, D.A., Tikuisis, P., Xu, X., Weseen, G., Giesbrecht G.G. Measurement and prediction of peak shivering intensity in humans. *Eur J Appl Physiol* 2001; 84: 100-6.

[2] Frank S.M., Higgins, M.S., Breslow, M.J. et al. The catecholamine, cortisol, and hemodynamic responses to mild perioperative hypothermia. *Anesthesiology* 1995; 82: 83-93.

[3] Frank, S.M., Fleisher, L.A., Breslow, M.J. et al. Perioperative maintenance of normothermia reduces the incidence of morbid cardiac events: A randomized clinical trial. *JAMA* 1997; 277: 1127–34.

[4] Frank, S.M., Beattie, C., Christopherson, R. et al. Unintentional hypothermia is associated with postoperative myocardial ischemia. The Perioperative Ischemia Randomized Anesthesia Trial Study Group. *Anesthesiology* 1993; 78: 468-76.

[5] Kurz, A., Sessler, D.I., Lenhardt, R.A. Perioperative normothermia to reduce the incidence of surgical-wound infection and shorten hospitalization. Study of Wound Infection and Temperature Group. *NEJM* 1996; 334: 1209-15.

[6] Schmied, H., Kurz, A., Sessler, D.I. et al. Mild hypothermia increases blood loss and transfusion requirements during total hip arthroplasty. *Lancet* 1996; 347: 289-292.

[7] Winkler, M., Akça, O., Birkenberg, B. et al. Aggressive Warming Reduces Blood Loss During Hip Arthroplasty. *Anesth Analg* 2000; 91: 978-84.

[8] Widman, J., Hammarqvist, F., Selldén, E. Amino acid infusion induces thermogenesis and reduces blood loss during hip arthroplasty under spinal anaesthesia. *Anesth Analg* 2002; 95: 1757-62.

[9] Lenhardt, R., Marker, E., Goll, V. et al. Mild intraoperative hypothermia prolongs postanesthetic recovery. *Anesthesiology* 1997; 87: 1318–23.

[10] Chung, S.H., Lee, B., Yang, H.J. et al. Effect of preoperative warming during cesarean section under spinal anesthesia. *Korean J Anesthesiol* 2012; 62(5): 454–460.

[11] Chakladar, A., Dixon, M.J., Crook, D. et al. The effects of a resistive warming mattress during caesarean section: a randomised, controlled trial. *IJOA* 2014; 23(4): 309–316.

[12] World Health Organization (WHO) (1996) *Thermal control of the newborn: a practical guide. Maternal Health and Safe Motherhood Programme.* Geneva (WHO/FHE/MSM/93.2).

[13] Horn, E.P., Schroeder, F., Gottschalk, A. et al. Active warming during cesarean delivery. *Anesthesia and Analgesia* 2002; 94: 409–14.

[14] Horn, E.P., Bein, B., Steinfath, M. et al. The Incidence and Prevention of Hypothermia in Newborn Bonding after Cesarean Delivery: A Randomized Controlled Trial. *Anesthesia & Analgesia* 2014; 118(5): 997-1002.

[15] Harper, C.M., Alexander, R. Hypothermia and spinal anaesthesia. *Anaesthesia* 2006; 61: 612.

[16] Snegovskikh, D., Clebone, A., Norwitz, E. Anesthetic management of patients with placenta accreta and resuscitation strategies for associated massive hemorrhage. *Current Opinion in Anesthesiology* 2011; 24: 274–281.

[17] Insler, S.R., Sessler, D.I. Perioperative thermoregulation and temperature monitoring. *Anesthesiol Clin* 2006; 24: 823-37.

[18] Butwick, A.J., Lipman, S.S., Carvalho, B. Intraoperative Forced Air-Warming During Cesarean Delivery Under Spinal Anesthesia Does Not Prevent Maternal Hypothermia. *Anesthesia & Analgesia* 2007; 105(5): 1413-19.

[19] Woolnough, M., Allam, J., Hemingway, C., Cox, M., Yentis, S.M. Intra-operative fluid warming in elective caesarean section: a blinded randomised controlled trial. *International Journal of Obstetric Anesthesia* 2009; 18(4): 346-51.

[20] Fallis, W.M., Hamelin, K., Symonds, J., Wang, X. Maternal and newborn outcomes related to maternal warming during cesarean delivery. *Journal of Obstetric, Gynecologic, & Neonatal Nursing* 2006; 35(3): 324-31.

[21] Azzam, F.J., Krock, J.L. Thermal burns in two infants associated with a forced air warming system. *Anesth Analg* 1995; 81: 661.

[22] Sessler, D.I., Schroeder, M., Merrifield, B., Matsukawa, T., Cheng, C. Optimal duration and temperature of prewarming. *Anesthesiology* 1995; 82: 674-81.

[23] Dewar, D.J., Fraser, J.F., Choo, K.L., Kimble, R.M. Thermal injuries in three children caused by an electrical warming mattress. *Br. J. Anaesth* 2004; 93(4): 586-589.

[24] National Institute for Health and Care Excellence. *Inadvertent perioperative hypothermia: The management of inadvertent perioperative hypothermia in adults.* CG65. London: National Institute for Health and Care Excellence; 2008.

[25] National Institute for Health and Care Excellence Medical Technologies Guidance. *Inditherm patient warming mattress for the prevention of inadvertent hypothermia*, MTG7. London: National Institute for Health and Care Excellence; 2011.

[26] Sappenfield, J.W., Hong, C.M., Galvagno, S.M. Perioperative temperature measurement and management: moving beyond the Surgical Care Improvement Project. *Journal of Anesthesiology and Clinical Science* 2013; 2: 8. http://dx.doi.org/10.7243/2049-9752-2-8 (Accessed 26/01/2015).

[27] Winkler, M., Akca, O., Birkenberg, B., Hetz, H., Scheck, T., Arkilic, C.F., Kabon, B., Marker, E., Grubl, A., Czepan, R., Greher, M., Goll, V., Gottsauner-Wolf, F., Kurz, A., Sessler, D.I. Aggressive warming reduces blood loss during hip arthroplasty. *Anesth Analg* 2000; 91: 978-84.

[28] Sessler, D.I. Temperature monitoring and perioperative thermoregulation. *Anesthesiology* 2008; 109: 318-38.

[29] Stone, J.G., Young, W.L., Smith, C.R., Solomon, R.A., Wald, A., Ostapkovich, N., Shrebnick, D.B. Do standard monitoring sites reflect true brain temperature when profound hypothermia is rapidly induced and reversed? *Anesthesiology* 1995; 82: 344-51.

[30] Akata, T., Setoguchi, H., Shirozu, K., Yoshino, J. Reliability of temperatures measured at standard monitoring sites as an index of brain temperature during deep hypothermic cardiopulmonary bypass conducted for thoracic aortic reconstruction. *J Thorac Cardiovasc Surg* 2007; 133: 1559-65.

[31] *Covidien Genius 2 Tympanic Thermometer and Base Operating Manual.* [Online] http://www.kendallhq.com/imageServer.aspx?contentID=14135&contenttype=application/pdf (Accessed 31/01/2015).