

TEMPERATURE MANAGEMENT IN CHILDREN ANAESTHESIA TUTORIAL OF THE WEEK 305 31ST MARCH 2014

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QUESTIONS

Before continuing, try to answer the following questions. The answers can be found at the end of the article, together with an explanation

1. Which of the following statements is correct? Hypothermia in neonates may cause:
 - a. A fall in pulmonary vascular resistance
 - b. Increased noradrenaline release
 - c. Left to right shunting
 - d. Rise in serum lactate

2. Children under general anaesthesia
 - a. Lose most heat by convection
 - b. Lose more heat by radiation than adults
 - c. May lose an important source of heat production when ventilated
 - d. Are unable to conserve heat by vasoconstriction

3. Name four simple measures to reduce heat loss in children

4. Forced air warmers
 - a. May be placed underneath or on top of children
 - b. Any size blanket can be used for any size of child
 - c. May be used before, or at induction to reduce the risk of hypothermia intraoperatively
 - d. Are recommended in adults for anaesthesia lasting more than 1 hour

5. True or false? In children:
 - a. Bladder probes may become inaccurate in a child who is oliguric
 - b. Oesophageal probes are accurate in open cardiac surgery
 - c. Bladder temperature is not an accurate measure of core temperature
 - d. Tympanic membrane thermometers always give an accurate measure of core temperature

INTRODUCTION

Maintenance of normothermia in children under going non cardiac surgery is challenging. There is clear evidence in adults that even mild intra operative hypothermia is associated with adverse outcome. There have been two landmark studies which have demonstrated an association between hypothermia in patients undergoing both clean and contaminated surgery, for example hernia repair and colorectal surgery respectively, and increased incidence of surgical site infection (1,2). Other studies have demonstrated an increased risk of adverse cardiac events (3), coagulopathy and increased transfusion requirements (4), increased length of stay in the post anaesthetic care unit (5), and hospital stay (1,3).

In children, the evidence base is lacking due partly to the ethical implications of randomising patients to non-warming. An observational study by Pearce et al compared outcome in children whose intra operative temperature remained above 36 degrees Celsius, and in those who became cold. They demonstrated that the incidence of inadvertent hypothermia was high, with intra operative temperature slipping below 36 degrees in 52% of children. In this group there was an association with increased blood loss and blood product requirement (6).

It is also known that cold stress in neonates is associated with increased noradrenaline release, and increased oxygen and substrate consumption. Activation of the sympathetic nervous system in this way may result in a rise in pulmonary vascular resistance, increased right to left shunting, reduced peripheral perfusion and oxygen delivery, and acidosis. The pharmacokinetics and dynamics of drugs such as muscle relaxants and volatile agents may also be affected by hypothermia.

Heat loss under anaesthesia

Children and adults lose heat differently under anaesthesia. Children lose more heat through conduction and radiation than adults, due to less insulating subcutaneous fat, and a higher surface area to volume ratio. During anaesthesia, heat production through basal metabolic processes is reduced in humans of all ages by a factor of 20-30%, and in addition, neonates who are mechanically ventilated will miss heat generated through work of breathing. Inhibition of central thermoregulation also occurs, with delay of vasoconstriction to much lower core temperatures, and loss of usual heat production from non-shivering thermogenesis and shivering.

PRACTICALITIES OF TEMPERATURE MONITORING AND WARMING

Monitoring

There are several methods of measuring both core and peripheral temperature in children. The type of monitoring chosen will depend on surgical and patient factors, and each is subject to pitfalls and inaccuracies.

Core temperature can be monitored at several sites including the rectum, nasopharynx, oesophagus, temporal artery, bladder, tympanic membrane and blood measurement. Non-core temperature measurement can be obtained using axillary thermometry (where accuracy relies on the device being in continuous close proximity to the axillary artery) or skin probes. A recent study has demonstrated that measuring the temperature of skin lying directly over the carotid artery equates closely with nasopharyngeal temperature in children (7).

It is generally accepted that monitoring core, rather than peripheral temperature is of the most relevance and value when patients are anaesthetised. Tympanic thermometers measure thermal radiation from the ear canal, and equate to the temperature of blood bathing the hypothalamus. Inaccuracies in children can occur when the ear canal is too small to permit the probe to sit in close proximity to the tympanic membrane, when the probe is likely to under-read (8).

Nasopharyngeal probes are usually placed blind once the child is asleep, and are positioned with the tip behind the soft palate. They may be affected by the cooling effect of inspired gases, in particular in the presence of an un-cuffed tracheal tube or supra-glottic airway, and may cause local trauma on insertion. They have however been shown to equate closely to pulmonary artery blood temperature in children in intensive care (9). Use of oesophageal probes may become inaccurate during surgery, for

example during thoracotomy, but may be less prone to cooling than nasopharyngeal probes due to their advanced position beyond the pharynx. In adults having cardiac surgery, they have been shown to equate most closely with pulmonary artery temperature (10).

Rectal probes are commonly used to monitor temperature in children when nasopharyngeal probes cannot be used. However, regional blood flow and presence of stool may affect the accuracy of readings. Rectal temperatures have also been shown to lag behind other core temperature measurements, particularly during rapid temperature changes (10). Similarly bladder temperature has been found to equate closely with pulmonary artery temperature in adults having cardiac surgery (10) and in critically ill children following cardiac surgery (9), but require a reasonable flow of urine: In the presence of oliguria, they may equate more closely with rectal temperature.

Intra-operative warming methods

In addition to active warming methods, there are simple measures which can be taken to reduce heat loss by radiation, conduction and convection. Pre operatively, attempts should be made to keep children warm, for example with sheets, blankets and hats, particularly if they are transferred long distances through the hospital to theatre. Where possible, older children should be encouraged to walk to theatre. Ambient theatre temperature can be maintained at 20-23 degrees Celsius: Although warmer temperatures may be favourable for prevention of hypothermia, especially in neonates, surgical staff may become too uncomfortable to perform optimally. Attempts should be made to limit exposure of large areas of skin surface, particularly wet skin, while waiting for surgery to start, and gases used to ventilate may be humidified by a heat and moisture exchanger (HME).

Guidance from the National Institute of Clinical Excellence (NICE) of the United Kingdom, suggests that to prevent inadvertent hypothermia, adults undergoing surgery with anaesthesia lasting more than 30 minutes should be warmed from induction using a forced air warming device (11). It is also advised that patients who are at higher risk of hypothermia, for example when using combined regional and general anaesthesia or those at risk of cardiovascular complications, should be warmed for even short procedures. In children there is as yet no clear guidance on identifying risk factors for intra-operative hypothermia, or which warming devices should be used to avoid it.

There may be a benefit to starting warming in the anaesthetic room, particularly for longer surgery where the child is likely to be exposed during wet skin preparation, or if the type of surgery requires a large surface area of skin exposure. A recent observational study of children having spinal surgery demonstrated an association between use of a forced air warming device prior to induction, and a reduction in the incidence of intra-operative hypothermia (13). An audit at our institution demonstrated an association between pre warming children in the anaesthetic room, and a significant reduction in the incidence of hypothermia intra-operatively.

Forced air warmers reduce radiant heat loss by providing a barrier between skin and ambient air (14). They may be placed underneath children, allowing warm air to circulate around the child and reduce both radiation and conductive heat loss, or on top. However, for under body blankets, care should be taken that the whole child is on the blanket, as limbs extending beyond the edge may obstruct uniform air flow, and thus become exposed to the risk of burns. Also ensure that cleaning fluid does not pool around patient as this will then evaporate, cooling them further.

Fluid warming devices

NICE state that adults receiving more than 500ml of intravenous fluid, or any blood products should have a fluid warmer used (11). There is no such guidance to date for children. However, extrapolating from evidence in adults, fluid warmers should probably be used when larger volumes of crystalloid or colloid are to be used, for example for open abdominal surgery, or when blood products are likely to be required. There may be a value to choosing an arbitrary volume, for example greater than 30ml/kg fluid, to provide guidance for when a fluid warmer should be considered.

Cautions

Children receiving active warming intra operatively are at risk of over-heating. In addition to the potential for burns from non-uniform warming devices, the effects of hyperthermia include localised increased skin and muscle blood flow, increased vascular permeability and oedema, and ultimately cell

death and organ failure. As such vigilance must be exercised throughout the perioperative course for hyperthermia, and all children receiving active warming must have continuous temperature monitoring.

SUMMARY

Children are at risk of hypothermia during surgery. Although there are no specific paediatric guidelines, the limited evidence available together with extrapolation from adult guidance suggests that avoidance of hypothermia in children under going non-cardiac surgery is beneficial. However, close attention to the type of surgery, choice of monitoring and warming devices used is necessary to avoid misinterpretation of temperature measurement and potential for overheating. Further evidence is needed to define the impact of prevention of hypothermia on outcomes in children, such as surgical site infection.

ANSWERS TO QUESTIONS

- 1a. False
- 1b. True
- 1c. False
- 1d. True

- 2a. False: children lose more heat via conduction and radiation
- 2b. True: This is due to a higher surface area to volume ratio
- 2b. True: Neonates generate a large proportion of heat through work of breathing
- 2c. False: Vasoconstriction in response to hypothermia still occurs, but at lower core temperature

3. Encourage older children to walk to theatre, use blankets and hats prior to induction, increase ambient temperature in theatre, limit exposure of skin prior to and during skin preparation.

- 4a. True
- 4b. False: Be careful that the whole of the child is able to fit on under-body blankets. The risk is of burns if the air channels are obstructed, and flow of warm air is not uniform,
- 4c. True
- 4d. False: The National Institute of Clinical Excellence in the UK advises that adults having anaesthesia which is planned to last for more than 30 minutes, should be warmed from induction with a forced air warmer. The reasoning for this is, at induction warm core blood is diverted to the cold periphery, and therefore a large amount of heat is lost at the start of anaesthesia,

- 5a. True: In this circumstance, bladder probes equate more closely to rectal temperature.
- 5b. False: Oesophageal probes have been shown to equate closely to temperature in the pulmonary artery, except when the chest is open. Cold cardioplegia may also have a similar effect.
- 5c. False: Bladder temperature has been shown to equate closely to pulmonary artery temperature, as long as there is a reasonable flow of urine.
- 5d. False: tympanic membrane thermometers may be inaccurate if the probe is not sitting next to the tympanic membrane.

REFERENCES

1. Kurz A, Sessler DI, Lenhardt R. Perioperative normothermia to reduce the incidence of surgical-wound infection and shorten hospitalization. Study of Wound Infection and Temperature Group. *N Engl J Med*. 1996;334(19):1209–1215.
2. Melling AC, Ali B, Scott EM, Leaper DJ. Effect of preoperative warming on the incidence of wound infection after clean surgery: a randomised controlled trial. *Lancet* 2001;358(9285):876-80
3. Frank SM, Fleisher LA, Breslow MJ, et al. Perioperative maintenance of normothermia reduces the incidence of morbid cardiac events. A randomized clinical trial. *JAMA*. 1997;277(14):1127–1134.
4. Schmied H, Kurz A, Sessler DI, Kozek S, Reiter A. Mild hypothermia increases blood loss and transfusion requirements during total hip arthroplasty. *Lancet*. 1996;347(8997):289–292.
5. Lenhardt R, Marker E, Goll V, et al. Mild intraoperative hypothermia prolongs postanesthetic recovery. *Anesthesiology*. 1997;87(6):1318–1323.
6. Pearce B, Christensen R, Voepel-Lewis T. Perioperative Hypothermia in the Pediatric Population: Prevalence, Risk Factors and Outcomes. *J Anesth Clin Res* 1:102 doi:10.4172/2155-6148.1000102
7. Jay O, Molgat-Seon Y, Chou S, Murto K. Skin temperature over the carotid artery provides an accurate noninvasive estimation of core temperature in infants and young children during general anaesthesia. *Paed Anaesth* 2013;23:1109-1116
8. Leduc D, Woods S; Canadian Paediatric Society, Community Paediatrics Committee. POSITION STATEMENT Temperature measurement in paediatrics. <http://www.cps.ca/en/documents/position/temperature-measurement>. Posted 2000. Accessed Dec 2013
9. Maxton FJ, Justin L, Gillies D. Estimating core temperature in infants and children after cardiac surgery: a comparison of six methods. *J Adv Nurs*. 2004 Jan;45(2):214-22.
10. Robinson J, Charlton J, Seal R, Spady D, Joffres MR. Oesophageal, rectal, axillary, tympanic and pulmonary artery temperatures during cardiac surgery. *Can J of Anaesth* 1998; 45: 317-323
11. National Institute for Health and Clinical Evidence. Clinical practice guideline: The management of inadvertent perioperative hypothermia in adults. <http://www.nice.org.uk/nicemedia/pdf/CG65Guidance.pdf>. Accessed Dec 2013.
12. Horwitz JR, Chwals WJ, Doski JJ, Suesun EA, Cheu HW, Lally KP. Pediatric wound infections: a prospective multicentre study. *Ann Surg* 1998;227(4):553-8
13. Gorges M, Ansermino JM, Whyte SD. A retrospective audit to examine the effectiveness of preoperative warming on hypothermia in spine deformity surgery patients. *Paed Anaesth* 2013;23:1054-61
14. Sessler DI. Forced-air warming in infants and children. *Paed Anesth* 2013;23: 467–468