Journal of Anesthesia & Clinical Research - Open Access

Research Article
OPEN ACCESS Freely available online
doi:10.4172/2155-6148.1000102

Perioperative Hypothermia in the Pediatric Population: Prevalence, Risk Factors and Outcomes

Bridget Pearce[1], Robert Christensen[2]* and Terri Voepel-Lewis[3]

[1]*Assistant Professor of Anesthesiology, The University of Michigan Hospitals and Health Centers, USA*
[2]*Clinical Lecturer, The University of Michigan Hospitals and Health Centers, USA*
[3]*Research Area Specialist, The University of Michigan Hospitals and Health Centers, USA*

Abstract

Background: Perioperative hypothermia has been associated with negative outcomes, and children may be at higher risk. This study describes the prevalence of pediatric perioperative hypothermia and evaluates its relationship to outcomes.

Methods: This observational cohort study included the following electronically and prospectively recorded data from children fewer than 18 years of age undergoing general anesthesia: perioperative temperatures, warming interventions, patient characteristics, and surgical procedures, duration of anesthesia and perioperative outcomes. Intraoperative hypothermia was defined as temperature (T) < 36°C for at least five minutes, and postoperative hypothermia as any T<36°C.

Results: Of the 530 patients studied, 278 (52%) experienced intraoperative hypothermia. Invasive procedures and skin probe monitoring were associated with intraoperative hypothermia. In children with core T monitoring undergoing invasive procedures, older age, longer duration of anesthesia, greater blood loss and blood transfusion were associated with hypothermia. Warming interventions is used in most hypothermic children during operation, but in few in the post-anesthesia care unit (PACU). T was re-assessed in <6% of children who were hypothermic in the PACU.

Conclusions: This study found a high prevalence of hypothermia and use of intraoperative warming techniques. Hypothermia was more common in older children and in those undergoing longer, invasive procedures and was associated with greater blood loss and blood transfusion.

Keywords: Anesthesia – Pediatric; Children; Hypothermia; Temperature

Abbreviations: T: Temperature; PACU: Post-Anesthesia Care Unit; LOS: Length Of Stay

Introduction

Perioperative hypothermia has been implicated in a number of negative outcomes in adults, including increased intraoperative blood loss and transfusions [1], adverse cardiac events, prolonged stay in the recovery room and hospital [2], delayed surgical wound healing and higher infection rates [3,4]. Hypothermia is known to have multiple physiologic effects that include cold-induced coagulation dysfunction [5], prolonged drug metabolism and compensatory coetaneous vasoconstriction that can impair wound healing and immune system function. The negative outcomes of perioperative hypothermia demonstrated in adults have been attributed to such effects [6]. Maintaining perioperative normothermia has therefore become of great interest to anesthesia providers as well as national regulatory bodies [7].

Infants and neonates have been shown to be at an increased risk for perioperative hypothermia [8] since they have a less effective thermoregulatory capacity [9,10] with greater heat loss due to an increased surface area to body weight ratio and less subcutaneous fat. Given the sparse data regarding perioperative hypothermia and its relationship to outcomes in the general pediatric population [11], data are needed to determine the clinical significance of this outcome in children. The purpose of this study was, therefore, to describe the current prevalence of hypothermia and evaluate its relationship to outcomes in a pediatric perioperative setting. A secondary aim was to evaluate the potential risk factors and short-term outcomes of perioperative hypothermia in children.

Methods

With institutional review board approval and waiver of consent, this observational, cohort study included electronically and prospectively recorded data from a convenience sample of children birth to 18 years of age undergoing general anesthesia for a surgical or diagnostic procedure at the University of Michigan Health System. Children undergoing cardiopulmonary bypass with deliberate intraoperative hypothermia, those requiring direct admission to an intensive care unit after operation and procedures conducted offsite where no intraoperative data capture was available were excluded. Perioperative and intraoperative data were captured in real time via the institutional electronic anesthetic data capture (Centricity®, GE, Inc.). Perioperative data included patient characteristics, American Society of Anesthesiologists (ASA) status and baseline temperature taken via tympanic thermometer (First Temp Genius, Covidien, Mansfield, MA). Intraoperative data included surgery type, duration of anesthesia and surgical procedure, estimated blood loss, blood transfusions, arrhythmias as documented by continuous electrocardiogram monitoring, method of temperature monitoring

***Corresponding author:** Robert Christensen, Clinical Lecturer, The University of Michigan Hospitals and Health Centers, USA, Tel: 734-936-0748; Fax: 734-763-6651; E-mail: whelton@med.umich.edu

Received August 19, 2010; **Accepted** September 17, 2010; **Published** September 17, 2010

Citation: Pearce B, Christensen R, Voepel-Lewis T (2010) Perioperative Hypothermia in the Pediatric Population: Prevalence, Risk Factors and Outcomes. J Anesthe Clinic Res 1:102 doi:10.4172/2155-6148.1000102

(i.e., nasopharyngeal, esophageal, rectal, bladder or skin sensors), lowest temperature between induction end and dressing, duration of T<36°C, and all warming techniques used (i.e., warmed cotton blankets, forced air warmers [Bair Hugger, Model: Arizant Medical, Eden Prairie, MN] and increased ambient temperature).

Temperatures were measured by the child's nurse on admission to the post-anesthesia care unit (PACU) via tympanic thermometer per routine practice and recorded by trained observers. While temperature measured in the ear has been shown to be less accurate compared to measurements in the rectum [12], this method was selected in our pediatric hospital given the balance between invasiveness and precision. Warming interventions, shivering, meperidine use, and PACU length of stay (LOS) were documented by the PACU bedside nurse. Intraoperative hypothermia was defined as T<36°C that lasted for at least five minutes, and postoperative hypothermia was defined as any T<36°C [12]. Data are presented as n (%) or mean ± SD as appropriate. Non-parametric, dichotomous data, including gender, procedure type, coded ASA status, and need for transfusion were compared between the groups using Chi-square tests. Continuous data, including age, duration of procedure, temperature, and blood loss were compared between the groups using unpaired t tests. P values <0.05 are considered significant.

Results

Data were collected from 717 patients between May 2007 and September 2008. Intraoperative temperature was not documented during 187 procedures, all of which were short, non-invasive procedures (e.g. myringotomy, lachrymal duct probing and cast change). The resultant sample included 530 patients, the characteristics of which are presented in (Table 1).

Two hundred seventy-eight children (52%) experienced intraoperative hypothermia in accordance with the study definition. The duration of hypothermia ranged from 5-142 minutes (25 ± 22.8). (Table 2) presents the relationship between patient and perioperative factors and intraoperative hypothermia in this study sample. Children who had invasive procedures (i.e., procedures involving an incision) and those who had skin probe monitoring were more likely to have documented hypothermia.

Further analysis of outcomes conducted for the subset of children who had undergone an invasive procedure and whose temperature was monitored via core temperature techniques. (Table 3) presents the relationship between patient and perioperative factors, outcomes and hypothermia in this subset of patients. Older age, longer duration of anesthesia, greater blood loss and transfusion rates were

Age (yrs)	6.8 ± 5.4 [birth to 18]
Infant (birth – 12m) **Pre-school Aged (>1 – 4 yr)** **School Aged (>4 – 12 yr)** **Adolescent (>12 – 18 yr)**	62 (12%) 161 (30%) 185 (35%) 122 (23%)
Weight (kg)	28.3 ± 23 [3.6-128.5]
Male gender	308 (58%)
ASA Physical Status I II III-IV	 201 (38%) 227 (43%) 101 (19%)
Procedure Non-invasive Gastroenterology Dental Radiology/cardiology Hematology Other **Invasive surgery** General surgery Otology Orthopedic Urology Ophthalmology Other	**n=79 (15%)** 28 (35%) 21 (27%) 10 (13%) 6 (8%) 14 (18%) **n=451 (85%)** 97 (22%) 84 (19%) 80 (18%) 74 (16%) 66 (15%) 50 (11%)
Anesthesia duration (min)	99.9 ± 83.9 [15-569]
Baseline Temperature (Celsius)	36.3 ± 0.5 [35-38]

Data presented as n (%) or mean ± SD [range], as appropriate

Table 1: Description of the Study Sample (n=530).

	Normothermic (n=252)	**Hypothermic (n=278)**	**P Value OR [CI]***
Age (yrs)	6.4 ± 5.2	7.2 ± 5.6	0.064
Weight (kg)	27.8 ± 23.4	28.7 ± 22.7	0.065
Baseline (perioperative) Temperature	36.27 ± 0.5	36.37 ± 0.54	0.043
ASA 1-2 **ASA 3-4**	210 (84%) 41 (16%)	218 (78%) 60 (22%)	0.15
Admission after surgery	201 (80%)	204 (73%)	0.084
Procedure type* Invasive Non-invasive	 205 (81%) 47 (19%)	 246 (89%) 32 (11%)	0.02 1.62 [1.1 – 2.5]
Temperature Monitoring Method Skin probe Core probe (bladder, esophageal or rectal)	 115 (47%) 131 (53%)	 158 (58%) 112 (42%)	 0.008 1.26 [1.06 – 1.49]

*OR= Odds Ratio; CI= Confidence Interval; Presented for significant comparisons only Invasive procedures included those involving an incision; non-invasive included diagnostic (e.g. computerized axial tomography, radiography, or magnetic resonance imaging).

Table 2: Relationship between Patient and Perioperative Factors and Intraoperative Hypothermia.

	Normothermic (n=118)	Hypothermic (n=108)	P Value OR [CI]
Age (yrs)	6.4 ± 5.3	8.4 ± 6.5	0.012
Weight (kg)	28.6 ± 24.5	32 ± 25	0.31
Baseline Temperature	36.39 ± 0.5	36.24 ± 0.54	0.05
ASA 1-2 **ASA 3-4**	88 (83%) 20 (17%)	81 (75%) 27 (25%)	0.14
Anesthesia duration (min)	114.8 ± 82.8	155.9 ± 123.2	0.004
Estimated blood loss (ml/kg) **Received blood product**	0.49 ± 1.89 1 (<1%)	2.96 ± 8.33 9 (8%)	0.003 0.006 10.6 [1.3 – 85]
PACU admission temperature (Celsius)	36.3 ± 0.68	35.9 ± 0.65	<0.001
Postoperative hypothermia	33 (28%)	62 (57%)	0.001 3.5 [1.99 – 6]
PACU stay (min)	63.9 ± 35.4	71.7 ± 47.5	0.166
Admission status Outpatient Admitted	 79 (67%) 39 (33%)	 61 (57%) 47 (44%)	0.105

Table 3: Factors and Outcomes Associated with Intraoperative Hypothermia in Children who Underwent Invasive Procedures and had Core Temperature Monitoring.

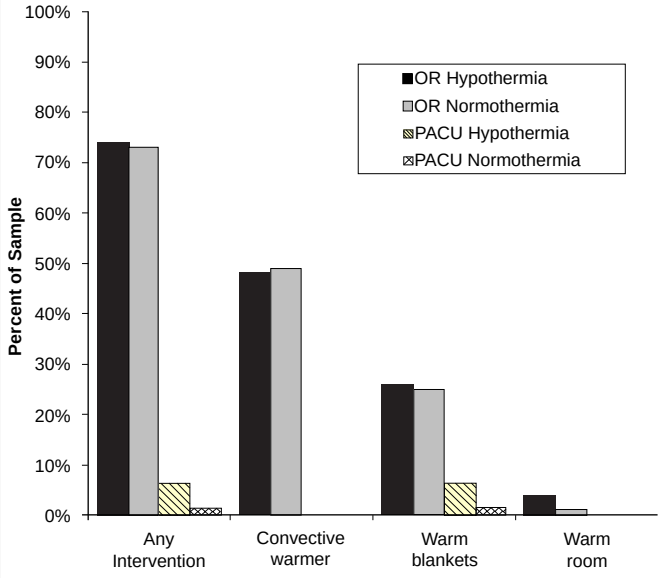

Figure 1: Description of Warming Interventions in the Groups.

significantly associated with hypothermia in this subset of children. Children who experienced intraoperative hypothermia were more likely to be hypothermic on admission to the PACU.

The figure 1 depicts the use of perioperative warming interventions in the sample. Intraoperative warming interventions documented in approximately 70% of cases, and there was no difference in the frequency of interventions between normothermic and hypothermic patients. Less than 10% of hypothermic patients in the PACU had a warming intervention documented, and temperature was re-assessed in this group less than 6% of the time (only 13% of those with postoperative hypothermia).

Discussion

This study represents the largest to date in the pediatric setting. Similar to previous studies in adults using similar definitions [13], this study found that more than 50% of children experienced intraoperative hypothermia. Furthermore, this study found that children undergoing prolonged, invasive (i.e., major) surgery and those with lower baseline temperature were at greater risk compared to non-invasive procedures, findings which are similar to previous studies [8]. There was also an association between blood loss, transfusion rates and hypothermia, but a causal relationship is unclear. While 70% of hypothermic patients received warming measures in the operating room, less than 10% had a warming intervention documented in the PACU.

A previous study found that heat loss following induction of anesthesia was greater in neonates compared to infants, more pronounced during major surgery and temperature decreased gradually over longer procedures [8]. The present study similarly found that hypothermia was associated with major and longer procedures. In contrast, however, we found that older age was associated with hypothermia. This finding may simply reflect differences related to types of procedures conducted in the various age groups (e.g., adolescents had more spine fusion). However, it may also be that temperature was more carefully managed in the youngest patients in this setting, compared to older children. Alternatively, this may represent a significant redistribution effect, with older children having relatively larger and cooler extremities to which to redistribute heat.

The poor rates of reassessment and use of warming interventions in this PACU indicate a significant gap in practice in this setting indicating either a lack of emphasis on or knowledge regarding the importance of thermoregulation in this population or setting. This suggests an opportunity for improvement with both PACU temperature monitoring and interventions for hypothermia. Use of electronic medical records for real time monitoring of temperature with automated prompts to physicians and nurses may provide one avenue for improved care [14].

The results of this study come from a single institution, based, in part, on electronic capture of intraoperative clinical data. While the use of electronic data capture may have reduced human error, it likely introduced occasional spurious values due to sensors disconnected from the patient. Not all patients received core temperature monitoring, with skin temperature monitoring making up approximately 30% of those patients with intraoperative temperatures less than 36 degrees. Since skin monitors are consistently two degrees cooler than core measures in adults [15], consideration of a different definition of hypothermia during their use may be warranted. Postoperative hypothermia in this setting was based on tympanic temperatures, which have been shown to differ in a non-systematic manner with rectal temperatures in a large, systematic review [16]. While this previous review could not rule out inaccuracies in rectal temperature methodology in the cohort of studies reviewed, the lack of agreement between tympanic and rectal temperature nonetheless

highlights a potential limitation in interpreting findings from the present study. Furthermore, such studies highlight the difficulties in defining perioperative hypothermia given the variation in methods used to monitor temperature in the clinical setting. Lastly, the smaller sample used to examine the relationship between hypothermia and outcomes is likely underpowered to detect other, potentially significant relationships. Data from this study may serve as a platform on which to base future studies in larger, heterogeneous samples of children.

This study found a significant prevalence of hypothermia in children despite a widespread emphasis on the importance of thermoregulation in the perioperative setting. Several areas for improvement identified, including improved use of warming techniques and consistent reassessment of temperature after operation. Increased vigilance in all patients, including older children may decrease the prevalence of this outcome. Further prospective studies in a larger sample are warranted in order to evaluate the relationship of perioperative hypothermia and outcomes in children.

Acknowledgements

The authors would like to thank Alan Tait, Shobha Malviya and Cathy Wenzel for their help with the preparation of this manuscript. The authors would also like to thank Jennifer Hemberg for her invaluable work in collecting the data for this manuscript.

Declaration of Interests: None of the authors have interests to declare.

Funding: This work is supported by no grants or other funds.

References

1. Rajagopalan S, Mascha E, Na J, Sessler DI (2008) The effects of mild perioperative hypothermia on blood loss and transfusion requirement. Anesthesiology 108: 71-77.
2. Lenhardt R, Marker E, Goll V, Tschernich H, Kurz A, et al. (1997) Mild intraoperative hypothermia prolongs postanesthetic recovery. Anesthesiology 87: 1318-1323.
3. Kurz A, Sessler DI, Lenhardt R (1996) Perioperative normothermia to reduce the incidence of surgical-wound infection and shorten hospitalization. Study of Wound Infection and Temperature Group. N Engl J Med 334: 1209-1215.
4. Mauermann WJ, Nemergut EC (2006) The anesthesiologist's role in the prevention of surgical site infections. Anesthesiology 105: 413-421.
5. Schmied H, Kurz A, Sessler DI, Kozek S, Reiter A (1996) Mild hypothermia increases blood loss and transfusion requirements during total hip arthroplasty. Lancet 347: 289-292.
6. Reynolds L, Beckmann J, Kurz A (2008) Perioperative complications of hypothermia. Best Pract Res Clin Anaesthesiol 22: 645-657.
7. Harper CM, Andrzejowski JC, Alexander R (2008) NICE and warm. Br J Anaesth 101: 293-295.
8. Tander B, Baris S, Karakaya D, Ariturk E, Rizalar R, et al. (2005) Risk factors influencing inadvertent hypothermia in infants and neonates during anesthesia. Paediatr Anaesth 15: 574-579.
9. Galante D (2007) Intraoperative hypothermia. Relation between general and regional anesthesia, upper- and lower-body warming: what strategies in pediatric anesthesia? Paediatr Anaesth 17: 821-823.
10. Sessler DI. (2008) Temperature monitoring and perioperative thermoregulation. Anesthesiology 109: 318-338.
11. Macario A, Dexter F (2002) What are the Most Important Risk Factors for a Patient's Developing Intraoperative Hypothermia? Anesth Analg 94: 215-220.
12. Hooper VD, Chard R, Clifford T, Fetzer S, Fossum S, et al. (2009) ASPAN's evidence-based clinical practice guideline for the promotion of perioperative normothermia. J Perianesth Nurs 24: 271-287.
13. Kasai T, Hirose M, Yaegashi K, Matsukawa T, Takamata A, et al. (2002) Perioperative risk factors of intraoperative hypothermia in major surgery under general anesthesia. Anesth Analg 95: 1381-1383,
14. Kheterpal S, Gupta R, Blum JM, Tremper KK, O'Reilly M, et al. (2007) Electronic reminders improve procedure documentation compliance and professional fee reimbursement. Anesth Analg 104: 592-597.
15. Langham GE, Maheshwari A, Contrera K, You J, Mascha E, et al. (2009) Noninvasive temperature monitoring in postanesthesia care units. Anesthesiology 111: 90-96.
16. Craig JV, Lancaster GA, Taylor S, Williamson PR, Smyth RL (2002) Infrared ear thermometry compared with rectal thermometry in children: a systematic review. Lancet 360: 603-609.