Comparison of two warming methods in preventing perioperative hypothermia in children: forced air versus warmer

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Abstract

Introduction: Perioperative hypothermia is common during anesthesia and surgery and is accompanied by several complications. Compared to adults, children are at a greater risk of hypothermia and its complications. The aim of this study was to compare forced air and warmer in maintaining normothermia during pediatric surgery.

Materials and Methods: This randomized controlled trial was performed on 90 children undergoing elective hernia repair equally distributed in three groups of warmer, forced air and control. Patients' body temperature was recorded preoperatively, intraoperatively, at the end of surgery and at the end of the postoperative care unit (PACU) stay. Time between anesthetic discontinuation and tracheal extubation and duration of PACU stay were also noted.

Results: Intraoperative and postoperative body temperature and body temperature on exit from PACU were significantly higher in forced air group in comparison to warmer and control groups and in warmer group in comparison to control group ($P<0.05$). Time between anesthetic discontinuation and tracheal extubation and duration of PACU stay were significantly shorter in forced air group compared to warmer and control groups and in warmer group compared to control group($P<0.05$).

Conclusion: In comparison between the two methods (Warmer vs. Forced air), we found that forced air was significantly more effective in maintaining normothermia during pediatric hernia repair.

Keywords

- Peri-operative
- Hypothermia
- Forced air
- Warmer
- Children

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Introduction

Hypothermia (core body temperature less than 36°C) has three main reasons: a reduction in heat production, an increase in loss of heat or dysfunction of the thermoregulatory mechanisms[1]. Unintended hypothermia is commonly encountered in the perioperative setting, owing to several factors such as contact with the operating room's cold environment, use of cold skin antiseptics, inhalation of cold anesthetic gases, administration of cold solutions and the dysfunction of thermoregulatory mechanisms due to anesthetics[2]. Unintended hypothermia is associated with both general and regional anesthesia, resulting in shivering, cardiac complications, prolongation of postoperative care unit (PACU) and hospital stay, an increase in infection rates and delay in wound healing and repair [1, 3, 4].

Children are at an increased risk for unintended hypothermia during surgery due to a less effective thermoregulatory capacity and an increased ratio of surface area to body weight; which results in greater heat loss[5, 6]. In fact, more than 50% of children experience intraoperative hypothermia[6]. Several factors can increase the risk of perioperative hypothermia in pediatric population; age, invasive surgery, lower baseline temperature, higher blood loss and transfusion rates [5, 6].

Metabolic rate is decreased by 20% in children undergoing general anesthesia, which is similar to the adult population [7]. Moreover, general anesthesia in most pediatric patients is applied in a setting where mechanical ventilation is partially or completely provided by the anesthesia team, thus very little heat is generated from breathing activity of the body [8]. Like adults, central inhibition of the thermoregulation and redistribution of body heat can increase the risk of perioperative hypothermia in pediatric population; but, the younger the age, the steeper are the slopes of each phase [9]. Greater surface area-to-volume and lesser insulating subcutaneous adipose tissue are other factors which contribute to greater transmittance of heat to the surroundings in pediatric patients undergoing surgery [8]. As a result, preservation of normal body temperature in pediatric patients is a chief priority during the perioperative phase.

Although passive measures such as warming blankets, sheets, or surgical draping, are used for warming in all patients, these measures have been reported to be ineffective in maintaining intraoperative core temperature [10]. Recent studies have shown that patients who have undergone active warming are 0.46 times less likely to develop hypothermia during operation as those who have received passive warming [11]. Circulating hot water blankets, infrared radiant heaters, forced air warmers and convection heaters are active warming methods which are commonly employed during surgery.

If occurrence of hypothermia in the OR (Operating Room) is reduced, cost-effectiveness and quality of patient care will improve in the healthcare setting. The purpose of this study was to compare the effectiveness of forced air and warmers in the prevention of hypothermia.

Materials and Methods

The present double-blind, randomized clinical study was carried out on 90 children undergoing

elective hernia repair in Children Medical Center, Tehran, Iran, from January to June 2017.

Participants

Inclusion criteria consisted of: patients with American Society of Anesthesiologists (ASA) class I and II, age between 1 and 6 years and absence of accompanying disorders such as coagulopathies and diabetes mellitus. Patients were excluded if they were outside the mentioned age range, experienced more than 20% change in their heart rate and blood pressure during operation or if parents refused to sign the informed consent form.

Sampling

Power analysis was done using a medium sample effect of 0.5, α= 0.05 and power of 0.8. For each group, sample size was 30 patients. Using a two-stage sampling method at first the eligible subjects were selected in an easy non-random method and then, they were randomly assigned to the three groups mentioned above.

Study protocol

Ninety patients were qualified for our study. Children were randomly divided in to three groups based upon the warming device; the forced-air warming system, warmer, and control. Duration of hernia repair was approximately 60 minutes in all patients.

Prior to surgery, patients' demographic characteristics (including age, sex and weight at the time of surgery) were recorded. The temperature of the OR and PACU was maintained at 22-23.5□. The temperature of the intravenous fluids was similar to the room temperature. All children received oral midazolam (0.5 mg /kg) and ketamine (5 mg /kg) 30 minutes before anesthesia induction. On arrival of the patient in the OR, peripheral vein catheter was inserted and standard hemodynamic monitoring was established. Next, thiopental sodium (3 mg/kg) was given using a face mask and anesthesia was induced using 8% sevoflurane and 100% oxygen inhalation by spontaneous breathing via a Mapleson F breathing system. To record intra-operative temperature, a digital nasopharynx thermometer was inserted after induction. When an adequate anesthetic depth was achieved, a dose of 1 μg /kg fentanyl was given intravenously and endotracheal tube was inserted. Patients were maintained on 2.5% isoflurane in 100% oxygen. Throughout the surgery, patients were monitored for heart rate, blood pressure and pulse oximetry. Participants were excluded from the study if a >20% change in intra-operative blood pressure and heart rate was recorded. Patients' body temperature was recorded four times; immediately after loss of consciousness, during surgery, at the end of surgery and at the end of the recovery room stay. Other data such as incidence of hypothermia and shivering, time between anesthetic discontinuation and tracheal extubation and duration of PACU stay were also recorded.

Statistical analysis

The results were analyzed by SPSS software, version 21. Quantitative and qualitative variables were described in terms of mean ± SD and percentages, respectively. In order to compare changes of temperature over time in the studied groups the ANOVA test was used. The significance level and power of the study were determined as 5% and 80%, respectively.

Ethics

The study protocol was approved by the Research Ethics Committee of Tehran University of Medical Sciences. It was also registered at the Iranian Registry of Clinical Trials. Parents/guardians provided informed, written consent for their children to participate in the study.

Results

A total of 90 children (66 boys, mean age 25.84±14.57 months) were included in the study. Thirty patients received intraoperative warming with forced air, 30 patients received intraoperative warming with warmer and 30 patients were assigned to the control group with no active warming device.

An ANOVA test was used to compare groups with respect to age, weight and the OR temperature which showed no statistically significant difference (**Table 1**). At the end of surgery, 18 patients (20%) experienced hypothermia and after gaining consciousness shivering was noted in 8(8.8%) patients (**Table 2**).

Table 1- Baseline characteristics of the three study groups

P-value	Control(N=30)	Warmer (N=30)	Forced air (N=30)	Variables
0.11	25.6±14.2	25.6±13.7	25.4±15.8	Age, months, mean±SD
0.16	23 (76.7%) (23.3%)7	10 (66.7%) 20 (33.3%)	23 (76.7%) 7(23.3%)	Sex, n (%) Male Female
0.12	12.48±1.9	12.33±2.8	12.7±2.82	Weight, kilo grams, mean±SD
0.108	23.14±0.33	23.8±0.28	23.12±0.48	OR temperature, ºC, mean±SD

The impact of forced air vs. warmer for management of patients' core body temperatures at four stages: preoperative (immediately after loss of consciousness), intraoperative (during surgery), postoperative (at the end of surgery) and at the end of recovery (on exit from PACU) was analyzed using the ANOVA.

The preoperative temperature didn't differ significantly between the three groups but there was a statistically significant difference with regards to patients' body temperatures at about mid way through surgery, at the end of surgery and on exit from PACU. Time between anesthetic discontinuation and tracheal extubation and duration of PACU stay were also significantly different between the three groups (**Table 2**).

Post-hoc comparisons using the Tukey's HSD test indicated that intraoperative body temperature, post-operative body temperature and body temperature on exit from PACU were significantly higher in forced air group compared to warmer and control groups and in warmer group compared to the control group (P-values<0.05). Time between anesthetic discontinuation and tracheal extubation and duration of PACU stay were significantly shorter in forced air group compared to warmer and control groups and in warmer group compared to control group (P-values<0.05).

Table 2- Study variables across the intervention groups

Variables	Forced air (N=30)	Warmer (N=30)	Control(N=30)	P-value
Preoperative temperature, ºC, mean±SD	36. 58±0.23	36. 5±0.22	36. 52±0.18	0.1
Intraoperative temperature, ºC, mean±SD	36. 44±0.26	36. 3±0.31	36. 2±0.6	0.001
Postoperative temperature, ºC, mean±SD	36. 5±0.24	36. 45±0.21	35. 97±0.63	0.000
Temperature at the end of recovery, ºC, mean±SD	36. 77±0.18	36. 73±0.24	36. 1±0.41	0.000
Time between anesthetic discontinuation and tracheal extubation, minutes, mean±SD	7. 1±1. 88	8. 3±1. 86	14. 8±2. 45	0.000
Duration of PACU stay, minutes, mean±SD	5. 7±1. 57	7. 3±2. 99	15. 36±5. 11	0.000
Hypothermia, n (%)	1(3. 33%)	3(10%)	14(46. 6%)	0.000
Shivering, n (%)	1(3. 33%)	1(3. 33%)	6(20%)	0.02

Discussion

Inadvertent hypothermia is a common concern in the perioperative period. It has been shown that core body temperature under 36ºC during the perioperative period may increase duration of hospital stay, infectious complications, cardiac comorbidities, increase the duration of muscle relaxant activity thus increasing body stress [12]. While the majority of studies on hypothermia have been carried out on the adult population, children undergoing surgery are more vulnerable to unintended perioperative hypothermia [6, 7]. This vulnerability is the result of increased heat loss and reduction of heat production during surgeries which are more common in children than adults [8]. The present study investigated forced air and warmer as different methods of warming in the prevention of hypothermia in pediatric population.

Our results showed that patients' core body temperatures during surgery, immediately after surgery and at the end of recovery were significantly higher in the forced air group compared to the warmer group. Moreover, time between anesthetic discontinuation and tracheal extubation and duration of PACU stay were significantly shorter in the forced air group (**Table 2**). Studies comparing the efficacy of different warming methods in prevention of unintended perioperative hypothermia have had different results. According to a recent review article, forced air warming methods had significant benefits for patients such as increased comfort and core temperatures in the intraoperative and postoperative periods along with decreased adverse outcomes of hypothermia in surgical patients [13]. On the other hand, according to Adriani and Moriber, preoperative warming with forced air combined with intraoperative warming has no advantage over intraoperative warming alone in keeping patients normothermic during the

perioperative period [12]. A recent study performed on patients undergoing transcatheter aortic valve replacement shows that intraoperative temperature, temperature at the end of surgery and temperature measured upon arrival to the ICU was higher in the water-circulating group in comparison to the forced-air group [14].

The difference in reported results can be attributed to several factors such as difference in study population, surgical procedures and characteristics of warming devices. According to Leeth et al. many factors may result in an increased risk of hypothermia during the prioperative period such as gender, extremes of age, the temperature of the room, duration and type of surgery, use of cold fluids, underlying conditions and type of anesthesia [15].

Our study was performed on pediatric patients aged 1-6 years who underwent elective hernia repair. Neonates and young infants were not included, all cases belonged to ASA class I and II and the duration of surgery was about 60 minutes in all patients. Rohrer's study included patients with a mean age of 80 years who had serious underlying cardiac involvement and the surgical procedure lasted about 3-4 hours [14]. In our study, factors such as sex, age, weight of patients and OR temperature were controlled and were statistically non significant among the three groups (**Table 1**). Moreover, the temperature of the OR and PACU were maintained at 22-23.5℃ and the temperature of the intravenous fluids was similar to the room temperature. All children underwent the same type of surgery (elective hernia repair) and the duration of surgery was about 60 minutes in all patients.

Conclusion

In summary, our results suggest that warming patients using forced-air is more effective than warmer in maintaining normothermia during pediatric hernia repair. Further trials should be undertaken to assess the effectiveness of other warming methods in the pediatric population. Moreover, other pediatric age groups undergoing major operations should also be assessed.

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