

Incidence, Risk Factors and Outcome of Perioperative Hypothermia in Pediatric Patients at the University Teaching Hospital of Kigali

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ABSTRACT

INTRODUCTION: To maintain normal temperature in pediatric patients is problematic. Patients who develop perioperative Hypothermia, are prone to severe complications, including impaired wound healing, postoperative infections and prolonged hospital stay.

Study Aims: This study aimed to determine the incidence of perioperative Hypothermia, factors associated with intraoperative Hypothermia, and the outcome of perioperative Hypothermia in pediatric patients operated at CHUK.

METHODS: A prospective observational study was conducted. All pediatric patients undergoing surgery under general anesthesia in theatre between June 2018 and August 2018 were eligible for the study. The temperature was taken on arrival in theatre, immediately after induction of anesthesia, then after every hour until the procedure finished. The postoperative temperature was taken every 30 minutes up to two hours, considering that patients stay in the postoperative care unit for 1-2 hours. Logistic regression was used to test each factor with the dependent variable and variables were carried to multivariate analysis. A P-value of <0.05 was a cutoff point to test for the significance of associations.

RESULTS: 103 pediatric patients were enrolled in the study, of whom 28 females and 75 males. Incidences of preoperative, intraoperative and postoperative Hypothermia were 67%, 71.7% and 67.7%, respectively. Female patients, general anesthesia, elective surgery, not using a warmer perioperatively and low operating room temperature were associated with intraoperative Hypothermia. Hypothermic patients had longer PACU stay compared to normothermic patients.

CONCLUSION: Perioperative Hypothermia is common at CHUK. Warming patients and management of operating room temperature should be done during anesthesia and in PACU.

Keywords: Perioperative, Hypothermia, Pediatric, Surgery, Outcome

INTRODUCTION

To maintain the normal temperature in pediatric patients is problematic [1]. Unintended Hypothermia is mostly encountered in children [2, 3]. Hypothermia can be divided into mild, moderate and severe when core temperature measurement is 35 to 35.9°C, 34 to 34.9°C and ≤ 33°C respectively [4,5].

Heat is lost through a number of processes (radiation, convection, conduction and evaporation), the major one being radiation. Radiation is the loss of heat from the body surface to a cooler solid surface with which the body is not in direct contact

but in relative proximity. Convection is the flow of heat from the body surface to cooler air. Conduction is the loss of heat from the body surface to cooler surfaces in direct contact. Evaporation is the humidification and warming of inspired air or skin moisture [4, 5, 6]. After anesthesia induction, there is a reduction in core temperature due to the loss of the core-periphery temperature gradient [3].

Hypothermia can cause physiological derangements, including coagulopathy, decreased drug metabolism and vasoconstriction [7, 8]. Patients who develop perioperative hypothermia are prone to severe complications, including impaired wound healing, postop-

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erative infections, increased bleeding with blood transfusions, cardiac disorders and prolonged hospital stay [7].

Children under one year-of-age are considered to be at high risk of perioperative Hypothermia as their thermoregulatory capacity is not well developed and can lose heat due to large surface area to body weight ratio and less subcutaneous fat [7, 9, 10]. Infants' response to Hypothermia is enhanced by vasoconstriction and non-shivering thermogenesis. The latter can be present up to 2 years-of-age. However, anesthetic agents can be inhibited and can lead to intraoperative Hypothermia [2, 10]. With cold stress in neonates, noradrenaline release, oxygen and substrate consumption are increased. Therefore, there is increased pulmonary vascular resistance, increased right to left shunting, decreased peripheral perfusion, oxygen delivery and acidosis [1].

Administration of cold intravenous fluids and evaporation from the surgical field to pediatric patients further expose them to perioperative Hypothermia. Hypothermia can still occur during the recovery phase and in the postoperative period. Therefore, postoperative rounds by anesthesia providers are mandatory [2].

A study of perioperative Hypothermia in the pediatric population at a tertiary hospital in Michigan, USA, found that 52% experienced intraoperative Hypothermia and Hypothermia was more common in older children and those undergoing longer, invasive procedures and was associated with more significant blood loss and blood transfusion [7]. A 2016 study in a tertiary hospital in Ethiopia, being more similar to our setting in Rwanda, revealed that intraoperative and postoperative Hypothermia is common. The incidence of postoperative Hypothermia being 79% of all pediatric patients [4].

Specific objectives: Kigali is a warmer place and we pre-hypothesized that rates of Hypothermia would be lower than other settings. We conducted this study to see whether Hypothermia is prevalent in a warmer area, determine its risk factors and length of stay in PACU. This study sought to determine the incidence of preoperative, intraoperative and postoperative Hypothermia in pediatric patients operated at an urban tertiary hospital in Rwanda. A secondary objective was to identify factors associated with intraoperative Hypothermia in pediatric patients operated at CHUK

METHODS

Study design: This is a prospective observational study conducted at CHUK.

Study setting: The University Teaching Hospital of Kigali (also known as Centre Hospitalier Universitaire de Kigali, CHUK) is a national public referral hospital [11]. CHUK is one of the major clinical teaching site for Rwandan residents undertaking their four-year residency to become specialists in anesthesia. Rwanda has a population of 12 million.

Inclusion criteria: The study included all pediatric patients undergoing major surgery under general anesthesia in theatre
Exclusion criteria: Patients were excluded if they met the following: fever, short procedures under local anesthesia, those;

those that bypass the post-anesthesia care unit, patients whose parents or guardians were not available to sign the consent

Sampling: All pediatric patients at CHUK operated between June 2018 to August 2018 were included.

The following formula estimated the sample size:

P is the prevalence or proportion of event of interest for the study. *E* is the Precision (or margin of error).

E will be 10% of *P*. For 5% level of significance.

$Z_{\alpha/2}$ is 1.96.

D is the design effect and is equal to 1 for simple random sampling.

The estimate of perioperative Hypothermia in pediatric patients is 78.9% (Ethiopia), and assuming 95% confidence interval or 5% level of significance and 10% margin of error, the sample size can be calculated as follow:

$$N = ((1.96)^2 \times 0.789(1-0.789) \times 1) / (0.1 \times 0.789)^2 = 103$$

Data collection: A structured questionnaire was used to collect data immediately from the patient and their case-files. We measured body temperature using a tympanic thermometer, and we considered patients to be hypothermic when their body temperature was <36°C [4,7,12,13]. Temperature was taken on arrival, immediately after induction, then after every hour until the procedure finished. The post-operative temperature was taken every 30 minutes for up to 2 hours, considering that patients stay on average in the post Anesthesia care unit for 1-2 hours.

Data Analysis: Data were analyzed with SPSS version 22.0. The quantitative variable was analyzed with "t" test and chi-square was used for qualitative variables. Logistic regression was used to test each factor with the dependent variable and variables were carried to multi-variant analysis. P-value of <0.05 was a cutoff point to test for the significance of associations.

Ethical considerations: Approval was granted from CHUK (Ref.:EC/CHUK/566/2018) and the University of Rwanda (No 057/CHMS IRB/2018) ethics committees to obtain data for this study, and informed consent was obtained from patients' parent or guardian. The confidentiality of the information from the patients was assured.

RESULTS

Personal and socio-demographic characteristics: Data were collected from 103 pediatric patients (Table 1). The majority of participants were male (73%). Most of the patients were ASA class I (ASA I) (64%). The highest number of patients, 27% belonged to the age group of pre-school (2-5 years) followed by infants (<1 year) (26%) and school-age children (6-12 years) (22%). Perioperatively a warmer was used in 34% of pediatric patients.

Hypothermia incidence: The incidence of intraoperative hypothermia was greater than postoperative hypothermia, the latter being greater than preoperative hypothermia (Figure 1). The incidence was 72% for intraoperative, 68% for postoperative and 67% for preoperative Hypothermia.

Length of procedure: The incidences of intraoperative Hypothermia after 3 or 4 hours of surgery were 83% and 100%, respectively

Table 1: Socio-demographic characteristics

Variables	Category	Frequency	Percentage
Age	Infant	27	26.2
	Toddler	15	14.6
	Preschool	28	27.2
	School age	23	22.3
	Adolescent	10	9.7
	Total	103	100.0
Sex	Male	75	72.8
	Female	28	27.2
	Total	103	100.0
ASA class	I	66	64.1
	II	13	12.6
	III	21	20.4
	IV	3	2.9
	Total	103	100.0
Anesthesia type	General	100	97.1
	Spinal	3	2.9
	Total	103	100.0
Warm IV fluids	Yes	10	9.7
	No	93	90.3
	Total	103	100.0
Operating room temperature	>24°C	98	95.1
	22-24°C	5	4.9
	Total	103	100.0
Type of surgery	Elective	75	72.8
	Emergency	28	27.2
	Total	103	100.0
Perioperative use of a warmer	Yes	35	34.0
	No	68	66.0
	Total	103	100.0

and they were greater than the other one after 1 hour of surgery at 75% (Figure 2).

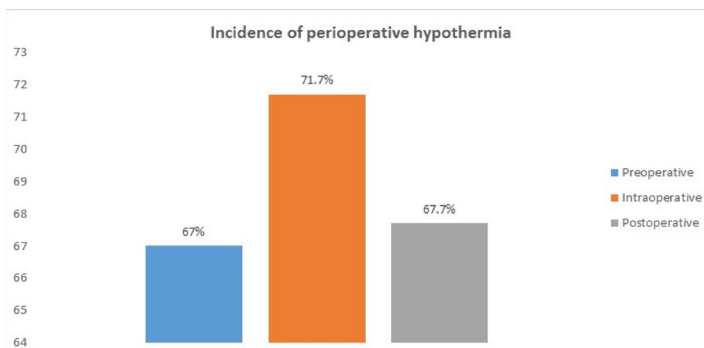


Figure 1: Distribution of preoperative, intraoperative and postoperative body temperature for pediatric patients

Factors associated with Hypothermia: not using a warmer perioperatively was strongly associated with intraoperative hypothermia $p < 0.05$ (Table 2).

The odds of developing postoperative Hypothermia when a warmer was not used perioperatively was almost three times as high as the odds of developing postoperative Hypothermia when a warmer was used. The odds of developing intraoperative Hypothermia for female patients was higher. The odds of developing intraoperative Hypothermia for patients who underwent surgery under general anesthesia were three times high as the odds of developing intraoperative Hypothermia for patients who underwent surgery under spinal anesthesia.

Operating room temperature: The odds of developing postoperative Hypothermia for operating room temperature of between

Table 2: The association of variables to intraoperative hypothermia for pediatric patients who underwent surgery at KUTH

Variables	Category	p-value	Odds ratio(OR)	95% C. I.
Sex	Female	0.5350	1.5556	0.3851-6.2832
	Male	*	*	*
Anesthesia type	General	0.4218	3.1875	0.1884-53.9157
	Spinal	*	*	*
Type of surgery	Elective	0.8434	1.1230	0.3552-3.5509
	Emergency	*	*	*
Perioperative use of a warmer	Yes	*	*	*
	No	0.0299	3.5238	1.1303-10.9857
Operating room temperature	>24°C	*	*	*
	22-24°C	0.7269	1.7327	0.0793-37.8782

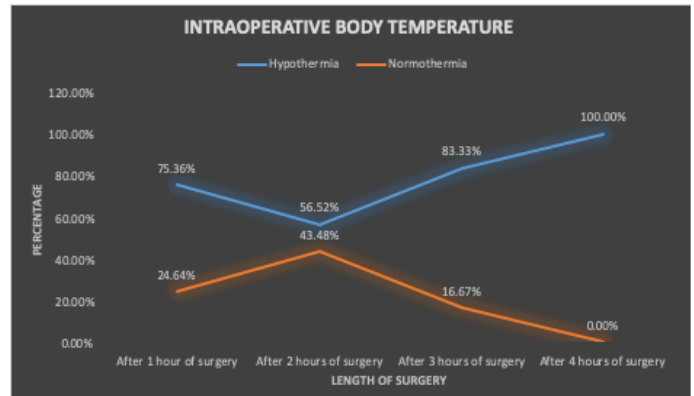


Figure 2: Incidence of intraoperative hypothermia and normothermia

22 to 24°C was almost six times, then a temperature of >24°C (Table 3).

Table 3: The association of variables to postoperative hypothermia

Variables	Category	p-value	Odds ratio (OR)	95% C. I.
Sex	Female	0.8128	1.1818	0.2966-4.7084
	Male	*	*	*
Perioperative use of a warmer	Yes	*	*	*
	No	0.1253	2.8000	0.7506-10.4454
Operating room temperature	>24°C	*	*	*
	22-24°C	0.2417	5.9434	0.3008-117.4248

Length of PACU stay: A high proportion of patients with Hypothermia stayed in PACU longer than patients with normothermia (Figure 3).

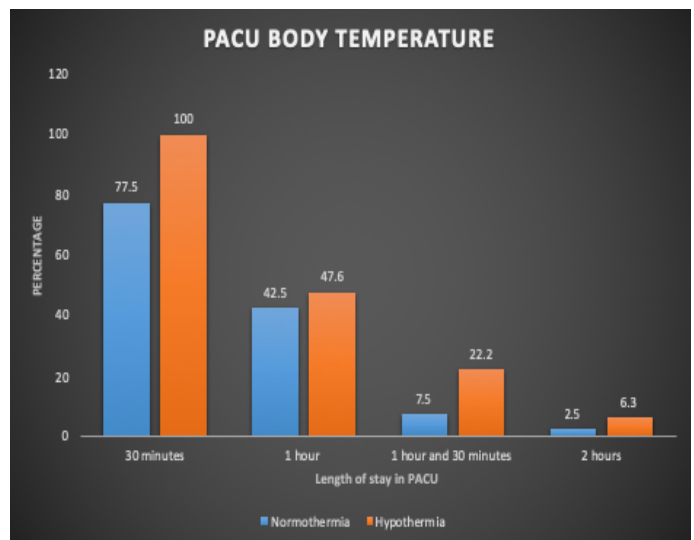


Figure 3: PACU length of stay

After 30 minutes in PACU, 100% of patients with Hypothermia were still in PACU compared to 78% of patients with normothermia. After 1 hour in PACU, 48% of patients with Hypothermia were still in PACU compared to 43% with normothermia. After two hours in PACU, 6% of patients with Hypothermia were still there compared to 2.5% of patients with normothermia.

DISCUSSION

Kigali is a warmer place. Before starting this study, it was hypothesized that perioperative Hypothermia might not be as common as other settings. This study sought to determine the incidence of preoperative, intraoperative and postoperative Hypothermia in pediatric patients operated at an urban tertiary hospital in Rwanda. A secondary objective was to identify factors associated with intraoperative Hypothermia in pediatric patients operated at CHUK

We found that pre, intra and post-operative Hypothermia incidence was high (67%, 72% and 68% respectively). The incidence of intraoperative Hypothermia is higher when compared to a study done by Pearce B et al. at the University of Michigan Health System where the incidence of intraoperative Hypothermia was 52% [7] and slightly higher when compared to a study done by Mossie in Ethiopia at where the incidence of intraoperative Hypothermia was 71 % [4]. The same study done by Mossie found that the incidence of postoperative Hypothermia was 79% [4], which was higher than the one found in our study.

A study done in 2017 in Tokyo, Japan by Yumoto M et al. on the incidence of inadvertent intraoperative Hypothermia with continuous air forced active warming in 16 years of age or younger patients found a hypothermia incidence of 54.5%, which was lower compared to the one found in our study [14].

The highest incidence found in our study may be because few perioperative warming interventions were being used at CHUK during our study period (only bair hugger was used in some patients) and therefore, this put our patients at risk of being more hypothermic. Another reason for having a high incidence of perioperative Hypothermia in our study may be due to the fact that perioperative temperature monitoring was not adequate as some health providers do not consider that perioperative Hypothermia can even occur in tropical countries. This suggests an opportunity for improvement with both using more perioperative warming interventions and adequate perioperative temperature monitoring.

In 2013, Yi J, Xiang Z, Deng X, Fan T, Fu R, Geng W, et al. conducted a prospective regional survey on the incidence of inadvertent intraoperative Hypothermia and its risk factors in patients undergoing general anesthesia in Beijing and found that high ambient temperature was protective of Hypothermia which is consistent with the result of our study [15].

In the study conducted in Ethiopia, Mossie found that the incidence of Hypothermia was 30.5% and 72%, respectively, after induction and between 2-3 hours of surgery. The results of Mossie's study showed an increased incidence of Hypothermia when the length of surgery was increased, which is consistent with our study, although the incidence in our study after 3 hour was higher than the other one of Mossie's study

In our study, we found that the use of general anesthesia increased the incidence of intraoperative by more than three times (OR=3.18) as compared to the use of spinal anesthesia, which is higher than the one found by Denu et al. in 2015 in Ethiopia where the use of general anesthesia increased incidence of intra-operative Hypothermia by more twice as compared to use of spinal anesthesia (AOR=2.3) [5]. The same study conducted in Ethiopia found that elective procedures increased intraoperative hypothermia incidence by 2.1 times [5], which is higher than the one found in our study for which elective procedures increased incidence of intraoperative Hypothermia by 1.12 times.

In the study he conducted in 2016 in Ethiopia, Mossie found that operating room temperature was strongly associated with postoperative Hypothermia and that females were three times more vulnerable for postoperative Hypothermia than male pediatric patients [4]. Compared to our study's findings, children who were operated at an ambient temperature of 22-24°C were more vulnerable to Hypothermia than children who were operated at an ambient temperature of >24°C and females were 1.18 times vulnerable for postoperative Hypothermia than male pediatric patients.

An observational study done in 2011, in Portugal on postoperative Hypothermia found that Hypothermia was a risk factor for longer length post-anesthesia care unit stay [16]. In our study, hypothermic pediatric patients had a longer post-anesthesia care unit stay compared to patients with normothermia (100% versus 77.5% after 30 minutes, 47.6% versus 42.5% after 1 hour, 22.2% versus 7.5% after 1 hour and 30 minutes and 6.3% versus 2.5%). This suggests that more investments need to be considered in preoperative and intraoperative temperature care, and it will lead to less resources being required in PACU.

Limitations: Although the results of this study are from CHUK, one of the biggest RWANDA referral hospitals, they may not be representative of the whole country due to different temperature monitoring practices and preventive measures about perioperative Hypothermia. However, data from this study may serve as a basis for conducting nationwide, large-scale research. Another limitation of our study was a small sample size used to detect the associations of variables to perioperative Hypothermia. But despite the small sample size, passive Insulation with routine thermal measures (warmed cotton blankets, socks, surgical drapes and head coverings), 2) early active external warming (forced-air warming with Bair Hugger device Medium" (38°C) or "High" (43°C), 30 minutes before anesthesia is induced and keeping the OR temperature within the required range need to be used to prevent perioperative hypothermia. Finally, the long-term complications of Hypothermia such as wound infection, wound healing, length of hospital stay, cardiac events and mortality were not followed in this study.

CONCLUSION

This study revealed a high incidence of preoperative, intraoperative and postoperative hypothermia in operated pediatric

patients. Female patients, general anesthesia, elective surgery, not using a warmer perioperatively, and low operating room temperature (22-24°C) were associated with intraoperative Hypothermia.

Female patients not using a warmer perioperatively and low operating temperature (22-24°C) were associated with postoperative Hypothermia. This study showed that hypothermic patients had increased transfusion requirements compared to patients with normothermia. From this study, hypothermic patients had longer PACU stay compared to normothermic patients.

Prewarming pediatric patients, use of warming techniques, and perioperative monitoring of temperature can decrease the incidence and improve the outcome of perioperative Hypothermia.

List of abbreviations

ASA: American Society of Anesthesiologists

IV: Intravenous

CHUK: Centre Hospitalier Universitaire de Kigali

OR: Operating Room

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PACU: Post Anesthesia Care Unit.

CMHS: College of medicine and health sciences

Availability of data and materials: Data analyzed during this study are included in this published article and are available from the corresponding author on reasonable request.

Authors 'contribution: JCU contributed to manuscript writing, editing and data analysis. JBU contributed to final data analysis, mentorship and interpretation. FN contributed to editing and mentorship. DN contributed to the final data analysis. The authors read the whole study and approved it to be ready for submission.

Clinical trial number: Not applicable

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