Cross-sectional Study

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Magnitude and associated factors of intraoperative hypothermia among pediatric patients undergoing elective surgery at Ayder Comprehensive Specialized Hospital 2023: prospective observational cross-sectional study Tigray, Ethiopia

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Background: Hypothermia is characterized by a drop in core body temperature of less than 36°C. It occurs frequently throughout the operating period and affects surgical patient outcomes differently in terms of morbidity and mortality. Because of coagulopathy, metabolic acidosis, multiple organ failure, hemodynamic instability, and infections, a core temperature below 34°C is strongly associated with mortality.

Objective: This study aimed to assess the magnitude and associated factors of intraoperative hypothermia in pediatric patients undergoing elective surgery at the Ayder Comprehensive Specialized Hospital.

Method: A prospective observational cross-sectional study was conducted on 399 pediatric patients undergoing elective surgery at Ayder Comprehensive Specialized Hospital in Tigray, Ethiopia, from 1 May 2023, to 30 July 2023. Participants in the study were selected by a systematic random sampling technique. The data collection procedure was chart review and intraoperative temperature measurement, and the collected data were analyzed by SPSS version 23. The independent variables were analyzed using binary and multi-logistic regression. The odds ratio, 95% CI, and *p* value of less than 0.05 were considered statistical significance.

Result: The magnitude of intraoperative hypothermia was 52.9%. Neonate and infant [adjusted odds ratio (AOR): 6, 95% CI: 3.7, 9.8], (AOR = 4.5, 95% CI: 2.9, 7) respectively, volume of fluid administered greater than half-liter [AOR: 4.37, (95% CI, 3, 6.4)], patients who underwent surgery during the morning [AOR: 5.3, (95% CI: 3.8, 7.4)], and duration of surgery and anesthesia greater than 120 minutes [AOR: 2.7, (95% CI, 1.8, 4)] and (AOR = 3.4, 95% CI, 2.4, 4.9], respectively, were factors significantly associated with intraoperative hypothermia.

Conclusion and recommendation: This study revealed a high magnitude of intraoperative hypothermia among pediatric patients. Being neonates and infants, having a cold volume of IV fluid administered greater than half a liter, entering surgery during the morning, the duration of surgery, and the anesthesia time were significantly associated with intraoperative hypothermia. The authors would like to advise anesthetists to use warm intravenous fluids, calculate IV fluids, and maintain room temperature.

Keywords: hypothermia, intraoperative, magnitude, risk factors

Introduction

Hypothermia is defined clinically as a core body temperature reduction of less than 36°C. It is a common condition that occurs in pediatric patients operating under general anesthesia[1].

HIGHLIGHTS

- Magnitude of intraoperative hypothermia in patients who underwent pediatric surgery was 52.9%, in 138 patients.
- Patients' body temperatures using the axillary site, were recorded and 29% of patients in body temperature were below normal on induction and 69.2% on the fourth hours.
- Age, volume of fluid administered greater than half a liter, type of operation, entry of surgery during the morning time, duration of surgery, and anesthesia time were significantly associated with intraoperative hypothermia ($P < 0.05$).
- Whereas co-morbidities, blood transfusion and intraoperative blood loss not significantly associated with intraoperative hypothermia ($P > 0.05$).
- Factors such as UN-warmed IV fluids, OR temperature, and blood transfusion were constant in this study.

Body temperature is tightly regulated in the core compartment, head, and trunk. But according to circadian rhythm and the

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menstrual cycle, core temperature varies by about 1°C. The mechanisms of heat loss during radiation convection, conduction, and evaporation during the intraoperative period are ~40–60%, 25–50%, 10%, and 25%, respectively[2,3].

Intraoperative hypothermia was a very common and severe complication in pediatric patients. The rates of hypothermia were 17.8%, 36.2%, 42.5%, and 44.1%, respectively, when temperature readings were taken at intervals of 1, 2, 3, and 4 h after the start of anesthesia and surgery. Patients who suffer from intraoperative hypothermia run the risk of experiencing serious side effects like slowed wound healing, infection after surgery, increased bleeding with blood transfusions, cardiac problems, and prolonged hospital stays[4].

In comparison to older children, children in the pediatric age groups have less insulating subcutaneous tissue, a higher surface area to volume ratio, and immature hypothalamic thermoregulatory capacity, which makes it easier for heat to escape and raises the risk of hypothermia. Non-shivering thermogenesis is a process used by the pediatric age group to generate heat without blood vessel constriction or shivering, though anesthesia compromises this mechanism[4,5].

The loss of body heat during the induction of anesthesia is brought on by three different mechanisms: the first is a quick, sharp drop in core body temperature that is observed during the first 40–60 min of anesthesia and is brought on by the re-distribution of heat from the core to the periphery as a result of anesthetic-induced vasodilatation; the second is a linear drop in core body temperature brought on by the difference between heat production and loss; the third The triggering core temperatures for vasoconstriction and shivering are reduced by 2–3°C when general anesthetics are administered[6].

There are numerous intraoperative risk factors, such as cold theater, wearing a theater gown, exposure to cool temperatures on transfer to the theater, the use of cool skin preparation fluids, anesthetic agents, operation room temperature, age, American Society of Anesthesiology (ASA) Class, systemic chronic diseases, regional block level, intraoperative blood loss, blood transfusion duration and type of surgery, and intravenous administration of cold fluids, which lead to hypothermia[7,8].

The morbidity and mortality of surgical patients are frequently affected by hypothermia, which frequently happens during surgery. A core temperature below 34°C is strongly linked to mortality because of infections, hemodynamic instability, coagulopathy, metabolic acidosis, and multiple organ failure[9].

Normothermia must be maintained throughout surgery to ensure the patient's comfort and prevent complications from hypothermia. The accuracy of the core body temperature can be determined, and the effects of various anesthetics on thermoregulation can be assessed using body temperature monitoring in the operating room (OR)[10,11]. It also aids in the detection of intraoperative hypothermia and malignant hyperthermia. The findings of this study are expected to be used as a foundation for revised pediatric management and further research into related issues because there is little research on the severity of intraoperative hypothermia in pediatrics in our region. The risk of intraoperative hypothermia in pediatric patients can be reduced by using a variety of preventive strategies, such as warming the patient's skin with a hot cloth, maintaining a constant operating room temperature, and warming intravenous fluid with other materials without any negative side effects[12,13]. None of these modern techniques are present in our setup, except for some efforts by anesthetists, such as warming blood by using boiled water. This method can have the danger of lysis because there is no way to know the temperature.

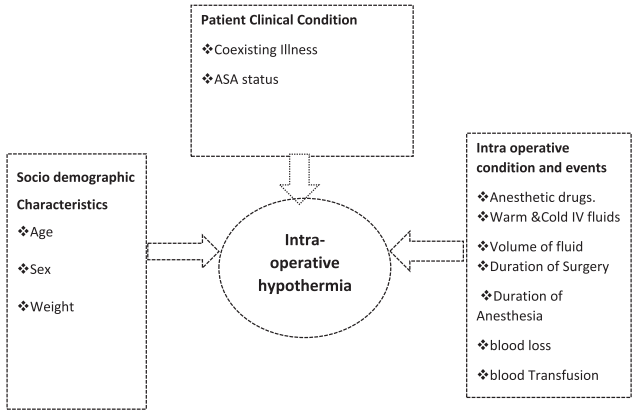

Figure 1. Conceptual framework showing of factors affecting intraoperative hypothermia. ASA, American Society of Anesthesiology.

Patients who are scheduled for surgery must wait in an open area outside the operating room, where they are exposed to the chilly air. As a result, there are no facilities for actively warming patients, who are already at risk of hypothermia before surgery. If they receive IV and inhalational medications, cold IV fluids over a half-liter, or the body cavity is exposed to a cold operating environment below 26°C, they will lose heat much more quickly[14].

Around three studies done on the incidence of postoperative hypothermia and associated factors for all patients who underwent surgery in 2014, as well as the incidence of perioperative hypothermia and associated factors for all patients who underwent surgery in 2015, were both the subject of studies at the Gondar University Hospital (GUH), and a study on the incidence of intraoperative hypothermia and associated factors for pediatric patients who underwent surgery in 2019 was conducted at the Tikur Anbessa Specialized Hospital[15–17]. since there has not been any prior research on the topic, the goal of this study is to ascertain the prevalence of intraoperative hypothermia and associated factors for pediatric patients undergoing surgery in the Ayder Comprehensive Specialized Hospital (Figure 1).

Methods

Study setting

The investigation was carried out in the Comprehensive Specialized Hospital in Ayder, Tigray, Ethiopia, The hospital is one of the largest hospitals in Tigray. It provides comprehensive health services to patients from all over the region of the country. There are seven operation tables in the surgical operation department from which one is always reserved for pediatric procedures. Ayder Comprehensive Referral Hospital offers referral and non-referral services such as medical, surgical, neuro, obstetric, ICU, and OR to the catchment populations of Tigray and Afara, with a total of 8 million residents. It provides surgical therapy to over 10 000 pediatric patients per year before wartime. This study was registered at www.researchregistry.com with

Research Registry UIN: research registry.\…\Desktop\research registry. doc and reported according to STROCSS criteria[18].

Study design and period

An institutional-based cross-sectional study was conducted at Ayder Comprehensive Specialized Hospital from 1 May 2023, until 30 July 2023.

Source population

All pediatric patients who underwent surgery at Ayder Comprehensive Specialized Hospital.

Study population

All pediatric patients who underwent surgery during the study period at Ayder Comprehensive Specialized Hospital and fulfilled inclusion criteria were included in the study.

Study variables

In this study, Dependent variables were -intraoperative hypothermia, yes/no

Independent variables were -socio-demographic variables such as age, sex, weight

The clinical condition of the patient -such as ASA status, co-existing medical illness

Intraoperatively related factors- blood transfusion, volume of blood loss, type of surgery and anesthesia, induction agents, duration of anesthesia and surgery, ambient temperature, warmed fluid and. Unwarmed fluid was administered, and a volume of intravenous fluid was administered.

Inclusion criteria

Pediatric patients who were less than 18 years old underwent surgery from 1 May 2023, until 30 July 2023.

Exclusion criteria

Patients with a body temperature less than 36°C, greater than 38° C, and who have sustained one or more traumatic injuries preoperatively.

Sample size determination

The sample size for the study participants was calculated using a single population proportion formula, assuming a Z-value of 1.96 at a 95% CI with a margin of error of 5%, and a 20% non-response rate with the value of population proportion ($P = 0.532$) based on a prior study of a similar nature carried out at Tikur Anbessa Specialized Hospital in 2019. 53.2% of patients experienced intraoperative hypothermia based on a prior study of a similar nature carried out at Tikur Anbessa Specialized Hospital in 2019. 53.2% of patients experienced intraoperative hypothermia[17]. $n = Z2\ \alpha/2 * p\ (1 - p)$

d2

$n = (1.96)2 * 0.532(0.468)$

$(0.05)2$

$n = 3.84 * 0.532(0.468)$

0.0025

$n = 382$

Where;

n = sample size,

α = the level of significance, 5%

P = hypothermia was 49.7%0.497)

d = Maximum acceptable difference (Margin of error = 5%)

$Z\alpha/2$ = the value under the standard normal table for the given value of confidence level

When the 5% non-response rate was considered, the overall sample size was equivalent to 382 + 19 = 401.

Sampling technique

Study participants were picked from the operational schedule using the systematic random sample approach and a skip interval of $K = N/n = 2$. K stands for the skip interval, N stands for the entire population being studied, and n for the overall sample size. Initial study participants were selected at random.

Data collection procedures

A systematic random sampling technique was used to conduct the survey. We took all pediatric patients who underwent surgery to Ayder. Data was collected using an observational, structured questionnaire. The structured questionnaire is developed in English in such a way that it includes some variables to meet the objectives, is translated into Tigrigna for a better understanding of the enumerators and respondents, and is then translated back to English to check for consistency. Data was collected from selected study participants using pretested questionnaires. After providing training for data collectors and having verbal informed consent taken from their, care givers then data was collected using structured questionnaire. Questionnaires mainly addressed socio-demographic data like the patient's age, sex, ASA physical status, co-existing illnesses, and other variables recorded in the chart. The temperature of the participants was measured intraoperatively on the day of Surgery using digital axillary thermometry by placing the probe of the thermometer in the armpit close to the axillary artery while tightly adducting the arm. The intraoperative body temperature of the patients was taken after surgery before extubating. Finally, each questionnaire was checked by the group for completeness, accuracy, clarity, and consistency of the information.

Data quality assurance

To ensure the quality of data, training on the objective and relevance of the study was given, and a brief orientation was given for data collectors. A pre-test of the questionnaire was done on 5% of patients from the study population at Mekelle Hospital. The results of the pre-test were not included in the final analysis. Based on the pre-test questions, questions were revised, and edited, and other modifications were made before actual data collection. During data collection, each questionnaire was revised by the principal investigator for completeness, accuracy, and clarity. In the case of missed questions, the necessary correction was done accordingly on the questionnaire for the main study. The data were collected by BSc anesthetists after training had been given. They were supervised by consulting anesthetists and investigators.

Data processing and analysis

The collected data was coded and entered into Epi-Data version 3.1 and exported to SPSS version 23 for analysis using the SPSS

version 23 window to assess the magnitude of intraoperative hypothermia and its associated factors in pediatric patients who underwent surgery. Independent variables were analyzed using binary and multivariable logistic regression to determine the clinical variables that were independently predictive of intraoperative hypothermia. The odds ratio, 95% CI, and *p* value were computed to identify associated factors and determine the strength of the association. Variables with a *p* value less than 0.2 on binary logistic analysis were taken to multivariable analysis. In multivariable logistic regression analysis, variables with a *p* value of less than 0.05 Both the crude odds ratio (COR) in binary logistic regression and the adjusted odds ratio (AOR) in multivariable logistic regression with the corresponding 95% CI were calculated to show the strength of the association and were considered statistically significant. 2.13. Anesthesia management standard protocols.

Anesthetic management was standardized according to the protocol of the hospital for different types of Modalities such as general anesthesia, spinal anesthesia and ultrasound guide nerve block. Monitoring was applied pre-induction and included an ECG, pulse oximeter, capnography and noninvasive blood pressure monitor.

Table 1

Socio-demographic characteristics and preoperative clinical condition.

Variables	Category	Frequency	Percent
	Neonate (0–30 days)	87	21.8
	Infant (1–12 months)	95	23.8
Age	Toddler (1–5 years)	93	23.3
	Children (6–12years)	69	17.3
	Adolescent (13–18 years)	55	13.8
	Total	399	100
Sex	Male	231	58
	Female	168	42
	Total	399	100
Weight	< 11 kg	203	50.9
	11–20 kg	89	22.3
	21–29 kg	29	7.3
	≥ 30 kg	78	19.5
	Total	399	100
ASA	ASA1	188	47.1
	ASA2	173	43.4
	ASA3	38	9.5
	Total	399	100
Co-existing	Yes	32	8
	No	367	92
	Total	399	100
Day time entry	Morning	286	71.7
	Afternoon	113	28.3
	Total	399	100
Surgical procedure	Orthopedics	32	8
	Neurosurgery	88	22
	ENT	98	24.6
	Gastrointestinal	18	4.5
	Urology	7	1.8
	General surgery	46	11.5
	Others	110	27.6
	Total	399	100

ASA, American Society of Anesthesiology.

Result

Socio-demographic characteristics and Preoperative clinical condition of study participants

This study involved 399 participants, with a response rate of 99.5%. The majority of participants were male, accounting for 58% of the total. 6.1 kg, ± the mean and SD Wight of participants were 16.1 ± 11.6, respectively. The highest number of age group were founded between 1 and 12 month, which was 95 (23.8%) and followed by the age group one up to 5 years old, which was 93 (23.3%) (Table 1).

With regards to the American Society of Anesthesiologists, 188 (47.1%) of participants were ASAI, 173 (43.4%) were ASA II, and 38 (9.5%) were ASA III (Table 1).

Seventy-one point seventh percent of the respondents underwent surgery in the morning. Table 1 indicates that ENT (Ear, Nose, and Throat) surgery had the highest number of procedures, followed by neurosurgical, general surgery, orthopedic, gastrointestinal, and urology procedures.

Anesthetic and surgical characteristics of study participants (Table 2)

According to the study, Propofol was used as the main anesthetic agent for induction in 44.1% of, patient followed by Thiopental in 37.6% of cases. In terms of intraoperative blood loss, 90.5% of cases had less than 7 ml/kg, while 9.5% had more than 7 ml/kg. The total amount of IV fluid utilized was less than 500 ml in 70.2% of cases and more than 500 ml in 29.8% of cases. The mean surgical duration was 109.36% min with ± 4.95 min, while the mean anesthetic duration was 117.86 ± 63 min (Table 2).

Table 2

Intraoperative surgery and anesthesia related factors

Variables	Category	Frequency	Percent
Induction agent	Ketamine	67	16.8
	Thiopental	150	37.6
	Propofol	176	44.1
	Isoflurane	6	1.5
	Total	399	100
Muscle relaxant			
Suxamethonium	330	82.7	
	Vecuronium	6	1.5
	Atracurarium	63	15.8
	Total	399	100
Total IV fluid used intraoperatively	< 500 ml	280	70.2
	> 500 ml	119	29.8
	Total	399	100
Duration of surgery	< 120 min	188	47.1
	> 120 min	211	52.9
	Total	399	100
Duration of anesthesia	< 120 min	159	39.8
	> 120 min	240	60.2
	Total	399	100
Intraoperative blood loss	< 7 ml/kg	361	90.5
	> 7 ml/kg	38	9.5
	Total	399	100

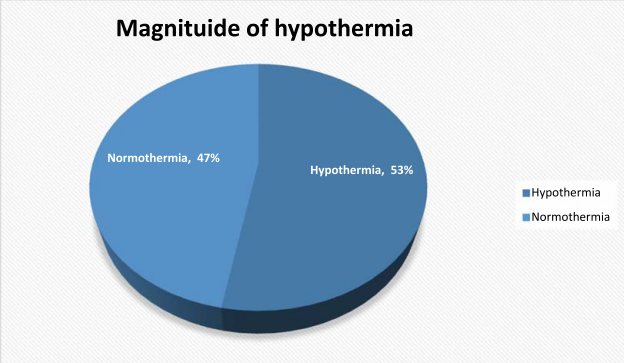

Figure 2. Magnitude of intraoperative hypothermia.

Magnitude of intraoperative hypothermia (Fig. 2)

In this study, the magnitude of intraoperative hypothermia in patients who underwent pediatric surgery was 52.9%, in 399 patients (Fig. 2).

Trend of intraoperative body temperature (Fig. 3)

According to Figure 3, Patients' body temperatures using the axillary site, were recorded and 29% of patients' body temperatures were below normal on induction and 69.2% on the fourth hour (Fig. 3).

Factors associated with intraoperative hypothermia: (Table 3)

Results of binary logistic regression analysis

Based on the binary logistic regression analysis conducted, the results indicate that neonates have a 1.4 times higher probability of experiencing intraoperative hypothermia compared to adolescents, with a CI of 95% ranging from 1.2 to 1.7. Additionally, patients classified as ASA States II according to the American Society of Anesthesiologists have a 2.4-fold increased risk of intraoperative hypothermia compared to patients in ASA I, with a CI of 95% ranging from 1.6 to 3 (Table 3).

Patients who received more than 500 ml of IV fluid were 1.8 times more likely than those who got less than 500 ml to experience inter-operative hypothermia with a CI of 95% ranging from 0.245 to 1.46. In this study, patients who had surgeries lasting more than 120 minutes had an increased risk of developing intraoperative hypothermia by 1.9 times compared to patients who had surgeries lasting less than 120 min with a CI of 95% ranging from 1.9 to 3.6 (Table 3).

Individuals who received anesthesia for more than 120 min had a 2.4-fold increased risk of developing intraoperative hypothermia Compared to patients who got anesthesia for less than 120 minutes with a CI of 95% ranging from 1.6 to 3.6. Those who underwent surgery in the morning had a 2.6-fold increased risk of experiencing intraoperative hypothermia compared to those who underwent surgery in the afternoon with a CI of 95% ranging from 1.8 to 4 (Table 3).

Results of multivariable logistic regression analysis (Table 4)

When adjusted those variables, age, daytime entry, the amount of fluid supplied, the length of the surgery, and the duration of the anesthesia were associated with intraoperative hypothermia (Table 4).

Based on the multivariable logistic regression analysis conducted, the results indicate that neonates have a 6-times higher probability of experiencing intraoperative hypothermia compared to adolescents, with a CI of 95% ranging from 3.7 to 9.8. Patients who got more than 500 ml of IV fluid have a 4.37 times higher probability of experiencing intraoperative hypothermia compared to those who got less than 500 ml, with a CI of 95% ranging from 3 to 6.4(Table 4).

In this study, patients who underwent surgery and anesthesia for greater than 120 min were 2.7 and 3.4 times more likely to develop intraoperative hypothermia than those who underwent surgery and anesthesia for less than 120 min with a CI of 95% ranging from 1.8 to 4 and 2.4 to 4.9, respectively(Table 4).

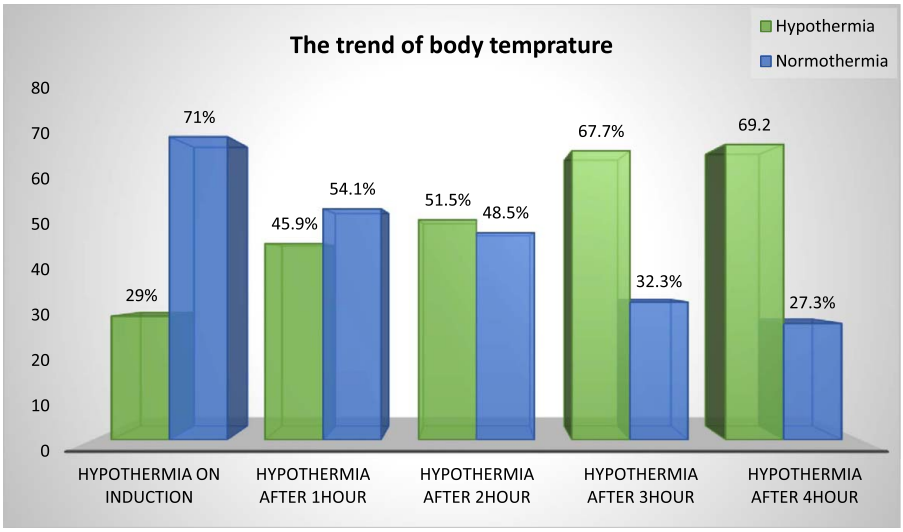

Figure 3. Illustrate the trend of intraoperative body temperature.

Table 3

Binary logistic regression analysis of factor associated with intraoperative hypothermia

Variables	Category	Intraoperative hypothermia		COR (95% CI)	*P*
		Yes, *n* (%)	No, *n* (%)		
Age group	Neonate (0–30 days)	67 (77)	20 (23)	1.4 (1.2, 1.7)	**0.001***
	Infant (1 12 months)	63 (66.3)	32 (33.7)	1.2 (1.10, 1.5)	**0.007***
	Toddler(1 5 years)	44 (47.3)	49 (52.7)	1.05 (0.9, 1.2)	**0.151***
	Children (6–12 years)	23 (33.3)	46 (66.7)	0.714 (0.189, 2.695)	0.850
	Adolescent (13–18 years)	14 (25.5)	41 (74.5)	1	
Sex	Male	115 (49.8)	116 (50.2)	0.76 (0.64, 0.90)	0.423
	Female	96 (57.1)	72 (42.9)	1	
Weight	< 11 kg	142 (70)	61 (30)	1. 8 (1.4, 2.3)	**0.001***
	11–20 kg	32 (36)	57 (64)	0.766 (0.253, 2.314)	0.636
	21–29 kg	14 (48.3)	15 (51.7)	0.421 (0.095, 1.868)	0.255
	≥ 30 kg	23 (29.5)	55 (70.5)	1	
ASA	ASAI	67 (35.6)	121 (64.4)	1	
	ASAII	115 (66.5)	58 (33.5)	2.2 (1.6, 3)	**0.001***
	ASAIII	29 (76.3)	9 (23.7)	3.64 (2.5, 5.3)	**0.011***
Co-existing	Yes	26 (81.2)	6 (18.8)	4.4 (3, 6.4)	**0.063***
	No	185 (50.4)	182 (49.6)	1	
Day time entry	Morning	170 (59.4)	116 (40.6)	2.6 (1.8, 4)	**0.013***
	After none	41 (36.3)	72 (63.7)	1	
Type of surgery	Orthopedics	12 (66.7)	20 (62.5)	1.021 (0.253, 4.115)	0.977
	Neurosurgery	71 (80.7)	17 (19.3)	2.4 (1.6–3.6)	**0.001***
	ENT	46 (47)	52 (53)	0.656 (0.256, 1.684)	0.381
	Gastrointestinal	6 (33.3)	12 (66.7)	1.167 (0.189, 7.207)	0.868
	Urology	3 (42.9)	4 (57.1)	0.583 (0.034, 10.075)	0.711
	General surgery	32 (69.6)	14 (30.4)	1.25 (0.9, 1.7)	**0.037***
	others	40 (36.4)	70 (63.6)	1	
Total IV fluid used intra- operatively	< 500 ml	139 (49.6)	141 (50.4)	1	
	> 500 ml	75 (63)	44 (37)	1.8 (0.245, 1 .467)	**0.011***
Duration of surgery	< 120 min	84 (44.7)	104 (55.3)	1	
	> 120 min	127 (60.2)	84 (39.8)	1.9 (1, 3.6)	0.037*
Duration of anastasia	< 120 min	66 (41.5)	93 (58.5)	1	
	> 120 min	153 (63.8)	87 (36.2)	2.4 (1.6, 3.6)	**0.014***
Intraoperative blood loss	< 7 ml/kg	182 (50.4)	179 (49.6)	1	
	> 7 ml/kg	29 (76.3)	9 (23.7)	0.305 (.080, 1.161)	**0.082***

1, reference Group; ASA, American Society of Anesthesiology; COR, crudes odds ratio.

*$p <$ 0.2 value.

Type of surgery neuro and general surgery were significantly associated with *P* values of (0.001, 0.028), respectively. Patients who underwent surgery during the morning time entry had more than 1.38 times higher odds of developing intraoperative hypothermia compared with those who underwent surgery during the afternoon time entry with a CI of 95% ranging from 3.8 to 7.4 (Table 4).

Discussion

Intraoperative hypothermia, one of the most common problems encountered during surgery and anesthesia, affects more than 70% of patients undergoing surgery. As a result, it increases both intraoperative and postoperative morbidity and mortality[1,3].

IV fluid temperature, OR temperature, and blood transfusion were constant as all IV fluids were cold, OR temperature was not adjusted, and no patient received a blood transfusion. These variables were removed from the analysis.

In this study, the overall incidence of intraoperative hypothermia was 52.9%, with a body temperature range of 32–35.9° C. This study's magnitude is similar to a prospective observational study conducted on 270 pediatric patients in the United States at the University of Michigan Hospitals and Health Centers[4]. The study had a magnitude of 52%.

The current finding has a higher magnitude compared to a prospective observational study conducted by Kioko *et al*.[19] in Kenya in August 2013, which involved 100 pediatric patients and found a magnitude of 30%. However, in the current study, the magnitude was 52.9%. The variation in results might be due to differences in sample size and environmental factors.

Our study, which found intraoperative hypothermia, was smaller in size than two other observational studies. A study conducted in November 2015 at Chengdu Women's and Children's Central Hospital on pediatric patients who had undergone intestinal surgery discovered a higher incidence of hypothermia. The other study, conducted in 2018 on 103 pediatric patients at the University Teaching Hospital of Kigali by Uwimana and colleagues, found a higher incidence of hypothermia[8,13]. Hypothermia occurred in 52.9% of our study participants. Differences in clinical study setups, types of surgery, environmental conditions, or seasonal variations may all contribute to the variability in findings.

Table 4

Multivariable logistic regression analysis of factor associated with intraoperative hypothermia

		Intraoperative hypothermia				
Variables	**Category**	**Yes, *n* (%)**	**No, *n* (%)**	**COR (95% CI)**	**AOR (95% CI)**	***P***
Age group	Neonate (0–30 days)	67 (77)	20 (23)	1.4 (1.2, 1.7)	6 (3.7, 9.8)	0.022*
	Infant (1–12 months)	63 (66.3)	32 (33.7)	1.2 (1.10, 1.5)	4.5 (2.9, 7)	0.029*
	Toddler (1–5 years)	44 (47.3)	49 (52.7)	1.05 (0.118, 1.391)	3.7 (2.5, 5.6)	0.019*
	Children (6–12 years)	23 (33.3)	46 (66.7)	0.714 (0.189, 2.695)	0.414 (0.057, 3.030)	0.385
	Adolescent (13–18 years)	14 (25.5)	41 (74.5)	1	1	
Weight	< 11 kg	142 (70)	61 (30)	1. 8 (1.4, 2.3)	9.606 (0.271, 340.488)	0.214
	11–20 kg	32 (36)	57 (64)	0.766 (0.253, 2.314)	10.469 (0.597, 183.454)	0.180
	21–29 kg	14 (48.3)	15 (51.7)	0.421 (0.095, 1.868)	0.812 (0.095, 6.966)	0.850
	≥ 30 kg	23 (29.5)	55 (70.5)	1	1	
ASA	ASAI	67 (35.6)	121 (64.4)	1	1	
	ASAII	115 (66.5)	58 (33.5)	2.2 (1.6, 3)	0.743 (0.205, 2.698)	0.652
	ASAIII	29 (76.3)	9 (23.7)	3.64 (2.5, 5.3)	0.172 (0.017, 1.718)	0.134
Co-existing	Yes	26 (81.2)	6 (18.8)	4.4 (3, 6.4)	0.159 (0.015, 1.646)	0.123
	No	185 (50.4)	182 (49.6)	1	1	
Day time entry	Morning	170 (59.4)	116 (40.6)	2.6 (1.8, 4)	5.3 (3.8, 7.4)	**0.048***
	After none	41 (36.3)	72 (63.7)	1	1	
Total iv fluid used intra- operatively	< 500ml	139 (49.6)	141 (50.4)	1	1	
	> 500ml	75 (63)	44 (37)	1.8 (0.245, 1 .467)	4.37 (3,6.4)	**0.017***
Type of surgery	Orthopedics	12 (37.5)	20 (62.5)	1.021 (0.253, 4.115)	0.315 (0.051, 1.948)	0.214
	Neurosurgery	71 (80.7)	17 (19.3)	2.4 (1.6–3.6)	5.84 (3.9, 8.7)	**0.001***
	ENT	46 (47)	52 (53)	0.656 (0.256, 1.684)	0.347 (0.090, 1.333)	0.123
	Gastrointestinal	6 (33.3)	12 (66.7)	1.167 (0.189, 7.207)	1.424 (0.196, 10.323)	0.727
	Urology	3 (42.9)	4 (57.1)	0.583 (0.034, 10.07)	0.410 (0.015, 11.073)	0.596
	General surgery	32 (69.6)	14 (30.4)	1.25 (0.9, 1.7)	3.2 (2, 5)	**0.028***
	others	40 (36.4)	70 (63.6)	1	1	
Duration of surgery	< 120 min	84 (44.7)	104 (55.3)	1	1	
	> 120 min	127 (60.2)	84 (39.8)	1.9 (1, 3 .6)	2.7 (1.8, 4)	**0.047***
Duration of Anastasia	< 120 min	66 (41.5)	93 (58.5)	1	1	
	> 120 min	153 (63.8)	87 (36.2)	2.4 (1.6, 3.6)	5.3 (3.8, 7.4)	**0.018***
Intra- operative blood loss	< 7 ml/kg	182 (50.4)	179 (49.6)	1	1	
	> 7 ml/kg	29 (76.3)	9 (23.7)	0.305 (0.080, 1.161)	1.069 (0.195, 5.878)	0.939

1, reference group; AOR, adjusted odd ratio; ASA, American Society of Anesthesiology; COR, crudes odds ratio.
*statically significant $p < 0.05$ value.

Neuro and general surgery were significantly associated, with *P* values of (0.001, and 0.028), respectively. This study was consistent with a previous study conducted by Wafaa Ibrahim Mahmoud at Cairo University in Egypt in 2019[20]. The use of cold fluid for recitation and lavage, as well as distorted thermoregulation in head injury patients, could be contributing factors.

The administration of more than half a liter of fluid was found to be significantly associated with intraoperative hypothermia. This finding is consistent with a 2019 study conducted at Tikur Anbessa Specialized Hospital in Addis Ababa, which found that pediatric patients receiving general anesthesia with a large volume of fluid administration were at a higher risk of intraoperative hypothermia due to unavoidable heat loss[21]. This association between fluid administration and intraoperative hypothermia was statistically significant ($P = 0.017$) in the study.

In multivariable analysis, age, volume of fluid administered, duration of surgery and anesthesia, and surgery during the morning were significantly associated with intraoperative hypothermia.

This study found that pediatric patients of all ages, especially neonates and infants, had a statistically significant association with intraoperative hypothermia. The study showed that neonates and infants had an AOR of 6 (with a 95% CI of 3.7 to 9.8) and 4.5 (with a 95% CI of 2.9 to 7), respectively. These findings are consistent with a previous study conducted in 2022 at Addis Ababa public hospitals by Getachew Mekete, which also found a significant association between intraoperative hypothermia and pediatric patients, including neonates and infants[17,21]. The possible reason for this association is that pediatrics have a higher surface area to volume ratio, immature hypothalamic thermoregulatory capacity, and less insulating subcutaneous tissue, which makes them more susceptible to heat loss.

During our study, we found that children who had undergone surgery for more than 120 min and received anesthesia for more than 120 min were significantly more likely to experience intraoperative hypothermia. This finding aligns with the results of a previous study conducted in 2010 at the Michigan Hospital and Health Center in the United States of America, as well as a study done at Tikur Anbessa Specialized Hospital in Addis Ababa, Ethiopia[4,17]. One possible explanation for this association is that patients who undergo prolonged surgery and anesthesia may experience a decrease in their response to heat loss due to the suppression of the thermoregulatory center by the anesthetic agent. Additionally, these patients may lose heat more easily due to contact with cold surgical instruments and the administration of intravenous fluids to replace blood loss and other deficits.

Patients who undergo surgery in the morning are more likely to develop intraoperative hypothermia than those who have surgery in the afternoon. The odds of developing hypothermia are 1.38 times higher for patients who have surgery in the morning compared to those who have surgery in the afternoon. This is a new finding that has not been seen in previous studies. One possible explanation for this phenomenon is the environmental temperature. If the temperature is cold, the patient may become hypothermic, and vice versa.

In our study, we found that variables like weight and ASA were not significantly linked to intraoperative hypothermia, with *P* values of 0.54 and 0.24, respectively. This finding is similar to a previous study conducted at the University Teaching Hospital in Lusaka, Zambia, in 2017[22].

We also observed that intraoperative blood loss was not significantly associated with intraoperative hypothermia, with a *P* value of 0.679. This is in line with a previous study conducted by Wafaa Ibrahim Mahmoud at Cairo University, Egypt[20]. The reasons for this could be attributed to the clinical setting, the expertise of surgeons, or the use of cautery.

In this study, it was found that pediatric patients with comorbidities were not significantly associated with intraoperative hypothermia, with a *P* value of 0.132. This study differs from a previous study conducted at the University of Gondar Comprehensive Specialized Hospital by Tegegne *et al.*[15]. The reason for this difference could be due to factors such as sample size, nutritional differences, or environmental factors.

Strengths and limitations of the study

In addition to the homogeneity of the study participants this study has the following strength & limitations. The study is observational, Patients were randomly allocated, and limited to a single center, the sample is small and this study used of digital axillary thermometer to measurement of core body temperature, in this study there was different types of case and procedure were included this may affect the result of due to confounding with each other, and limited publish article in Ethiopia and Africa.

Conclusion

This study revealed a high magnitude of intraoperative hypothermia among pediatric patients. Age, volume of fluid administered greater than half a liter, type of operation, entry of surgery during the morning time, duration of surgery, and anesthesia time were significantly associated with intraoperative hypothermia.

Recommendation

Based on this study finding, our recommendation for warded to:

For anesthetists

During the clinical practice of anesthesia, every anesthetist should avoid using the volume of fluid administered greater than half a liter, and the duration of surgery, and anesthesia time as much as possible should be shortened. We recommended that the researcher to conduct further study on the prevention and outcome of intraoperative hypothermia with strong method of study designs.

For public healthy planner and administrator

We would like to advice for public healthy planner to develop guide line for prevention and management of intraoperative hypothermia, and For Ayder comprehensive specialized Hospital Administrators we recommended to plan ways of strategic method for prevention of intraoperative hypothermia for better outcome.

Ethical approval

Ethical clearance and approval was obtained from the ethical review committee, Mekelle University. Permission was obtained from Comprehensive referral Hospital and the study was undertaken on the basis of the parent's wish by obtaining informed oral and written consent. There was no coercion, and or no incentives to be involved in the study. At last, the confidentiality of information obtained was secured or assured.

Consent

Written informed consent was obtained from the patient for publication and any accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal on request.

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The study was self-sponsored.

Author contribution

Y.B. and M.T.: developed the proposal, collected the data, analyzed the data and designing the study, data interpretation prepared and critically reviewed the manuscript. A.B., A.M., and Y.H.: assist in conceive of data and designed the study, supervised the data collection, performed the analysis, interpretation of data, drafted the manuscript and final approval of the revision for publication. All authors also read and approved the final manuscript.

Conflicts of interest disclosure

The authors declare that they have no competing interests.

Research registration unique identifying number (UIN)

The research is register eat http://www.researchregistry.com with UIN number Your unique identifying number is: researchregistry9759,Desktop\researchregistry.docx.

Guarantor

All authors.

Data availability statement

A copy of the written consent is available for review by the Editor-in-Chief of this journal on request.

Provenance and peer review

We hereby state that this work is original, has not been published or accepted for publication, and is not under consideration for publication in another journal.

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