INCIDENCE AND ASSOCIATED RISK FACTORS FOR INTRAOPERATIVE HYPOXEMIA IN PEDIATRIC PATIENTS WHO UNDERWENT ELECTIVE AND EMERGENCY SURGERY UNDER GENERAL ANESTHESIA AT TIKUR ANBESSA SPECIALIZED HOSPITAL, ADDIS ABABA, ETHIOPIA, 2023/24.

By: SURAFIEL ATALE (ACCPMR YEAR 3)

THE THESIS IS TO BE SUBMITTED TO ADDIS ABABA UNIVERSITY SCHOOL OF MEDICINE IN PARTIAL FULFILLMENT FOR THE REQUIREMENT OF SPECIALTY CERTIFICATE IN ANESTHESIOLOGY, CRITICAL CARE, AND PAIN MEDICINE.

MAY: 2024

Acknowledgment

First of all, I would like to express my gratitude to the department of anesthesiology, critical care, and pain medicine at Addis Ababa University School of Medicine for providing me with the means to conduct this study. I would like to express my sincere gratitude to my advisor, Dr. Blen Ayele and Dr. Semira Endris, for all of your help with this proposal development, include recommendations, expert advice, and support. I would like to express my gratitude to the nurse anesthetists and anesthesia residents for their unwavering assistance with data collection.

Declaration of the investigator

In partial fulfillment of the requirements for a specialty certificate in Anesthesiology, Critical Care, and Pain medicine, I, Dr. Surafiel Atale, declare that this thesis is my original paper work on the incidence and associated risk factors of intraoperative hypoxemia in pediatric patients underwent elective and emergency pediatric surgery at Tikur Anbessa specialized hospital. This research was conducted from October 1st to April 29th, 2024, as described in the methodology section of the proposal.

Investigator	Address	Sign
Dr. Surafiel Atale	ethiopiandocs@gmail.com	……………………..

Submission: For Addis Ababa University, College of Health Science, school of Medicine

Department of Anesthesiology, Critical Care and Pain Medicine.

Advisor name	Sign
Dr. Blen Ayele (MD)	…………….
Dr. Semira Endris (MD)	……………..

Department head

Dr. Fetiya Alferd (MD)	…………….

Table of Contents

List of abbreviations

List of table

List of figures

Abstract

Background: Intraoperative hypoxemia is a very common respiratory adverse event in pediatric anesthesia. It causes hemodynamic instability like tachycardia, bradycardia, cardiac arrest, and hypoxic brain insults, and it is associated with increased morbidity and mortality. Even though it is common, there are a few studies' that show the incidence of intraoperative hypoxemia increases with younger ages.

Objective: The objective of this study is to determine the incidence of intraoperative hypoxemia and its associated patient, surgical, and anesthesia related risk factors in elective and emergency pediatric surgery at TASH.

Method: The study design was a single-center analytic prospective observational study at Tikur Anbessa Specialized Hospital with a sample size of 208. Convenience consecutive sampling technique was used to select the patient. The data was collected from pediatric patients who have had non-cardiac surgery from induction to the emergence of general anesthesia by continuous monitoring and observation of the pulse oximetry record from the monitor. The observed data was documented in the prepared anonymous questionnaire. The data was entered, coded, cleaned, and analyzed by SPSS 29 software. Logistic regression was used to assess the association between the dependent and independent variable and p value< 0.05 at Confidence interval of 95% was used for assessing the statistical significance.

Result: Among the 208 pediatric patients included in the study, 117 (56.2%) were experienced a drop in saturation at or below 90%. Forty four (37.6%) of this study participants (117) had only a one minute duration of desaturation, and 49 (41.8%) of the participants had one episode. From 117, 91 (77.7%) were attributed to true hypoxemia, and the other 26 (22.2%) were artifacts. 34 (29%) occurred during induction, and the remaining occurred during maintenance and emergence. From all true hypoxemia, 46(50.5%) were mild, and the remaining's were in the moderate to severe ranges. The study finding showed that the urgency of the surgery, neonatal age, higher ASA class and the presence of comorbidity were associated with hypoxemia by bivariate and multivariate logistic regression.

Conclusion: Since intraoperative hypoxemia is prevalent in pediatric patients, understanding and addressing these risk factors may help to improve perioperative care and outcomes.

Chapter one

1. Introduction

1.1. Background

Hypoxia is a state in which oxygen is not available in sufficient amounts at the tissue level to maintain adequate homeostasis, which results from inadequate oxygen delivery to the tissues either due to low blood supply or low oxygen content in the blood (hypoxemia) (3). Hypoxemia can be measured by continuous pulse oximetry, which has a comparable result with arterial blood gas analysis (1, 3).

In the context of pediatric surgery, intraoperative hypoxemia is commonly defined as any arterial oxygen saturation (SpO2) value less than or equal to 90% for duration of at least 1 minute, excluding instances attributed to artifacts. Artifacts in this context refer to SpO2 readings below 90% that are clearly caused by factors such as sensor displacement, electro cautery interference, patient movement, or other disturbances affecting the SpO2 probe's contact with the patient and peripheral perfusion. Accurate identification and differentiation of true hypoxemia from artifact-induced fluctuations are essential for effectively monitoring and managing oxygen levels during pediatric surgical procedures to ensure patient safety and optimal outcomes (1). The severity can be classified by oxygen saturation (Sp02) into 86–90% mild hypoxemia, 80–85% moderate hypoxemia, and <80%% as severe hypoxemia (1).

Intraoperative hypoxemia poses a substantial risk related to hypoxic end organ damage to pediatric patients undergoing surgical procedures. Children are particularly vulnerable to hypoxemia due to their higher metabolic rates, smaller airway diameters, and reduced functional residual capacity compared to adults. Several factors contribute to the development of intraoperative hypoxemia in pediatric surgery, including preexisting respiratory conditions, airway abnormalities, positioning during surgery, anesthesia-related factors, and surgical complexity (4).

Even though intraoperative hypoxemia is common and associated with significant increased mortality and morbidity, only a few articles are available in the body of knowledge. From a few previous studies, the incidence of intraoperative hypoxemia was ranging from 12% to 52 % during general anesthesia in age less than 16 with a higher incidence in younger age.

1.2. Statement of the problem

The incidence of intraoperative hypoxemia in pediatric surgery isn't explained in relation to patient, surgery, and anesthesia-related risk factors in TASH, including in other parts of Ethiopia.

Worldwide, most knowledge about intraoperative hypoxemia comes from self-report (1).

Due to the limited protocol based practice, the patients experience end organ damage, intraoperative hemodynamic instability, agitation, delayed awakening, and cardiac arrest. Failure to anticipate its incidence and risk factors will pose a threat to the well-being and safety of the patient and leads to a poor outcome for the surgical procedures. This increased threat causes increased mortality, increased morbidity, and increased cost to the patient, to the hospital and to the nation at large.

1.3. Significance of study

Knowing the incidence and risk factors helps the anesthesia personnel to reduce the possibility of hypoxemia and its complication by improving the preanesthetic condition, early detection, and prompt treatment of intraoperative hypoxemia. It will also act as a source for teaching and a guide for hospital protocol developer, add knowledge to the existing source; improve patient safety and surgical outcomes; reduce hospital morbidity and mortality; and it will reduce the cost for the family and for the hospital.

Chapter two

2. Literature review

There are two published articles on intraoperative hypoxemia and one article on associated risk factors. Most articles and abstracts tried to include a good sample size and followed patients with pulse oximetry. They all explained that intraoperative hypoxemia increases in younger individuals.

A prospective study was conducted in 2005 in Netherlands pediatric hospital examined the incidence of intraoperative hypoxemia and pulse oximetry artifacts in 575 pediatric non-cardiac surgery patients aged between 0 and 16 years. The study found a total of 117(20%) episodes from 69 (12%) of 575 patients experienced $SpO2 \leq 90\%$, with 35% attributed to artifacts and 65% to true hypoxemia. Among the cases of true hypoxemia, 28% occurred during induction and 25% during emergence from anesthesia. Saturation less than 90 occurred in 56% of neonates (1).

The observational study conducted in Bangkok from 2003 to 2004 on risk factors for intraoperative desaturations during anesthesia in 152,314 patients of all ages provides valuable insights into the factors that contribute to oxygen desaturation events. The study identified several significant risk factors that were associated with intraoperative desaturations, including age, ASA physical status, history of recent upper respiratory tract infections, and history of heavy smoking, site of surgery, anesthetic technique, and duration of anesthesia (4).

Another observational study was also done on the frequency of hypoxic episodes during general anesthesia in children in Germany in 1989. From this, 52% of all children experienced at least one hypoxic episode, with major hypoxic episodes occurring in 54% of the newborns, 26% of the infants, 8% of the children under 6, and 7% of the children under 14 (5).

Chapter three

3. Objectives

3.1. General objectives

To assess the incidence and associated risk factors for intraoperative hypoxemia in pediatric patients who underwent elective and emergency surgery under general anesthesia at TASH, Addis Ababa, Ethiopia, 2023/24.

3.2. Specific objective

- To identify the incidence of intraoperative hypoxemia.
- To assess patient-related risk factors for intraoperative hypoxemia.
- To assess surgical-related risk factors for intraoperative hypoxemia
- To assess anesthesia-related risk factors for intraoperative hypoxemia.

Chapter four

4. Methodology

4.1. **Study design**

The study design is single center analytic prospective observational study.

4.2. **Study period**

Data collection for this study occurred over a seven-month period, commencing on October 1st, 2023 and concluding on April 29th, 2024.

4.3. **Study center**

The study was conducted at the Tikur Anbessa specialized hospital at the elective and emergency pediatric surgery table in Addis Ababa, Ethiopia. It is located in the central part of Addis Ababa City Administration, the capital of Ethiopia. Tikur Anbessa Specialized Hospital is a tertiary hospital that provides services for referral cases from other specialized referral hospitals throughout the country. It has one elective pediatric table and two emergency nonselective case tables. More than 50 pediatric elective surgeries can be done per month, and more than 40 patients can be operated on in an emergency.

4.4. **Sampling method**

Convenience consecutive sampling technique was used to all available pediatric patients during the study period that fulfilled the inclusion criteria in both tables until sample size was attained.

4.5. Population

4.5.1. Source of population

All pediatric patients who underwent surgery under general anesthesia at the emergency and elective tables at TASH, Addis Ababa, Ethiopia, 2023/24. The estimated population for 1 year was more than 1000 from different anesthesia log books.

4.5.2. Study population

All pediatric patients who underwent surgery under general anesthesia at TASH emergency and elective tables and met the inclusion criteria from October to April 2023/24 were included in the study.

4.5.3. Inclusion

Pediatric patients who underwent surgery at elective and emergency table under general anesthesia age =<16 years who were available from October 1st to April 29th, 2023/24.

4.5.4. Exclusion:

Pediatric patients who underwent surgeries with preoperative desaturation less than or equal to 90% with off oxygen, patient on oxygen therapy and patient who underwent cardiac surgery. Cardiac surgery was excluded due to the cardiopulmonary bypass time that interferes with pulse oximetry monitoring.

4.6. **Sample size**

The actual sample size for the study is determined by using the single population proportion formula $Sample\ size\ n = \frac{\left[(z_{\alpha/2})^2 \times p(1-p)\right]}{d^2}$

Where:

n= Initial estimated sample size,

(Zα/2)^2 = Desired level of confidence level at 95% =1.96.

P = Incidence from previous study average (0.2),

D= Marginal error (0.05),

n= (1.96)2*(0.2)*(1-0.2)/ (0.05)2 = 246.

The initial sample size for the study was 246. However, since the population per year was under 10,000 individuals, a finite population correction was applied, reducing the effective sample size to 197. To account for potential non-respondents, this number was further adjusted to 217 by anticipating a 10% dropout rate. Finally, after excluding 9 entries during data collection with incorrect data entry, the final analysis was conducted on a sample of 208 participants.

4.7. Variable

4.7.1. Dependent Variable

- Intraoperative hypoxemia

4.7.2. Independent variable

- **Sociodemographic and Patient factors:** Age, sex, weight, comorbidities and ASA class.
- **Surgical factors:** Type /urgency, site, duration and positioning.
- **Anesthesia factors:** Anesthesia drugs, airway issue, human factors and equipment failures.

4.8. Operational definition

Intraoperative saturation less than or equal to 90% can be true hypoxemia or an artifact.

True hypoxemia can be defined as any SpO2 value ≤ 90% for at least 1 minute and not being the result of an artifact as supported by patient's clinical status.

Artifacts is defined as any SpO2 ≤90% that was the obvious result of sensor dislodgment, electro cautery, patient motion or any other motion of the SpO2 probe (e.g., manipulation of the limb where the pulse oximetry was located), and low peripheral perfusion (e.g., during blood pressure measurement on the limb where the probe was located).Severity can be categorized in to mild hypoxemia defined as SpO2 ≤ 90% to 86 %, moderate hypoxemia SpO2 80% to 85% and severe hypoxemia defined as SpO2 ≤ 80%.

Pediatric age defined age less than or equal to 16 years from previous study.

4.9. Data collection procedures

Informed consent was taken from family and data collectors were trained and followed by principal investigators. Modified structured questionnaires were prepared containing Sociodemographic factors, patient health status, intraoperative anesthesia factors, intraoperative saturation pattern and surgical factors. Data collection for this study differed based on surgery type. For elective surgeries, preoperative data was compiled from a pre-anesthetic evaluation document review. Emergency cases, on the other hand, relied solely on the physician taking a history and documenting it on anonymous questionnaire. Intraoperative data collection, however, followed a consistent protocol for both elective and emergency procedures. Data collectors were directly observing patients and measured their peripheral oxygen saturation using pulse oximetry throughout the surgery, starting from induction to emergence. Baseline saturation was documented for all before the surgery started and for those who had a drop in saturation below 90%, saturation were documented starting from induction then maintenance and emergence with its duration, frequency and severity. It's worth noting that data collection itself was a collaborative effort, with the principal investigator, anesthesia residents, and nurse anesthetists, who were primarily responsible for patient care during surgery.

4.10. Data analysis procedures

After data collection, a meticulous process ensured its quality. Each day, the data was compiled, and checked for completeness. SPSS version 29 was then used for data entry, cleaning, coding, and analysis. Bivariate and multivariate logistic regressions were used to identify risk factors associated with the dependent variable. Initially, the variable was selected with P value less than 0.25 with bivariate logistic regression and then analyzed with multivariate logistic regression. A p-value of less than 0.05 with adjusted odd ratio and 95% confidence interval were set as the threshold for statistical significance. Finally, the results were presented in a clear and informative manner using tables summarizing key findings, and visuals like bar graphs and pie charts.

4.11. Data quality assurance

The data collectors were trained before data collection and there were daily meetings during data collection to clear up if there was any ambiguity during data collection.

4.12. Ethical statement

The data collection was done after securing an ethical clearance letter from the ethical review committee of the school of medicine via ACCPM department. Written informed consent was taken from the family and the purpose of the study and the data collection procedures were explained very well.

Chapter five

5. Result

5.1. Sociodemographic characteristics

More than half of the operation was done in elective tables; 105 (50.5%) and 140 (67.3%) of the participants were male, and 116 (55.8%) were in the age group of 1–8 years. Almost 90% of the study participants had a normal weight for their age, as shown in Table 1.

Table 1 Sociodemographic characteristics

Variable	Frequency	Percent
Table of operation site		
Emergency	103	49.5
Elective	105	50.5
Sex of the patient		
Male	140	67.3
Female	68	32.7
Age of patients		
0 - 28 days	37	17.8
29 days - 1 year	34	16.3
1 - 8 years	116	55.8
8 - 16 years	21	10.1
Weight (BMI) of the patient		
Overweight	2	1.0
Underweight	19	9.1
Normal	187	89.9

5.2. **Patient health status related risk factors**

Two-thirds of the study participants (141) were ASA class 1 and 100 (48.1%) had comorbid disease. From those with comorbid disease, 44% had congenital anomalies, followed by foreign body aspiration with or without pneumonia (19%), foreign body swallowing (13%), and URTI. 1.4% of the study participants had a history of allergy, and all participants had a baseline PSO2 of >90.

Table 2 Patient health status related risk factors

Variable	Frequency	Percent
ASA class of patients		
1	141	67.8
2	30	14.4
3	35	16.8
4	2	1.0
Comorbidity		
Yes	100	48.1
No	108	51.9
Types of comorbid disease (n=100)		
Pneumonia	7	7
OSA	2	2
URTI	6	6
Congenital anomalies	44	44
Foreign body aspiration	9	9
Foreign body swallow	13	13
Sepsis	2	2
Foreign body aspiration and Pneumonia	10	10
Others	7	7
Allergy		
Yes	3	1.4
No	205	98.6
Fasting status		
Optimal	149	71.6
Not optimal	59	28.4
Baseline saturation		
>90	208	100

5.3. **Intraoperative Anesthesia related risk factors**

Seventy-six percent of the study participants used ETT for airway protection, and 68.5% of the participants had only one attempted intubation. Almost 32 percent of the intubations were done by first-year residents. Ninety percent of the study participants received premedication, and of those, 55.4% used atropine and dexamethasone. Sixty-seven percent of the study participants used fentanyl for induction, and 59.6% used Propofol for IV anesthetics for induction. 97.1 of the study participants used Vecuronium as a relaxant, and 72.1% used Isoflurane for maintenance.

Table 3 Study participants' intraoperative anesthesia related characteristics

Variable	frequency	Percent
Airway protection method(n=208)		
ETT	158	76
Laryngeal mask airway	8	3.8
Facemask	23	11.1
Rigid bronchoscope then facemask	2	1
Rigid bronchoscope then ETT	17	8.2
Number of attempts to intubate (n=175)		
1	120	68.5
2	30	17.1
3	19	10.8
4	6	3.4
Intubating physician (n=261 attempt)		
Anesthesia resident year 1	83	31.7
Anesthesia resident year 2	67	25.7
Anesthesia resident year 3	52	20.1
Nurse anesthetist	29	11
Surgical and anesthesia residents	30	11.5
Premedication		
Yes	188	90.4
No	20	9.6
Name of drug used for premedication		
Atropine and Dexamethasone	104	55.4
Ketamine	18	9.6
Midazolam	14	7.4
Dexamethasone	2	1.1
Atropine and ketamine	32	17.0
Midazolam and atropine	18	9.6

Analgesia used for induction		
Fentanyl	140	67.3
Paracetamol	1	.5
Multimodal	67	32.2
IV anesthetics used for induction		
Propofol	124	59.6
Ketamine and Propofol	44	21.2
Propofol with lidocaine	35	16.8
Propofol, lidocaine and ketamine	5	2.4
Relaxant used for induction		
Vecuronium	31	14.9
Succinylcholine	124	59.6
no relaxant	53	25.5
Inhalational agent used for induction		
Isoflurane	33	15.9
Halothane	59	28.4
No inhalational agent used	113	54.3
Analgesia used for maintenance		
Fentanyl	163	78.4
Paracetamol	12	5.8
Morphine	7	3.4
Caudal	1	.5
Multimodal	25	12.0
IV anesthetics used for maintenance		
Propofol	63	30.3
Ketamine	8	3.8
No iv anesthetics	137	65.9
Relaxant used for maintenance		
Vecuronium	202	97.1
Succinylcholine	3	1.4
No relaxant	3	1.4
Inhalational used for maintenance		
Isoflurane	150	72.1
Halothane	58	27.9

5.4. Surgery related risk factors

Foreign body aspiration and HSD were diagnosed in 23% of the study participants, followed by abdominal wall defect, TEF, and small bowel obstruction. The majority of surgeries (86%) were performed in the supine position, with 51% classified as emergency procedures. Approximately two-thirds of participants received 20-40 ml/kg of crystalloid during surgery, and the vast majority of procedures (87.5%) had duration of less than 3 hours. Additionally, 95.2% of participants underwent anesthesia for less than 4 hours.

Table 4 Surgical related risk factors

Variable	Frequency	Percent
Surgical diagnosis		
Foreign body aspiration	24	11.5
Foreign body swallow	13	6.3
Anorectal malformation	8	3.8
Wilms tumor	6	2.9
HSD	24	11.5
Acute appendicitis	13	6.3
TEF	16	7.7
Infantile hypertrophic pyloric stenosis	6	2.9
Abdominal wall defect	15	7.2
Small bowel obstruction	14	6.7
Large bowel obstruction	8	3.8
Pelviureteric Junction Obstruction	5	2.4
Hypospadiasis	8	3.8
Bladder outlet obstruction	12	5.8
Adenotonsilar hypertrophy	3	1.4
Acute myeloid leukemia	5	2.4
Wound site infection	6	2.9
Undescended tests	6	2.9
Thoracic empyema	3	1.4
Abdominal mass	2	1.0
Esophageal stricture	5	2.4
Congenital diaphragmatic hernia	2	1.0
Splenomegaly	2	1.0
Right lung mass	2	1.0
Positions of patient during surgery		
Supine	178	85.6
Lateral	25	12.0

Prone	3	1.4
Lithotomy	2	1.0
Urgency of surgery		
Emergency	106	51.0
Elective	102	49.0
Fluid intake ml/kg		
<20	67	32.2
20-40	141	67.8
Duration of surgery in minute		
<3hrs	182	87.5
≥3hrs	26	12.5
Duration of anesthesia in minute		
<4hrs	198	95.2
≥4hrs	10	4.8
Disposition		
PACU	176	84.6
PICU	28	13.5
Ward	4	1.9

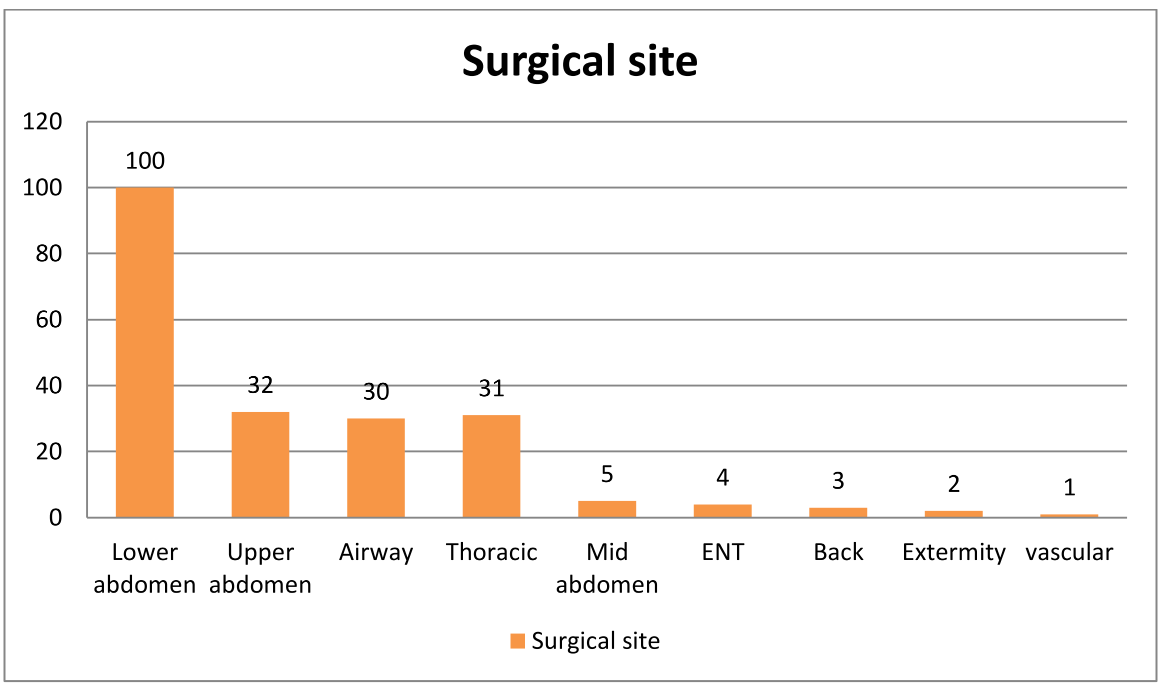

Figure 1 the site of the surgery of the study participants

5.5. Intraoperative saturation

The figure below showed that 56.2% of the patient had saturation less than or equal to 90% during the intraoperative period.

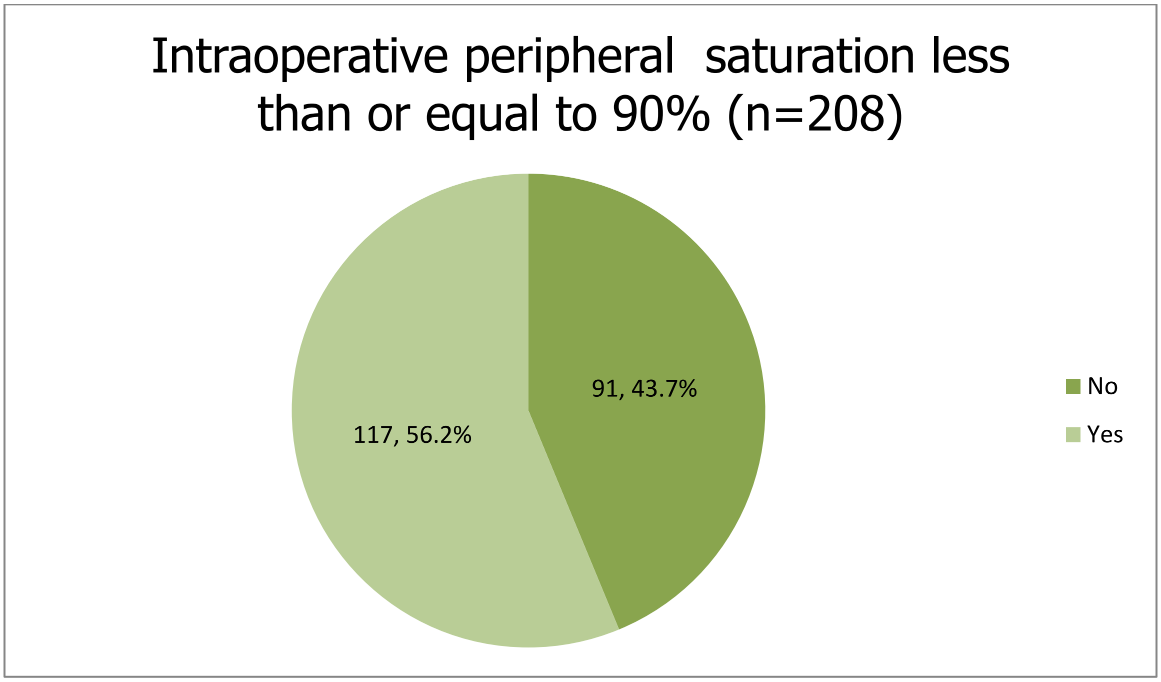

Figure 2 the incidence of intraoperative peripheral saturation less than or equal to 90%

5.6. Peripheral saturation less than or equal to 90% related characteristics

Over thirty-seven percent of the study participants had only one minute of duration, followed by five minutes with a frequency of 23%. The majority of participants experienced 1 or 2 episodes saturation of less than equal to 90%, with frequencies of 41.8% and 32.4%, respectively. A smaller proportion of participants had 3, 4, or 5 episodes. Tachycardia was the most prevalent hemodynamic effect, observed in 58.1% of cases. Bradycardia and cardiac arrest were less common, affecting 14.5% and 5.1% of participants, respectively. A significant portion (22.2%) experienced normal hemodynamic responses during desaturation events. Induction and emergence stages were the most common timings for hypoxemia events, at 29% and 25.6%, respectively. The maintenance stage had a lower frequency compared to induction and emergence. Combined stages (induction and maintenance, induction and emergence, maintenance and emergence) also occurred, but with lower frequencies.

Among patient with saturation less than or equal to 90% (117), 77.7% was recorded as true hypoxemia and the rest 22.2% was an artifact. The most common cause of artifact was due to patient movement accounting 38.4%.

Table 5 Saturation less than 90 related characteristics of the study participants

Variable	Frequency	Percent
Duration in minutes (n=117)		
1	44	37.6
2	24	20.5
3	9	7.6
4	1	0.8
5	27	23
10	6	5.1
15	3	2.5
30	3	2.5
Number of saturation less than or equal to 90 episodes (n=117)		
1	49	41.8
2	38	32.4
3	17	14.5
4	7	5.9
5	6	5.1
Hemodynamic effect of saturation less than or equal to 90 (n=117)		
Tachycardia	68	58.1
Bradycardia	17	14.5
Cardiac arrest	6	5.1
Normal	26	22.2
Cause of Saturation less than 90 or equal to (n=117)		
True hypoxemia	91	77.7
Artifact	26	22.2
Cause of artifact (n=26)		
Sensor problems	9	34.6
Patient movement	10	38.4
Dislodged	6	23.0
Perfusion problem	1	3.8
Timing of saturation less than or equal to 90 (n=117)		

Induction	34	29
Maintenance	14	12.2
Emergence	30	25.6
Induction and maintenance	18	15.3
Induction and emergence	11	9.4
Maintenance and emergence	10	8.5

5.7. **The severity level of true hypoxemia**

The figure below showed the distribution of hypoxemia severity among 91 truly hypoxemic patients. It is evident that the majority of cases were classified as mild, accounting for approximately 50.5% of the total. This suggests that mild hypoxemia was the most prevalent severity level within the sample.

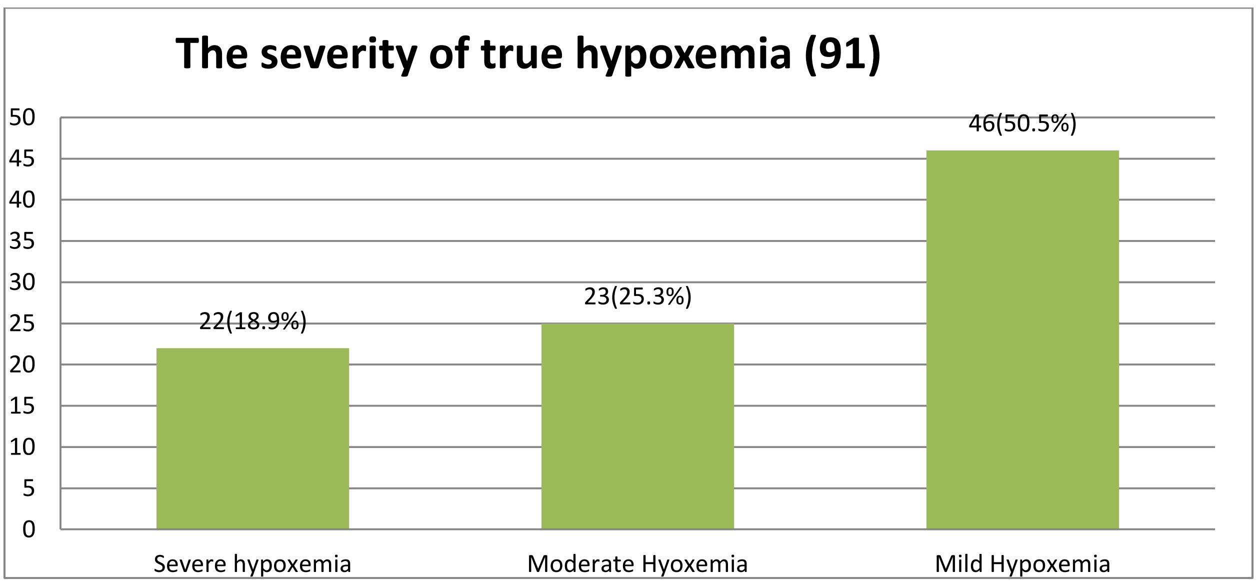

Figure 3 the level of true hypoxemia

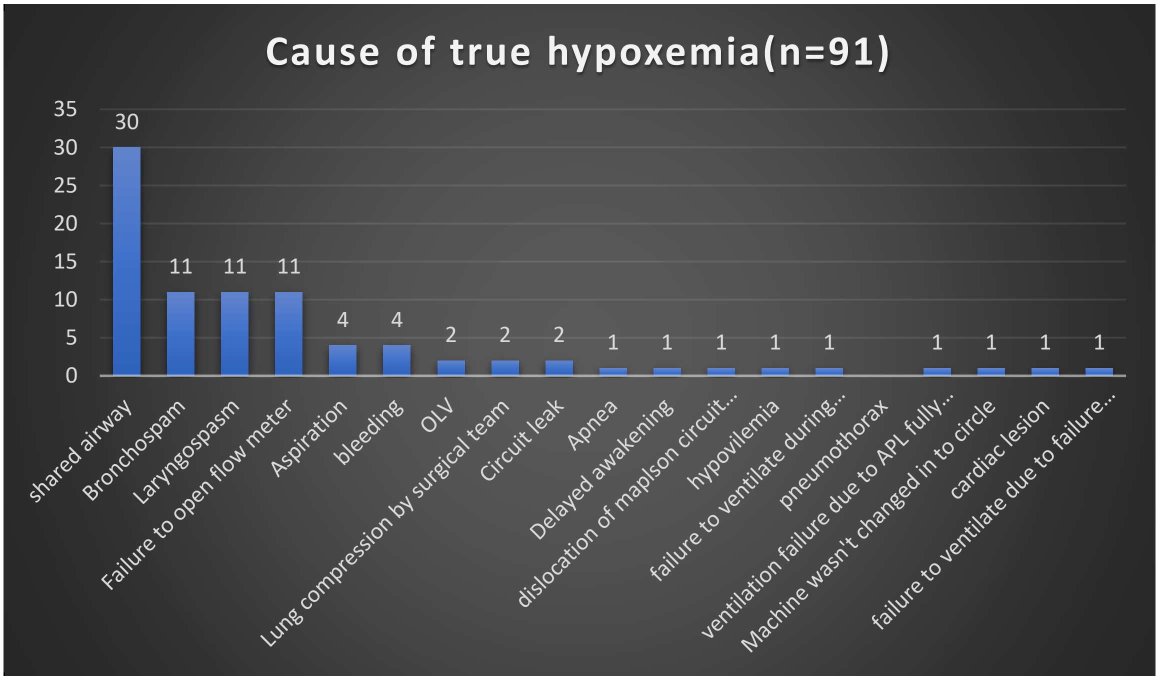

Figure 4 Cause of true hypoxemia (n=91)

5.8. The Associated risk factors affecting hypoxemia among children who underwent pediatric surgery

A bivariate logistic regression analysis revealed significant associations ($p < 0.05$) between hypoxemia and the following factors: urgency of surgery, neonatal age, higher ASA class and presence of comorbidity. The multivariate logistic regression and AOR with 95% CI revealed that study participants with comorbid disease had 5.4 fold increased hypoxemia compared to their opposite compartment (AOR = 5.4, 95% CI = 2.54, 11.57).

Table 6. The bivariate and multivariate logistic regression of association between independent variable and intraoperative hypoxemia

Variable	Hypoxia		p-value	COR with 95%CI	P-value	AOR with 95%CI
	Yes	No				
Operation table						
Emergency	56	47	0.002	2.4(1.36, 4.18)	0.207	4.6(0.43, 50.08)
Elective	35	70	1		1	
Age of the patient						
0 - 28 days	26	11	0.008	4.7(1.49, 14.91)	0.697	1.4(0.28, 6.59)
ASA class						
I	52	89	1		1	
>II	39	28	0.004	2.4(1.32, 4.32)	0.547	1.4(0.49, 3.86)
Comorbidity						
Yes	65	35	0.000	5.9(3.21, 10.70)	0.000	**5.4(2.54, 11.57)**
No	26	82	1		1	
Urgency of surgery						
Emergency	56	50	0.007	2.1(1.26, 3.75)	0.247	0.24(0.02, 2.69)
Elective	35	67	1		1	

Chapter six

6. Discussion

Intraoperative hypoxemia is a drop in saturation level that is accompanied by a drop in the partial pressure of the arterial oxygen level. Failure to detect and predict it with its associated risk factors will lead to catastrophic intraoperative emergencies.

The drop in saturation might be due to true hypoxemia or an artifact. Different authors define true intraoperative hypoxemia in different ways. One of the authors defines intraoperative hypoxemia as a saturation level < or = to 85% or saturation less than 90% for 3 minutes. But this author doesn't define what an artifact is (4). Another piece of literature defines intraoperative hypoxemia as a saturation level less than or equal to 90% that lasts for at least 1 minute and is not the result of an artifact. Artifact was defined as a saturation value less than or equal to 90% due to sensor, perfusion problems, and patient movements (1). In this study, intraoperative hypoxemia is defined as blood oxygen saturation (SpO_2) of 90% or below lasting for at least one minute. We differentiate true hypoxemia from artifacts through various methods. Hemodynamic instability can be a sign of hypoxemia, but it's not always present. Therefore, we also considered other factors alongside SpO_2 levels to assess the severity of hypoxemia and its potential impact.

The incidence of intraoperative hypoxemia in patients who underwent non-cardiac pediatric surgery at Tikur Anbessa Specialized Hospital's elective and emergency tables was 43.7% of the study participants. This finding was higher than the study done at the University Medical Center Utrecht, Netherlands, in 2005 (12%). In this study, the inclusion of emergency pediatric surgery and the presence of various comorbidities may account for this disparity. This finding also less than the study done at Germany Tubingen in university hospital (52%) but this data was studied in 1989 and they included small sample size. The incidence of artifacts was also 12.5%, which was also higher than the Netherlands study in 2005 (8.3%) (1). From this study, there were 117 cases with a drop in saturation less than or equal to 90, of which 77.7% were true hypoxemia, which was higher than the Netherlands study in 2005 (54%). The result also shows increased incidence with younger ages.

The severity of intraoperative hypoxemia was studied and showed that 50.5% had mild hypoxemia (86–90%), 25.3% had moderate hypoxemia (80–85%), and 18.9% had severe hypoxemia (less than 80%). This finding was comparable to the study done in the Department of Anesthesia at Herlev Hospital, University of Copenhagen, Denmark, in 1991, where 53% had mild hypoxemia and severe hypoxemia below 81 was 20% but, they used a different cut off value for severity assessment of hypoxemia.

This study also showed that 29% of saturation less than or equal to 90% occurred during induction and 25.6% during emergence. This result has a comparable finding to the University Medical Center Utrecht, Netherlands: 28% at induction and 25% at emergence.

The current study showed hemodynamic instability caused by true hypoxemia and the commonest was tachycardia (58.1%), followed by bradycardia (14.5%) and cardiac arrest (5.1%). There was no reportable death and there was no previous data that support this finding. In this study, the common causes of true hypoxemia were shared airways (34.8%), followed by bronchospasm (12.8%), laryngospasm (12.8%), and failure to open the flow meter of the anesthesia machine during induction (12.8%). In the same study, the cause of the artifact was assessed, and the common cause was patient movement in 40%, followed by pulse oximetry sensor problems (32%), and detachment from the patient in 24%.

Bivariate and multivariate logistic regressions were used to examine the relationship between intraoperative hypoxemia and surgical, anesthetic, and patient variables.

A P value of 0.008 indicated a correlation between intraoperative hypoxemia and study participants aged 0 to 28 days. The University Medical Center Utrecht, Netherlands investigations and a research conducted in French (1, 5) provided support for this study.

Intraoperative hypoxemia has been associated with patients with an ASA class greater than two, with a P value of 0.004. A Thai study provided support for this evidence (4).

Additionally, both bivariate and multiple regression analyses revealed a statistically significant correlation between the presence of patient comorbidities and intraoperative hypoxemia. Out of the 100 patients who had co-occurring conditions, 48 percent of them had intraoperative hypoxemia episodes, which was 5.4 times higher than the rate in the non-comorbid group.

The analysis from this study showed that the study participant who was operated at emergency table for emergency surgery has a higher risk for intraoperative hypoxemia by bivariate logistic regression with the P value 0.002.

7. **Conclusion**:

This study found that the incidence of intraoperative hypoxemia was quite common and that the following factors were associated with increased incidence of intraoperative hypoxemia: neonatal age, presence comorbidity, higher ASA class and emergency surgery performed at the emergency table. It needs further study with in the elective and emergency table in separate area to characterize the potential problem that causes increased intraoperative hypoxemia in this population group.

Chapter seven

7. Strength and limitation of the study

7.1. Strength of the study

The study tried to address the incidence and associated risk factors for intraoperative hypoxemia in pediatric surgery at TASH elective and emergency table for the first time. This study used pulse oximetry, patient hemodynamic status and clinician clinical judgments to differentiate between true hypoxemia and artifact.

The data was collected with anonymous online prepared questioner which reduced the fear of judgment after data documentation.

It assessed the artifact and true hypoxemia in both tables which act as a base for further future study. It also tried to address the common risk factors for intraoperative hypoxemia and it also mentioned the common hemodynamic instability once the hypoxemia occurred.

7.2. Limitation of study

The study was done at single referral hospital with small sample size at TASH. Since the hospital is a tertiary referral hospital, most pediatric patients are referred to it with comorbidity which poses the patient at risk of intraoperative hypoxemia.

Measuring peripheral saturation by pulse oximetry but not by arterial blood gas analysis might be affected by different situation like poor perfusion, anemia and cold hands and documentation bias was reduced by making anonymous data collection and by monitoring the data collectors by principal investigator but couldn’t be avoided.

8. Recommendation

The development of intraoperative hypoxemia protocol at the hospital and national level is necessary to lower the rate of morbidity and death among patients undergoing pediatric surgery and to set guidelines for the administration of pediatric anesthesia.

The occurrence of serious adverse events such as bradycardia, cardiac arrest, and anoxic brain insults can be prevented by early identification of patients who are at risk of intraoperative hypoxemia.

Younger age, higher ASA class, presence of comorbidity and urgency of the surgery significantly affect the occurrence of intraoperative hypoxemia. Therefore, the anesthesia practitioner needs to be vigilant in order to stop hypoxemia before it happens by identifying the higher risk group.

Further study should be done with larger sample size in different center to establish a good hospital and national protocol.

9. Reference

1.de Graaff, J. C., Bijker, J. B., Kappen, T. H., van Wolfswinkel, L., Zuithoff, N. P. A., & Kalkman, C. J. (2013). Incidence of intraoperative hypoxemia in children in relation to age. Anesthesia and Analgesia, 117(1), 169–175. https://doi.org/10.1213/ANE.0b013e31829332b5

2. Moller JT, Johannessen NW, Berg H, Espersen K, Larsen LE. Hypoxaemia during anaesthesia--an observer study. Br J Anaesth. 1991 Apr;66(4):437-44. doi: 10.1093/bja/66.4.437. PMID: 2025470

3.The Airway Jedi</i>. (n.d.). Retrieved May 21, 2020, from https://airwayjedi.com/2015/12/09/difference-oxygen-saturation-pao2/</div>

4. Charuluxananan S, Suraseranivongse S, Punjasawadwong Y, Somboonviboon W, Sriswasdi S, Pranootnarabhal T, Chanchayanon T, Chau-in W, Intarut N. Risk factors of intraoperative oxygen desaturation: a case-control study of 152,314 anesthetics. J Med Assoc Thai. 2007 Nov;90(11):2359-65. PMID: 18181320.

5. Schulz C, Lenz G, Madee S, Schulze M. Fréquence des épisodes hypoxiques au cours de l'anesthésie générale de l'enfant [Frequency of hypoxic episodes during general anesthesia in children]. Cah Anesthesiol. 1989 Oct;37(6):403-7. French. PMID: 2605533.

10. Annexes

Annex 1: American Society of Anesthesiologist physical status classification

- Class I: A normal healthy patient
- Class II: Patient with mild systemic disease.
- Class III: Patient with severe systemic disease that is not incapacitating.
- Class IV: A patient with incapacitating life threatening systemic disease.
- Class V: A moribund patient who is not expected to survive for 24 hours with or without operation

Annex 2: Intraoperative saturation less than equal to 90% can be

- True hypoxemia or
- Artifact.

Annex 3: Intraoperative hypoxia severity

- Mild SpO2 ≤ 90% to 86 %
- Moderate SpO2 80% to 85%
- Severe SpO2 ≤ 80%.

Annex 4: Age

- 0 to 28 days (Neonate)
- 29 days to 1 year (Infant)
- >1 year to 8 years (Younger child)
- >8 years to 16 years (Older child)

Annex: 5 questioners

Sociodemographic factors.

- Table
  1. Emergency
  2. Elective
- Sex
  1. Male
  2. Female
- Age
  1. 0 to 28 days
  2. 29 days to 1yr
  3. >1yr to 8yrs
  4. >8 to 16 years
- Weight
  1. Overweight
  2. Underweight
  3. Normal for the age
  4. Obese
- ASA
  1. 1
  2. 2
  3. 3
  4. 4
  5. 5
- Comorbidity
  1. Yes
  2. No
- If yes, what is the comorbidity?
  1. Pneumonia
  2. OSA
  3. URTI
  4. Congenital anomalies
  5. Foreign body aspiration
  6. Foreign body swallow
  7. Sepsis
  8. Difficult airway
  9. Other …………
- Allergy
  1. Yes
  2. No
- Fasting status
  1. Optimal
  2. Not optimal
- Base line normal saturation

………………..

Anesthesia related risk factors

- Airway protection
  1. Ett
  2. LMA
  3. Facemask
  4. Rigid bronchoscope with facemask
  5. Rigid bronchoscope then ETT
- Number of attempt
  1. 1
  2. 2
  3. 3
  4. 4
  5. 5

Intubating personnel

1. Anesthesia resident year 1
2. Anesthesia resident year 2
3. Anesthesia resident year 3
4. Anesthetist
5. Surgical and anesthesia residents
6. Consultant

- Premedication
  1. Yes
  2. no
- If yes, name of premedicated drug
  1. Atropine and dexamethasone
  2. Ketamine
  3. Midazolam
  4. …………………………
- Induction agent
  - Analgesia
  1. Fentanyl
  2. PCM
  3. Morphine
  4. Caudal
  5. Ketamine
  6. Thoracic epidural
  7. Multimodal (combination)
  - IV anesthetics
  1. Propofol
  2. Ketamine

3. Lidocaine
4. Ketamine and Propofol
5. Propofol with lidocaine
6. No iv anesthetics
   - Relaxant
     1. Vecuronium
     2. Suxamethonium
     3. No
   - Inhalation
     1. Isoflurane
     2. Halothane
     3. No inhalation
- Maintenance
  - Analgesia
  1. Fentanyl
  2. PCM
  3. Morphine
  4. Caudal
  5. Multimodal
  - IV anesthetics
  1. Propofol
  2. Ketamine
  3. Ketamine and Propofol
  4. No iv anesthetics
  - Relaxant
  1. Vecuronium
  2. Suxamethonium
  3. No relaxant
  - Inhalation
  1. Isoflurane
  2. Halothane
- **Saturation <90%**
  1. Yes
  2. No
- Level
  1. <90 to 86
  2. 85 to 80
  3. <80
- Duration in min
  1. 1
  2. 2
  3. 3
  4. 4
  5. 5
  6. 6
  7. 7
  8. Other ………………
- Frequency
  1. 1
  2. 2
  3. 3
  4. 4
  5. 5
  6. Other
- Hemodynamic effect
  1. Tachycardia
  2. Bradycardia
  3. Cardiac arrest
- Cause of hypoxemia
  1. True hypoxemia
  2. Artifact
- Cause of artifact
  1. Sensor problem
  2. Electro cautery
  3. Patient movement
  4. Dislodged
  5. Perfusion problem
- Cause of true hypoxemia
  1. Laryngospasm
  2. Bronchospasm
  3. Shared airway
  4. OLV
  5. Apnea
  6. Light anesthesia
  7. Other ……………….

Timing

1. Induction
2. Maintenance
3. Emergence

Surgical related risk factors

Diagnosis

1. Foreign body aspiration
2. Foreign body aspiration
3. Anorectal malformation
4. Wilms tumor
5. HSD
6. Acute appendicitis
7. Tracheoesophageal fistula
8. IHPS
9. Write the diagnosis ……………

Position

1. Supine
2. Lateral
3. Prone
4. Lithotomy
5. …………………..

Types of surgery

1. Emergency
2. Elective

Surgical site

1. Airway
2. Thoracic
3. Upper abdomen
4. Mid abdomen
5. Lower abdomen
6. Back
7. ENT
8. Other …………………….

Fluid

1. 10 to 20
2. >20 to 40
3. >40

Duration of surgery

1. <3
2. >3

Duration of anesthesia

1. <4 hours
2. >= 4 hrs.

Disposition

1. Pediatric ICU
2. Post Anesthesia care unit
3. Ward
4. ……………………