

Original article

COMPLICATIONS ASSOCIATED WITH VARIOUS TYPES OF ANESTHESIA IN CHILDREN AGED 1–5 YEARS: A CROSS-SECTIONAL OBSERVATIONAL STUDY IN LAHORE, PAKISTAN

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ABSTRACT

Background: Children are particularly susceptible to anesthesia-related perioperative complications because of age-related anatomical and physiological differences. However, evidence describing the pattern of these complications in Pakistan remains limited. **Objective:** To determine the frequency and pattern of perioperative complications associated with different anesthesia techniques among children aged 1–5 years undergoing surgery at a tertiary care hospital in Lahore, Pakistan. **Methods:** A cross-sectional observational study was conducted over four months in the pediatric surgical ward and post-anesthesia care unit of a tertiary care hospital. One hundred children aged 1–5 years undergoing elective or emergency surgery were enrolled using non-probability sampling. Demographic characteristics, anesthesia type, and perioperative complications were recorded using a structured data collection tool. Data were analyzed using SPSS version 27. Descriptive statistics were calculated, and associations between anesthesia type and perioperative complications were assessed using the Chi-square test, with $p < 0.05$ considered statistically significant. **Results:** Most patients were classified as ASA I–II (88%), underwent elective surgery (68%), and received general anesthesia (70%). Intraoperative complications included hypothermia (12%), hypoxemia (9%), bronchospasm (6%), tachycardia (4%), bradycardia (4%), hyperthermia (4%), and laryngospasm (3%). Postoperatively, nausea and vomiting was the most common complication (53%), followed by hypoxemia (16%) and hypothermia (8%). No perioperative cardiac arrest or mortality was observed. A significant association was identified between anesthesia type and postoperative nausea and vomiting. **Conclusion:** Pediatric anesthesia demonstrated an acceptable safety profile in this tertiary care setting, with most complications being minor and manageable. Respiratory adverse events, postoperative nausea and vomiting, and temperature-related complications remain important targets for quality improvement through standardized monitoring and preventive perioperative strategies. **Keywords:** Pediatric anesthesia; perioperative complications; general anesthesia; postoperative nausea and vomiting; respiratory adverse events; hypothermia; pediatric surgery.

EDITORIAL INFORMATION

Author Contributions: Concept: MAB, MSM; Design: MAB, MSM, TRU; Data Collection: MAB, TRU; Analysis: MAB, MSM; Drafting: MAB, MSM, TRU.

Ethical Approval: Faculty of Allied Health Sciences, The University of Lahore, Lahore, Pakistan.

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INTRODUCTION

Children undergoing anesthesia differ substantially from adults because of developmental differences in airway anatomy, respiratory physiology, cardiovascular reserve, thermoregulation, and pharmacokinetic responses to anesthetic agents. Their relatively narrow airways, increased oxygen consumption, reduced functional residual capacity, immature autonomic regulation, and limited physiological reserve make them particularly susceptible to perioperative adverse events, especially during induction, airway manipulation, and emergence from anesthesia (1–4). Consequently, pediatric anesthesia requires meticulous perioperative assessment, vigilant monitoring, and timely intervention to minimize anesthesia-related morbidity and improve surgical outcomes.

Perioperative respiratory adverse events remain the most frequently reported complications in pediatric anesthesia. Laryngospasm, bronchospasm, oxygen desaturation, and airway obstruction account for

the majority of anesthesia-related morbidity in children and are influenced by patient age, airway anatomy, respiratory infections, anesthetic technique, and provider experience (4–8). Although serious cardiovascular complications such as cardiac arrest are uncommon, they remain among the leading causes of anesthesia-related mortality when they occur. Improvements in perioperative monitoring, standardized safety protocols, simulation-based training, and advances in anesthetic practice have substantially reduced the incidence of severe complications over recent decades (1,8–10).

The occurrence of perioperative complications is multifactorial and reflects the interaction of patient-related, surgical, and anesthesia-related factors. Younger children, those with recent upper respiratory tract infections, congenital airway abnormalities, chronic pulmonary disease, congenital heart disease, poor nutritional status, and higher American Society of Anesthesiologists (ASA) physical status are at increased risk of adverse perioperative events (5,6,11,12). Procedure-related characteristics, including emergency surgery, airway or thoracic procedures, prolonged operative duration, and inadequate perioperative temperature or fluid management, further contribute to complication risk (13,14). In addition, the choice of anesthetic technique may influence perioperative outcomes through differences in airway manipulation, anesthetic depth, opioid requirements, postoperative analgesia, and recovery profiles (15).

To facilitate early identification of high-risk patients, several perioperative risk prediction tools have been developed, including the COLDS score and emerging machine-learning models capable of estimating respiratory and cardiovascular complications in pediatric patients (11,16). However, most predictive models have been derived from high-income healthcare systems and may not accurately reflect clinical practice in low- and middle-income countries (LMICs), where patient characteristics, disease burden, resource availability, staffing, and perioperative infrastructure differ substantially (13,17). Studies conducted in resource-limited settings continue to report preventable perioperative complications, highlighting the importance of strengthening context-specific evidence to support quality improvement initiatives and optimize patient safety (13,17,18).

Despite the growing international literature, published evidence describing anesthesia-related perioperative complications among young children in Pakistan remains limited. Most available studies originate from high-resource settings and may not be directly applicable to local clinical practice. Reliable local data are essential for understanding the frequency and pattern of perioperative complications, identifying potentially modifiable risk factors, and informing evidence-based institutional protocols aimed at improving pediatric anesthesia safety. Generating such evidence is particularly important for tertiary care hospitals that manage both elective and emergency pediatric surgical cases within resource-constrained healthcare systems.

Therefore, this study aimed to determine the frequency and pattern of anesthesia-related perioperative complications among children aged 1–5 years undergoing elective or emergency surgical procedures at a tertiary care hospital in Lahore, Pakistan, and to evaluate the association between different anesthesia techniques and the occurrence of intraoperative and postoperative complications.

MATERIALS AND METHODS

This quantitative cross-sectional observational study was conducted in the Pediatric Surgical Ward and Post-Anesthesia Care Unit (PACU) of a tertiary care hospital in Lahore, Pakistan, over a four-month period. The study was designed to determine the frequency and pattern of perioperative anesthesia-related complications among children aged 1–5 years undergoing surgical procedures and to evaluate their association with different anesthesia techniques. Ethical approval was obtained from the Institutional Review Board (IRB)/Ethics Review Committee of the University of Lahore prior to the commencement of the study (Ref. No.: DRC/DHPT021/04/25). The research was conducted in accordance with the ethical principles of the Declaration of Helsinki and its subsequent amendments.

The study population comprised children aged 1–5 years who underwent elective or emergency surgical procedures requiring general anesthesia, caudal anesthesia, combined general and caudal anesthesia, sedation, or other anesthetic techniques during the study period. Children classified as American Society of Anesthesiologists (ASA) physical status I–IV were eligible for enrollment. Patients with incomplete perioperative records, discharge within 24 hours following surgery, or whose parents or legal

guardians declined participation were excluded from the study. Participants were recruited using a consecutive non-probability sampling technique until the target sample size of 100 children was achieved.

Written informed consent was obtained from the parents or legal guardians of all eligible participants before enrollment. Guardians were informed about the purpose, objectives, potential benefits, and voluntary nature of the study, and were assured that refusal to participate or withdrawal from the study at any stage would not influence the quality of medical care provided to their child. Participant confidentiality and anonymity were strictly maintained by assigning unique identification codes, removing personal identifiers from study records, securely storing hard-copy data in locked cabinets, and restricting electronic data access to the principal investigators through password-protected files. All collected information was used exclusively for research purposes.

Data were collected using a structured, pre-tested data collection form specifically developed for the study. Information regarding demographic characteristics, ASA physical status, type of surgical procedure, anesthesia technique, and perioperative complications was obtained from anesthesia records, perioperative monitoring charts, recovery room documentation, and hospital medical records. Demographic variables included age, sex, surgical urgency (elective or emergency), and ASA physical status. The primary exposure variable was the type of anesthesia administered, categorized as general anesthesia, combined general plus caudal anesthesia, caudal anesthesia alone, sedation, or other anesthetic techniques.

The primary study outcome was the occurrence of anesthesia-related perioperative complications. Intraoperative complications included tachycardia, bradycardia, hypoxemia, bronchospasm, laryngospasm, cardiac arrest, hypothermia, and hyperthermia. Postoperative complications included tachycardia, bradycardia, hypoxemia, bronchospasm, laryngospasm, cardiac arrest, hypothermia, hyperthermia, and postoperative nausea and vomiting (PONV). Intraoperative events were identified from anesthetic records and continuous intraoperative monitoring documentation, whereas postoperative complications were assessed in the Post-Anesthesia Care Unit (PACU) and documented during the immediate postoperative recovery period.

Data were reviewed for completeness and consistency before analysis. Statistical analyses were performed using IBM SPSS Statistics version 27.0. Descriptive statistics were used to summarize demographic characteristics, anesthetic techniques, and perioperative complications. Categorical variables were presented as frequencies and percentages. Associations between anesthesia type and perioperative complications were evaluated using the Chi-square test. A two-tailed p-value of less than 0.05 was considered statistically significant. The findings were presented using appropriately formatted tables and figures to facilitate comparison of perioperative outcomes among the different anesthesia techniques.

RESULTS

A total of 100 children aged 1–5 years undergoing elective or emergency surgical procedures under different anesthetic techniques were included in the study. Most participants were classified as ASA physical status I–II (88%), while 12% were categorized as ASA III–IV. Elective procedures accounted for 68% of surgeries and emergency procedures for 32%. General anesthesia was the most frequently administered anesthetic technique (70%), followed by combined general and caudal anesthesia (19%), whereas caudal anesthesia alone, sedation, and other anesthetic techniques were used less frequently.

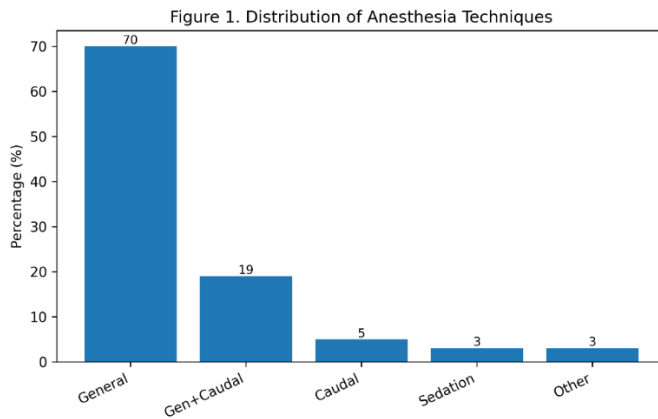
Table 1. Baseline Characteristics of the Study Population

Characteristic	n	%
ASA Physical Status		
ASA I–II	88	88.0
ASA III–IV	12	12.0
Type of Surgery		
Elective	68	68.0
Emergency	32	32.0
Anesthesia Technique		
General anesthesia	70	70.0

Characteristic	n	%
General + Caudal	19	19.0
Caudal alone	5	5.0
Sedation	3	3.0
Other	3	3.0

Table 1 demonstrates that the study population predominantly consisted of low-risk pediatric patients undergoing elective surgical procedures. General anesthesia was the principal anesthetic technique employed, whereas regional anesthesia alone and sedation were used in relatively few patients.

Figure 1. Distribution of Anesthesia Techniques Among the Study Population



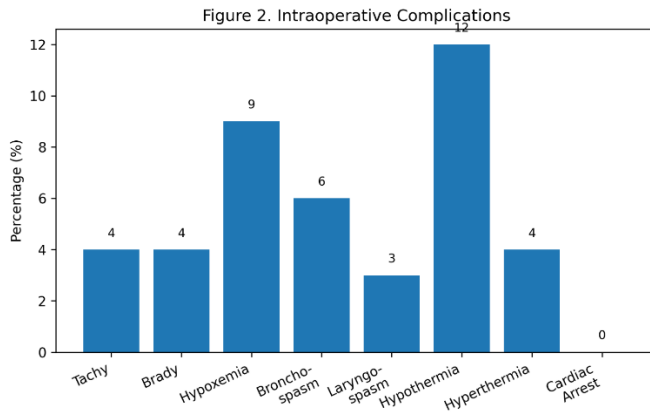
The frequency of intraoperative complications was generally low. Hypothermia was the most common intraoperative adverse event (12%), followed by hypoxemia (9%) and bronchospasm (6%). Cardiovascular complications, including tachycardia and bradycardia, occurred in 4% of patients each, while laryngospasm and hyperthermia were uncommon. No intraoperative cardiac arrest was observed.

Table 2. Frequency of Intraoperative Anesthesia-Related Complications

Complication	n	%
Tachycardia	4	4.0
Bradycardia	4	4.0
Hypoxemia	9	9.0
Bronchospasm	6	6.0
Laryngospasm	3	3.0
Hypothermia	12	12.0
Hyperthermia	4	4.0
Cardiac arrest	0	0.0

As shown in Table 2, perioperative respiratory events and disturbances in body temperature constituted the most frequent intraoperative complications. Serious cardiovascular events were rare, and no episodes of cardiac arrest occurred during surgery.

Figure 2. Frequency of Intraoperative Anesthesia-Related Complications



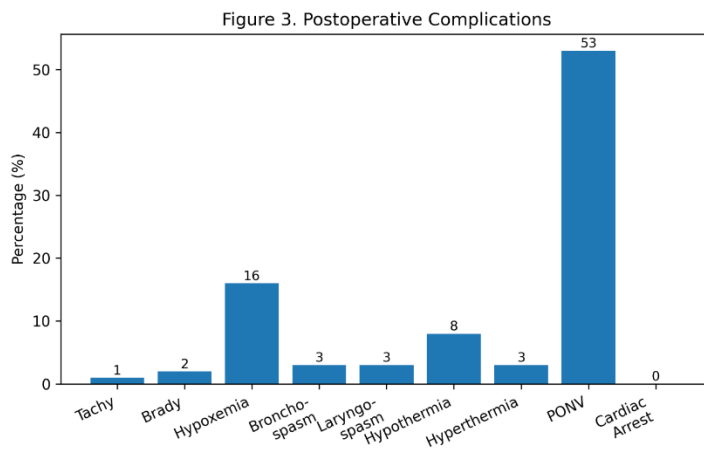
Postoperative complications were more frequently encountered than intraoperative complications. Postoperative nausea and vomiting (PONV) represented the most common adverse event, affecting 53% of participants. Postoperative hypoxemia occurred in 16% of children, whereas hypothermia was documented in 8%. Respiratory complications remained uncommon, and no postoperative cardiac arrest was recorded.

Table 3. Frequency of Postoperative Anesthesia-Related Complications

Complication	n	%
Tachycardia	1	1.0
Bradycardia	2	2.0
Hypoxemia	16	16.0
Bronchospasm	3	3.0
Laryngospasm	3	3.0
Hypothermia	8	8.0
Hyperthermia	3	3.0
Postoperative nausea and vomiting (PONV)	53	53.0
Cardiac arrest	0	0.0

Table 3 indicates that postoperative nausea and vomiting was the predominant postoperative complication, occurring in more than half of the study population. Respiratory complications and thermoregulatory disturbances occurred considerably less frequently, while cardiovascular complications remained rare.

Figure 3. Frequency of Postoperative Anesthesia-Related Complications



Perioperative complications were observed most frequently among children who received general anesthesia or combined general and caudal anesthesia, reflecting the predominance of these anesthetic techniques in the study cohort. Children managed with caudal anesthesia alone, sedation, or other anesthetic techniques experienced comparatively fewer adverse events.

Table 4. Distribution of Perioperative Complications According to Anesthesia Technique

Complication	Predominant Anaesthesia Technique
Intraoperative tachycardia	General anaesthesia
Postoperative tachycardia	General anaesthesia
Intraoperative bradycardia	General anaesthesia
Postoperative bradycardia	General anaesthesia
Intraoperative hypoxemia	General anaesthesia
Postoperative hypoxemia	General anaesthesia
Intraoperative bronchospasm	General anaesthesia
Postoperative bronchospasm	General anaesthesia
Intraoperative laryngospasm	General anaesthesia
Postoperative laryngospasm	General anaesthesia
Intraoperative hypothermia	General anaesthesia
Postoperative hypothermia	General anaesthesia
Intraoperative hyperthermia	General anaesthesia
Postoperative hyperthermia	General anaesthesia
Postoperative nausea and vomiting	General anaesthesia and General + Caudal

Table 4 demonstrates that the majority of perioperative complications were reported among children receiving general anesthesia. However, these observations should be interpreted cautiously because general anesthesia was administered to the largest proportion of patients, and the study was not designed to establish causal associations between anesthesia type and complication risk.

DISCUSSION

This study evaluated the pattern of perioperative anesthesia-related complications among children aged 1–5 years undergoing surgery in a tertiary care hospital in Pakistan. The principal findings indicate that pediatric anesthesia was generally safe, with no perioperative mortality or cardiac arrest observed. Most complications were minor and manageable, with postoperative nausea and vomiting (PONV), hypothermia, hypoxemia, and respiratory adverse events representing the most frequent complications. These findings support previous evidence that modern pediatric anesthesia is associated with a low incidence of major complications when appropriate monitoring and perioperative care are available. (1,13,20,21)

Respiratory complications remain a major concern in pediatric anesthesia because of anatomical and physiological characteristics unique to young children. In the present study, bronchospasm, laryngospasm, and perioperative hypoxemia occurred infrequently, although they represented the predominant intraoperative adverse events. Similar observations have been reported by von Ungern-Sternberg et al., Peiffer et al., Tao et al., and Gai et al., who identified respiratory adverse events as the leading cause of anesthesia-related morbidity in pediatric patients, particularly during airway manipulation and emergence from anesthesia. (4,7,12,17,20) The relatively low incidence observed in our study may reflect effective airway management, continuous monitoring, and timely intervention by the anesthesia team.

General anesthesia was the most frequently used anesthetic technique and therefore accounted for most perioperative complications. However, this observation should not be interpreted as evidence that general anesthesia is inherently less safe than other techniques, as nearly three-quarters of children received this modality. Previous multicenter observational studies have similarly demonstrated that complication rates are influenced by patient characteristics, procedure complexity, and airway management rather than anesthetic technique alone. (13,16,18,21) Increasing use of regional techniques as an adjunct to general anesthesia may further improve postoperative analgesia while reducing opioid requirements in selected pediatric procedures. (22)

Postoperative nausea and vomiting was the most common complication, affecting more than half of the study population. Pediatric patients are particularly susceptible to PONV because of age-related physiological factors, anesthetic exposure, and perioperative opioid administration. Eberhart et al. developed a validated pediatric PONV risk score that facilitates identification of high-risk patients and supports targeted prophylaxis. (3) Routine implementation of risk-based antiemetic protocols could

substantially reduce postoperative discomfort, facilitate early oral intake, and shorten recovery room stay in similar settings.

Hypothermia and postoperative hypoxemia were also observed in a proportion of patients. Young children have limited thermoregulatory capacity and a relatively large body surface area, predisposing them to perioperative heat loss. Consistent with previous reports, maintenance of normothermia through active warming systems and continuous temperature monitoring remains an essential component of safe pediatric anesthesia. (15) Likewise, careful postoperative respiratory surveillance is necessary because residual anesthetic effects and airway events may persist into the recovery period despite uneventful intraoperative management. (7,12,17)

Encouragingly, no perioperative cardiac arrests or mortality were recorded in this study. Contemporary international evidence demonstrates a substantial decline in anesthesia-related cardiac arrest among children owing to advances in monitoring technologies, standardized perioperative protocols, improved provider training, and early recognition of physiological deterioration. (1,10,11) Continued investment in pediatric anesthesia services, simulation-based education, and multidisciplinary teamwork is likely to further enhance patient safety, particularly in resource-limited healthcare systems. (2,8,14)

The present findings also have important implications for pediatric anesthesia practice in low- and middle-income countries. Although studies from Rwanda, Nigeria, Ethiopia, and Tunisia have reported higher perioperative complication rates than those observed in high-income countries, many of these differences are attributable to resource availability, workforce limitations, and delayed access to specialized perioperative care. (5,11,16,18) Risk stratification tools such as the COLDS score and emerging machine-learning prediction models may further support perioperative decision-making by identifying children at greatest risk for respiratory and other anesthesia-related complications. (6,19)

This study has several limitations. Its single-center design and relatively modest sample size may limit generalizability, while the observational design precludes causal inference between anesthetic technique and perioperative outcomes. In addition, the predominance of relatively healthy ASA I–II children may have contributed to the low incidence of major adverse events. Nevertheless, the study provides valuable contemporary data regarding pediatric anesthesia safety from Pakistan, where published evidence remains limited.

In conclusion, pediatric anesthesia demonstrated an acceptable safety profile in this tertiary care setting, with most complications being mild and readily managed. Respiratory adverse events, postoperative nausea and vomiting, hypothermia, and hypoxemia remain important targets for quality improvement. Future multicenter studies with larger cohorts are warranted to validate these findings and evaluate interventions aimed at reducing preventable perioperative complications in children.

CONCLUSION

Among children aged 1–5 years undergoing surgery in this tertiary care hospital, anesthesia-related perioperative complications were generally minor and manageable, with no cardiac arrest or mortality observed. Postoperative nausea and vomiting was the most frequent complication, while hypoxemia, hypothermia, bronchospasm, and laryngospasm remained important perioperative concerns. These findings indicate an acceptable pediatric anesthesia safety profile in the study setting and support continued emphasis on respiratory surveillance, temperature control, and prevention of postoperative nausea and vomiting.

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