Pediatric Anesthesia and Critical Care Journal 2025;13(2):70-79
doi:10.14587/paccj.2025.12

PACCJ

Epidemiology of anesthetic complications in pediatric surgery in Kinshasa: a multicenter historical cohort study. *Original article*.

G. Makeya[1,3], A. Makembi Bunkete[2], W. Mbombo[1,4], K. Anga[1], S. Ndjoko[1,5], JJ. Kalongo[1,6], P. Mukuna[1], J. Nsiala[1], M. Bulabula[1], B. Barhayiga[1]

[1]Department of Anesthesiology and Critical Care, University Clinics of Kinshasa, University of Kinshasa, Kinshasa, Democratic Republic of Congo
[2]Department of Internal Medicine, Division of Nephrology, University Clinics of Kinshasa, University of Kinshasa, Kinshasa, Democratic Republic of Congo
[3]Faculty of Medicine, University of Kikwit, Kikwit, Democratic Republic of Congo
[4]Department of Anesthesiology and Critical Care, Monkole Hospital Center, Kinshasa, Democratic Republic of Congo
[5]Department of Anesthesiology and Critical Care, Kalembelembe Pediatric Hospital, Kinshasa, Democratic Republic of Congo
[6]Department of Anesthesiology and Critical Care, Biamba Marie Mutombo Hospital, Kinshasa, Democratic Republic of Congo

Corresponding author: A. Makembi Bunkete, Department of Internal Medicine, Division of Nephrology, University Clinics of Kinshasa, University of Kinshasa, Kinshasa, Democratic Republic of Congo. Email: docteur.makarriel2017@gmail.com,

Keypoints

The study aimed to assess the incidence and risk factors of anesthetic complications in children in Kinshasa to inform strategies for improving perioperative safety. The findings provide an evidence base to guide health policy and targeted interventions.

Abstract

Introduction

Pediatric anesthesia poses unique challenges due to the physiological and anatomical characteristics of children. In low-resource settings such as the Democratic Republic of Congo, the risk of anesthetic complications remains high, significantly affecting postoperative morbidity and mortality. This study aimed to assess the incidence and risk factors of anesthetic complications in children in Kinshasa to inform strategies for improving perioperative safety.

Methods

A retrospective cohort study included 394 children aged 0 to 15 years who underwent surgical procedures under general or regional anesthesia in four hospitals in Kinshasa between June and December 2024. Demographic, clinical, and anesthetic data, as well as perioperative complications, were collected. Statistical analyses were performed to identify factors associated with complications, with significance set at $p < 0.05$.

Results

The overall incidence of anesthetic complications was 28.4%, predominantly respiratory (14.5%) and cardiac (13.7%). Thirty-day mortality was 10.4%, with a notably higher rate among neonates (32.1% of deaths). Independent risk factors included ASA score ≥ 3, emergency surgery, prolonged operative duration, and reoperations.

Conclusion

Pediatric anesthetic morbidity and mortality in Kinshasa remain substantial. Enhancing specialized training, improving resources, and implementing standardized protocols are critical to improving perioperative safety. This

findings provide an evidence base to guide health policy and targeted interventions.

Keywords

Anesthesia, Pediatric; Perioperative Complications; Risk Factors; Child; Developing Countries; Democratic Republic of Congo; Epidemiology

Introduction

Pediatric anesthesia represents a highly specialized field of medical practice due to the anatomical, physiological, and pharmacological characteristics unique to children. The small airway diameter, relatively large head and tongue, limited oxygen reserve, and high metabolic demand predispose children to rapid desaturation in the event of obstruction or apnea. In addition to these anatomical features, immaturity of the autonomic nervous system, variable pharmacokinetics of anesthetic agents, and heightened sensitivity to hemodynamic fluctuations render anesthetic management in children more delicate than in adults [1,2].

In high-income countries, decades of technological and organizational advancements have significantly reduced anesthetic morbidity and mortality. The introduction of modern monitoring equipment (pulse oximetry, capnography, automated surveillance), the development of pediatric-specific drugs, the specialization of pediatric anesthesia, and the implementation of standardized protocols explain this improvement. The multicenter European APRICOT study, conducted across 33 countries and including over 30,000 children, reported a 5.2% incidence of severe perioperative events, predominantly respiratory, with a mortality rate below 0.5% [3]. These exceptionally low figures reflect the effectiveness of safety strategies in well-resourced settings.

In contrast, the situation in sub-Saharan Africa remains concerning. A shortage of trained anesthesiologists, lack of essential equipment (pulse oximeters, ventilators, syringe pumps), limited availability of pediatric medications, and the absence of appropriately equipped intensive care units contribute to a persistently high incidence of complications [4,5]. Local studies highlight alarming rates : in Cameroon, Amengle et al. reported a 33.1% incidence of pediatric anesthetic complications, with a mortality of 7.9% [6]; in Togo, Koudouvo et al. observed complications in 12% of cases, some life-threatening [7]. These results stand in stark contrast to industrialized countries, where anesthesia-related pediatric mortality is now exceedingly rare.

In the Democratic Republic of Congo (DRC), available data are outdated and indicate significant challenges. In Kinshasa, a study published over ten years ago reported a pediatric anesthetic mortality of 14% [8] ; in Lubumbashi, Kanda et al. reported a rate as high as 19.8% [9]. These figures, far above international standards, reflect structural and organizational constraints within which anesthetic care is delivered. Since then, initiatives have been undertaken, including the development of university-level training in anesthesia and critical care, international cooperation programs, and gradual strengthening of technical facilities [10]. However, the actual impact of these measures on pediatric anesthetic safety has not yet been systematically documented.

Given this context, updated data are required to evaluate changes in pediatric anesthetic care in the Congolese capital. This study aimed to determine the incidence of anesthetic complications in pediatric surgery in Kinshasa, describe their main characteristics, and identify associated risk factors. An additional objective was to compare these findings with African and international data to inform strategies to improve anesthetic safety for children in the DRC.

Methods

Study design

This was a retrospective (historical) cohort study designed to evaluate the epidemiology of anesthetic complications in children aged 0 to 15 years undergoing general or regional anesthesia for surgical or diagnostic procedures, whether urgent or elective. Patients were

followed from anesthetic induction until hospital discharge or up to 30 days postoperatively.

Study setting

The study was conducted in four hospitals in the city-province of Kinshasa: The University Clinics of Kinshasa, Monkole Hospital Center, Biamba Marie Mutombo Hospital, and Kalembelembe Pediatric Hospital, between June 1 and December 31, 2024. These hospitals were selected based on functional operating theaters supervised by at least one resident and one anesthesiologist, and their agreement to participate. Data were extracted from hospital registers, anesthetic monitoring sheets, and medical records.

Participants

Inclusion criteria were children aged 0–15 years who underwent general or regional anesthesia for surgical or diagnostic procedures in the selected hospitals, with complete follow-up until discharge or 30 days postoperatively. Exclusion criteria were incomplete records and local anesthesia alone. All eligible patients were consecutively included. Patients were grouped according to the presence or absence of anesthetic complications. Follow-up was performed retrospectively from induction until discharge or 30 days postoperatively.

Variables

Collected variables included:

- **Sociodemographic:** age, sex, weight.
- **Preoperative:** surgical indication, urgency, surgical specialty, ASA score, laboratory results (CBC, electrolytes, urea, creatinine).
- **Perioperative:** anesthesia type, anesthetic agents, ease of intubation, monitoring, duration of anesthesia, qualifications of anesthesiologist and surgeon.
- **Postoperative outcomes:** perioperative complications, vital status at day 1, day 3, and day 30.

Operational definitions were established for key events: difficult intubation, laryngospasm, bradycardia, desaturation, hypo-/hypertension, delayed emergence, and respiratory depression.

Data sources and measurement

Data were collected from hospital registers, medical records, preanesthetic evaluation forms, and anesthetic monitoring sheets. Collectors were trained by the principal investigator. A two-step quality control ensured completeness and consistency. Missing or aberrant values were corrected or excluded.

Bias

Selection bias was minimized by consecutive inclusion of all eligible patients during the study period. Information bias was reduced using standardized forms and cross-checking. Confounding variables were addressed in multivariate analysis.

Sample size

The minimum sample size was calculated using Keyes' formula with $p = 33.1\%$ (estimated prevalence of complications), $q = 66.9\%$, $Z = 1.96$, and $\alpha = 0.05$, yielding $n = 340$. A total of 394 children were included.

Quantitative variables

Continuous variables (age, weight, anesthesia duration) were analyzed as mean ± SD or median (IQR), depending on distribution. Analytical categories were defined based on clinical relevance.

Statistical methods

Categorical variables are presented as frequencies and percentages, continuous variables as mean ± SD or median (IQR). Frequency comparisons used Chi-square or Fisher's exact test; continuous variables were compared using Student's t-test or ANOVA. Factors associated with complications were identified using multivariate logistic regression including variables significant in univariate analysis. Results are expressed as adjusted odds ratios (aOR) with 95% confidence intervals. Missing data were handled via complete-case analysis. Significance was set at $p < 0.05$.

Results

Distribution of patients by hospital and age group

The distribution of pediatric patients across hospitals and age groups revealed notable differences in both volume and demographic structure. The University Clinics of Kinshasa (CUK) recorded the highest total number of patients, with 143 children: 27 neonates, 39 infants, 18 young children, and 59 older children/adolescents. Kalembelembe Pediatric Hospital (HPKL) followed with 123 patients : 25 neonates, 57 infants, 19 young children, and 22 older children/adolescents. Monkole Hospital Center (CH Monkole) accounted for 91 patients : 1 neonate, 32 infants, 14 young children, and 44 older children/adolescents. Finally, Biamba Marie Mutombo Hospital (HBMM) had the lowest volume, with 37 patients : 9 neonates, 6 infants, 5 young children, and 17 older children/adolescents. This distribution highlights the pediatric admission structure in each institution (Figure 1).

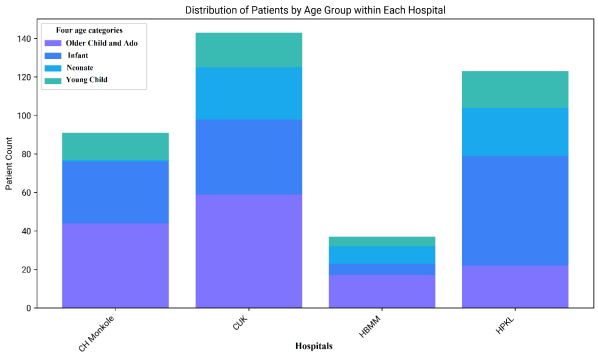

Figure 1. Distribution of Pediatric Patients by Age Group across Four Hospitals.

Socio-demographic characteristics

Analysis by age and sex revealed a male predominance among infants (21.32%) and older children/adolescents (19.29%). Young females were the least represented (4.82%). Mean weight increased with age, from 3.35 kg in male neonates to 39.35 kg in adolescent females. Among older children/adolescents, girls had a slightly higher mean weight than boys (39.35 kg vs. 36.33 kg), while in other age groups, boys had similar or slightly higher weights than girls (Table 1).

Age Group	Sex	Count	Percentage	AverageWeight(kg)
OCA	Female	66	16.75%	39.35
OCA	Male	76	19.29%	36.33
Infant	Female	50	12.69%	10.36
Infant	Male	84	21.32%	11.04
Neonate	Female	33	8.38%	3.38
Neonate	Male	29	7.36%	3.35
Young Child	Female	19	4.82%	16.16
Young Child	Male	37	9.39%	16.68

Table 1. Socio-demographic characteristics of the study population. This table presents the distribution of participants by age group and sex, including the number of individuals (Count), their percentage of the total sample (Percentage), and the average weight in kilograms (Average Weight). Age groups are defined as follows: Neonate (birth to 28 days), Infant (1–12 months), Young Child (1–5 years), and OCA/Older Child/Adolescent (10–15 years).

Preoperative biological characteristics

Preoperative laboratory values varied across age groups. Mean creatinine was highest in neonates (0.97 mg/dL), though not statistically significant ($p = 0.1$).

White blood cell counts differed significantly ($p < 0.01$), with the highest mean in young children (9635/mm³).

Blood glucose did not vary significantly ($p = 0.19$).

Hemoglobin levels differed markedly ($p < 0.001$), highest in neonates (14.6 g/dL) and lowest in infants (10.9 g/dL).

Lymphocyte and neutrophil percentages also varied significantly ($p = 0.033$ and $p = 0.031$, respectively), with higher lymphocyte counts in infants and young children, and peak neutrophil percentages in neonates.

Blood urea levels showed no significant difference ($p = 0.087$), although young children had the lowest mean (Table 2).

Parameter	OCA	Infant	Neonate	YoungChild
Creat Mean	0.660	0.350	0.967	0.390
Creat SD	0.428	0.100	0.404	0
WBC Mean	8153	9002	8756	9635
WBC SD	5144	4194	3111	6311
Glucose Mean	131	107	110	112
Glucose SD	24.8	17.4	19.8	36.7
Hb Mean	12.5	10.9	14.6	11.1
Hb SD	9.62	1.71	1.90	1.33
Lymph Mean	36.0	43.6	31.1	43.6
Lymph SD	16.8	19.9	18.1	12.7
Neut Mean	54.8	47.8	62.1	44.6
Neut SD	18.8	23.3	16.2	12.4
Urea Mean	31.3	53.7	45.9	4.64
Urea SD	28.0	46.6	17.8	0
n	14	201	41	309
p	0.1	<0.01	0.19	<0.001

Table 2. Preoperative Biological Characteristics. **OCA** = Older Child/Adolescent, **Creat** = Creatinine, **Mean** = Average value, **SD** = Standard Deviation (measure of variability), **WBC** = White Blood Cells, **Glucose** = Blood sugar level, **Hb** = Hemoglobin, **Lymph** = Lymphocytes (type of white blood cell), **Neut** = Neutrophils (type of white blood cell), **Urea** = Urea (blood waste product), **n** = Number of samples, **p** = p-value (statistical significance)

Preoperative anesthetic characteristics

Most neonates and infants were classified as ASA I (~53%) or ASA III (40.3% and 27.6%), indicating a considerable proportion with severe conditions. Young children were mostly ASA I (78.6%), reflecting better general health. Older children/adolescents had a notable proportion of ASA III (29.6%). Emergency surgery was most common among neonates (67.7%), whereas infants and young children underwent mainly elective procedures (65.7% and 85.7%). General/digestive surgery predominated across age groups, especially in neonates (46.8%) and older children/adolescents (54.2%). Malformation-related surgeries were frequent in neonates (46.8%) but rare in other groups. Ent, ophthalmologic, orthopedic, plastic, and urologic procedures were more common in young children and older children/adolescents. Main indications included congenital malformations in neonates (laparoscisis 19.4%, spina bifida 17.7%), acute intestinal obstruction (17.9%) and retinoblastoma (16.4%) in infants, adenoidectomy and genu valgum in young children, and digestive perforations and appendicitis in older children/adolescents (Table 3).

Var.	Cat.	Neonate	Infant	YoungChild	GEA
ASA	I	53.2%	53.7%	78.6%	61.3%
	II	6.5%	16.4%	10.7%	6.3%
	III	40.3%	27.6%	10.7%	29.6%
	IV	-	2.2%	-	2.8%
Surg.nature	Elective	32.3%	65.7%	85.7%	57.7%
	Emergency	67.7%	34.3%	14.3%	42.3%
Surg. type	DigGen	46.8%	50.0%	19.6%	54.2%
	Ent	1.6%	2.2%	16.1%	4.9%
	Ophtha	1.6%	16.4%	1.8%	2.8%
	Ortho	-	11.2%	19.6%	19.0%
	Plast	1.6%	6.7%	16.1%	1.4%
	Uro	-	8.2%	19.6%	12.7%
	Malform	46.8%	2.2%	1.8%	-
	Neuro	-	2.2%	1.8%	4.2%
	Others	Maxill(1.6%)	Imag(0.7%)	Thorac(3.6%)	Gyn(0.7%)
Main indic.	Top1	Laparosch(19.4%)	AIO(17.9%)	Adenoid(7.1%)	Adp(11.3%)
	Top2	SpinaBif(17.7%)	Retino(16.4%)	Knock-knee(7.1%)	Udt(5.6%)
	Top3	Adp(12.9%)	Phimosis(6.0%)	Hydrocele(5%)	Multiapp(10%)

Table 3. Preoperative Anesthetic Characteristics. **OCA** = Older Child & Adolescent; **ASA (I-IV)** = American Society of Anesthesiologists classification of health status (**I** = healthy, **IV** = very ill); **Surg.nature** = type of surgery (**Elective** = scheduled, **Emergency** = urgent); **Surg.type** = surgery type: **DigGen** = digestive/general, **Ent** = ENT (ear, nose, throat), **Ophtha** = ophthalmologic, **Ortho** = orthopedic, **Plast** = plastic/aesthetic, **Uro** = urological, **Malform** = malformation surgery, **Neuro** = neurosurgery, **Others** = other types (**Maxill** = maxillofacial, **Imag** = imaging, **Thorac** = thoracic, **Gyn** = gynecology); **AIO** = main indications: **Laparosch** = laparoschisis, **AIO** = acute intestinal obstruction, **Adp** = acute digestive perforation, **SpinaBif** = spina bifida, **Retino** = retinoblastoma, **Udt** = undescended testicle, **Multiapp** = multiple appendicitis.

Intraoperative anesthetic characteristics

Patients were categorized into neonates, infants, and older children/adolescents (OCA). In OCA, techniques included general anesthesia (GA) with endotracheal intubation (4 cases), laryngeal mask airway (LMA, 2 cases), and one iliofascial block with sedation. Agents used

included ketamine, propofol, sevoflurane, and their combinations. Infants underwent GA with LM, GA with facial mask (FM), or spinal anesthesia (SA) with sedation, using propofol-ketamine, sevoflurane, and no agents for SA/sedation. Neonates underwent two GA cases, one with endotracheal intubation and one with LM, using propofol and sevoflurane combinations. Intraoperative monitoring was performed in all cases, with anesthesia duration ranging from 30 to 170 minutes. Anesthesiologist and surgeon qualifications included both specialists and senior trainees (Table 4).

Age	AnesType	Agent	Mon	Dur(min)	AnesQual	SurgQual	Cases
OCA	GA + OTI	Ketamine	Yes	70	St	St	1
OCA	Block/Sed	None	Yes	35	Spec	St	1
OCA	GA + LM	Propofol	Yes	35	Spec	Spec	2
OCA	GA + OTI	Sevoflurane	Yes	150	Spec	Spec	1
OCA	GA + OTI	Prop+Sevo	Yes	170	Spec	Spec	1
Infant	GA + LM	PropoKet	Yes	30	Spec	Spec	1
Infant	GA + FM	Sevoflurane	Yes	45	Spec	Spec	1
Infant	SA/Sed	None	Yes	65	Spec	Spec	1
Neonate	GA + OTI	Prop+Sevo	Yes	170	Spec	Spec	1
Neonate	GA + LM	Prop+Sevo	Yes	30	St	St	1

Table 4. Intraoperative Anesthetic Characteristics. **Anes Type:** GA = General Anesthesia, OTI = Orotracheal Intubation, LM = Laryngeal Mask, FS = Face Mask, SA = Spinal Anesthesia, Sed = Sedation, Bloc = Nerve Block | **Agent:** Propo = Propofol, Ket = Ketamine, Sevo = Sevoflurane, PropoKét = Propofol + Ketamine, RAS = None | **Monitor:** Yes = Monitoring Present | **Dur:** Duration (min) | **Anes Qual:** St = Senior Trainee, Spec = Specialist | **Surg Qual:** St = Senior Trainee, Spec = Specialist | **Cases:** Number of Cases

Distribution of complications

Overall complication prevalence

The prevalence of complications was high and comparable in older children/adolescents, infants, and neonates, with 163, 157, and 152 cases respectively. Young children had a significantly lower number of complications (62), suggesting reduced incidence in this group (Figure 2).

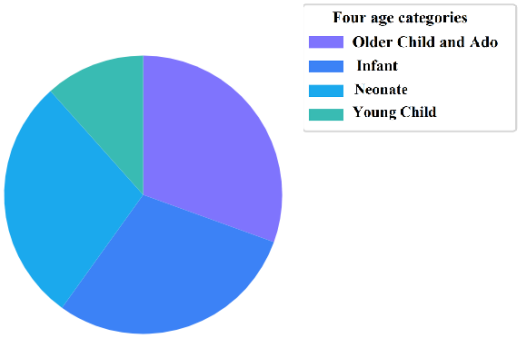

Figure 2. Overall distribution of complications by age groups. This pie chart illustrates the proportion of complications across four age categories: Neonate, Infant, Young Child, and OCA (Older Child and Adolescent). Neonate, Infant, and OCA groups show similar shares of complications, while the Young Child group accounts for a smaller proportion.

Frequency of complications

Sixteen types of complications were analyzed, including neurological, cardiac, respiratory, hematological, renal, infectious, oncological, and various intra- and postoperative incidents. The most frequent category was incidents/accidents (112 cases), followed by intraoperative incidents (100 cases), infectious complications and sepsis (69 each).

Maintenance-related incidents occurred 63 times, while intraoperative respiratory and cardiac complications accounted for 57 and 54 cases, respectively. Intraoperative neurological complications occurred 45 times, other intraoperative complications 33 times, and induction incidents 29 times.

Rare complications included oncological (13), hematological (9), respiratory (7), neurological (3), renal (2), and cardiac (1) cases (Figure 3).

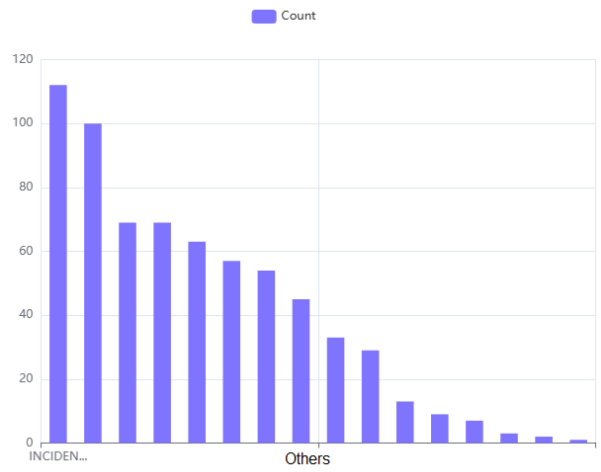

Figure 3. Frequency of anesthesic complications. The chart shows the number of cases for various complications, with incidents and perioperative incidents being the most common, followed by infections and sepsis. Other complications occur less frequently.

Age distribution by 30-day outcome

Age group distribution differed notably between survivors and patients deceased at day 30. Older children/adolescents and infants represented over 70% of survivors, while neonates were underrepresented. Conversely, neonates accounted for 32.1% of deaths, with lower proportions among older children/adolescents and infants, highlighting the strong age-related variation in 30-day outcomes (Figure 4)

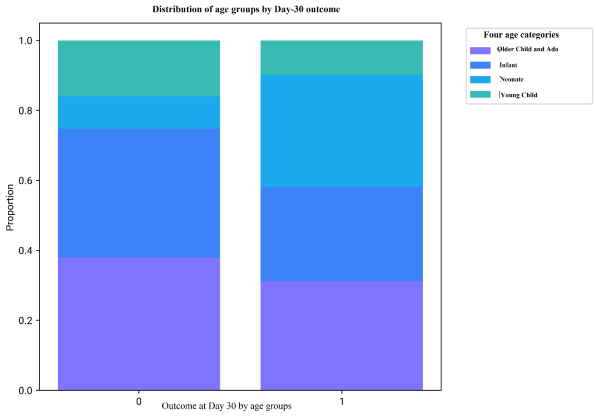

Figure 4. Differences in age group distribution according to 30-day outcome. This figure shows the proportional distribution of four age categories (Older Child and Adolescent, Infant, Neonate, Young Child) according to 30-day outcomes (0 = survivors, 1 = deaths). The proportions of age groups differ notably between survivors and deceased patients, with an overrepresentation of neonates among deaths and a predominance of older children/adolescents and infants among survivors.

Discussion

This multicenter study in Kinshasa revealed a high incidence of anesthetic complications in pediatric surgery (28.4%) and a 30-day mortality rate of 10.4%. These rates remain considerably higher than those reported in high-income countries, yet reflect improvement compared to previous Congolese data, which reported pediatric anesthetic mortality of 14% in Kinshasa [8] and 19.8% in Lubumbashi [9].

In industrialized countries, advanced monitoring, pediatric anesthesia specialization, and standardized protocols have reduced morbidity and mortality to very low levels [1–3]. The APRICOT study reported only a 5.2% incidence of severe events and mortality below 0.5% [3]. Conversely, sub-Saharan Africa continues to face shortages in trained personnel, essential equipment, and pediatric-appropriate medications [4,5]. These constraints explain the high complication rates reported regionally, e.g., 33.1% in Cameroon [6] and 12% in Togo [7]. Our results, intermediate between African data and international standards, confirm this persistent disparity.

Identified risk factors — ASA score ≥ 3, emergency surgery, prolonged operative time, and reoperations — align with international literature. The POCA registry demonstrated that urgency, severe pathology, and intraoperative anomalies significantly increased the risk of cardiac arrest in children [11]. Comorbidities such as obesity have also been associated with higher rates of perioperative complications [12].

Respiratory complications, the most frequent in our series, are consistent with APRICOT and African studies [3,6–9], underscoring the need for appropriate monitoring. Despite recent improvements in the DRC [10], a substantial gap remains compared to high-income countries, where pediatric anesthesia-related mortality is now exceptional [13].

These disparities are linked to inadequate specialized training, insufficient pediatric ICU infrastructure, and limited technical resources [14,15]. Systematic reviews

confirm that perioperative and anesthetic mortality remains significantly higher in low-resource settings [16]. Potential solutions exist. WHO's *Safe Surgery Saves Lives* program emphasizes standardized protocols and checklists to reduce surgical and anesthetic morbidity and mortality [17]. Strengthening local anesthesia capacities in low-and middle-income countries has demonstrated positive impacts on care quality and safety [18]. Furthermore, studies highlight the need to reorganize anesthesia services in resource-limited settings, emphasizing targeted investments to ensure minimum safety standards [19,20]. Such measures are essential to gradually close the gap with international standards and enhance pediatric anesthetic safety in the DRC.

Limitations

This study has several limitations. Its retrospective design introduces information bias due to the quality and completeness of medical records. The absence of strict standardization of anesthetic protocols across participating hospitals may have introduced uncontrolled variability. Minor complications may have been underreported due to incomplete documentation. These biases, if present, would likely underestimate the true incidence of complications. However, the large sample size and multicenter design strengthen the robustness of the findings.

Conclusion

Pediatric anesthesia in Kinshasa continues to be associated with significant morbidity and mortality, despite improvements over previous decades. Emergency surgery, ASA score ≥ 3, prolonged operative duration, and reoperations are key predictors of complications and mortality. Efforts must focus on strengthening human and material resources and implementing standardized, child-adapted protocols to improve anesthetic safety.

Ethical considerations

The protocol was approved by the Ethics Committee of the School of Public Health (ESP/CE/236/2024) and authorized by hospital administrators. Due to the retrospective design, parental consent was not required, but hospitals inform patients that data may be used for research purposes. Ethical principles of respect for persons, beneficence, and justice were upheld. No conflicts of interest were declared.

Funding: This study received no external funding. The funders had no role in study design, data collection, analysis, interpretation, or decisions regarding publication.

Competing interests: The authors declare no competing interests.

Author contributions: G.M. and K.A. contributed equally to the study conception, design, data collection, and drafting of the manuscript. A.M.B. and W.M. contributed to data analysis and interpretation. M.B., B.B., S.N., J.K., P.M., and J.N. performed clinical evaluations and data acquisition. All authors supervised the study, provided critical revisions, and approved the final manuscript.

Acknowledgements: The authors sincerely thank the pediatric and anesthesiology staff at the University of Kinshasa and the four participating hospitals—University Clinics of Kinshasa, Kalembelembe Pediatric Hospital, Monkole Hospital Center, and Biamba Marie Mutombo Hospital—for their invaluable support in patient care, perioperative monitoring, data collection, and clinical assessments. We are also grateful to the children and their families for their participation, as well as to the medical and administrative teams of these hospitals for their collaboration throughout the study.

References

1. Kuratani N, Kanmura Y. Pediatric anesthesia: current status and future directions. J Anesth. 2016 Apr;30(2):185–6. doi: 10.1007/s00540-015-2102-0. Epub 2015 Nov 25. PMID: 26607733.
2. Powell WF Jr, Echeto-Cerrato MA, Gathuya Z, Gray RM, Hodges S, Nabukenya MT, Newton MW, Rai E, Evans FM. Delivery of safe pediatric anesthesia care in the first 8000 days: realities, challenges, and

solutions in low- and middle-income countries. World J Surg. 2023 Dec;47(12):3429–35. doi: 10.1007/s00268-023-07229-5. Epub 2023 Oct 27. PMID: 37891383.

3. Habre W, Disma N, Virag K, Becke K, Hansen TG, Jöhr M, Leva B, Morton NS, Vermeulen PM, Zielinska M, Boda K, Veyckemans F; APRICOT Group of the European Society of Anaesthesiology Clinical Trial Network. Incidence of severe critical events in paediatric anaesthesia (APRICOT): a prospective multicentre observational study in 261 hospitals in Europe. Lancet Respir Med. 2017 May;5(5):412–25. doi: 10.1016/S2213-2600(17)30116-9. Epub 2017 Mar 28. Erratum in: Lancet Respir Med. 2017 May;5(5):e19. doi: 10.1016/S2213-2600(17)30137-6. Erratum in: Lancet Respir Med. 2017 Jun;5(6):e22. doi: 10.1016/S2213-2600(17)30164-9. PMID: 28363725.
4. Brima N, Morhason-Bello IO, Charles V, Davies J, Leather AJ. Improving quality of surgical and anaesthesia care in sub-Saharan Africa: a systematic review of hospital-based quality improvement interventions. BMJ Open. 2022 Oct 11;12(10):e062616. doi: 10.1136/bmjopen-2022-062616. PMID: 36220318; PMCID: PMC9557325.
5. Bharati SJ, Chowdhury T, Gupta N, Schaller B, Cappellani RB, Maguire D. Anaesthesia in underdeveloped world: present scenario and future challenges. Niger Med J. 2014 Jan;55(1):1–8. doi: 10.4103/0300-1652.128146. PMID: 24970961; PMCID: PMC4071655.
6. Desalu I, Sarpong P, Osazuwa MO, et al. Global pediatric anesthesia–Anglophone West Africa perspective. Pediatr Anesth. 2024;34:835–47. doi: 10.1111/pan.14852.
7. Mouzou T, Egbohou P, Tomta K, Sama H, Assenouwe S, Akala Y, et al. Pratique de l'anesthésie pédiatrique dans un pays en développement: expérience du CHU Sylvanus Olympio de Lomé au Togo. Rev Afr Anesth Med Urg. 2016;21(3):38–43.
8. Longombe AO, Muvunga PJ, Vadza E, Iteke FR. Anesthésie pour chirurgie des fentes labiopalatines en milieu à ressources limitées: bilan et perspectives. Rev Afr Anesth Med Urg. 2016;21(1):9–12.
9. Umba DM. Pratique de l'anesthésie pédiatrique dans la ville de Lubumbashi en RD Congo: indications, complications et facteurs de mortalité. Am J Med Clin Res Rev. 2023;2:1–12. doi: 10.58372/2835-6276.1055.
10. Koch R, Felsted AM, Virk S, Roy N, Jayaraman S. Surgical capacity building in low- and middle-income countries: lessons for thoracic surgery. Thorac Surg Clin. 2022;32(3):269–78. doi: 10.1016/j.thorsurg.2022.02.003.
11. Braz LG, Braz JRC, Tiradentes TAA, Porto DSM, Beserra CM, Vane LA, do Nascimento Junior P, Modolo NSP, Braz MG. An update on the mechanisms and risk factors for anesthesia-related cardiac arrest in children: a narrative review. Braz J Anesth (Engl Ed). 2024;74(5):844519. doi: 10.1016/j.bjane.2024.844519.
12. Nafiu OO, Prasad Y, Chimbira WT. Association of childhood high body mass index and sleep disordered breathing with perioperative laryngospasm. Int J Pediatr Otorhinolaryngol. 2013 Dec;77(12):2044–8. doi: 10.1016/j.ijporl.2013.10.004. Epub 2013 Oct 14. PMID: 24182867.
13. Cohen MM, Cameron CB, Duncan PG. Pediatric anesthesia morbidity and mortality in the perioperative period. Anesth Analg. 1990 Feb;70(2):160–7. doi: 10.1213/00000539-199002000-00005. PMID: 2301747.
14. Tao KM, Sokha S, Yuan HB. The challenge of safe anesthesia in developing countries: defining the problems in a medical center in Cambodia. BMC Health Serv Res. 2020 Mar 12;20(1):204. doi: 10.1186/s12913-020-5068-z. PMID: 32164745; PMCID: PMC7068932.
15. Mittnacht AJC, Romero Garcia CS, Cadwell JB, Huang J, Sofjan I, ElTahan MR, Liu H, Mukherjee

C, Guarracino F, Shaw A, Motta P. Global cardiac anesthesia workforce assessment: a cross-sectional observational survey study. J Cardiothorac Vasc Anesth. 2025;39(8):1930–44. doi: 10.1053/j.jvca.2025.02.042.

16. Bainbridge D, Martin J, Arango M, Cheng D; Evidence-based Peri-operative Clinical Outcomes Research (EPiCOR) Group. Perioperative and anaesthetic-related mortality in developed and developing countries: a systematic review and meta-analysis. Lancet. 2012 Sep 22;380(9847):1075–81. doi: 10.1016/S0140-6736(12)60990-8. PMID: 22998717.
17. World Health Organization. Safe Surgery Saves Lives. Geneva: WHO; 2016.
18. Hadler RA, Chawla S, Stewart BT, McCunn MC, Kushner AL. Anesthesia care capacity at health facilities in 22 low- and middle-income countries. World J Surg. 2016 May;40(5):1025–33. doi: 10.1007/s00268-016-3430-4. PMID: 26822158; PMCID: PMC5842804.
19. Hodges SC, Mijumbi C, Okello M, McCormick BA, Walker IA, Wilson IH. Anaesthesia services in developing countries: defining the problems. Anaesthesia. 2007 Jan;62(1):4–11. doi: 10.1111/j.1365-2044.2006.04907.x. PMID: 17156220.
20. Walker IA, Wilson IH. Anaesthesia in developing countries—a risk for patients. Lancet. 2008 Mar 22;371(9617):968–9. doi: 10.1016/S0140-6736(08)60432-8. PMID: 18358913.