Original Article

Pediatric Perioperative Mortality in Southeastern (SE) Nigeria—A Multicenter, Prospective Study

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Abstract

Background: The perioperative mortality rate is a key indicator of the quality of surgical services in low and middle-income countries (LMIC). **Objective:** To determine the perioperative mortality rate of pediatric surgical conditions and the predictive factors in Southeastern Nigeria. **Methodology:** A prospective, multicenter study of peri-operative mortalities occurring in children under 18 years in five tertiary hospitals in Southeastern Nigeria over nine months was conducted. All-cause and case-specific in-hospital peri-operative mortality rates, as well as predictive factors, were identified. The mortality rate was expressed as percentages with a 95% confidence interval. The data were analyzed using SPSS 26. **Results:** A total of 775 patients underwent anesthesia or surgery, with 28 deaths. The 30-day perioperative mortality rate was 3.61% (95% CI = 2.41-5.18); 1.94% (95% CI = 1.09-3.17 within 24 hours, and 1.17% (95% CI = 0.91-2.91) from 24 hours to 30 days after the procedure. The mortality rate was 100% for gastroschisis and ruptured omphalocele, with overwhelming sepsis being the major cause of death (53.6%). Significant determinants of mortality were a higher ASA status (AOR)=13.944, 95% CI=1.509-128.851, *p*=0.020, sedation without ventilatory support (AOR)=15.295, 95% CI=3.304-70.800, *p*=0.001, and associated comorbidities (AOR)=65.448, 95% CI=11.244-380.962, *p*=0.001. **Conclusion:** The pediatric peri-operative mortality rate in Southeastern Nigeria is high for gastroschisis. Associated comorbidities, higher ASA status, and sedation without ventilatory support were significant predictors ofmortality.

Keywords: *Anaesthesia, mortality, pediatric, peri-operative, Southeastern Nigeria*

Introduction

The demand for surgeries differs worldwide, with western sub-Saharan Africa requiring an estimated 6495 operations per 100,000 people.[1] Available data suggest that between 6% and 12% of pediatric hospitalizations in sub-Saharan Africa are due to surgical procedures.[2] However, the percentage may be higher in specific urban locations. In Uganda, about a third of pediatric deaths result from surgical conditions.[3] The Lancet Commission on Global Surgery recommended using the national perioperative mortality rate (POMR) as one of six key indicators for evaluating a country's surgical system.[4]

Despite the usefulness of hospital mortality data in monitoring and evaluating healthcare services, there is

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a dearth of information on the availability, accessibility, and quality of hospital mortality data in most of sub-Saharan Africa.[5] There is limited information on the risk of specific patient subgroups and the contribution of anesthesia and surgery to short- and long-term mortality.[6]

The POMR defined as death following surgery, and anesthesia within two time periods: on the day of surgery (including death in the operating theater) and before discharge from the hospital or within 30 days of surgery, divided by the number of procedures performed, has been championed as a useful indicator to measure surgical safety at an institutional and national level.[7] Perioperative mortality may not reflect poor performance but could be attributable to complications from the operation or pre-existing medical conditions.[4]

Pediatric perioperative mortality is low, but it is inadequately reported in peer-reviewed journals, making it difficult to appreciate the enormity of the problem.[8] The low POMR in pediatric surgery precludes effective analysis of mortality at individual institutions. Therefore, analysis of multi-institutional data is essential to determine any patterns of perioperative death in children.[9] To our knowledge, this is southeastern Nigeria's first multi-institutional, prospective study of pediatric perioperative mortality.

The study aims to provide multi-institutional benchmark data on pediatric perioperative mortality in southeastern Nigeria.

The objectives are as follows:

1. To determine all-cause and case-specific pediatric POMRs in southeastern Nigeria
2. Identify the possible predictive factors.

Methodology

Study design

A prospective, multicenter study of perioperative mortalities in children under 18 years in five tertiary hospitals in the five states in southeastern Nigeria between May 2021 and January 2022 was performed. The all-cause and the case-specific POMRs were determined, and predictive factors were identified.

Study area

The hospitals involved in the study were the University of Nigeria Teaching Hospital (UNTH) Enugu State, Nnamdi Azikiwe University Teaching Hospital Nnewi, Anambra State (NAUTH), Alex Ekwueme Federal University Teaching Hospital, Abakaliki, Ebonyi State, (AEFUTHA), Federal Medical Center, Umuahia, Abia State (FMC, Umuahia), and Federal Medical Center Owerri, Imo State (FMC, Owerri). These hospitals receive the majority of referrals in pediatric surgery in southeastern Nigeria. None of them has a neonatal intensive care unit (NICU) or pediatric total parenteral nutrition (TPN). Other features of the participating hospitals are shown in Table 1.

Data collection

The study recruited patients from clinics, children's emergency room (CHER), and special care baby units (SCBU). Inclusion criteria included children with a surgical problem for which anesthesia may/may not be required and those whose parents consented to be part of the study. Exclusion criteria included children undergoing cardiac, plastic, orthopedic, and ophthalmic surgeries (not performed by pediatric surgeons), those whose parents did not consent, and patients for whom 30-day follow-up was unavailable.

The data collection tool was adapted to Talabi *et al*.[10] Patients' biodata, weight at presentation, symptom diagnosis, associated anomalies, The American Society of Anesthesiologists (ASA) grade, urgency of the procedure, time to intervention, the cadre of attending surgeon and anesthesiologists, surgical procedure and the number of surgeries within 30 days, anesthetic technique, mortalities, time of death, cause of death, and duration of hospital stay were entered into a register opened for this purpose. A pediatric surgeon from each participating hospital ensured data were verified and correct before being documented in the register.

Ethical considerations

The nature and motives of the planned study were explained to parents, guardians, and caregivers including older patients. Those who wished to participate gave verbal consent as written consent was impossible in most cases. Patients and caregivers were free to withdraw from the study anytime they wanted. Ethical clearance for the study was obtained from each participating institution's Health Research Ethics Committee (HREC).

Children were grouped as follows: preterm (less than 37-week gestational age), neonates (0–28 days), infants (1 month–12 months), preschool (1–3 years), young children (4–10 years), and older children (11–18 years). Each mortality was discussed by a panel of surgeons and anesthesiologists involved in the management to determine the cause of death.

The primary causes of death were classified according to a study by de Bruin L *et al*.[6] as follows:

1. Attributed to preoperative child condition
2. Attributable to a preoperative trauma event (with subsequent surgery)

3. Anesthesia either fully or partially contributed to the death (when the child's disease or condition was the primary factor, but anesthesia-related problems represented an additional factor)
4. The surgical procedure either fully or partially contributed to the death (when the child's disease or condition was the primary factor, but surgery-related problems represented an additional factor)

Categories 1 and 2 include all deaths in which the panel agreed that neither surgery nor the esthetic procedure contributed to death. Category 3 was defined as described by Bonasso *et al*.[9] as patients who the panel agreed that anesthesia or factors under the anesthesiologists' supervision contributed to death. The same panel-based assessment was applied to category 4 ("surgery-related death)." Consensus was usually reached between the panel of surgeons and anesthesiologists and the supervising consultant of each unit. This protocol was replicated in all the participating hospitals.

Statistical analysis

The mortality rate was calculated in percentages with a 95% confidence interval using the Clopper-Pearson exact method. The risk per procedure was reported. Variables were described using frequencies and proportions. Univariate and multivariate logistic regression analyses were conducted to identify risk factors for perioperative mortality. The Statistical Package for the Social Sciences (SPSS) version 26.0 was used with a $P < 0.05$ significance level.

Results

A total of 789 surgical procedures, 477 being major surgeries (surgeries in which the abdominal, chest, or pelvic cavity was breached or surgeries lasting more than 3 hours), were conducted on 775 patients with 28 mortalities (all from major surgeries). The 30-day POMR was 3.61% (95% CI = 2.41–5.18); 1.94% (95% CI = 1.09–3.17 within 24 hours), and 1.17% (95% CI = 0.91–2.91) from 24 hours to 30 days after the procedure [Table 2].

The case-specific mortality rates ranged from 100% for gastroschisis (5/5) and ruptured omphalocele (1/1) to 3.4% for Hirschsprung's disease (1/29) [Table 3].

Most mortalities were attributed to the disease process [Figure 1], resulting commonly from late presentation and with overwhelming sepsis 18 (75%) and metabolic and organ failure. Anesthesia-related deaths occurred in five (21%) patients (two patients with gastroschisis had a death on table (DOT); two patients with oesophageal atresia-tracheoesophageal fistula (EA-TOF), and one patient with intussusception had intraoperative aspiration pneumonitis and persistent postoperative hypoxia and later died on the ward). Surgery-related death occurred in four (17%) patients (two patients had an anastomotic breakdown and repeated surgeries for intussusception, and two patients died of poorly managed fluids and electrolytes following Swenson's procedure and anoplasty, respectively). One (4%) patient with acquired immunodeficiency syndrome and a burst abdomen on presentation was classified as a preoperative trauma death.

Univariate logistic regression identified neonatal age group, higher ASA status, emergency surgery, and presence of associated congenital abnormalities as factors related to increased mortality. On multivariate regression analysis, the significant determinants of mortality were a higher ASA status (adjusted odds ratio (AOR)) =13.944, 95% CI = 1.509–128.851, $P = 0.020$, sedation (with midazolam or diazepam) alone or with local anesthesia (with lignocaine) (AOR) =15.295, 95% CI = 3.304–70.800, $P = 0.001$, and associated comorbidities (AOR) =65.448, 95% CI = 11.244–380.962, $P = 0.001$ [Table 4].

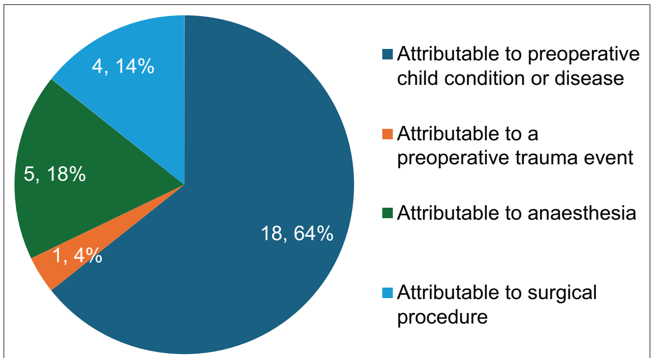

Figure 1: Classification of primary cause of death

Table 1: Hospitals participating in the study

Hospital	Capacity[a]	Pediatric nurses	Pediatric anesthesiologists	Pediatric surgeons	Pediatric ORs	Surgical volume/ pediatric[ab]
UNTH	530	2	0	6	0	1865/288
NAUTH	430	0	0	4	0	1041/204
AEFETHA	740	0	0	3	0	
FMC, Umuahia	405	0	0	2	0	3700/202
FMC, Owerri	523	2	0	2	0	1709/211

[a]Capacity indicates number of hospital beds. [ab]Total hospital volume/pediatric surgical volume

Discussion

The POMRs within 24 hours and 30 days after the procedure were 1.94% (95% CI = 11.09–3.17) and 1.17% (95% CI = 0.91–2.91), respectively, and agree with a similar study conducted in a single center in southwest Nigeria by Talabi *et al*.[10] A Kenyan multicenter study reported 24-hour and 7-day mortality rates of 0.8% and 1.7%, respectively,[11] in contrast to middle-income countries (MICs) and high-income countries (HICs) with 0.7% and 0.3%, respectively,[12] and represented more than twofold and sixfold increased mortality in LMICs in comparison with MICs and HICs, respectively.

Table 2: Patient's demographic characteristics and mortality rates

	Cases (*n*)	Death ≤30 days (%)	χ^2	*P*
Gender			3.05	0.081
Male	493	14 (2.84)		
Female	254	14 (5.51)		
Age			108.71	<0.001
Preterm	1	1 (100)		
Neonate	81	17 (20.99)		
Infant	182	6 (3.30)		
Preschool	239	2 (0.84)		
Young children	149	1 (0.67)		
Older children	123	1 (0.81)		
Nature of surgery			29.91	<0.001
Elective	458	2(0.44)		
Emergency	315	24 (7.62)		
ASA status			52.03	<0.001
I and II	528	1 (0.19)		
III	136	13 (9.56)		
IV and V	109	12 (11.01)		
Missing	2			
Time of death				
≤24 hours		15 (53.6)		
24 hours to 30 days		13 (46.4)		
Total	775	28		

CI=Confidence intervals are for the proportion of the deaths relative to the specific group

The highest perioperative mortalities occurred in patients with gastroschisis and esophageal atresia, with 100% and 60.0% mortality rates, respectively. Four patients with gastroschisis presented in deplorable clinical conditions and died before any form of intervention and were excluded from this study. Three had improvised silo applications, and two had laparotomies and primary surgical closure. In Kano, Northern Nigeria, Anyanwu *et al*.[13] reported an 87.2% mortality rate for gastroschisis and later observed a significant improvement in outcome (*P* = 0.035) when they reverted to sutureless application of improvised silo. As was the case in this study, most mortalities were due to starvation and late presentation with sepsis. A Global PedSurg prospective study (2021) reported 90.0% POMRs for gastroschisis in LICs, 31.9% in MICs, and 1.4% in HICs.[12] Lack of prenatal diagnosis and immediate postnatal interventions might be responsible for the dismal outcome in LMICs.[10,13,14] Two mortalities in EA-TOF had thoracotomy with primary repair, and one had additional laparotomy for associated duodenal atresia. Others had gastrostomies with gastric banding due to late presentation with aspiration pneumonitis. All required prolonged ventilatory support, like the report by Puri *et al*.[15] However, this could not be sustained owing to the unavailability of NICU and requisite expertise, especially in the nursing care of such patients. The need for prolonged oxygen or ventilatory support has been linked to higher neonatal perioperative mortality.[16]

Neonates accounted for the majority (60.7%) of deaths, mirroring Talabi *et al*.'s[10] finding of 58.8%. Neonates encounter distinct challenges as they transition from intrauterine life to postnatal life, and going through

Table 3: Case-specific mortality rates

Diagnosis	No. of cases	No. of deaths	Percentage mortality (%)	Percentage of total (%)
Gastric outlet obstruction	7	1	14.3	3.6
Ruptured omphalocele	1	1	100	3.6
Duodenal atresia	6	2	33.3	7.1
EA-TEF	5	3	60.0	10.7
Hirschsprung's disease	29	1	3.4	3.6
Bowel perforations	44	3	6.8	10.7
Tumors	34	2	5.9	7.1
Gastroschisis	5	5	100	17.6
Intussusception	79	6	7.6	21.4
Malrotation	21	1	4.7	3.6
Anorectal malformation	45	2	4.4	7.1
Jejunoileal atresia	18	1	5.6	3.6

Table 4: Univariate and multivariate logistic regression analyses of variables that predict mortality

Variable	Univariate analysis			Multivariate analysis		
	OR	95%CI	*P*	AOR	95%CI	*P*
Age of patients						
Neonates	16.49	7.41-36.72	<0.001	1.810	0.397-8.258	0.444
1–216 months (ref)						
ASA grade						
I and II (ref)	59.89	8.06-444.70	<0.001	13.944	1.509-128.851	0.020
III, IV, and V						
Surgeon cadre						
Consultant (ref)	0.330	0.113-0.968	0.043	0.270	0.052-1.417	0.122
Resident						
Anesthetic cadre						
Consultant (ref)	0.913	0.376-2.220	0.841	1.570	0.230-10.738	0.646
Resident						
Nature of surgery						
Elective (ref)	19.72	4.64-83.90	<0.001	5.337	0.556-51.193	0.147
Emergency						
Congenital abnormality						
Present	313.29	95.86-1023.91	<0.001	65.448	11.244-380.962	<0.001
Absent (ref)						
Type of anesthesia						
GA + ETI (ref)	15.529	6.762-35.664	<0.001	15.295	3.304-70.800	<0.001
Other						

ref=reference

surgery can disrupt this delicate balance, making them more vulnerable to sepsis, nutritional deficiencies, and respiratory problems.[15] The neonatal surgical mortality (NSM) rate in this study was 19.8%, lower than reports from India (33.33%),[15] Bangladesh (14.6%),[17] and Tunisia[18] but higher than those from HICs.[12,19-21] The lower neonatal mortality rates in HICs have been linked to advanced perioperative support systems, prenatal diagnosis, improved perinatal care, availability of NICUs, and TPN.[10,12,22-24]

Most (72%) mortalities were attributed to preoperative child conditions, and overwhelming sepsis was the leading cause of death (53.6%), consistent with other reports on pediatric POMRs.[10,12,15] Late presentation, often with complications and sepsis, is common in the subregion.[25] In this study, all the patients who died from intussusception presented more than 24 hours after the onset of symptoms in poor clinical conditions, and some required multiple surgeries. Limitations in theater space availability created further delays in intervention, contributing to the observed mortality. Presentation after 24 hours is known to increase the risk of perioperative mortality in children with intussusception.[25]

Factors related to anesthesia were responsible for or confounded the pre-existing condition in 20% of deaths, which is a significant contrast to de Bruin L *et al*.'s[6] report of less than 0.02%. The absence of pediatric anesthesiologists and the lack of suitable equipment for pediatric anesthesia in the participating hospitals may account for this difference. Emergency surgeries had significantly more mortalities than elective surgical cases. In contrast, surgical procedures accounted for 16% of mortalities, and this may be due to technical errors and suboptimal theater conditions for pediatric surgeries. Consultant surgeons performed most of the more delicate surgeries, which might explain why more mortalities were seen when the consultant, not the Resident, was the surgeon.

Contrary to Talabi,[10] we found no significant difference in perioperative mortalities in surgeries for congenital and acquired cases, and this might be due to the exclusion of cardiac cases in this study.

Multivariable logistic regression showed that higher ASA status and associated comorbidities were significant predictors of perioperative mortality, as was noted elsewhere.[10,12,13] Associated comorbidities were congenital malformations, low birth weight, and immunosuppression with an increased odds of 30-day mortality. Nasr and colleagues[26] highlighted the exaggerated risk of 30-day mortality when comorbidities interact with surgical procedures' intrinsic risk and corroborated this study's findings. Other forms of anesthesia aside from general anesthesia with or without ETT were significantly related to increased mortality. These forms of anesthesia were mostly sedation (with midazolam or diazepam) in combination with local infiltration with lignocaine. While anesthesia could be blamed for these deaths, the patients involved presented late with advanced disease. More mortalities were recorded when the anesthesiologist was a trainee and trainees performed anesthesia for most emergencies. The Anaesthesia PRactice In Children Observational Trial (APRICOT) study underscored the importance of pediatric anesthesiologists, particularly in very ill children with higher ASA status.[27] The level of anesthesiologist's expertise was, however, not significant in multivariate analysis in this study. It is possible that the lack of proper equipment, limited ventilatory support, and unavailability of airway devices contributed to mortality; it might be necessary to provide additional oversight for trainees in anesthesiology undertaking major pediatric surgeries while efforts to improve expertise continue.

Limitations of the study

Despite the high POMRs reported in this study, the actual figure could be higher because data collection was at tertiary centers with access to expert pediatric surgical services. Pediatric surgeries performed outside these centers were not captured. The exclusion of cardiac, orthopedic, and plastic surgeries in the pediatric age group may affect the overall POMR for pediatric surgeries, and this needs to be considered when interpreting the results. Telephone follow-up would have increased the number of patients enrolled in the study, and this strategy would be considered in future studies, though Internet availability could be a challenge.

Recommendations/future study

A follow-up study is necessary to explore the impact of a combination of sedation and ventilatory support on pediatric perioperative mortality. Research that includes all pediatric surgical procedures (cardiac, orthopedic plastic, and thoracic) performed in all hospitals, including tertiary, private, and mission hospitals, is necessary to capture the actual POMR in Nigeria. A shift toward sutureless silo application in gastroschisis and improved supervision of anesthesiologist residents during major pediatric surgeries should be encouraged. It is crucial to maintain efforts toward training and retaining pediatric anesthesiologists and pediatric surgery nurses in the subregion and provide essential resources, such as TPN and NICU facilities. Furthermore, it is important to focus on establishing these resources at tertiary centers in southeastern Nigeria to manage at-risk neonates effectively.

Conclusion

The risk of death in children undergoing major surgeries, particularly gastroschisis and esophageal atresia, in southeast Nigeria is unacceptably high. Emergency surgeries, neonatal age, late presentation with overwhelming sepsis, and unsupervised anesthesiologist trainees contribute to increased perioperative mortality. Higher ASA status, associated comorbidities, and sedation alone or in combination with local anesthesia without ventilatory support significantly increase the POMR.

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Conflicts of interest

There are no conflicts of interest.

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