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ORIGINAL RESEARCH

Prospective, observational study of perioperative critical incidents, anaesthesia and mortality in elective paediatric surgical patients at a national referral hospital in Niger

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Aims: To describe perioperative critical incidents, the conduct of anaesthesia and perioperative mortality in elective paediatric surgery patients in a national referral hospital in Niger.

Methods: This is a prospective, observational study conducted from January to March 2018. All paediatric patients 15 years and younger, who underwent elective surgery in the Niamey National Hospital were included. The following variables were studied: age, sex, type of surgery, American Society of Anesthesiologists physical status (ASA PS) classification, monitoring system, anaesthesia technique, critical incidents, blood transfusion, analgesia, qualification of the anaesthesia practitioner, postoperative destination and mortality. Data were analysed with Excel 2007 and Epi Info 6™ (Centers for Disease Control and Prevention Atlanta, GA). The chi^2 test was used for univariate associations with critical incidents. Statistical significance was considered if $p < 0.05$.

Results: There were 231 (27.2%) paediatric patients of 849 surgical patients during the study period. Within the paediatric group, the mean age was 6 ± 4 years. The male:female sex ratio was 1.65. A full blood count was completed preoperatively in all patients. Three per cent of the patients received a preoperative blood transfusion. The most frequently performed surgery was abdominal (42.4%). Most patients were classified as ASA PS I (55%) and ASA PS II (45%). General anaesthesia was performed in 96.1% of cases and spinal anaesthesia in 3.9%. The median duration of general anaesthesia was 63 (interquartile range 45–90) minutes. There were 27 reported critical incidents (11.7%), ten of which occurred during induction (4.9%), five intraoperatively (2.2%) and 12 postoperatively (5.2%). Multimodal postoperative analgesia was used in 33.8% of these patients. One patient died in the postoperative period (0.43%).

Conclusion: Perioperative critical incidents in paediatric surgical patients in Niger remain high. To improve this situation requires paediatric training of anaesthetic staff, and improved paediatric monitoring and the use of safer anaesthesia agents.

Keywords: critical incidents, morbidity, mortality, paediatric anaesthesia, elective surgery, paediatric surgery, low- and middle-income countries

Introduction

The risks associated with anaesthesia, in children and in adults, has improved significantly over time.[1] Contributing factors may include better training of anaesthesiologists, improved equipment and monitoring. Paediatric anaesthesia, however, continues to carry additional risk due to the anatomical, physiological, pharmacological and psychological particularities of childhood.

Children under the age of 15 years make up 50% of the population of Niger.[2] It is likely, therefore, that a high percentage of surgeries will be for children in Niger. Most of these surgeries will be done in a general hospital by a general anaesthesiologist or a non-physician anaesthetist, since there are few paediatric hospitals, and even fewer dedicated paediatric anaesthesiologists. Perioperative morbidity and mortality in children is higher than in adults, even in high-income countries (HICs).[3] The few, mainly retrospective, studies which have been done in low- and middle-income countries (LMICs) indicate perioperative mortality occurs in 1–1.7% of paediatric patients, which is almost 20 fold higher than in HIC,[4,5] and while critical incidents occur in up to 2.4– 5.2% of paediatric patients in HIC,[3,6-9] it is reported at 12% and higher in LMICss.[10-14]

The high perioperative morbidity and mortality reported in LMICs may be due to a lack of both human and physical resources. It is important to measure perioperative outcomes so that specific, cost-effective strategies and systems can be put in place to improve the quality of care and patient outcomes. This will reduce the overall burden of morbidity on the healthcare system.

The primary aim of this study was to describe perioperative critical incidents in elective paediatric surgery patients in a national referral (tertiary) hospital in Niger. The secondary aims were to describe the conduct of anaesthesia and the incidence of mortality in this group of patients.

Methods

This was a prospective, observational study conducted from 1 January to 31 March 2018. All children ≤ 15 years who underwent elective surgery in the Niamey National Hospital were included in the study. This is a general referral tertiary hospital in Niger

that has 850 beds, including 250 surgical and eight intensive care unit (ICU) beds. The study was approved by the ethics review committee of the Faculty of Medicine, Abdou Moumouni University of Niamey. Informed consent was obtained from the patient's parents or guardians.

The following variables were studied: age, sex, type of surgery, American Society of Anesthesiologists physical status (ASA PS) classification, intraoperative monitoring, anaesthesia technique, critical incidents, blood transfusion, postoperative analgesia, qualification of the anaesthesia practitioner, mortality and postoperative level of care. Anaemia was defined according to WHO definition.[15] Data were collected by paper case record form and analysed with Excel 2007 and Epi Info 6™ (Centers for Disease Control and Prevention Atlanta, GA).

Data presented as number (proportion), mean (standard deviation) and median (interquartile range), according to the distribution of the data. Univariate analysis of the association of risk factors with critical incidents were analysed using the chi^2 test. For the bivariate analysis, we examined possible associations between the dependent variable (critical incidents) and the explanatory variables by using statistical tests for unpaired series, the dependent variable being the occurrence of adverse events with the yes/no modalities. The results are presented as the odds ratio (OR) and the 95% confidence interval (CI). The significance level was set at 0.05.

Results

Out of a total of 849 patients who had surgery, 231 (27.2%) were paediatric patients. Data were complete for the paediatric patient cohort. The characteristics of the cohort are shown in Table I. Mean age was 6 ± 4 years. The 2–6 years age group was the largest group, representing 36% of patients, 62% of patients were male, with a sex ratio of 1.65. Preoperative anaemia was present in 8.7% of patients. All patients had a preoperative full blood count, prothrombin time was performed in 20.4% of patients. Among the patients, 3% received a preoperative blood transfusion, and in 15.2% blood was reserved for intraoperative use. Abdominal surgery was commonly performed in 42.4%, followed by urological and trauma-orthopaedic surgery in 19.0% and 17.3% respectively.

The patients were predominantly of a low ASA category, with ASA PS I in 55% and ASA PS II in 45% of cases. All anaesthesia was performed by nurse anaesthetists under the supervision of a specialist anaesthetist (one anaesthetist covering three operating rooms). Most patients received general anaesthesia (96.1%), with spinal anaesthesia in the remaining 3.9%. Inhalational induction was performed in 87.8% of general anaesthetic cases: halothane (83.6%), and sevoflurane (16.4%). Intravenous induction was performed in 12.2% of patients with propofol (55.6%), ketamine (37.0%) and thiopental (7.4%). The opioid used was fentanyl in 63.3% and sufentanil in 36.0%. For airway control, intubation was performed most commonly in 60.8% and laryngeal mask airway in 34.7%.

Table I: Characteristics of the paediatric cohort ($n = 231$)

Characteristic	*n* (%), mean (SD), median [IQR]
Age	5.8 (4.4) years
< 2 years	60 (26%)
2–6 years	83 (36%)
7–11 years	53 (23%)
12–15 years	35 (15%)
Sex	
Male	144 (62%)
Female	87 (38%)
ASA physical status	
ASA I	127 (55%)
ASA II	104 (45%)
Type of surgery	
Abdominal	98 (42.4%)
Urology	44 (19.0%)
Orthopaedic and trauma	40 (17.3%)
Neurosurgery	30 (13.0%)
Dental	15 (6.5%)
Ear, nose and throat	2 (0.9%)
Gynaecology	2 (0.9%)
Monitoring	
Pulse oximetry	231 (100%)
Non-invasive blood pressure monitoring	53 (22.9%)
Type of anaesthetic	
General anaesthesia	222 (96.1%)
Inhalation induction	195/222 (87.8%)
Intravenous induction	27/222 (12.2%)
Airway	
Endotracheal tube	135 (60.8%)
Laryngeal mask	77 (34.7%)
Face mask	6 (2.7%)
Tracheostomy	4 (1.8%)
Regional anaesthesia (spinal)	9 (3.9%)
Preoperative haemoglobin	10.9 (1.7) g/dL
Transfusion	
Preoperatively	7/231 (3%)
Intraoperatively	6/231 (2.6%)
Duration of anaesthesia	63 [45–90] minutes
Duration of surgery	50 [30–73] minutes

ASA – American Society of Anesthesiologists, SD – standard deviation, IQR – interquartile range

Spinal anaesthesia was conducted with bupivacaine and fentanyl or sufentanil. Oxygen saturation and heart rate were monitored intraoperatively using a pulse oximeter in all patients. Fifty-three patients (22.9%) also had non-invasive blood pressure monitoring. Six (2.6%) patients were transfused intraoperatively because of bleeding. The median duration of anaesthesia was 63 (45–90) minutes. Postoperative analgesia was multimodal in 33.8% of patients, while the majority only received paracetamol postoperatively (66.2%). Morphine was given to one patient.

There were 27 critical incidents (11.7%). Most were cardiovascular (10) and respiratory (9) (Table II).

Table II: Critical incidents in the paediatric cohort

Type	Critical incidents	Number of patients
Cardiovascular (10)	Bradycardia	5
	Hypotension	3
	Tachycardia	1
	Cardiac arrest	1
Respiratory (9)	Laryngospasm	4
	Hypoxia	3
	Difficult intubation	2
Others (8)	Delayed emergence	4
	Vomiting	2
	Intraoperative awakening	1
	Dental trauma	1
Total		27

Critical incidents occurred in 4.9% during induction, 2.2% intraoperative and 5.2% postoperatively. Two patients (0.9%) were admitted to ICU and 229 (99.1%) to the post-anaesthesia care unit. One death occurred in the postoperative period, in a patient with neck trauma. The univariate associations with critical incidents are shown in Table III.

Discussion

We found that in a tertiary referral hospital in Niamey the incidence of perioperative critical incidents (11.7%) is similar to the incidence in other LMICs,[10-14] and at least twice that of HICs.[3,6-9] Among the critical incidents observed in our series, respiratory complications were the most common, accounting for about a 1/3 of all critical incidents, and cardiovascular for about a 1/4.

Our findings are consistent with other reports from the Maghreb region of Africa.[16] Habre et al. reported severe intraoperative critical incidents in 5.2% of paediatric patients in Europe.[3] The incidence of respiratory complications, however, varies according to definitions and the population studied.[6] Risk factors for perioperative critical incidents have been described in the literature.[6] These risk factors include: an age less than one year, emergency surgery, ASA classification greater than two, occasional practice of paediatric anaesthesia and the experience of the anaesthesiologist. Critical incidents have been more commonly associated with a younger age group, where it has been reported four times more commonly in children under one year of age, than in older children.[16] In our study, critical incidents were most common in the seven to eleven year age group. It is likely that in low resource environments, critical incidents are a concern across the paediatric age spectrum. Other contributing factors in a low resource environment characteristic of the practice of anaesthesia in Africa, include the use of halothane, insufficient monitoring (pulse oximetry and capnograph), the absence of a post-interventional monitoring room and in certain situations, the lack of an anaesthetist.[16] Many of these risk factors were prevalent in our cohort, including nurse anaesthesia provision for all patients, the use of halothane anaesthesia in the majority of cases and the inability to provide non-invasive blood pressure monitoring in more than 75% of the cases.

The need and burden of paediatric surgery is large in Africa. During the period of our study, nearly a third of surgical cases were paediatric elective surgical patients. This is similar to a study in Morocco, where 20–25% of surgeries are performed on children.[16] This burden extends to emergency surgeries too, where, in a previous study carried out at the Niamey National Hospital, it was reported that 16.3% of abdominal emergency surgeries were in children.[17] Some authors report paediatric surgical rates lower than ours, with 15.9% of surgeries at the Libreville Hospital Center in children.[18] According to Ouro-Bang'na Maman et al., 6% of all paediatric admissions in sub-Saharan Africa are linked to surgical diagnoses. These rates vary between hospitals and countries, for example, 11.3% in a Gambian public hospital; 6.6% in Nigeria; and 4% in Tanzania.[19]

The mean age of our patients was 5.8 (4.4) years. The 2–6 years age group was most prevalent at 36%. This age group is generally the most prevalent in other paediatric surgical cohorts reported from low resource African environments. Otiobanda et al. reported an average age of 5.4 years,[20] Essola et al. reported an average age of 8 years, but a predominance of the age group over 10 years of 44%.[18] It must be noted that in our series, we did not have any newborn babies because they are managed in another hospital which has a paediatric surgery unit. Male sex is also more commonly represented in these paediatric surgical cohorts than female paediatric patients; 62% of our patients were male, similar to Essola et al. (Gabon) and Macq et al. (France) with 69% and 62% respectively.[18,21] Kaboré et al. (Burkina Faso) also report a male predominance with a sex ratio of 2.09.[22] These paediatric surgical patients are also relatively well medically, where our patients were classified as ASA PS I and II in 55% and 45% of cases, which is similar to other African cohorts. Kaboré et al. reported 41.4% and 42.7% of the patients being ASA PS I and II, respectively.[22]

A large proportion of these paediatric surgeries are managed by nurse anaesthetists. Anaesthesia in our study was performed by nurse anaesthetists under the supervision of an anaesthesiologist in all cases. Essola et al. report that anaesthesia was performed by the nurse anaesthetists in the absence of the specialist anaesthesiologist in 52.6% of the cases because of the lack of specialist anaesthesiologists in sub-Saharan African countries.[18,23]

The majority of anaesthesia was general anaesthesia (96%) with orotracheal intubation in 65% of cases. The use of spinal anaesthesia was limited. These results are consistent with data from the African medical literature.[9,24] In French-speaking sub-Saharan Africa, general anaesthesia was the most common technique.[14] Locoregional anaesthesia techniques are used less frequently and are mainly limited to spinal anaesthesia.[14] Inhalation induction is the most common induction (88%) performed mostly with halothane (84%). Propofol (56%) and ketamine (37%) are most frequently used for intravenous induction. In other cohorts, these findings are also seen. In Gabon, induction with halogenated anaesthetics was practised in 71% of patients and intravenous induction in 29%. Only halothane was used for induction inhalation and intravenous induction was performed with thiopental in 69% of patients.[18]

Table III: Univariate associations with critical incidents

Risk factor	Critical incidents		Total	Odds ratio	95% confidence interval	*p*-value
Age range	**Yes**	**No**				
< 2 years	1	47	48	0.77	(0.32 ; 1.87)	0.57
2–6 years	4	91	95	1.12	(0.57 ; 2.22)	0.74
7–11 years	5	48	53	0.66	(0.31 ; 1.42)	0.29
12–15 years	1	34	35	0.55	(0.18 ; 0.18)	0.29
Halothane						
Yes	8	146	154	1.01	(0.48 ; 2.12)	0.98
No	3	74	77			
ASA physical status						
I	6	121	127	0.94	(0.48 ; 1.87)	0.87
II	5	99	104			
Type of surgery						
Abdominal surgery						
No	27	105	132	0.64	(0.32 ; 1.29)	0.21
Yes	14	85	99			
Total	41	190	231			
Neurosurgery						
No	34	166	200	1.4	(0.57 ; 3.57)	0.45
Yes	7	24	31			
Total	41	190	231			
ENT surgery						
No	41	188	229			0.51
Yes	0	2	2			
Total	41	190	231			
Maxillofacial surgery						
No	37	179	216	1.75	(0.53 ; 5.83)	0.35
Yes	4	11	15			
Total	41	190	231			
Pelvis and limb trauma						
No	33	158	191	1.19	(0.51 ; 2.83)	0.68
Yes	8	32	40			
Total	41	190	231			
Urology						
No	34	153	187	0.85	(0.35 ; 2.07)	0.72
Yes	7	37	44			
Total	41	190	231			
Gynaecology						
No	40	189	229	4.72	(0.29 ; 77.14)	0.23
Yes	1	1	2			
Total	41	190	231			

ASA – American Society of Anesthesiologists, ENT – ear, nose and throat

In French-speaking sub-Saharan Africa, general anaesthesia is the most frequent technique using inhalation induction with halothane.[14]

Monitoring is also a concern. All our patients were continuously monitored for peripheral arterial saturation (SpO_2) and heart rate using a pulse oximeter, but only 53 patients (23%) also had non-invasive blood pressure monitoring. Our findings are comparable to that of Kaboré et al., where anaesthetic monitoring consisted of pulse oximetry and inconsistently of ECG and non-invasive blood pressure measurement.[22] Indeed, it is only through the Lifebox project's pulse oximeter donations, that monitoring of oxygen saturation has become the minimum monitoring standard in our operating rooms.[25]

Mortality in our series was 0.43%. The African Surgical Outcome Study (ASOS) reported a perioperative mortality of 1% in Niger in adult surgical patients.[26] In Gabon, paediatric mortality was reported at 0.1%.[18] The SFAR-INSERM mortality survey has shown a reduction in anaesthetic mortality by a factor of 10 over the last twenty years. This is encouraging and may reflect an improvement in monitoring, training and the increasing

safety margin of modern anaesthetic agents.[6] However, the high incidence of critical incidents described in the paper and others, and the continued used of halothane, with minimal monitoring by predominantly nurse anaesthetists, suggests that there is still a lot of work to be done to improve outcomes. In paediatric patients, prospective studies in Africa have shown a perioperative mortality of 1.1–1.7%.[4,5] This is significantly higher than in HIC[3] and particularly intolerable in ASA PS I and II children undergoing minor surgery. Analysis of the causes of paediatric deaths in anaesthesia, have been based on surveys of the training of the medical and paramedical staff, and the organisation of hospitals.[27] The practice of paediatric anaesthesia in a general hospital in a low resource environment could be improved by better training of the anaesthetic and surgical teams, including supervision of non-physician anaesthesia providers by specialist anaesthesiologists. Better equipment and monitoring, and availability of paediatric consumables are also needed.

There are a number of strengths associated with this study. The data were complete for the cohort, and it was prospectively collected. The limitations of the study include the small number of critical incidents, which therefore did not allow for a multivariable assessment of the associations of risk factors with these critical incidents. Furthermore, emergency surgery was not studied, and this is a group of surgical patients which is associated with increased morbidity and mortality.[4]

Conclusion

The practice of paediatric anaesthesia in a tertiary hospital in Niger continues to pose a substantial risk for critical incidents. It is important that we develop strategies to decrease critical incidents in low resource environments, such as these, especially as a significant proportion of surgical patients in Niger are children. Improvements could be achieved by specific paediatric training of the anaesthetic, surgical and nursing teams, and the provision of medications and equipment suitable for paediatric patients. The use of safer anaesthesia agents, e.g. sevoflurane instead of halothane, and compliance with the minimum standards of monitoring[28] could improve paediatric perioperative outcomes and reduce overall burden on the healthcare system. It is important to continue to audit paediatric perioperative critical incidents and mortality to document the successes (and failures) of initiatives to make paediatric anaesthesia safer in low resource environments.

Conflict of interest

The authors report no conflicts of interest in this work.

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