Original Article

The Use of Narco SS Score in Predicting Adverse Events in Children Undergoing Major Elective Abdominal Surgery at The University Teaching Hospital, Lusaka, Zambia

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Abstract

Background: The neurological, airway, respiratory, cardiovascular and other, with a subscore of surgical severity (NARCO-SS) is a scoring system which assesses the presence of systemic disease and the risk the operation poses to the patient. A number of patients that undergo major abdominal surgery suffer adverse events. The aim of the study was to determine the reliability of NARCO-SS in predicting peri-operative adverse events and to determine the risk factors for peri-operative adverse events in paediatric patients undergoing elective abdominal surgery. **Materials and Methods:** Prospective cohort study. Consecutively sampled patients from December 2019 to December 2020 were used. Patients scheduled for elective abdominal surgery were scored pre-operatively and end points were; when an adverse event occurred or up to day 30. Analysis of the reliability of the tool, bivariate and multivariate logistics regression was done. **Results:** One hundred and nineteen patients were enrolled and 49% of them had adverse events. Both bivariate and multivariate analyses showed no significant association between the NARCO-SS score and the occurrence of adverse events. The area under the receiver operating characteristics curve (area under the curve) of the NARCO-SS for adverse events was 0.518; there was a significant correlation between high scores and mortality. Longer duration of surgery and complex surgery were the risk factors for adverse events. **Conclusions:** The NARCO-SS score was found to be a poor predictor of adverse events with a fair inter-rater reliability as a scoring tool. Future research could evaluate a modification of neurological and airway categories.

Keywords: Paediatric scoring system, perioperative adverse events, risk

Introduction

Scoring systems can assist surgeons to predict patients' post-operative course and efficiently allocate resources.[1] One such score is the neurological, airway, respiratory, cardiovascular and other (NARCO) with a sub-score of surgical severity (SS) which accounts for the risk posed by the procedure itself.[2] The NARCO-SS is a system-based risk assessment tool which is able to predict the occurrence of adverse events and the need for escalation of care in patients before surgery.[2]

Some of the patients who underwent major procedures at our institution suffered adverse events including mortality at approximately 7.6%.[3] No standard tool is available to predict if patients would suffer adverse events.

The objectives were to determine the reliability of NARCO-SS in predicting perioperative adverse events and to determine the risk factors for perioperative adverse events in patients undergoing abdominal surgery.

Materials and Methods

Ethics

Written informed consent was obtained from parents/guardians and assent for patients older than 7 years. Ethical clearance and approval were sought from the local research ethics board.

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This study was conducted in accordance with the principles of research as stipulated by the Declaration of Helsinki.[4]

Study design

A prospective cohort study at a tertiary facility which is the highest referral centre in the country with intensive care services and some specialised staff such as paediatric surgeons and paediatric anaesthetists. The study included all paediatric patients (below age 16) who underwent elective major abdominal surgery. Exclusion criteria were paediatric patients who underwent emergency abdominal surgery and those who underwent re-laparotomy. Consecutive sampling method was used and sample size of 117 was calculated using the assumptions that NARCO-SS would correctly classify (*P*) 84% (0.84) of the patients.[5]

Procedure

Enrolled patients were assessed and scored by the principal investigator and anaesthesiologist scheduled to run that elective list using the NARCO-SS tool pre-operatively [Table 1]. The surgeons performing the operations were blinded to the score.

The patients were followed up intraoperatively and post-operatively. The end point for follow-up was either up to when an adverse event occurred or when the 30 days period elapsed. The adverse events, escalation of care and admission status were recorded in the data collection sheet [Supplementary Table 1].

Statistics

Analysis was performed using the Statistical Package for the Social Sciences (SPSS) computer software version 25.0 ,2017 (The International Business Machine (IBM) corporation, Chicago, Illinois, USA). Descriptive statistics were presented as proportions and means. The analysis to compare the relationship between the categorical variables was by the Chi-square test or Fisher exact test, while for the continuous variables, it was by *t*-test or Wilcoxon test depending on whether the data were parametric or non-parametric. A univariate analysis of independent variables was conducted. A multivariate analysis of association of independent variables and the outcome was done at confidence interval (CI) of 95%. In all cases, $P = 0.05$ was taken to be significant. Logistic regression models were used to assess the relationship between the outcome variable and the rest of the variables. The performance of predictive model was determined by examining its discrimination and calibration. For binary outcomes, discrimination was determined by plotting a receiver operating characteristics (ROC) curve of the true positive rate against the false positive rate for consecutive cut-offs for the probability of an outcome, and measuring the area under the curve (AUC-ROC).

Results

Patient demographics

The study enrolled 119 patients who underwent major abdominal surgery, of which the mean age was 41 months and more than half (52.1%) of the patients were males. Sixty-two (52.1%) patients resided in a high density area and the mean weight and height were 13 kg and 86.4 cm, respectively.

The study shows that more surgical procedures were performed by senior registrars and consultant paediatric surgeons at 46.2% (55) and 42.9% (51), respectively. Seventy-seven of the procedures were managed by consultant anaesthesiologists at 64.7% followed by anaesthesia registrars at 10.1% (12) and paediatric anaesthesiologists at 5% (6). One hundred and 10 surgical procedures (92.4%) took over 1 h duration, with 65 (54.6%) cases taking 1–2 h, 22 (18.5%) cases taking 2–3 h and 23 (19.3%) cases taking more than 3 h, respectively. The distribution of surgical procedures is outlined in Figure 1. The mean NARCO-SS score was categorised in three groups all of which were Class C according the classification of NARCO-SS, 67 patients (56%) were scored IC, while 1 (1%) and 51 (43%) were scored IIC and IIIC, respectively.

Adverse events and escalation of care

The overall adverse event incidence was 49% (58 patients). The major adverse event experienced by 32 study participants (26.9%) was excessive surgical bleeding requiring blood transfusion followed by mortality of 16 patients (13.4%) post-operatively. Other adverse events experienced were: seven patients (5.9%) had respiratory events such as laryngospasm, obstruction and significant oxygen desaturation and three patients (2.5%) had a difficult airway. Table 2 illustrates the escalation of care both intraoperatively and post-operatively.

Association of patients' characteristics with adverse events

The results from bivariate analysis show no relationship of patients' demographics with the occurrence of adverse events. However, although not significantly associated with adverse events, patients' weight showed a trend towards occurrence of adverse events in patients with lower weights compared to those with higher weight: 10.9 kg for those with adverse events, and 14.9 kg for those without adverse events ($P = 0.051$). Figure 2 shows the distribution of adverse events across the

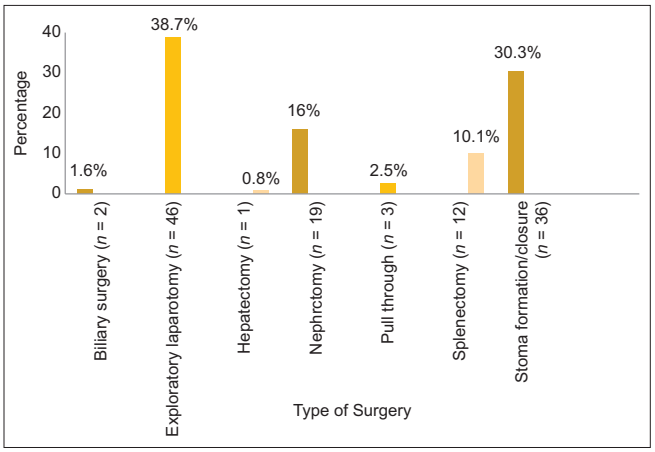


Figure 1: Type of surgeries performed

Table 1: Neurological, airway, respiratory, cardiovascular and other, with a subscore of surgical severity score (reprinted with permission from British Journal of Anaesthesia via Elsevier)

	0	1	2
N	No neurologic abnormality, age-appropriate development and behaviour, alert and oriented	Seizures, mild-to-moderate cognitive impairment, spasticity or hypotonia, depressed sensorium but arousable	Status epilepticus, severe cognitive impairment, spasticity or hypotonia, unresponsive to painful stimuli, active posturing, dysconjugate gaze
A	Normal airway: Full range of neck mobility	Possible difficulty with ET intubation but mask ventilation expected to be easy, e.g., obesity, microstomia and established tracheostomy	Known or likely difficult mask ventilation and/or ET intubation, e.g., facial trauma, c/spine instability, maxillary or mandibular hypoplasia, laryngeal stenosis, asymmetry of the airway; fresh tracheostomy
R	No signs or symptoms of respiratory illness	Mild respiratory illness, current or recent upper respiratory illness, well controlled asthma that is not active	Bronchopulmonary dysplasia, chronic obstructive airway disease, restrictive pulmonary disease, lower respiratory infection, steroid dependent asthma, active X-ray or ascultatory findings, sleep apnoea, respiratory support
C	No cardiac disease	Non-complex CHD, corrected CHD, compensated CHF, well controlled HTN, stable non-sinus rhythm	Uncorrected or partially corrected CHD, poor ventricular function, CHF, PH, single ventricle physiology, significant dysarrthmia, poorly controlled HTN; requiring vasoactive drugs
O	No hepato-renal or musculoskeletal abnormality: Born at full term; no reflux or well controlled	Mild abnormality of hepatic and/renal function or musculoskeletal system, controlled metabolic or endocrine disturbances, mild coagulation defect, born pre-mature >50 weeks PCA; mild reflux with frequent spitting up or GI symptoms, BMI >30	Severe hepatic and/or renal dysfunction, severe musculoskeletal abnormality, uncontrolled metabolic or endocrine disease; profound anaemia, or severe coagulation defect; DIC, born pre-mature <50 weeks PCA, severe reflux w/associated aspiration, full stomach; BMI >35
Sub-score of surgical severity	Non-invasive diagnostic procedure, superficial or peripheral surgery with anticipated minimal blood loss	Invasive diagnostic or therapeutic procedure, airway procedure, invasive procedure with anticipated moderate blood loss, emergent procedure	Major intra-abdominal, thoracic, intracranial, or cardiac or airway procedure, anticipated excessive blood loss Organ donor

Scoring instructions		
I	Total score 0–3 with no individual score >1	Low risk, suitable for ambulatory surgery if procedure permits
II	Total score 4–5 with no individual score >1	Moderate risk may not be suitable for ambulatory surgery, may need close observation in PACU or monitored hospital bed following surgery
III	Total score 6–8 or any individual score of 2	High risk, requires high degree of vigilance, may need invasive monitoring and/or ICU bed following surgery, balance need for optimisation of clinical status versus risk
IV	Total score of 9–10	Poor anaesthetic risk, requires careful consideration of risk versus benefit, may or may not survive surgery

Malviya *et al*.,[2] 2011. GI: Gastrointestinal, CHF: Chronic heart failure, CHD: Coronary heart disease, HTN: Hypertension, PH: Pulmonary HTN, PCA: Post-onceptual age, DIC: Disseminated intravascular coagulation, BMI: Body mass index, PACU: Post-anaesthesia care unit, ICU: Intensive care unit, ET: Endotracheal

surgical operations performed. The results shows that there was a significant association between the groups ($P = 0.015$). Results of multivariate regression analysis show that the surgeries lasting longer than 1 h are three times more like to develop adverse events than those lasting <1 h [Table 3].

Association between neurological, airway, respiratory, cardiovascular and other, with a subscore of surgical severity and the outcome

Both bivariate and multivariate analyses showed no significant association between the NARCO-SS score and the occurrence of adverse events and escalation of care, as shown in Table 4. However, the NARCO-SS was predictive of mortality: patients with class IIIC score were more likely to die after surgery than those with class IC or IIC. The NARCO-SS had a low sensitivity of 60.3% and poor specificity of 42.6% for adverse events (positive predictive value = 51%, negative predictive value = 47%, CI at 95% = 0.478–0.684 with a cutoff of 1.5).

The area under a ROC curve (AUC) of the NARCO-SS for adverse events was 0.518 and for escalation of care it was 0.587, as shown in Figures 3 and 4, respectively. The NARCO-SS overall had a fair inter-rater reliability, with the cardiovascular and other components being excellent [Table 5].

Discussion

The study presents a preliminary evaluation of the NARCO-SS measure of perioperative risk for children. The findings do not support the reliability of the measure for perioperative risk. The NARCO-SS score had no significant correlation with perioperative outcomes and had a fair inter-rater reliability. This was not comparable to Malviya *et al*. study where the NARCO-SS was predictive of the child's need for escalation of care, hospital admission, hospital length of stay and prevalence of adverse events and mortality.[2] Findings from this study do not support the reliability for total NARCO scores and for each of its categories except cardiovascular and other

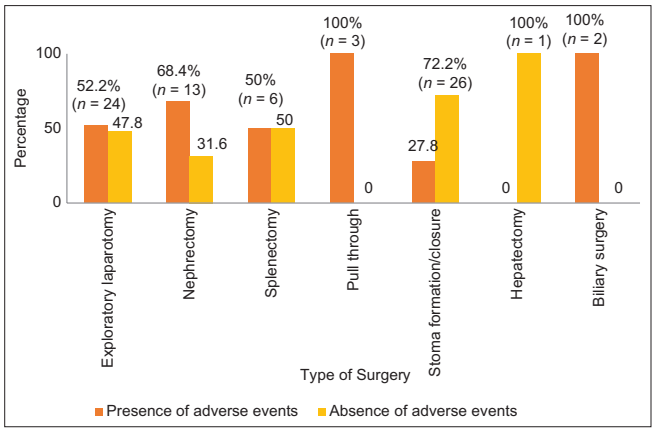


Figure 2: Incidence of adverse events with type of surgery ($P = 0.015$)

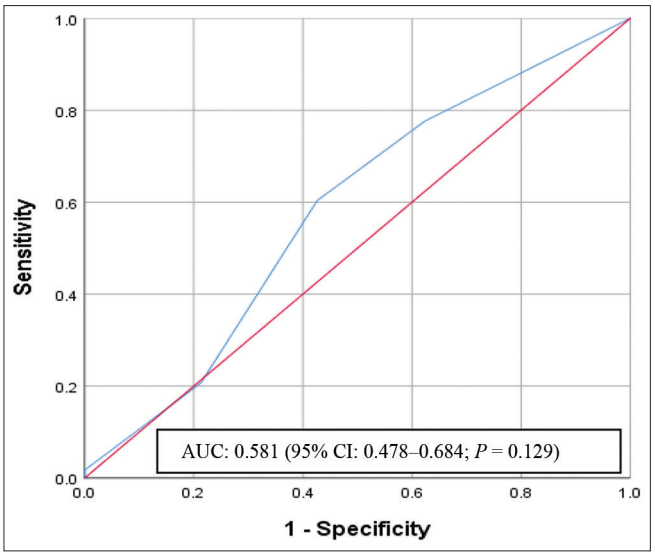


Figure 3: The receiver operating characteristics curve of the neurological, airway, respiratory, cardiovascular and other, with a subscore of surgical severity for adverse events. AUC: Area under the curve, CI: Confidence interval

categories which showed almost perfect agreement. This could be explained in part by the burden cardiovascular problems put on the body systems compared to other categories of the NARCO-SS.

The findings of the study also show that there was poor discrimination of the NARCO-SS for both escalation of care and adverse events (AUC-ROC = 0.518 [95% CI = 0.478–0.684]; 0.587, [95% CI = 0.469–0.704]), respectively. Udupa *et al*. in their comparative study between the NARCO-SS and American Society of Anaesthesiologists-physical status (ASA-PS) found that the NARCO-SS showed greater discrimination than the ASA-PS (AUC-ROC = 0.778 vs. 0.710 for escalation of care and 0.822 vs. 0.724 for adverse events, $P < 0.01$) with a poor calibration.[5] This study however did not compare the NARCO-SS with other scoring tools.

The overall incidence of adverse events in the study was 49%. This finding was high compared to Wood *et al*. and Malviya *et al*. studies who found the overall incidence of complication was 3.9% and 24%, respectively.[1,2] The huge gap could be explained by the general inclusion of all surgical procedures in Wood *et al*. study which was different from considerations in the present study.[1] Furthermore, it was noted that major abdominal surgery which was given a subscore C was more likely to have adverse events as seen in the study by Udupa *et al*. where the patients with surgical severity C had an adverse event incidence of 50%.[5] The major adverse event experienced by study participants was excessive surgical bleeding requiring blood transfusion (26.9%) followed by mortality (13.4%) post-operatively. The occurrence of excessive bleeding requiring blood transfusion was higher in this study compared to Malviya *et al*. and Udupa *et al*. which had 10% and 13.7%, respectively.[2,5] Malviya *et al*. had an overall mortality rate of 1%.[2] However, the mortality rate for patients with a surgical score of C had a mortality rate of 17% which is comparable to the findings in this study.

In this study, escalation of care was seven times more likely to have occurred in patients with high NARCO scores, which is comparable to Udupa *et al*. where there was escalation of care in 83.7% of patients with scores of IIIC supporting the notion of targeted interventions.[5] Indeed, the prevalence of adverse events and mortality was as much as fourteen times greater in children with high scores.

Item analyses of the NARCO-SS demonstrated that the respiratory, other and cardiac components accounted for most of the variance in scores and were the only categories associated with all major outcomes. Furthermore, the distribution of scores based on the proposed schematic was

Table 2: Description of intraoperative and post-operative escalation of care

Variable	*n* (%)
Escalation of care (use of any of the following)	88 (73.9)
Intraoperative	
Special airway equipment (e.g., stylet)	58 (65.9)
Haemodynamic agents (e.g., dopamine, vasopressin and epinephrine)	5 (5.7)
Post-operative	
Anticholinergic agents (e.g., atropine)	4 (4.5)
Invasive monitoring	1 (1.1)
Post-operative intubation/ventilation	1 (1.1)
Admission to acute bay or ICU	71 (80.7)

ICU: Intensive care unit

Table 3: Regression results of patient's demographics, clinical characteristics and adverse events

Variable	OR (95% CI)	*P*
Age (months)	0.396 (−0.004–0.006)	0.693
Weight (kg)	1.158 (−0.01–0.38)	0.249
Duration of surgery (>1 h)	3.444 (0.071–4.089)	0.001
Surgery type (more complex)	2.836 (1.118–7.195)	0.021

OR: Odds ratio, CI: Confidence interval

Table 4: Relationship between neurological, airway, respiratory, cardiovascular and other, with a subscore of surgical severity and the outcomes

NARCO-SS	Escalation of care	Adverse events	Mortality
Class I–IIC	46 (67.6)	31 (46.3)	2 (2.9)
Class IIIC	42 (82.4); [0.45; 0.19–1.08]; 0.07	27 (52.9); [0.745; 0.36–1.54]; 0.43	14 (27.5); [0.08; 0.02–0.37]; 0.001

n (%) [OR; 95% CI]; *P*. NARCO-SS: Neurological, airway, respiratory, cardiovascular and other, with a sub score of surgical severity, OR: Odds ratio, CI: Confidence interval

Table 5: Reliability of the neurological, airway, respiratory, cardiovascular and other, with a subscore of surgical severity measure

	Inter-rater reliability
Neurological	0.019 (−0.161–0.198)
Airway	0.069 (−0.111–0.246)
Respiratory	0.437 (0.28–0.572)
Cardiovascular	0.1 (−0.81–0.274)
Other	0.848 (0.789–0.892)
Total NARCO-SS classification	0.26 (0.187–0.345), 0.678

NARCO-SS: Neurological, airway, respiratory, cardiovascular and other, with a subscore of surgical severity

skewed towards NARCO-I and-III with few scores of II and none of IV. These findings suggest that revisions of the NARCO-SS or its scoring style are necessary to improve its predictive reliability. Additional descriptors may be required such as the presence of airway obstruction or intravascular volume depletion to improve the precision of the NARCO-SS. Further revisions should also include a higher weighting of respiratory, other and cardiac components that were the only categories associated with the major outcomes.

Unlike the SS score component of the NARCO-SS used in this study which provides a gross pre-operative measure, most of the previously described SS scores grade the patient's immediate post-operative condition which require scoring multiple intraoperative variables such as estimated blood loss, vital signs and extent of tissue trauma.[6,7] Although this latter approach may provide a more precise estimate of risk for post-operative complications, the simple SS score assigned before operation may facilitate anaesthetic planning and allocation of resources and provide a platform for informed decision-making.

The study enrolled 119 patients who underwent major abdominal surgery, of which the mean age was 41 (49) months and more than half (52.1%) of the patients were males. The findings are similar to what Berry *et al*. found in their study where the median age was 8 (interquartile range: 2–15) years and the majority of their patients were males.[8]

The study shows that more surgical procedures were performed by senior registrars (46.2%) and consultant paediatric surgeons (42.9%). Moreover, the majority of the anaesthesia was managed by consultant anaesthesiologists (64.7%) and registrars (20.2%). However, there was no association between the surgical experience of the attending surgeon/anaesthetist and the development of adverse events.

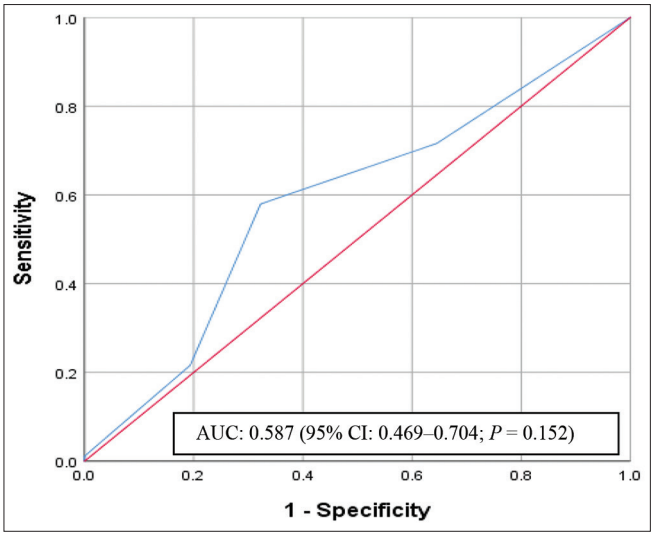


Figure 4: The receiver operating characteristics curve of the neurological, airway, respiratory, cardiovascular and other, with a subscore of surgical severity for escalation of care. AUC: Area under the curve, CI: Confidence interval

The findings of the study show that there were more exploratory laparotomies (46/119) performed than other abdominal procedures. These laparotomies included explorations for abdominal masses such as mesenteric cysts, cerebrospinal fluid pseudocyst, suspected neuroblastoma and suspected abdominal malignancies from various origins. Both bivariate and multivariate analyses suggest that undergoing abdominal surgery contribute to the development of adverse events. In addition to the physical condition of the patient, the type of the surgical procedure has been emphasised in determining peri-operative risk.[6,9]

The finding of this study further suggests that the duration of surgery has an effect on the development of adverse events and escalation of care. The study found a strong correlation between surgical procedures lasting longer than 1 h and the development of adverse events and multivariate regression analysis suggested that patients undergoing abdominal surgeries lasting for more than 1 h are three times more likely to develop adverse events than those patients undergoing short surgical procedures. From this study, it could be noted that complex surgical procedures tended to have higher incidence of adverse events compared to less complex procedures. These findings can be compared to a study done by Freilich where it was found that in urological surgeries which took longer than 2 h; these patients had significant risk of developing an

adverse event ($P = 0.001$) and these were found to be more complex surgeries.[10]

The strengths of the study are that this was a prospective study and we were able to assess the occurrence of adverse events as they happened.

Limitations of the study are that data were captured at a single site; therefore, the ability to generalise the findings to other settings may be limited. Furthermore, part of the study duration was during the COVID-19 pandemic period, where the types of elective abdominal surgeries were limited to patients whose surgeries could not be postponed for several reasons. Thus, the types of abdominal surgeries were biased to a certain type and might have had an influence on the incidence and nature of the adverse events and the overall findings.

The recommendations are that; there should be a focus on evaluating the NARCO-SS score and interactions between the perioperative outcomes in all types of surgeries in future research. Modification of neurological and airway categories may improve the predictive accuracy of the NARCO-SS. Further studies will be needed to determine if this scoring system is applicable to children undergoing surgery at other institutions and if the use of the scoring system would result in improved clinical outcomes.

Conclusions

The study found an overall perioperative adverse event of 49% among paediatric patients who underwent major elective abdominal surgery, with a mean age of 41 months. The NARCO-SS score was found to be a poor predictor of adverse events with a fair inter-rater reliability as a scoring tool overall. However, there was a significant correlation between high scores and mortality only. The finding of this study further suggests that a longer duration of surgery has an effect on the development of adverse events and escalation of care. Moreover, from the study, it was noted that complex surgical procedures tended to have higher incidence of adverse events as compared to less complex procedures.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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Supplementary Table 1: Data collection sheet

Demographic data

Index number		
Age (months)		
Sex (circle)	Male	Female
Weight (kg)		
Height (cm)		
Location of stay (tick)	High-density housing	
	Intermediate housing	
	Low-density housing	

Physician (tick)

Anaesthesiologist grade	Registrar	Senior registrar	Consultant	Consultant paediatric anaesthesiologist
Surgeon grade	General surgeon	Registrar	Senior registrar	Consultant paediatric surgeon

Surgery type (tick)

Exploratory laparotomy	
Nephrectomy	
Splenectomy	
Pull through	
stoma formation/closure	
Cholecystectomy	
Hepatotectomy	
Biliary surgery	

Duration of surgery (tick)

<1 h	1–2 h	2–3 h	>3 h

Adverse events and escalation of care (intra-operative and post-operative events)

Difficult airway	1. Yes	a. Difficult mask ventilation
	2. No	b. Difficult laryngoscopy
		c. Difficult tracheal intubation
Special airway equipment	1. Yes	a. Bougie
	2. No	b. Stylet
		c. Use of LMA or i-gel for rescue
Anti-arrthymia therapy	1. Yes	a. Lidocaine
	2. No	b. Adenosine
		c. Amiodarone
		d. Electrical cardioversion
Bradycardia	1. Yes	a. Atropine
	2. No	b. Glycopyrrolate
Hypotension requiring haemodynamic drugs	1. Yes	a. Dopamine
	2. No	b. Milrinone
		c. Vasopressin
		d. Epinephrine
Respiratory events	1. Yes	a. Laryngospasm
	2. No	b. Bronchospasms
		c. Obstruction
		d. Significant oxygen desaturation
Excessive surgical bleeding requiring blood transfusion	1. Yes	
	2. No	
Post-operative bleeding	1. Yes	
	2. No	

Contd...

Neurological events (seizures)	1. Yes 2. No	
Invasive monitoring	1. Yes 2. No	a. Arterial catheter b. Central venous catheter
Post-operative intubation/ventilation	1. Yes 2. No	
Surgical site infection	1. Yes 2. No	a. Superficial b. Deep
Admission status		a. Main ward b. Acute bay/HDU c. ICU
Mortality	1. Yes 2. No	a. Within 7 days post-operative b. Between 7 and 14 days c. Between 14 and 30 days

LMA: Laryngeal mask airway, ICU: Intensive care unit, HDU: High-dependency unit