Southern African Journal of Anaesthesia and Analgesia 2018; 24(5):122–127
https://doi.org/10.1080/22201181.2018.1517476

South Afr J Anaesth Analg
ISSN 2220-1181 EISSN 2220-1173

RESEARCH

Surgical outcomes in eastern Uganda: a one-year cohort study

A Hewitt-Smith[a†*], F Bulamba[a†], C Olupot[b], F Musana[a], JP Ochieng[a], MS Lipnick[c] and RM Pearse[d]

[a]*Faculty of Health Sciences, Busitema University, Mbale, Uganda*
[b]*Mbale Regional Referral Hospital, Mbale, Uganda*
[c]*Department of Anesthesia and Perioperative Care, University of California, San Francisco, CA, USA*
[d]*Barts and The London School of Medicine & Dentistry, Queen Mary University of London, London, UK*
**Corresponding author, email: adamhewittsmith@gmail.com*

Introduction: There is urgent need to improve access to safe surgical treatments for patients in low- and middle-income countries (LMICs). However, few data exist to characterise clinical outcomes for this patient population.
Methods: Consecutive patients undergoing surgery at a referral hospital in Uganda were prospectively followed between October 2016 and October 2017. The primary outcome was in-hospital, postoperative mortality. Secondary outcomes were in-hospital complications for patients undergoing laparotomy and Caesarean section. Results are presented as *n* (%) or odds ratios (OR) with 95% confidence intervals.
Results: A total of 4 773 patients of mean age 28 years were included; 3 754 were female (79.0%) and 4 259 patients (89.4%) were classified as American Society of Anesthesiologists class I or II. Some 3 501 (73.8%) procedures were performed on an emergency basis. The most frequent procedure was Caesarean section (2 634 patients [55.3%]). There were 93 deaths (2.0%), 49 of which occurred after the day of surgery (59.0%). In multivariable analysis, patients undergoing general (abdominal) surgery were at greatest risk of death (OR 4.34 [2.02–9.30]). Postoperative complications were recorded for 24/412 (5.8%) patients undergoing Caesarean section and 18/107 (16.8%) patients undergoing emergency laparotomy. Infection was the most frequent complication in these patient groups (33/519 patients [6.4%]).
Conclusions: This study confirms the feasibility of longitudinal audit of postoperative outcomes in LMICs. Data collected over a one-year period were highly consistent with the findings of a recent seven-day cohort study conducted across Africa.

Keywords: anaesthesia outcomes, global surgery, low-income country, postoperative care, surgical outcomes

Introduction

It is estimated that almost 900 million people (93% of the population) in sub-Saharan Africa do not have access to safe, affordable surgical and anaesthesia care.[1] The global unmet burden of surgical disease is highest in this region, with an additional 40 million surgical procedures required each year.[2] Surgery is a key component of universal health coverage.[3] Despite clear evidence of cost-effectiveness, surgical and anaesthesia care continue to receive little support and face numerous barriers.[4–7] Strategies to improve access to safe surgical and anaesthesia care are urgently needed but should be informed by epidemiological data describing current surgical activity and patient outcomes.[8]

Despite the Lancet Commission on Global Surgery recommendation to use perioperative mortality as an indicator to describe the state of a country's surgical system, literature reports detailing patient outcomes after surgery in low-income countries are limited in number.[2] Mortality rates in this setting have been described as between 0.2% and 6.5%, but significant heterogeneity exists between the definitions of postoperative mortality used in these studies.[9–12] In addition, mortality rates after surgery are reported to be significantly worse in sub-Saharan Africa compared with high-income settings, but there is little published evidence to support these assumptions.[10–13] The first of its kind in Africa, a large international, prospective, observational cohort study of adult patients undergoing surgical procedures in 25 countries in Africa was recently published in *The Lancet* (the African Surgical Outcomes Study, ASOS).[14] When compared with international surgical outcomes, patients in this study were younger, had fewer complications but were twice as likely to die. The study's seven-day cohort design was chosen for pragmatic reasons, resulting in limitations for generalising these data to individual hospitals and countries.[15]

There are few national reporting systems in place in low-income countries that are able to track surgical volumes and outcomes despite the fact that these data are routinely documented in paper-based theatre and ward logbooks.[16] We describe surgical outcomes from a one-year cohort of patients who underwent surgical procedures at a regional hospital in eastern Uganda. This study was conducted concurrently with ASOS, as part of a long-term quality improvement programme with an additional aim of testing the feasibility of auditing postoperative outcomes in this setting.

Methods

Setting

Mbale Regional Referral Hospital (RRH) is a 440-bed hospital that serves 14 districts and a population of more than 4 million people in the east of Uganda. It is the busiest of Uganda's 14 regional referral hospitals with almost 10 000 maternal deliveries and 55 000 in-patient admissions each year.[17] The hospital has one physician and nine non-physician anaesthesia providers, three obstetricians and three surgeons. It has four functioning

†Joint first authors

operating theatres but no intensive care unit. Patients of any age undergoing either elective or emergency in-patient surgery at Mbale RRH between October 1, 2016 and September 30, 2017 were eligible for inclusion. Patients undergoing surgery within the hospital's private wing were excluded. Ethics approval to conduct a prospective audit of in-hospital, postoperative outcomes was granted by the Mbale RRH Research and Ethics Committee.

Data collection

Data describing all surgical procedures and ward admissions are routinely collected at Mbale RRH using paper logbooks. Additional data were collected for patients undergoing laparotomy and Caesarean section for shorter periods. Theatre logbooks contain demographic information, details of surgical procedures, anaesthesia type and staff involved in the patient's care. Ward logbooks duplicate basic demographic data and also contain information on patient outcomes (discharge, referral etc). We designed an electronic case report form that allowed us to collate data from logbooks using a simple spreadsheet (Numbers, Apple Inc, Cupertino, CA, USA). Data were anonymised before exporting for further analysis. A single research assistant supported department staff in data collection.

Outcome measures

The primary outcome measure was in-hospital mortality censored at 30 days for patients who remained in hospital. Secondary outcome measures were 30-day in-hospital, postoperative complications among patients undergoing laparotomies and Caesarean section during the supplemental data period.

Statistical analysis

We aimed to recruit all eligible patients over a one-year period. No formal sample size calculation was performed. Data were summarised descriptively using mean (SD) or number (%) as appropriate. We also assessed the association between four covariates (gender, ASA score, surgical specialty, and urgency of surgery) and 30-day, in-hospital mortality using a multivariable logistic regression model. We used multiple imputations to account for missing data in the covariates. Patients with missing outcome data were excluded from the analysis. The imputation model included the four covariates, as well as the outcome (30 day in-hospital mortality). Imputations were performed using chained equations, and 10 imputations were used.[18] Results from each imputed dataset were combined using Rubin's Rules. These results are reported in Table 2 as adjusted odds ratio with associated *p*-values and 95% confidence intervals. Our findings are presented in accordance with the STROBE guidelines for reporting of cohort studies (Figure 1).[19]

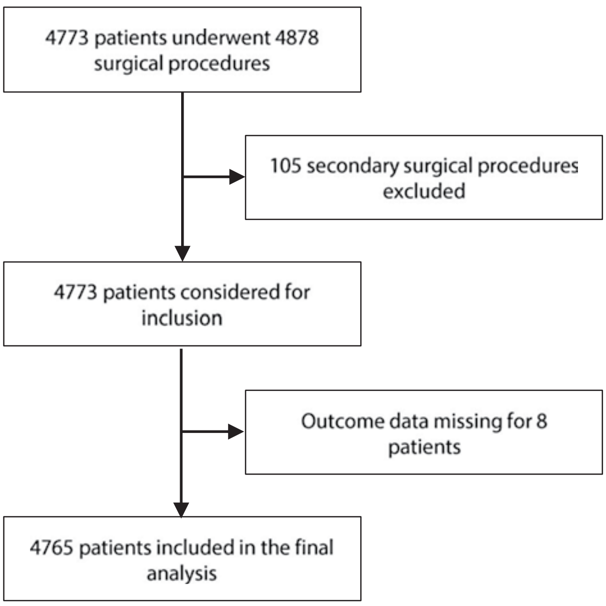

Figure 1: Patients excluded from the study.

Results

Demographics

Data describing 4 773 patients were collected at Mbale RRH. This represented 100% of surgical procedures conducted and recorded in theatre logbooks within the hospital's main operating theatres and obstetric theatre during the one-year study period. A total of 3 754 (79.0%) patients were female and the mean (SD) age of all patients was 27.9 (15.3) years. Some 773 (16.2%) patients were children under 18 years of age, 266 (5.6%) were under five years of age and 24 (0.5%) were neonates. Three-quarters of surgical procedures were emergency cases (3 501, 73.8%) and the majority were ASA class I and II (4 259, 89.4%).

Data completeness

Eight (0.2%) patients were missing outcomes and were therefore excluded from the data analysis. The number of patients missing data for additional individual variables included in the main analysis ranged from 5 (0.1%, surgical procedure) to 97 (2.0%, ASA score).

Surgical procedures

A total of 4 878 surgical procedures were conducted on 4 773 patients, with an average of 397 per month (see Figure 2). The busiest department was obstetrics and gynaecology conducting 3 158 surgeries (66.3%), followed by general surgery which conducted 1 044 procedures (21.9%). The 10 commonest surgical procedures are described in Table 1. Caesarean section was the most common procedure (2 634, 55.3%) followed by laparotomy (304, 6.4%) and hernia surgery (142, 3.0%).

Clinical outcomes

A total of 93 (2.0%) patients died before hospital discharge. Mortality was more common in children aged less than five years (7.1%) compared with older children (5–18 years, 0.8%) and adults (1.8%). Patients with an ASA score of IV were over 100 times more likely to die than ASA I patients (see Table 2). In all, 12/1 244 (1.0%) patients undergoing elective surgery died before hospital discharge compared with 81/3 501 (2.3%) undergoing emergency surgery. In-hospital mortality for the commonest surgical procedures varied between 0.3% (Caesarean section) and 22.4% (laparotomy). Of the patients who died, 49 (59.0%) did so after the day of surgery.

Complications following laparotomy

Complications data were collected over a period of three months for all patients undergoing laparotomies ($n = 107$). Data are presented in Table 3. The mean (SD) age of these patients undergoing laparotomy was 32.0 (18.6) years. Some 81.7% (58/71) of laparotomies were conducted by doctors without any specialist training in surgery. Anaesthesia for 90.2% (74/82) of these cases was provided by non-physician anaesthesia providers; 85/107 (79.4%) were conducted under general anaesthetic and the remainder under spinal anaesthesia. Antibiotics were given in theatre for 55/107 (51.4%) of cases and

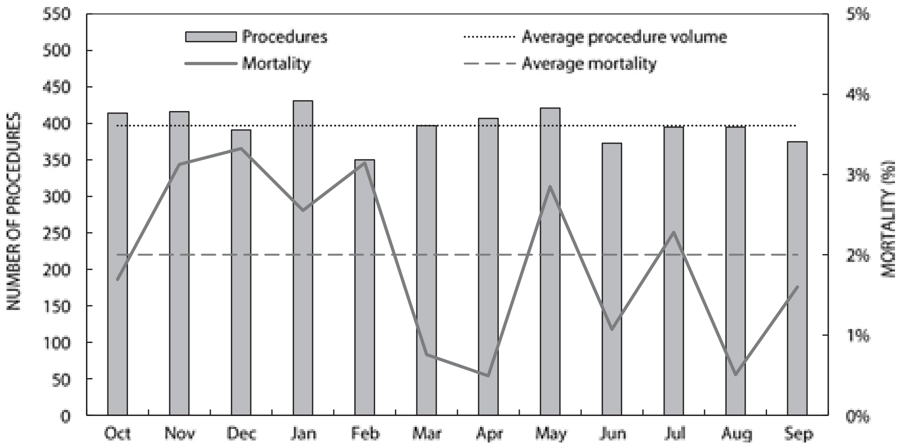

Figure 2: Variation in monthly surgical procedure rates and monthly mortality rates at Mbale Regional Referral Hospital. Dashed lines represent yearly average rates for procedure volume and mortality respectively.

the surgical safety checklist was used during 19/107 (17.8%). A total of 18 (16.8%) patients undergoing laparotomy developed postoperative complications. There were 10 (9.4%) infectious complications and 10 (9.4%) cardiac arrests. Mortality following cardiac arrest was 100%.

Complications following Caesarean section

Complications data were collected over a period of two months for all patients undergoing caesarean section ($n = 412$). Data are presented in Table 3. The mean (SD) age of these patients undergoing Caesarean section was 25.4 (6.3) years; 84.7% (349/412) of Caesarean sections were conducted by doctors without any specialist training in surgery. Anaesthesia for 99.2% (359/362) of these cases was provided by non-physician anaesthesia providers; 391/412 (94.9%) were conducted under spinal anaesthesia and the remainder under general anaesthesia. Antibiotics were given in theatre for 138/412 (33.5%) of cases, and the surgical safety checklist was used during 150/412 (36.4%). A total of 24 (6.1%) patients undergoing Caesarean section developed postoperative complications. There were 23 (5.6%) infectious complications and 2 (0.5%) cardiovascular complications (one pulmonary embolus and one cardiac arrest). Mortality following cardiac arrest was 100%.

Discussion

This study confirms the feasibility of conducting longitudinal audits of postoperative outcomes in a low-income country although patient follow-up and data entry will often require additional human resources. In this cohort of surgical patients in Eastern Uganda, overall in-hospital postoperative mortality was 2.0%. Mortality rates were more than three times higher in children under five. Patients with increasing ASA scores and those undergoing emergency surgical procedures were more likely to die and one-fifth of patients who underwent a laparotomy died. In patients undergoing laparotomy or Caesarean section, the overall number of postoperative complications was small; however, mortality following cardiac arrest was 100%. Notably, more than half of patients who died did so after the day of surgery, suggesting that improvements in postoperative care may result in a significant reduction in the mortality associated with surgical procedures in this setting.

Table 1: Baseline patient characteristics and in-hospital 30-day mortality[1]

Item	No. of patients	Patients who survived	Patients who died
All patients	4 765 (100.0)	4 672/4 765 (98.0)	93/4 765 (2.0)
Age, years, mean (SD)	27.9 (15.3)	27.7 (15.0)	33.5 (25.6)
Age, years, median (range)	25.0 (0.0–96.0)	25.0 (0.0–96.0)	30.0 (0.0–92.0)
< 29 days	24 (0.5)	21 (87.5)	3 (12.5)
29 days–5 years	242 (5.1)	226 (93.4)	16 (6.6)
5–18 years	507 (10.6)	503 (99.2)	4 (0.8)
Common surgical procedures:			
Caesarean section	2634 (55.3)	2626 (99.7)	8 (0.3)
Laparotomy	304 (6.4)	236 (77.6)	68 (22.4)
Hernia operations	142 (3.0)	140 (98.6)	2 (1.4)
Open reduction and internal fixation	87 (1.8)	86 (98.9)	1 (1.1)
Hysterectomy	79 (1.7)	78 (98.7)	1 (1.3)
Incision and drainage	60 (1.3)	58 (96.7)	2 (3.3)
Salpingectomy	40 (0.8)	40 (100.0)	0 (0.0)
External fixation	40 (0.8)	40 (100.0)	0 (0.0)
Primary wound closure	39 (0.8)	39 (100.0)	0 (0.0)
Sequestrectomy	34 (0.7)	34 (100.0)	0 (0.0)

[1]All data presented as *n* (%) unless otherwise stated. Patients with data incomplete for that category were excluded.

Table 2: Factors associated with 30-day, in-hospital mortality (multiple imputation model)

Factor	Alive	Died	Odds ratio (95% CI)	*p*-value
Male	950/999 (95.10)	49/999 (4.90)	Reference	–
Female	3 710/3 754 (98.83)	44/3 754 (1.17)	0.65 (0.36–1.18)	0.16
ASA score:				
I	1 918/1 922 (99.79)	4/1 922 (0.21)	Reference	–
II	2 313/2 337 (98.97)	24/2 337 (1.03)	5.94 (2.02–17.50)	0.001
III	314/353 (88.95)	39/353 (11.05)	28.66 (9.72–84.57)	< 0.001
IV	35/56 (62.50)	21/56 (37.50)	116.79 (35.60–383.16)	< 0.001
Surgical specialty:				
Obstetrics	2860/2878 (99.37)	18/2878 (0.63)	Reference	–
General	980/1044 (93.87)	64/1044 (6.13)	4.34 (2.02–9.30)	< 0.001
ENT	140/141 (99.29)	1/141 (0.71)	0.61 (0.08–5.04)	0.65
Gynaecology	272/280 (97.14)	8/280 (2.86)	3.90 (1.51–10.04)	0.005
Orthopaedics	418/420 (99.52)	2/420 (0.48)	0.71 (0.14–3.49)	0.67
Urgency of surgery:				
Elective	1232/1244 (99.04)	12/1244 (0.96)	Reference	–
Emergency	3420/3501 (97.69)	81/3501 (2.31)	1.52 (0.74–3.15)	0.26

ASA: American Society of Anesthesiologists; ENT: Ear, Nose and Throat.

Mortality rates from our one-year cohort of patients are remarkably consistent with ASOS data, both in all patients and in those undergoing elective surgery (Figure 3). Mbale RRH contributed to ASOS, collecting data over seven days during the same study period. This cohort therefore serves to validate the reliability of the ASOS outcomes. We describe mortality in accordance with the recommendations of the Lancet Commission on Global Surgery, including all patients within our hospital who underwent a surgical procedure in an operating theatre. Some 60% of all our surgical procedures were obstetric, a representative statistic for most hospitals in low-income countries. However, this raises difficulty when directly comparing our postoperative mortality with published literature in other hospitals in similar settings. Postoperative mortality at a regional referral hospital in western Uganda has been reported as 2.4%. Although data collection there was limited to a four-week period, the overall figure is comparable.[16] A teaching hospital in Rwanda described its perioperative mortality rate as 6.5%, three times higher than ours, but included only procedures involving surgical residents in their study.[11] If obstetric patients are excluded from our cohort, our mortality rate doubles to 4%. This is analogous to mortality rates following elective and emergency surgery in Europe (4%),[20] but less than among a cohort of over 10 000 patients in 58 high-, middle- and low-income countries undergoing emergency abdominal surgery who had an overall mortality rate at 30 days of 5.4%.[10] In a population of 45 000 patients undergoing elective surgery in high-, middle- and low-income countries the in-hospital mortality rate was lower at 0.5%.[21] In comparison, following elective surgery in our hospital, patients are twice as likely to die despite, on average, being 30 years younger. This reinforces the recently published African Surgical Outcomes Study (ASOS) where patients in Africa were twice as likely to die after surgery when compared with the global average for postoperative deaths.[14] A major deficit exists in the specialist surgical workforce in many parts of the world.[22] At Mbale RRH, seven obstetric, surgery and anaesthesia specialists cover a catchment population of 4.5 million. Over 84% of laparotomies and Caesarean sections were conducted by doctors without specialist training in surgery and over 97% of anaesthetics were performed by non-physician anaesthesia providers. Although safe surgical and anaesthesia care has only recently come into focus at a global level, previous interventions aimed at improving outcomes have focused on making operative procedures safer.[19,23] Almost 60% of the postoperative deaths in our hospital occurred more than 24 hours after surgery. In the African Surgical Outcomes Study, more than 95% of patients who died did so in the postoperative period.[14] It is known that poor patient outcomes commonly result from a failure to promptly recognise deteriorating patients on the wards.[24] It has also been suggested that a failure to rescue patients following the development of postoperative complications may be a better measure of the quality of perioperative care within a health facility.[25] In our cohort, no patients survived following a cardiac arrest. In the International Surgical Outcomes Study, conducted mainly in high- and middle-income countries, 40% of cardiac arrest patients survived.[21] This suggests that postoperative care in our setting, in particular ward care, should be a focus for future interventions and we advocate for more research and funding in this area. In Mbale RRH, our data have been presented to hospital staff and are being used to inform interventions to improve patient care, for example by establishing a high-dependency unit. We recognise that patients given an ASA classification of III or IV are more likely to die. Interestingly, 75% of our ASA IV patients underwent an emergency laparotomy. They were classified as ASA IV based on their acute illness rather than on their underlying chronic disease as in many high-income countries. We were surprised by the monthly variation in our mortality rates. Figure 2 demonstrates, on average, higher rates during the period November–February with a dramatic reduction during March and April (Figure 2). We did not set out to investigate seasonal variation in outcomes and are unable to clearly identify causal factors.

There is a huge burden of untreated surgical disease in Uganda, and we suspect a significant number of these patients never reach theatre because of delays in seeking care, travelling to health facilities and between presentation to hospital and reaching theatre.[26,27] By looking at postoperative mortality alone, we have limited our data and are unable to measure these gaps. We are therefore likely to be missing a significant proportion of the mortality associated with surgical disease in this setting. We also consider the low rates of postoperative complications in our cohort to be a limitation. In our hospital,

Table 3: Additional baseline characteristics collected for subsets of patients following laparotomy and Caesarean section and in-hospital postoperative complications

Factor	Laparotomy	Caesarean section
Total patients	107/304 (35.2)	412/2 634 (15.6)
Age, mean (SD)	31.96 (18.6)	25.43 (6.3)
Senior surgeon present:		
Consultant	3/71 (4.2)	3/360 (0.8)
Medical Officer Special Grade	10/71 (14.1)	8/360 (2.2)
Medical Officer	52/71 (73.2)	41/360 (11.4)
Intern	6/71 (8.5)	308/360 (85.6)
Senior anaesthesia provider present:		
Physician anaesthetist	8/82 (9.8)	3/362 (0.8)
Anaesthetic officer (non-physician)	74/82 (90.2)	359/362 (99.2)
Anaesthetic technique:		
General anaesthetic	85/107 (79.4)	21/412 (5.1)
Spinal anaesthetic	22/107 (20.6)	391/412 (94.9)
Endotracheal tube	67/67 (100.0)	4/21 (19.1)
Antibiotics given (Yes)	55/107 (51.4)	138/412 (33.5)
Surgical checklist used (Yes)	19/107 (17.8)	150/412 (36.4)
Complications:		
Complications	18/107 (16.8)	24/412 (5.8)
Mortality	10/107 (9.4)	1/412 (0.2)
Death following a postoperative complication	10/18 (55.6)	1/24 (4.2)
Infectious complications:		
Surgical site	5/107 (4.7)	19/412 (4.6)
Body cavity	3/107 (2.8)	2/412 (0.5)
Pneumonia	1/107 (0.9)	0/412 (0.0)
Blood	1/107 (0.9)	2/412 (0.5)
Total	10/107 (9.4)	23/412 (5.6)
Cardiovascular complications:		
Pulmonary embolus	0/107 (0.0)	1/412 (0.2)
Cardiac arrest	10/107 (9.4)	1/412 (0.2)
Total	10/107 (9.4)	2/412 (0.5)
Other complications		
Unplanned return to theatre	2/107 (1.9)	0/412 (0.0)

Data presented as *n* (%).

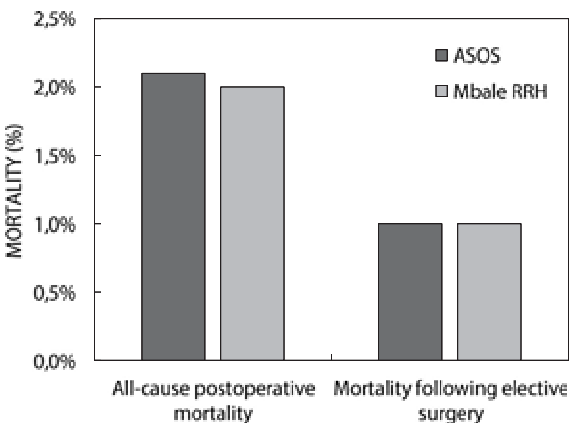

Figure 3: Comparison of in-hospital postoperative mortality data from Mbale Regional Referral Hospital with mortality following emergency and elective surgery across Africa. ASOS = African Surgical Outcomes Study.

like many low-income settings, documentation of postoperative reviews is often poor, complications are not sought out and laboratory tests or radiology examinations are often unavailable to confirm complications when they are suspected. We have relied on data collection from logbooks and patient medical records and did not define potential complications a priori. If we had conducted routine reviews of all postoperative patients, we might have identified additional complications. This was not feasible in our setting due to resource limitations for this study but this has allowed us to identify a focus area for future quality improvement. A previous study in Uganda has also shown only 94% of surgical-related deaths to be recorded in logbooks.[16] It is possible that we may have missed some postoperative deaths. Paper-based logbooks are routinely used in all health facilities in Uganda to help collate aggregate data to provide feedback to the Ministry of Health. This method of data collection is time-consuming and places a significant burden on staff who are already working in challenging conditions, for example nursing to patient ratios of 1:40. It is also a barrier to the routine use of these data for quality improvement initiatives at health facility level. We have successfully managed to collate this level of data for our patients but only with the assistance of a dedicated data assistant whose primary role was collection and entry of all data. An alternative strategy is to replace paper logbooks with an electronic registry. The reported challenges of implementing an electronic data registry, e.g. poor staff training, lack of regular power supply and inadequate infrastructure, can all be overcome with appropriate technology and focused investment of time and money commensurate with the scale of the data collection.[28–30]

Conclusion

The original aim of our project was to collect outcome data on patients undergoing surgical procedures in order to inform ongoing quality improvement in a referral hospital in eastern Uganda. Our data, which are likely to be representative of all similar health facilities in the region, demonstrate that patients who die following surgery are more likely to do so in the days following their operation, especially if they have a higher ASA classification. We have demonstrated that this level of data collection is feasible and that it generates discussion with hospital leadership. Future efforts should focus on refining methodology for efficient and accurate data collection in resource-constrained settings, while also ensuring utilisation of these data in real-time for quality improvement interventions in perioperative care.

Acknowledgements – The authors would like to acknowledge the dedicated staff providing care for surgical patients at Mbale RRH often in very challenging circumstances. They would also like to thank Brennan Kahan who helped with the statistical analysis.

Declaration of interest – R.M.P. holds research grants and has given lectures and/or performed consultancy work for Nestle Health Sciences, BBraun, Medtronic, Glaxo SmithKline, Intersurgical, and Edwards Lifesciences, and is a member of the Associate editorial board of the British Journal of Anaesthesia. All other authors declare no conflicts of interests.

Authors' contributions – A.H.S. and F.B. were responsible for the initial audit design with input and guidance from F.M. and M.S.L. A.H.S., F.B. and C.O. were responsible for data collection and, together with J.P.O. and F.M, the initial data analysis. Further data analysis was guided by R.M.P. The manuscript was drafted by A.H.S. and revised following critical review by R.M.P. and all other authors.

ORCID

A Hewitt-Smith http://orcid.org/0000-0002-6019-2441

References

1. Alkire BC, Raykar NP, Shrime MG, et al. Global access to surgical care: a modelling study. Lancet Glob Health. 2015;3:e316–323.
2. Meara JG, Leather A, Hagander L, et al. Global Surgery 2030: evidence and solutions for achieving health, welfare, and economic development. The Lancet. 2015;386:569–624.
3. Grimes CE, Henry JA, Maraka J, et al. Cost-effectiveness of surgery in low- and middle-income countries: a systematic review. World J Surg. 2014;38:252–263.
4. Chao TE, Sharma K, Mandigo M, et al. Cost-effectiveness of surgery and its policy implications for global health: a systematic review and analysis. Lancet Glob Health. 2014;2:e334–45.
5. Hodges SC, Mijumbi C, Okello M, et al. Anaesthesia services in developing countries: defining the problems. Anaesthesia. 2007;62:4–11.
6. Grimes CE, Bowman KG, Dodgion CM, et al. Systematic review of barriers to surgical care in low-income and middle-income countries. World J Surg. 2011;35:941–50.
7. Lilaonitkul M, Kwikiriza A, Ttendo S, et al. Implementation of the WHO surgical safety checklist and surgical swab and instrument counts at a regional referral hospital in Uganda - a quality improvement project. Anaesthesia. 2015;70:1345–55.
8. Meara JG, Hagander L, Leather AJM. Surgery and global health: a Lancet Commission. The Lancet. 2014;383:12–3.
9. Watters DA, Hollands MJ, Gruen RL, et al. Perioperative mortality rate (POMR): a global indicator of access to safe surgery and Anaesthesia. World J Surg. 2015;39:856–864.
10. GlobalSurg Collaborative. Mortality of emergency abdominal surgery in high-, middle- and low-income countries. Br J Surg. 2016;103:971–988.
11. Rickard JL, Ntakiyiruta G, Chu KM. Associations with perioperative mortality rate at a major referral hospital in Rwanda. World J Surg. 2016;40:784–790.
12. Heywood AJ, Wilson IH, Sinclair JR. Perioperative mortality in Zambia. Ann R Coll Surg Engl. 1989;71:354–8.
13. Bainbridge D, Martin J, Arango M, et al. Perioperative and anaesthetic-related mortality in developed and developing countries: a systematic review and meta-analysis. The Lancet. 2012;380:1075–1081.
14. Biccard BM, Madiba TE, Kluyts H-L, et al. Perioperative patient outcomes in the African Surgical Outcomes Study: a 7-day prospective observational cohort study. The Lancet. Advance Access published on January. 2018;3. doi:10.1016/S0140-6736(18)30001-1
15. Dare AJ, Onajin-Obembe B, Makasa EM. A snapshot of surgical outcomes and needs in Africa. The Lancet. Advance Access published on January. 2018;3. doi:10.1016/S0140-6736(18)30002-3
16. Anderson GA, Lenka Ilcisin AB, Abesiga L, et al. Surgical volume and postoperative mortality rate at a referral hospital in Western Uganda: measuring the lancet commission on global surgery indicators in low-resource settings. Surgery. 2017;161:1710–19.
17. Ministry of Health. Annual health sector performance report. Uganda; 2016.
18. White IR, Royston P, Wood AM. Multiple imputation using chained equations: Issues and guidance for practice. Stat Med. 2011;30:377–99.
19. Scott DA, McDougall R. The effective introduction of Lifebox pulse oximetry to Malawi. Anaesthesia. 2017;72:675–677.
20. Pearse RM, Moreno RP, Bauer P, et al. Mortality after surgery in Europe: a 7 day cohort study. The Lancet. 2012;380:1059–1065.
21. International Surgical Outcomes Study group. Global patient outcomes after elective surgery: prospective cohort study in 27 low-, middle- and high-income countries. Br J Anaesth. 2016;117:601–609.
22. Kempthorne P, Morriss WW, Mellin-Olsen J, et al. The WFSA global anesthesia workforce survey. Anesth Analg. 2017;125:981–90.
23. Haynes AB, Weiser TG, Berry WR, et al. A surgical safety checklist to reduce morbidity and mortality in a global population. N Engl J Med. 2009;360:491–499.
24. McGinley A, Pearse RM. A national early warning score for acutely ill patients. BMJ. 2012;345:e5310.
25. Ahmad T, Bouwman RA, Grigoras I, et al. Use of failure-to-rescue to identify international variation in postoperative care in low-, middle- and high-income countries: a 7-day cohort study of elective surgery. Br J Anaesth. 2017;119:258–66.
26. Tran TM, Fuller AT, Butler EK, et al. Burden of surgical conditions in Uganda. Ann Surg. 2017;266:389–399.
27. Butler EK, Tran TM, Fuller AT, et al. Pilot study of a population-based survey to assess the prevalence of surgical conditions in Uganda. Surgery. 2015;158:764–72.
28. Dasari M, Garbett M, Miller E, et al. Implementation of a hospital electronic surgical registry in a lower-middle-income country. World J Surg. 2016;40:2840–6.
29. Mehmood A, Razzak JA, Kabir S, et al. Development and pilot implementation of a locally developed Trauma Registry: lessons learnt in a low-income country. BMC Emerg Med. 2013;13:32.
30. Sileshi B, Newton MW, Kiptanui J, et al. Monitoring anesthesia care delivery and perioperative mortality in kenya utilizing a provider-driven novel data collection tool. Anesthesiology. 2017;127:250–271.

Received: 5-06-2018 Accepted: 27-08-2018