World J Surg (2016) 40:784–790
DOI 10.1007/s00268-015-3308-x

ORIGINAL SCIENTIFIC REPORT

Associations with Perioperative Mortality Rate at a Major Referral Hospital in Rwanda

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Published online: 6 November 2015

Abstract

Background Little is known about perioperative mortality in sub-Saharan Africa. The perioperative mortality rate (POMR) and associated factors at a major referral hospital in Rwanda were measured.

Methods The operative activity at University Teaching Hospital of Kigali was evaluated through an operative database. As a part of this larger study, patient characteristics and outcomes were measured to determine areas for improvement in patient care. Data were collected on patient demographics, surgeon, diagnosis, and operation over a 12-month period. The primary outcome was POMR. Secondary outcomes were timing and hospital location of death.

Results The POMR was 6 %. POMR in patients under 5 years of age was 10 %, 3 % in patients 5–14 years and 6 % in patients age >14 years. For emergency and elective operations, POMR was 9 and 2 %, respectively. POMR was associated with emergency status, congenital anomalies, repeat operations, referral outside Kigali, and female gender. Orthopedic procedures and age 5–14 years were associated with decreased odds of mortality. Forty-nine percent of deaths occurred in the post-operative recovery room and 35 % of deaths occurred within the first post-operative day.

Conclusions The POMR at a large referral hospital in Rwanda is <10 % demonstrating that surgery can save lives even in resource-limited settings. Emergency operations are associated with higher mortality, which could potentially be improved with faster identification and transfer from district hospitals. Nearly half of deaths occurred in the post-operative recovery room. Multidisciplinary audits of operative mortalities could help guide improvements in surgical care.

This paper was presented at the American College of Surgeons Global Surgery Surgical Forum, in San Francisco, CA, October 2014.

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Introduction

Surgical disease has been shown to be an important component of global public health [1–3]. While the importance of surgery in global health is beginning to be recognized, there is little information regarding the quality of surgical care in low and middle-income countries (LMICs) where most of the burden of surgical disease originates.

Measuring the quality of surgical care is complex and can be evaluated through structure, process, and outcome indicators [4–6]. Structural measures include surgeon or hospital features. Process measures often refer to care that patients actually receive, whereas outcome measures include metrics such as morbidity and mortality [4].

There are myriad ways surgical quality is measured and regulated in high-income countries (HIC). The National

Surgical Quality Improvement Program is one example of a quality assurance database developed by the US Veterans Administration that collects structural, process, and outcome indicators [8]. However, it is resource-intensive and costly as staff are employed to extract and record data [8]. In LMICs there are scarce resources available for clinical care and even less for monitoring. Short term outcomes, such as perioperative mortality rate (POMR), are relatively easy to collect in resource-limited settings [7, 9]. POMR can be defined as death after surgery and before discharge, within 30 days of the operation [7].

Rwanda has a population of 11 million people with 80,000 surgical procedures annually [10, 11]. University Teaching Hospital of Kigali (CHUK) is one of the major referral hospitals in Rwanda and treats a wide range of elective and emergent surgical conditions in addition to serving as a training site for surgical residents. Surgical residents are taught by general surgeons, orthopedists, urologists, and neurosurgeons. There are no full-time pediatric surgeons, but there are visiting pediatric surgeons throughout the year. Like most LMICs hospitals, few resources are in place for objectively measuring surgical quality at CHUK.

The objective of this study was to evaluate POMR at CHUK and its associated risk factors as a measure of the quality of surgical care in a resource-limited setting. The secondary objectives were to determine the timing and location of death to target hospital-based improvements.

Materials and methods

This was a retrospective review of data collected from an electronic database as part of a larger study evaluating the operative activity of surgical residents at CHUK [12]. All procedures involving surgical residents at CHUK during the period October, 2012–September, 2013 were included in this study. To assess the quality of surgical care within the residency program, operations not including surgical residents were excluded. Data were collected on patient demographics, level of surgeon training, referral hospital, diagnosis, emergency and trauma status, initial versus repeat operation, and perioperative mortality. Diagnosis was categorized into general surgery, orthopedic, urology, neurosurgery, and congenital anomalies. General surgery conditions included acute abdomens (intestinal obstruction, peritonitis), burns, hernias, cholecystitis, thyroid goiters, and breast masses. Orthopedic conditions consisted primarily of fractures and dislocations. Urology conditions included urinary tract obstructions (benign prostatic hypertrophy, renal lithiasis), testicular torsion, and urologic tumors (bladder, prostate, and penis). Neurosurgical conditions included epidural and subdural hematomas, skull fractures, brain tumors, hydrocephalus, and brain abscesses. Congenital anomalies included intestinal atresia, hypertrophic pyloric stenosis, anorectal malformations, Hirschsprung's disease and tracheoesophageal fistula. Other pediatric surgical conditions were categorized as general surgery (ex: burns, intussusception, appendicitis, etc.). This study excluded obstetrics/gynecology, otorhinolaryngology, and ophthalmology conditions as these operations are performed by residents in separate training programs.

POMR was defined as the number of patients who died in the operating room or during the post-operative hospital stay divided by the total number of operative patients. Deaths were categorized by hospital location: the operating room (OR), the post-anesthesia care unit (PACU), the intensive care unit (ICU), or the post-operative surgical ward. The cause of death and deaths after hospital discharge were not captured. The OR, PACU, ICU, and post-operative surgical ward registers were analyzed to determine the location and date of death.

Data were analyzed using STATA13 (Irving, TX). The primary outcome was POMR. Secondary outcomes were post-operative date and location of patient death. Logistic regression was used to determine factors associated with mortality. Variables included age, gender, resident as primary surgeon, diagnosis category, referral province, emergency status, trauma status, and initial versus repeat operation. Factors with a p- value <0.1 on univariate analysis were included in the multivariate model. A p value of <0.05 on multivariate analysis was considered statistically significant.

The National Health Research Committee (Kigali, Rwanda), CHUK Ethics Committee (Kigali, Rwanda), Rwanda Ministry of Health (Kigali, Rwanda), and Brigham and Women's Hospital Institutional Review Board (Boston, MA, USA) approved the study.

Results

A total of 2832 procedures were recorded in the operative database. 52 (2 %) operations were excluded because they did not involve a surgical resident. 2780 procedures were included in the final analysis. Sixty-six percent of patients were male and the median age was 28 years (interquartile range 12–44). Sixty-four percent of procedures were emergent and 50 % were for trauma (Table 1) [12].

Perioperative mortality rate

POMR was 6.5 % ($n = 180$). POMR in patients under 5 years of age was 10 %, 3 % in patients age 5–14 years

Table 1 Surgical patient characteristics at University Teaching Hospital of Kigali from 2012–2013

	n	Percentage (%)
Total Cases	2780	
Gender		
Male	1798	66
Female	931	34
Age		
>14 years	1965	72
5–14 years	400	15
≤5 years	362	13
Primary surgeon		
Faculty	889	32
Resident	1875	68
Surgical specialty		
General surgery	1333	49
Orthopedics	1018	36
Urology	114	4
Neurosurgery	207	8
Congenital anomalies	40	1
Procedure Type		
Emergent	1767	64
Elective	996	36
Trauma	1356	50
Non-Trauma	1374	50
Procedure Timing		
Initial	2303	83
Repeat	454	16

and 6 % in patients age >14 years (Table 2). POMR for emergency and elective operations were 9 and 2 %, respectively ($p < 0.001$). Certain surgical conditions such as intestinal atresia had high mortality (71 %) while others such as hernia repair were not associated with any mortality (Table 3).

Multivariate analysis

Variables included in the multivariate model were age, gender, referral province, emergency operation, trauma, repeat operation, diagnostic category, and resident as surgeon (Hosmer–Lemeshow goodness of fit, p value = 0.8557). A backwards selection algorithm was used to confirm goodness of fit.

On multivariate analysis, POMR was associated with emergency status [adjusted odds ratio (aOR) 4.62; 95 % confidence interval (95 % CI) 2.77, 7.70], congenital anomalies (aOR 3.63; 95 % CI 1.55, 8.53), repeat operation (aOR 1.57; 95 % CI 1.06, 2.33), referral from outside Kigali city (aOR 1.49; 95 % CI 1.05, 2.13), and female gender (aOR 1.43; 95 % CI 1.02, 1.99). Orthopedic conditions (aOR 0.07; 95 % CI 0.03, 0.19) and age 5–14 years (aOR 0.49; 95 % CI 0.27, 0.90) were associated with decreased odds of mortality (Table 2).

Timing and location of death

Data on location of perioperative death were available for 127 (71 %) patients. Of these, 62 (49 %) deaths occurred in the PACU, 31 (24 %) in the post-operative surgical ward, 31 (24 %) in the ICU and 3 (2 %) in the OR (Fig. 1). Date of death was available for 122 (68 %) patients. Of these, 43 (35 %) deaths occurred on the first post-operative day (Fig. 2).

Discussion

POMR can be utilized as a marker of surgical quality in a low-resource setting. We demonstrate that POMR can be monitored in Rwanda using a simple operative database maintained without outside funding, maintenance, or support.

In this study, POMR ranges greatly depending on the type of procedure and the setting. The overall POMR at CHUK, the main referral hospital of Rwanda, was 6.5 %. This is similar to mortality reported in other studies from this same hospital [13]. CHUK serves as a national referral center for emergent and congenital surgical conditions, which were risk factors for perioperative mortality. While other authors have reported lower operative mortality in sub-Saharan Africa [14], they had a lower proportion of these conditions.

Emergency operations are a risk factor for operative mortality in both HIC [15–17] and LMICs [14, 18, 19] and we report similar findings at CHUK. Reducing emergency procedures would require improved public health and upscaling of elective surgical services. Over the next few years, there will be an increase in the number of provincial and referral hospitals, which could decrease the burden of emergency cases on CHUK. Early recognition and transfer of emergency patients from district hospitals could decrease mortality and the severity of the conditions. Improved nutrition and sanitation could decrease conditions such as typhoid perforation, abscesses, and other infections. Better road safety could decrease road traffic injuries. Rwanda is already one of the few African countries that enforce motorcycle helmet and seatbelt laws [20]. Correction of elective surgical conditions such as inguinal hernias could prevent later complications; however, Rwanda's health system is already burdened with emergency surgical conditions and does not have sufficient

Table 2 Risk factors associated with mortality

			Univariate analysis		Multivariate analysis	
	Mortality	Percentage	OR**	*p* value	aOR***	*p* value
Total	180	6.5				
Gender						
Male*	98/1798	5.4	1 (reference)			
Female	80/931	8.6	1.63 (1.20, 2.22)	0.002	**1.43 (1.02, 1.99)**	**0.037**
Age						
>14 years*	126/1965	6.4	1 (reference)			
5-14 years	13/400	3.3	0.49 (0.27, 0.88)	0.016	**0.49 (0.27, 0.90)**	**0.022**
≤5 years	36/362	10.0	1.61 (1.09, 2.38)	0.016	0.91 (0.58, 1.43)	0.692
Referral Province						
Kigali City*	55/1252	4.4	1 (reference)			
Outside Kigali	125/1528	8.2	1.94 (1.40, 2.69)	<0.001	**1.49 (1.05, 2.13)**	**0.027**
Primary surgeon						
Faculty*	47/889	5.3	1 (reference)			
Resident	131/1875	6.9	1.35 (0.95, 1.90)	0.09	0.81 (0.54, 1.21)	0.306
Emergency						
Elective*	22/971	2.3	1 (reference)			
Emergency	157/1792	8.7	4.14 (2.63, 6.52)	<0.001	**4.62 (2.77, 7.70)**	**<0.001**
Trauma						
Non-Trauma*	135/1360	10.0	1 (reference)			
Trauma	41/1372	3.0	0.28 (0.19, 0.40)	<0.001	0.72 (0.47, 1.08)	0.114
Repeat Procedures						
Initial*	138/2303	6.000	1 (reference)			
Repeat	41/454	9.031	1.55 (1.08, 2.24)	0.017	**1.57 (1.06, 2.33)**	**0.025**
Diagnosis Category						
General surgery*	145 (11 %)	1333	1 (reference)			
Orthopedics	5 (0.5 %)	1018	0.04 (0.02, 0.10)	<0.001	**0.07 (0.03, 0.19)**	**<0.001**
Neurosurgery	15 (7 %)	207	0.64 (0.37, 1.11)	0.114	0.80 (0.41, 1.57)	0.513
Urology	2 (2 %)	114	0.15 (0.04, 0.60)	0.007	0.26 (0.06, 1.09)	0.066
Congenital anomalies	11 (28 %)	40	3.11 (1.52, 6.36)	0.002	**3.63 (1.55, 8.53)**	**0.003**

* Reference category

** OR, odds ratio

*** aOR, adjusted odds ratio

resources to treat the elective burden of surgical disease [10].

Similar to other studies, congenital anomalies were a risk factor for perioperative mortality at this hospital [21, 22]. In Rwanda, most of these neonates presented with delays in diagnosis, severe electrolyte imbalance and malnutrition making perioperative care challenging. Rwanda does not have any pediatric anesthesiologists and intraoperative monitoring of neonates at CHUK is limited.

In this setting, most orthopedic conditions were trauma-associated injuries and associated with lower odds of mortality, similar to other studies [23, 24]. More complex, critically ill trauma patients may have died before transfer to CHUK or were classified as general surgery or neurosurgery conditions if they had associated injuries. A larger proportion

Table 3 Mortality by specific surgical conditions

	Mortality n/N	Percentage (%)
Diagnosis category		
General surgery	145/1333	10.9
Acute abdomen	78/538	14.5
Infected, gangrenous soft tissue	19/190	10.0
Burn	18/96	18.8
Hernia	0/88	0.0
Orthopedics	5/1018	0.5
Fracture/Dislocation	2/902	0.2
Neurosurgery	15/207	7.2
Epidural/subdural hematoma	5/75	6.7
Skull fracture	1/29	3.4
Hydrocephalus	2/26	7.7
Brain tumor	3/19	15.8
Urology	2/114	2.0
Urinary tract obstruction	1/44	2.3
Testicular torsion	0/17	0.0
Congenital anomalies	11/40	27.5
Anorectal malformation	3/13	23.0
Intestinal atresia	5/7	71.4
Hypertrophic pyloric stenosis	0/7	0.0

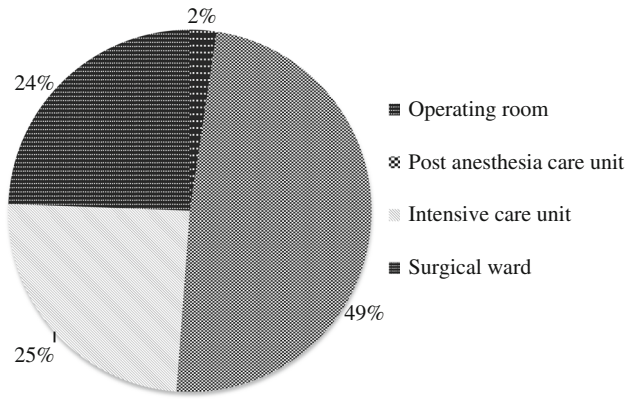

Fig. 1 Location of in-hospital surgical deaths

of these orthopedic injuries could potentially be treated at the provincial and district level given the low mortality rate. However, further efforts would be needed to ensure adequate material resources and staffing at these hospitals.

Referral from outside Kigali was associated with increased odds of death. Referrals from other provinces were potentially subjected to prolonged transport time, ambulance shortages, and delays in communication and diagnoses. Currently a study is underway to assess the impact of mortality from delays in transfer. Patient

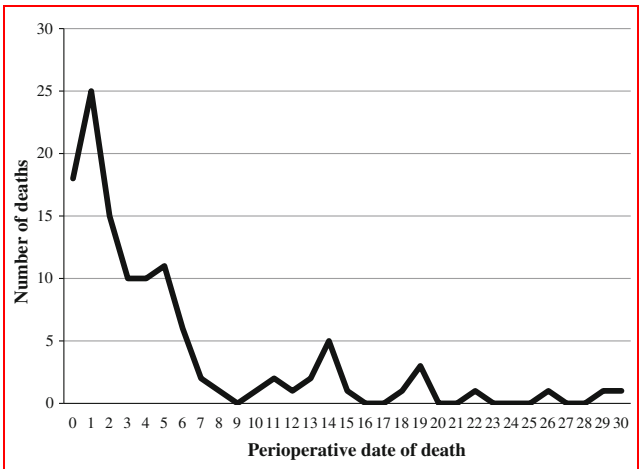

Fig. 2 Timing of in-hospital perioperative deaths

education campaigns to encourage patients to seek medical care earlier and district hospital educational campaigns highlighting recognition and early referral of emergency patients could help reduce mortality.

Implications

A third of perioperative deaths at CHUK occurred in the first 24 hours and half of deaths occurred in the PACU. Most operations (64 %) were emergent with some patients presenting to the hospital in septic shock with organ failure. While only 2 % died intraoperatively, many left the OR with unstable cardiovascular or respiratory status. Like other LMICs hospitals, CHUK is not equipped to care for many critically ill patients. Solutions include increasing PACU monitoring equipment, nursing and physician coverage. Currently, efforts are underway to implement a high dependency unit, which will allow for augmented management of critically ill patients.

Addressing care processes could reduce mortality. Studies have cited minimum standards for surgery that includes necessary infrastructure such as electricity, clean water, and trained surgical personnel [4, 25]. The Human Resources for Health Program, implemented to develop the human resource capacity within Rwanda, places US physicians, nurses and health managers in Rwanda to mentor local faculty and trainees and improve systems of care [26]. Educational efforts focus on teaching locally relevant and applicable surgical care and techniques.

Limitations

POMR at CHUK may be underestimated due to incomplete data capture in the operative database, which is maintained by surgical residents. To minimize this, additional case

finding was done by systematically searching for in-hospital deaths, which are recorded in ward logbooks maintained by nurses. In addition, deaths after patients were transferred or discharged home were not captured.

Future directions

Illness severity, an important component of operative mortality, was not measured in this study. Common measurements of illness severity such as the acute physiology and chronic health evaluation (APACHE) II and the simplified acute physiology score II (SAPS II) [27–29] are difficult to capture in resource-limited settings [30]. New methods for evaluating illness severity, such as the surgical apgar score, need to be validated in a low-resource setting [31, 32]. Measures of illness severity could be included in the operative database to help risk-stratify patients.

In the future, the operative database should capture data on morbidity in addition to mortality as well as specific causes of death. The database could also be expanded to include other referral and teaching hospitals in Rwanda to determine if the factors impacting mortality are comparable across sites.

Conclusion

The POMR at CHUK is <10 % and associated with emergency procedures and congenital anomalies. The majority of deaths occur in the PACU within the first 24 hours postoperatively. Efforts should be made to improve management of emergency patients and strengthen care in the recovery room as well as address preventable causes of death. Implementation of a simple surgical database can be used to monitor surgical quality in a low-resource setting.

Compliance with ethical standards

Conflicts of interest The authors have no conflicts of interest to report.

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