Surgery 166 (2019) 193–197

Contents lists available at ScienceDirect

Surgery

journal homepage: www.elsevier.com/locate/surg

Global Surgery
Presented at the Academic Surgical Congress 2019

A cross sectional survey of factors influencing mortality in Rwandan surgical patients in the intensive care unit

Gisele Juru Bunogerane, MMed[a,b], Jennifer Rickard, MD, MPH[b,c,*]

[a] Department of Surgery, University of Rwanda, Kigali, Rwanda
[b] University Teaching Hospital of Kigali, Kigali, Rwanda
[c] Department of Surgery, University of Minnesota, Minneapolis, MN

ARTICLE INFO

Article history:
Accepted 17 April 2019
Available online 28 May 2019

ABSTRACT

Background: Management of critically ill patients is a challenge in low resource settings where there is a paucity of trained staff, infrastructure, resources, and drugs. We aimed to study the characteristics of surgical patients admitted in intensive care unit in a limited resource setting and determine factors associated with mortality.
Methods: This was a cross-sectional observational study of all surgical patients admitted to the intensive care unit of a tertiary referral hospital in Rwanda. Data included demographics, diagnosis, management, and outcomes. Logistic regression was used to determine factors associated with mortality.
Results: Over a 7-month period, there were 126 surgical patients admitted to the intensive care unit. Common diagnoses included head injury ($n = 55$, 44%), peritonitis ($n = 33$, 26%), brain tumor ($n = 15$, 12%), and trauma ($n = 15$, 12%). The overall mortality was 47% with the highest mortality seen in patients with peritonitis (76%). Factors associated with mortality on intensive care unit admission included hypotension (odds ratio, 12.50; 95% confidence interval, 3.04, 51.32) and having any comorbidity (odds ratio 5.69, 95% confidence interval, 1.58, 20.50).
Conclusion: Surgical patients admitted to the intensive care unit bear a significant mortality. Common surgical intensive care unit diagnoses include head injury and peritonitis. We recommend a review of the admission policy to optimize utility of the intensive care unit.

Introduction

Accessing quality surgical care remains a significant challenge in low-and middle-income countries (LMICs) where there are a significant number of surgical diseases associated with high mortality. There is little information regarding predictors of mortality for surgical patients in LMICs. Challenges exist in reducing surgical mortality, including insufficient trained staff and limitations in infrastructure. However there are recent global efforts to reduce surgical mortality including developing intensive care units (ICUs) for high-risk patients.[1]

The care of critically ill patients is a young specialty compared with other clinical disciplines. However, it has gained much attention and become an essential part of medical system in developed countries. LMICs largely differ from high-income countries in terms of the care provided to the severely sick patients. Similar to other medical fields, there is a deficit of equipment, medications, and staff. The number of surgical patients requiring access to critical care units represents a large resource burden, which is particularly marked in LMICs that have a limited number of critical care beds, trained staff, and infrastructure. However, there are several interventions such as rapid fluid resuscitation, early antibiotics, and patient monitoring, which have been proven to be effective in critical care, are relatively inexpensive.[2] These critical care interventions can be cost-effective when compared with other global health interventions such as immunizations and human immunodeficiency virus (HIV) care.[2]

ICU mortality ranges from 15% to 50%, depending on the patient population and degree of critical illness. In an observational multinational cohort study in Europe, there were 5,834 patients admitted to the ICUs, and 1,113 (19%) patients died.[3] The criteria for ICU admission varies widely in different settings. ICU patient selection should take into account the general outcome of patients, and adequate balance of available resources. The population of

Presented at the Academic Surgical Congress in Houston, TX on February 7, 2019.

* Reprint requests: Jennifer Rickard, MD, MPH, Department of Surgery, University of Minnesota, 420 Delaware St, SE, MMC 195, Minneapolis, MN 55455.
E-mail address: gehr0059@umn.edu (J. Rickard).

https://doi.org/10.1016/j.surg.2019.04.010
0039-6060/

Table I
Intensive care unit resources at University Teaching Hospital of Kigali

	No.
Staffing	
Fellowship trained intensivists	1
Specialist anesthesiologists	7
Physician-to-patient ratio	1:7
Masters-trained critical care nurses	2
Nurses	28
Nurse-to-patient ratio	1:2
Nutritionists	1
Respiratory therapists	0
Material resources	
Bed capacity	7
Ventilators	7
Cardiac monitors	7
Oxygen supply ports	7
Invasive blood pressure monitoring (arterial line)	0
Arterial blood gas analyzer	0
Central venous pressure monitoring	0
Portable ultrasound	1
Portable x-ray	1
Infusion pumps	7
Pulse oximetry	7
Electrocardiogram machine	1
Renal replacement therapy	0
Capnography monitoring capacity	0

critically ill patients in an ICU is not homogeneous and many of the studies on which the guidelines are based are not always applicable in resource limited settings.

Rwanda is a country of 11.9 million in East Africa.[4] There are ≈80,000 surgical procedures performed annually in Rwanda, 510 major operations per 100,000 populations.[5] The University Teaching Hospital of Kigali (CHUK) is a public, tertiary referral hospital in Kigali, Rwanda. It provides ≤4,164 major operative cases across all surgical services every year.[6] It has 565 beds and 6 operating theaters shared among all surgical services. There are 7 ICU beds with capacity for mechanical ventilation and hemodynamic monitoring (Table I). The aim of this study was to assess the demographic, diagnosis, and factors influencing outcome of surgical patients in the CHUK ICU. We hypothesized that patients with an unplanned ICU admission had higher mortality compared with patients with planned ICU admission.

Material and Methods

The study was a cross-sectional observational study including all surgical patients admitted in ICU at CHUK in Rwanda from September 2017 to March 2018. All surgical patients were enrolled at ICU admission. Data collection was done using a coded checklist form. Data were recorded by the investigator, ICU staff, or surgical residents rotating in ICU during the study period. The investigator had no influence on patient management or discharge plans. Patients were primarily admitted to ICU either from the operating room side or through the emergency department. All participants or care takers signed a written consent before participation in the study. Follow-up was done on a daily basis, checking the proposed management and its implementation until the patient either died or discharged from the ICU.

Variables recorded included age, sex, duration of symptoms, time spent at district hospital before transfer, admission vital signs, surgical and critical care diagnosis on admission, vasopressors in the first hours of ICU admission, time of nutrition initiation, time spent on mechanical ventilation, and disposition from the ICU. Tachycardia was defined as heart rate >90 beats per minute. Tachypnea was defined as respiratory rate >20 breaths per minute. Hypotension was defined as systolic blood pressure <90 mm Hg. Febrile was defined as temperature greater that 38°C. Diagnoses were categorized as traumatic brain injury, trauma (nonhead injury), peritonitis, abdominal tumor, brain tumor, other neurologic condition. Head injury and trauma (nonhead injury) were categorized separately because of the differences in management at this hospital. Isolated head trauma patients are managed by the neurosurgery team, whereas polytrauma patients are managed by the acute care surgical service.

Data were recorded using Excel. Statistical analysis was done with STATA (College Station, TX, version 13.0). Categorical variables were analyzed with χ^2 or Fisher exact test. Continuous variables were analyzed with Wilcoxon rank sum test. Variables with P value $< .1$ were entered into a multivariate model to determine associations with mortality on ICU admission.

The research protocol was reviewed and approved by the University of Rwanda College of Medicine and Health Sciences institutional review board and the CHUK Ethics committee. The purpose of this study was explained to the patients or caretakers before being included in the study. Written informed consent was collected from each patient or caretaker before the start of the study.

Results

During a 7-month period, there were 126 surgical patients admitted to the ICU (Table II). Most ($n = 86$, 68%) were male with a median age of 39 years (interquartile range [IQR]: 26, 54). Most patients ($n = 106$, 85%) did not have any comorbidities. The most commonly identified comorbidities included HIV ($n = 10$, 8%), hypertension ($n = 6$, 5%), and cardiomyopathy ($n = 1$, 0.8%). Many ($n = 56$, 44%) patients had only 1 day of symptoms and presented emergently ($n = 105$, 83%). Median symptom duration was 2.5 days (interquartile range [IQR]: 1–21). Most patients ($n = 90$, 73%) spent <1 day at the district hospital. The most common diagnoses were head injury ($n = 55$, 44%), peritonitis ($n = 33$, 26%), brain tumor ($n = 15$, 12%), and trauma ($n = 15$, 12%).

Common indications for ICU admission included respiratory support ($n = 62$, 50%) and postoperative recovery ($n = 38$, 31%; Table III). There was no association between booking an ICU bed and mortality. There was no association between booking an ICU bed and access time to the ICU ($P = .523$). Most patients ($n = 124$, 98%) required mechanical ventilation, and only 42 (33%) patients required vasopressors. Dopamine and adrenaline are the vasopressors commonly available. Need for vasopressors was associated with a decreased survival ($P < .001$). Median duration of mechanical ventilation was 3 days (IQR: 1–4.5). Median duration of sedation was 2.5 days (IQR: 1–4.5). Most patients ($n = 94$, 75%) had nutrition initiated within 24 hours of ICU admission. Nutritional support initiated within 24 hours was associated with increased survival ($P < .001$). No patients received renal replacement therapy. The median ICU duration of stay was 3 days (IQR: 2–5.5).

The overall ICU mortality was 47% with the highest mortality seen in patients with peritonitis (76%; Table IV). On univariate analysis, factors associated with mortality included temperature, heart rate, respiratory rate, blood pressure, duration at district hospital, having any comorbidity, admitting team, and diagnosis. HIV status was not associated with mortality on univariate analysis ($P = .513$). After controlling for factors on multivariate analysis, variables associated with mortality included hypotension (odds ratio [OR]: 12.50, 95% confidence interval [CI]: 3.04, 51.32) and any comorbidity (OR: 5.69, 95% CI: 1.58, 20.50; Table V).

Table II
Characteristics of surgical patients admitted to the intensive care unit of a tertiary referral hospital in Rwanda

		Total N = 124	Survivors N = 66	Nonsurvivors N = 58	P value
Age, y	16–30	38 (30)	20 (29)	18 (31)	.933
	31–50	50 (40)	28 (41)	22 (38)	
	>50	38 (30)	20 (29)	18 (30)	
Sex	Male	85 (67)	43 (63)	42 (74)	.212
	Female	40 (32)	25 (37)	15 (26)	
Vital signs*	Febrile†	20 (16)	6 (9)	14 (24)	.028
	Tachycardia	91 (73)	40 (61)	51 (88)	.001
	Tachypnea†	27 (22)	7 (11)	20 (34)	.002
	Hypotension†	26 (21)	3 (5)	23 (40)	<.001
Glasgow coma scale	<8	37 (29)	15 (22)	22 (38)	.144
	9–12	18 (14)	14 (21)	4 (7)	
	13–15	15 (12)	8 (12)	7 (12)	
	Sedated	56 (44)	31 (46)	25 (43)	
Comorbidity†	Any	18 (15)	6 (9)	12 (21)	.078
	None	106 (85)	60 (91)	46 (79)	
Symptom duration	<7 d	68 (55)	38 (58)	30 (52)	.514
	≥7 d	56 (45)	28 (42)	28 (48)	
Duration at district hospital	≤1 d	90 (73)	54 (82)	36 (62)	.014
	>1 d	34 (27)	12 (18)	22 (38)	
Type of surgery	Elective	21 (17)	17 (25)	4 (7)	.007
	Emergent	105 (83)	51 (75)	54 (93)	
Admitting team†	General surgery	45 (36)	15 (22)	30 (52)	.003
	Neurosurgery	74 (59)	49 (72)	25 (43)	
	Orthopedics	7 (6)	4 (6)	3 (5)	
Surgical diagnosis†	Traumatic brain injury	55 (44)	32 (48)	22 (38)	.001
	Peritonitis	33 (26)	8 (12)	25 (43)	
	Brain tumor	15 (12)	13 (19)	2 (3)	
	Trauma (nonhead injury)	15 (12)	9 (14)	6 (10)	
	Abdominal tumor	4 (3)	2 (3)	2 (3)	
	Other neurologic	3 (2)	2 (3)	1 (2)	
Reoperation†	Yes	12 (10)	3 (4)	9 (16)	.065
	No	114 (90)	65 (96)	49 (84)	

* *Febrile*, temperature <38°C; *tachycardia*, heart rate >90 beats per minute; *tachypnea*, respiratory rate >20 breaths per minute; *hypotension*, systolic blood pressure <90 mm Hg.
† Fisher exact test.

Table III
Management in surgical patients admitted to the intensive care unit of a tertiary referral hospital in Rwanda

		Total N = 124	Survivors N = 66	Non-survivors N = 58	P value
Planned ICU admission	Yes	66 (52)	37 (54)	29 (50)	.621
	No	60 (48)	31 (46)	29 (50)	
Access time to ICU	Immediate	92 (73)	53 (78)	39 (67)	.479
	Delay 1–24 h	32 (25)	14 (21)	18 (31)	
	Delay 24–48 h	2 (1.7)	1 (1.5)	1 (1.7)	
Indication for ICU admission*	Respiratory support	62 (50)	35 (53)	27 (47)	<.001
	Postoperative recovery	38 (31)	27 (41)	11 (19)	
	Sepsis	23 (19)	3 (5)	20 (34)	
	Hemorrhagic shock	1 (1)	1 (1.5)	0	
Vasopressors*	Yes	42 (33)	3 (4)	39 (67)	<.001
	No	84 (67)	65 (96)	19 (33)	
Nutrition*	Within 24 h	94 (75)	61 (90)	33 (57)	<.001
	24–48 h	15 (12)	6 (9)	9 (16)	
	Not initiated	17 (13)	1 (1.5)	16 (28)	
Mechanical ventilation*	Yes	122 (98)	64 (97)	58 (100)	.498
	No	2 (2)	2 (3)	0 (0)	
Duration mechanical ventilation	0–5 d	98 (78)	51 (75)	47 (81)	.619
	5–10 d	16 (13)	9 (13)	7 (12)	
	>10 d	12 (10)	8 (12)	4 (7)	
ICU duration of stay, d	<1 d	7 (6)	1 (1.5)	6 (10)	.035
	1–7 d	96 (76)	51 (75)	45 (78)	
	>7 d	23 (18)	16 (24)	7 (12)	

* Fisher exact test.

Discussion

Surgical patients are commonly admitted to ICU in Rwanda like in other developing countries. In our study the main causes of ICU admissions were traumatic brain injury followed by peritonitis, brain tumors, and other trauma. Neurologic conditions and sepsis were common diagnoses in the ICU compared with other sub-Saharan African studies.[7] Prior studies have shown that the

Table IV
Mortality based on diagnosis

	Mortality (%)
Total	47
Peritonitis	76
Abdominal tumor	50
Traumatic brain injury	41
Trauma (non-head injury)	40
Other neurologic	33
Brain tumor	13

Table V
Multivariate analysis of factors on intensive care unit admission associated with mortality in surgical patients at a tertiary referral hospital in Rwanda

Variable	Odds ratio	95% Confidence Interval	*P* value
Febrile*	2.23	0.50, 9.99	.293
Tachycardia*	2.95	0.97, 8.92	0.56
Tachypnea*	2.44	0.80, 7.45	.117
Hypotension*	12.50	3.04, 51.31	<0.01
Any comorbidity	5.69	0.58, 20.50	0.08
Duration at district hospital >1 d	0.78	0.21, 2.89	.707
General surgery admission	0.80	0.08, 7.98	.849
Neurosurgery admission	0.60	0.08, 4.19	.603
Diagnosis peritonitis	2.25	0.37, 14.13	.389
Diagnosis brain tumor	0.27	0.04, 1.72	.166

* *Febrile*, temperature <38°C; *tachycardia*, heart rate >90 beats per minute; *tachypnea*, respiratory rate >20 breaths per minute; *hypotension*, systolic blood pressure <90 mm Hg.

incidence of and mortality from traumatic brain injury are disproportionately higher in low resource settings.[8]

The high mortality found in our study (46.1%) is comparable to results found in Africa (47%) in the Intensive Care over Nations audit.[9] However, ICU mortality is lower in high income countries.[9] In an observational multinational cohort study done in 17 European countries where 5,834 patients were admitted in ICUs, 1,113 (19%) patients died in the ICU.[3] ICU mortality in different studies varies widely, with ICU mortality rates ranging from 15% to 50%. This is likely related to patient selection and critical illness. The mortality rate in this ICU population was relatively high at 46.1%. Owing to resource limitations, we are unable to calculate Acute Physiologic Assessment and Chronic Health Evaluation II scores or other measures of critical illness. However, almost all (98%) of patients admitted to the ICU required mechanical ventilation. This suggests a critically ill patient population. At this hospital, patients are not admitted to the ICU for close monitoring. They are admitted to the ICU because they need ICU-specific interventions.

Mortality was highest in patients with peritonitis, consistent with prior studies in the patient population.[10] Other studies have shown high mortality in ICU patients with septic conditions.[9] Delayed presentation is a challenge in this population. Patients with peritonitis generally present after 4 days of symptoms.[11] A prior study of critical care management of patients with peritonitis showed that 85% of patients with peritonitis that required ICU admission had sepsis on hospital admission and 91% had an American Society of Anesthesiologists score of 3 or 4.[10] Although the hospital laboratory is able to process specimens for culture and antibiotic sensitivity, not all patient's families are able to afford these tests. In addition, there are limited antibiotic options, making it challenging to tailor antibiotics. Specific details on bacterial pathogens and antibiotic therapy was not captured in this study but has been reported in elsewhere.[12]

In this study, unplanned ICU and booking was not found to be associated with delayed ICU admission or poor outcomes as we would expect.[13] This can be partially explained by the fact that at the time when there was no bed available, an ICU-like environment was created in the post anesthesia care unit (PACU). This temporary solution delays the PACU flow of patients and progress of theatre program. In other low-resource settings, due to a shortage of ICU beds, patients may be refused ICU admission.[14]

In our study the Glasgow Coma Scale score (GCS) was not found to be associated with an increased risk of mortality ($P = .144$). This is in contrast a study done in the United Arab Emirates where a significant risk were found with decreased GCS ($P = .001$).[15] It may be due to the fact that many of the patients in our study were sedated at the time of evaluation complicating accurate assessment of the GCS.

Most patients were started on enteral nutrition within 24 hours. Early nutrition was found to be associated with low mortality rate in our study. This is comparable with many studies done worldwide. In a meta-analysis done in 2009, 6 randomized control trials with 234 participants were analyzed and found that provision of early enteral nutrition was associated with a significant reduction in mortality (OR = 0.34, 95% CI, 0.14–0.85).[16]

Most patients required mechanical ventilation. This is in contrast to a study in Sudan where only 35% of patients required mechanical ventilation.[7] In our study, being on vasopressors in the first 48 hours of admission was associated with poor outcome. This is consistent with a prior study which found that vasopressor exposure early after critical injury was associated with increased risk of mortality, regardless of fluid status.[17]

There are several study limitations. One limitation is the small sample size. However, we captured data during a 7-month period and believe this is representative of surgical patients admitted to the ICU at this hospital. This study only looked at surgical patients admitted to the ICU. Although this accounts for the majority of patients in Rwandan ICUs, it does not represent all patients.[18] Because this study focused on all surgical ICU patients, we did not collect disease specific risk factors, such as ISS (or Kampala Trauma Score) in trauma patients. This study only includes surgical patients admitted to the ICU. Some patients may have died before ICU admission. Also, owing to delays, some patients may have improved in the PACU and thus avoided ICU admission. Other patients may have been refused ICU admission owing to a lack of beds or because of advanced disease. Other studies have shown the importance of triage in low resource settings to optimize use of resources such as ICU beds.[14] There is limited data on cause of death available. Although there is a mortality log, it unfortunately does not capture granular detail on cause of death, with most deaths attributed to "cardiac arrest."

Surgical patients admitted to the ICU bear a significant mortality. Common surgical ICU diagnoses include head injury and peritonitis with the highest mortality rates seen in patients with peritonitis. We recommend a review of the admission policy to optimize utility of the ICU, favoring those patients who are more likely to benefit from ICU admission.

Acknowledgement

We acknowledge the University of Rwanda and CHUK staff for the support of this work.

Conflict of interest

The authors have indicated that they have no conflict of interest.

Funding

No funding was received for this manuscript.

References

1. Adhikari NK, Fowler RA, Bhagwanjee S, et al. Critical care and the global burden of critical illness in adults. *Lancet*. 2010;376:1339–1346.
2. Riviello ED, Letchford S, Achieng L, et al. Critical care in resource-poor settings: lessons learned and future directions. *Crit Care Med*. 2011;39:860–867.
3. Capuzzo M, Volta C, Tassinati T, et al. Hospital mortality of adults admitted to Intensive Care Units in hospitals with and without intermediate care units: a multicentre European cohort study. *Crit Care*. 2014;18:551.
4. The World Bank In Rwanda: World Bank Group; 2019. Available from: http://www.worldbank.org/en/country/rwanda. Accessed January 12, 2019.
5. Petroze RT, Nzayisenga A, Rusanganwa V, et al. Comprehensive national analysis of emergency and essential surgical capacity in Rwanda. *Br J Surg*. 2012;99:436–443.
6. Notrica MR, Evans FM, Knowlton LM, et al. Rwandan surgical and anesthesia infrastructure: a survey of district hospitals. *World J Surg*. 2011;35:1770–1780.
7. Sulieman H, El-Mahdi W, Awadelkareem M, et al. Characteristics of critically-ill patients at two tertiary care hospitals in Sudan. *Sultan Qaboos Univ Med J*. 2018;18:e190–e195.
8. Kuo BJ, Vaca SD, Vissoci JRN, et al. A prospective neurosurgical registry evaluating the clinical care of traumatic brain injury patients presenting to Mulago National Referral Hospital in Uganda. *PLoS One*. 2017;12:e0182285.
9. Sakr Y, Jaschinski U, Wittebole X, et al. Sepsis in intensive care unit patients: worldwide data from the intensive care over nations audit. *Open Forum Infect Dis*. 2018;5:ofy313.
10. Rickard J, Ngarambe C, Ndayizeye L, et al. Critical care management of peritonitis in a low-resource setting. *World J Surg*. 2018;42:3075–3080.
11. Ndayizeye L, Ngarambe C, Smart B, et al. Peritonitis in Rwanda: epidemiology and risk factors for morbidity and mortality. *Surgery*. 2016;160:1645–1656.
12. Rickard J, Ngarambe C, Ndayizeye L, et al. Antibiotic use and antimicrobial resistance of surgical patients with peritonitis at a tertiary referral hospital in Rwanda. *Surg Infect (Larchmt)*. 2018;19:382–387.
13. Cardoso LT, Grion CM, Matsuo T, et al. Impact of delayed admission to intensive care units on mortality of critically ill patients: a cohort study. *Crit Care*. 2011;15:R28.
14. Bouneb R, Mellouli M, Dardouri M, et al. Determinants and outcomes associated with decisions to deny intensive care unit admission in Tunisian ICU. *Pan Afr Med J*. 2018;29:176.
15. Hefny AF, Idris K, Eid HO, et al. Factors affecting mortality of critical care trauma patients. *Afr Health Sci*. 2013;13:731–735.
16. Khalid I, Doshi P, DiGiovine B. Early enteral nutrition and outcomes of critically ill patients treated with vasopressors and mechanical ventilation. *Am J Crit Care*. 2010;19:261–268.
17. Plurad DS, Talving P, Lam L, et al. Early vasopressor use in critical injury is associated with mortality independent from volume status. *J Trauma*. 2011;71:565–570; discussion 70-2.
18. Riviello ED, Kiviri W, Fowler RA, et al. Predicting mortality in low-income country icus: the rwanda mortality probability model (R-MPM). *PLoS One*. 2016;11:e0155858.