

Mortality Trends at the Kenyatta National Hospital Surgical Operating Theaters: A 5-Year Retrospective Study

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Abstract

Background: Mortality studies inform hospital disease trends and predict possible poor outcome. This study aimed to establish mortality trends over the last 5 years and the associated risk factors at the Kenyatta National Hospital (KNH) surgical operating theaters and to establish the completeness of surgical safety checklist.

Methods: In this analytical retrospective study, study population was 94,820 patients operated between January 2015 and December 2019 and a sample of all 145 patients who died intraoperatively. Sampling was done by census. Data were extracted from available 118 deceased patients' records and analyzed using Statistical Package for Social Sciences version 25. **Results:** Theater mortality rate was 0.153%. Sex-specific mortality rate was higher in males than in females (23.7 and 7.4 per 10,000, respectively). The mortality rate slowly declined over the period. The risk of death in theater was higher in neonates and in patients older than 80 years (54.3 and 39.2 per 10,000, respectively),

emergency patients, and general anesthesia ($p < 0.001$). The risk of death in theater increased with American Society of Anesthesiologists (ASA) class and was higher in surgeries conducted off working hours ($p < 0.001$). The surgical safety checklist was fully filled in 39.0% cases. **Conclusion:** Theater mortality trend was declining. Risk factors included extremes of age, sex, emergency surgery, increasing ASA class, and off working hours. Advocacy for use of a surgical safety checklist is needed.

Keywords: Theater death, Peri-operative mortality rate, Risk factors, Surgical safety checklist, Kenya

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Introduction

Theater mortality inadvertently occurs. Study of mortality trends informs disease trends seen at an institution, predicts possible poor outcome, and helps make informed decisions on improvement of quality of patient care.

Kenyatta National Hospital (KNH) is a tertiary teaching and referral hospital in Kenya with a bed capacity of 1,800 and 18 operating theaters (1). It serves as a regional referral hospital for all specialties and a training institution for various medical colleges, handling both

elective and emergency surgeries. There are 76 intensive care unit beds, of which 10 are dedicated to medical cases.

The operating theaters are designed such that there is a common receiving area for all patients, individual operating rooms, and a common post-anesthetic care unit (PACU). Intra-operative mortality at KNH is recorded as death once a patient is received into the operating room for a surgical procedure and dies before discharge from PACU. Patients are discharged from

PACU once they meet a modified Aldrete score of 9. Review of publications that used the same definition showed mortality rates of 0.16% over 7 years in Brazil (2) and 0.057% between 2004 and 2006 and 0.133% between 2015 and 2016 in a Malawi hospital (3). At the time of this study, KNH aimed at maintaining it at $\leq 0.1\%$ (4).

Various factors have been associated with increased risk of peri-operative mortality. These include emergency surgery (3,5,6), American Society of Anesthesiologists (ASA) physical status >3 (7,8), extremes of age (2,5,9,10), type of operation (6,9,10,11), and multiple surgeries (10,11). Recently, the use of the World Health Organization's (WHO) surgical safety checklist has been shown to reduce peri-operative morbidity and mortality (12,13).

The purpose of this study was to establish the mortality trends at the KNH operating theaters over the last 5 years. Secondary objectives were to establish risk factors associated with theater mortality and completeness of surgical safety checklist. There has been no published baseline data on theater mortalities at the time of this study.

Methods

Logistical and ethical approval (P151//03/2020) was obtained from the KNH University of Nairobi Ethics and Research Committee (reference KNH-ERC/A/243), and the study was registered with the Department of Research and Programs at Kenyatta National Hospital (reference Theatre/26/2020).

This was an analytical retrospective study carried out at KNH operating theaters. The study population was 94,820 patients who received surgery between January 2015 and December 2019 and a sample of all 145 patients who died during operation. Intra-operative mortality at KNH is recorded as death once a patient is received into operating room for a surgical procedure, and dies before discharge from PACU. Patients are discharged from PACU once they meet a modified Aldrete score of 9. Sampling was by census to reduce bias. Data were extracted using a structured template. The extracted data included age, sex, patient type (walk-in or referral), urgency of surgery (emergency or

elective), day and time of surgery, surgical specialty, ASA classification and completeness of WHO checklist. Off working hours were between 1700 and 0800 hours and on weekends. Validity was ensured and reliability of data was ascertained using a Cronbach's alpha coefficient of 0.987. Data were analyzed using the Statistical Package for Social Sciences version 25 (IBM Corp., Armonk, NY, USA) Descriptive statistics included frequencies and percentages. Mortality trend analysis included crude, age-adjusted, and sex-adjusted mortality rates. Linear forecast was conducted using least square methods, line of best fit of mortality rates, and moving averages of mortality rates. To compare differences between population sections, t-test, chi-square test, and binomial tests were used.

Results

In the 5-year period, 94,820 operations were performed (Figure 1). Of these, 29,591 (31.2%) operations were performed on males, whereas 65,229 (68.8%) were performed on females. Among these patients, there were 145 theater deaths, giving a mortality rate of 15.3 per 10,000 operations (0.153%). Of the 145 theater deaths, 27 (18.6%) patient records were missing. The available records comprised of 70 (59.3%) males and 48 (40.7%) females.

For the linear forecast, the negative gradient (0.001) in the forecast model indicated a general slow decline in the mortality rate over time (Figure 2). The moving averages are presented in Figure 3.

Analysis of risk factors

The patient characteristics are presented in Table 1. There were significantly more males (70, 59.3%) than females (48, 40.7%) ($p=0.05$). Sex was a significant patient-related risk factor in this study. Sex-specific mortality rate was 7.4 per 10,000 for females and 23.7 per 10,000 for males. Males were 3.2 times more likely than females to die during operation. Patient type (walk-in and referral) was not a significant patient-related risk factor in this study. Proportions of walk-in (52, 44.1%) and referral (66, (55.9%) patients were not significantly different ($p=0.231$). Sections of emergency (95, 80.5%) and elective surgery (23, 19.5%) patients were

significantly different, with emergency patients being at a higher risk of death ($p<0.001$). Risk of death in theater significantly increased with ASA class ($p=0.003$). The risk of death in theater was significantly higher in neonates and patients ≥ 80 years ($p<0.001$) (Figure 4 and Table 2).

Table 1. Patient characteristics

DEMOGRAPHIC CHARACTERISTICS	CATEGORIES	FREQUENCY	PERCENTAGE
Sex	Female	48	40.7
	Male	70	59.3
Patient category	Walk-in	52	44.1
	Referral	66	55.9
Surgical category	Elective	23	19.5
	Emergency	95	80.5
ASA class	Not indicated	73	61.9
	I	3	2.5
	2	8	6.8
	3	13	11.0
	4	17	14.4
	5	4	3.4

ASA, American Society of Anesthesiologists.

Institutional factors

The study assessed time of surgery, support systems, and type of anesthesia as probable institution-related risk factors for deaths in theaters (Table 3). Time of surgery was a significant risk factor for death. Most (62, 52.5%) of the surgeries among the deceased were conducted off working hours, that is, on weekends and between 1700 and 0800 hours. Surgeries conducted off working hours presented a higher risk of death ($p<0.001$). General anesthesia was significantly associated with most (92, 78.0%) mortal outcomes ($p<0.001$). Arrest at maintenance (54, 45.8%) was the highest recorded antecedent event ($p<0.001$). Other antecedent events included arrest at induction (11, 9.3%), arrest at reception (15, 12.7%), arrest at recovery (29, 24.6%), and arrest at reversal (9, 7.6%) (Table 4).

Availability of blood and critical care units

Of the deceased patients, 43 (36.4%) needed post-operative critical care unit (CCU) beds, but only 24 (55.8%) were available. Meanwhile, 66 (55.9%) deceased patients needed blood, and most (54, 81.8%) received blood. Unavailability of blood was not a significant factor for death in theaters ($p=0.231$).

Type of surgery

Patients from general surgery (29, 24.6%), neurosurgery (21, 17.8%), reproductive health (21, (17.8%)), and cardiothoracic surgery (17, 14.4%) were significantly associated with more deaths compared with other surgeries ($p<0.001$) (Table 5).

Table 2. Patient age

AGE	TOTAL CASES	NO. OF DEATHS	AGE-SPECIFIC MORTALITY RATE PER 10,000
New born to 30 days	1288	7	54.3478
31 days to <1 year	2193	5	22.7998
1 to <4 years	5672	8	14.1044
4 to 18 years	6187	11	17.7792
19 to 35 years	55,544	49	8.82183
36 to 50 years	14,955	19	12.7048
51 to 64 years	5304	11	20.7391
65 to 79 years	3167	5	15.7878
≥ 80 years	510	2	39.2157

Completeness of Surgical Safety Checklist

The surgical safety checklists were fully filled among 46 (39.0%) patients and partially filled among 7 (5.9%) patients. Information was missing among 53 (44.9%) patients.

Table 3. Institutional risk factors

<i>SURGE RY PERIOD</i>	<i>CATEG ORY</i>	<i>FREQUE NCY</i>	<i>PERCENT AGE</i>	<i>P VAL UE</i>
<i>Time of surgery</i>	<i>Off working hours</i>	62	52.5	<i><0.0 01</i>
	<i>Working hours</i>	56	47.5	
<i>Blood requirem ent</i>	<i>Not needed</i>	52	44.1	0.231
	<i>Needed</i>	66	55.9	
<i>Availabil ity of blood CCU bed request</i>	<i>Not available</i>	12	18.2	<i><0.0 01</i>
	<i>Available</i>	54	81.8	
	<i>Not requeste d</i>	75	63.6	0.006
	<i>Requeste d</i>	43	36.4	
<i>CCU bed availabil ity</i>	<i>Not available</i>	19	44.2	0.542
	<i>Available</i>	24	55.8	
<i>Type of anesthesi a</i>	<i>None/CP R</i>	15	12.7	<i><0.0 01</i>
	<i>protocol</i>			
	<i>General anesthesi a</i>	92	78.0	
	<i>Local anesthesi a</i>	5	4.2	
	<i>Regional anesthesi a</i>	6	5.1	

CCU, critical care unit; CPR, cardiopulmonary resuscitation.

Table 4. Type of anesthesia

<i>ANTECEDE NT EVENTS</i>	<i>FREQUENC Y</i>	<i>PERCENTA GE</i>	<i>P VALU E</i>
Arrest induction	at 11	9.3	<0.001
Arrest maintenance	at 54	45.8	
Arrest reception	at 15	12.7	
Arrest recovery	at 29	24.6	
Arrest reversal	at 9	7.6	

Table 5. Type of surgery

<i>TYPE SURGERY</i>	<i>OF Y</i>	<i>FREQUENC Y</i>	<i>PERCENTAG E</i>	<i>P VALU E</i>
Cardiothoraci c surgery	17	14.4	<0.001	
Neurosurgery	21	17.8		
General surgery	29	24.6		
Reproductive health	21	17.8		
Ear/nose/thro at surgery	7	5.9		
Medical ward	1	0.8		
Orthopedic surgery	7	5.9		
Pediatric surgery	8	6.8		
Pediatric ward	9	7.6		
Plastic surgery	2	1.7		
Urology	1	0.8		

MORTALITY TRENDS AT THE KENYATTA NATIONAL HOSPITAL SURGICAL OPERATING THEATERS

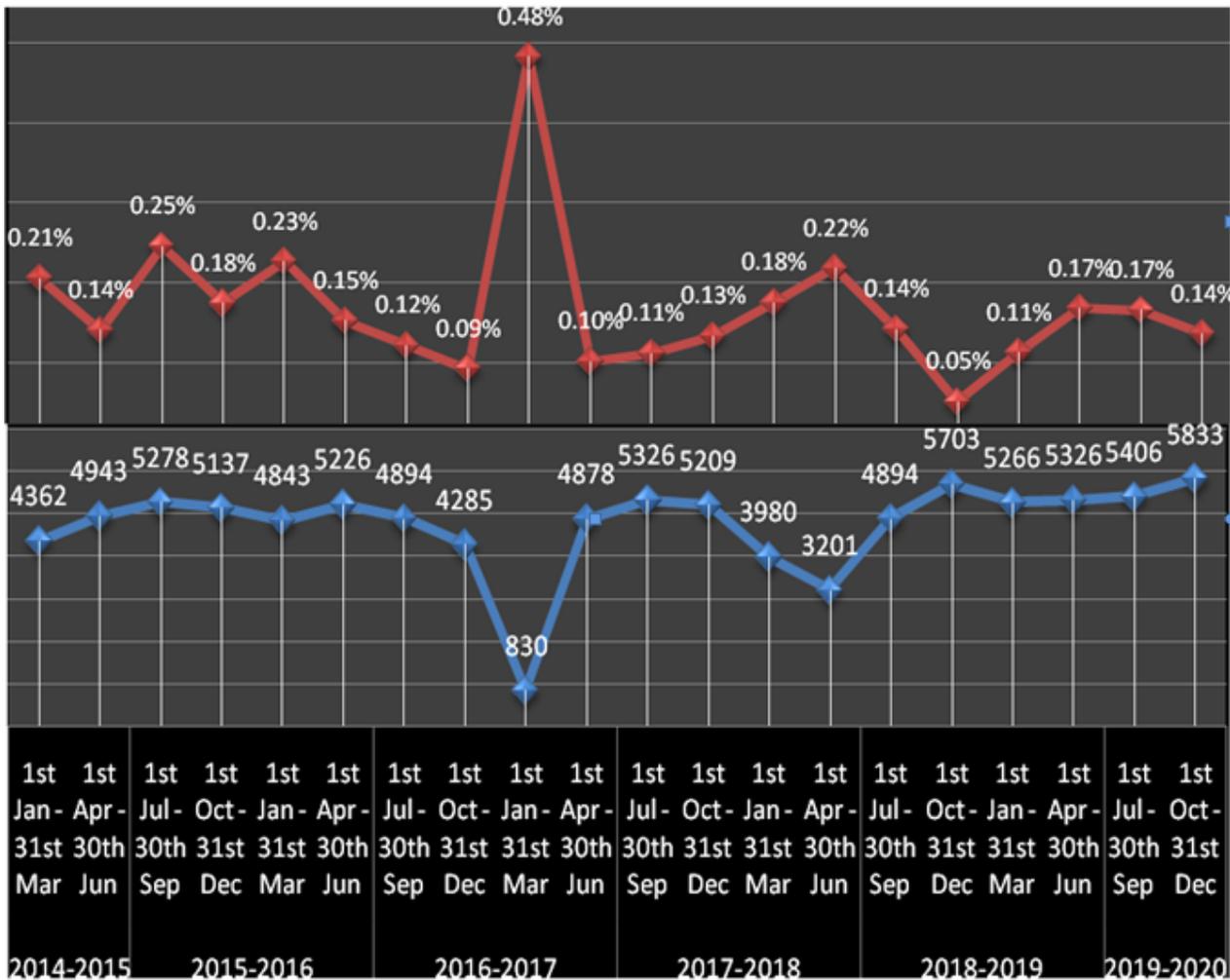


Figure 1. Mortality trend and total cases done.

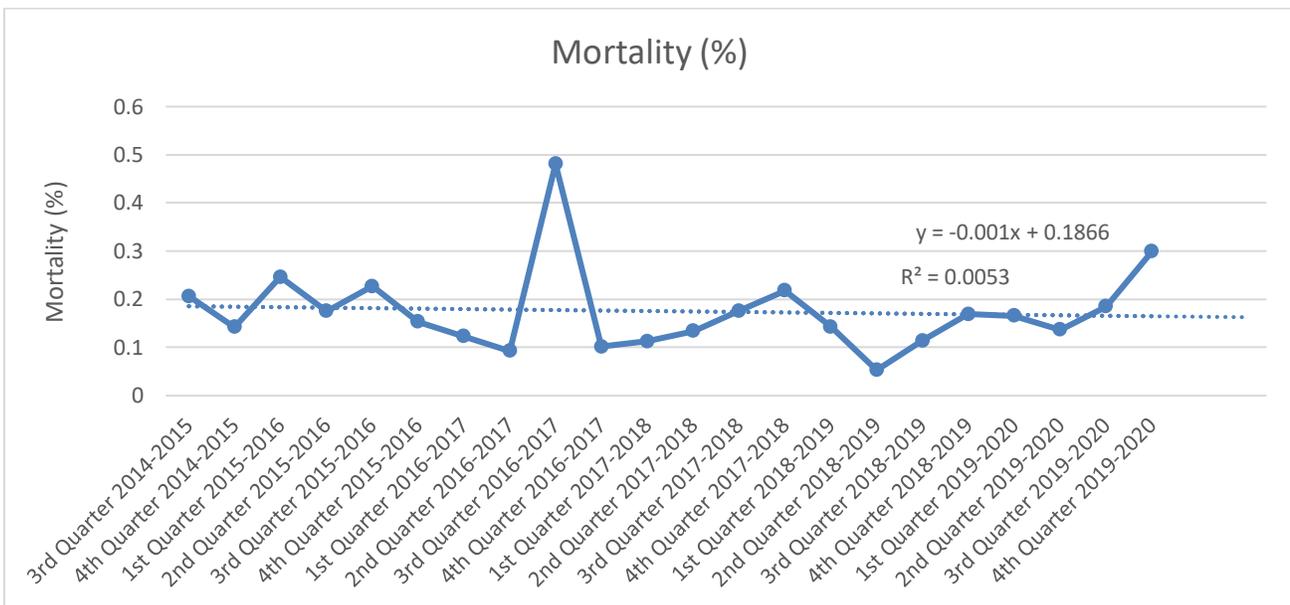


Figure 2. Responses assessing students' challenges to online learning.

Figure 3. Moving averages.

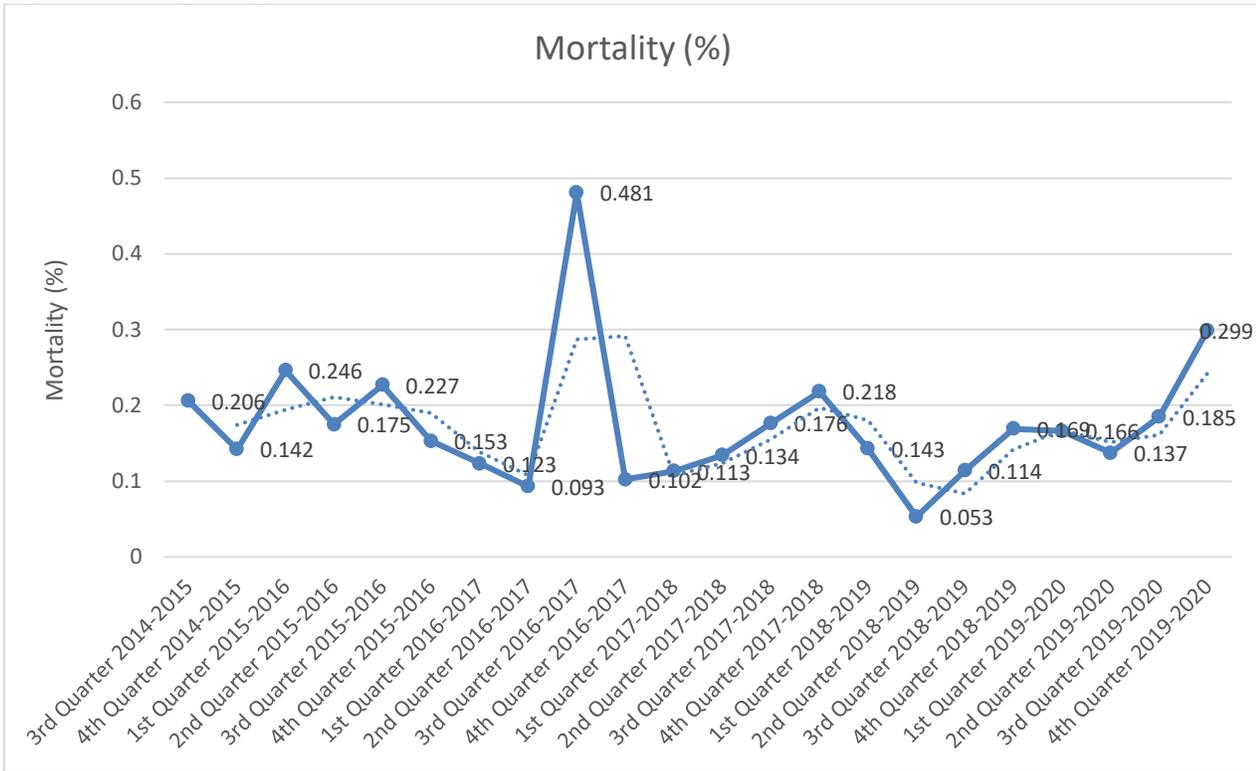
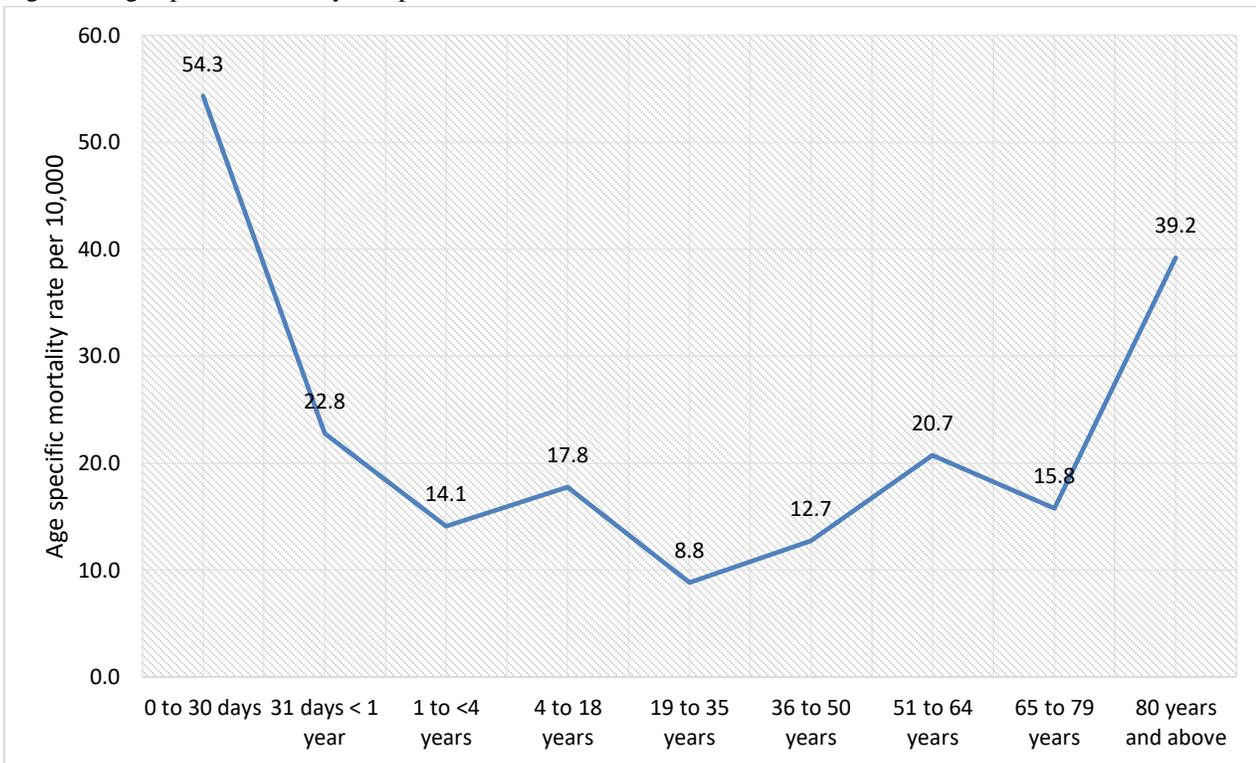


Figure 4. Age-specific mortality rate per 10,000.



Discussion

The purpose of this study was to establish theater mortality trends and associated risk factors at KNH. Global trends of intra-operative mortality have not been easy to analyze due to substantial variations in study methodology and definitions of terminology (14,15). Different publications use varied definitions for peri-operative mortality. The peri-operative period has been defined as intra-operative only (16), intra-operative and recovery from anesthesia (17,18), the first 12 post-operative hours (19), the first 24 post-operative hours (20,21), 2 or 3 post-operative days (22), or 7 post-operative days (23), and 30-day mortality. KNH records intra-operative death as death once patient is received into operating room for a surgical procedure and dies before discharge from PACU.

The theater mortality rate over 5 years was found to be 0.153%, with a progressive decline over time. This is comparable to a study done in Brazil, which found an intra-operative mortality rate of 0.16% (2). In contrast, studies in Malawi showed an intra-operative mortality rate of 0.057% between 2004 and 2006, which increased to 0.133% between 2015 and 2016 (3).

The risk factors associated with increased mortality include extremes of age, male sex, emergency surgery, ASA status >3, and surgery conducted off working hours. General anesthesia had a close association with mortal outcomes. However, this study is not powered to conclusively state its causation, knowing that several other patient-specific factors may be confounding.

Emergency surgery

Patients undergoing emergency surgery were found to be at a higher risk of death compared with elective surgery. This is consistent with what was found in other studies done in Malawi, Kenya, Malaysia, and Brazil (3,5,6,9). This may be explained by the fact that patients for emergency surgery may not be as optimized as elective patients and may have serious life-threatening conditions that have progressively deteriorated.

In this study, 12.7% of patients died on being received to theater even before induction of anesthesia, and it is possible surgery in this group of patients was salvage or the last attempt to save life. Severe trauma that is not

adequately compensated for in resuscitation may also account for the increased risk of death among the emergency patients.

ASA physical status, age, and sex

Consistent with other studies (7,8), risk of death increased significantly with increasing ASA class. This truly confirms the use of the ASA classification for risk stratification and may contribute to the discussion of informed consent for surgery with the patients and their guardians.

Age was also a significant risk factor, with neonates and patients ≥ 80 years being at a higher risk of death. This was consistent with other studies (2,7,9,10). The influence of age in those studies for neonates and infants was attributed to immaturity and congenital diseases, whereas for older patients, chronic diseases, including cancer and cardiovascular disease, contributed to the higher risk of death. It would be of interest to study the disease profiles of the neonates seen at KNH. The general lack of pediatric surgical services in the country would probably point at most of the children being from referral placement, with precious time lost in transit, and arriving beyond physiological salvage.

Males were found to be at a higher risk of death than females. This is similar to findings in other studies (2,9,18,20). The higher mortality in males can be attributed to the higher predisposition to trauma and vascular diseases.

Time of surgery

Surgeries conducted off working hours and weekends presented a higher risk of death compared with those done during regular working hours. This could be explained by the availability of more staff and support systems during working hours. In a study that looked at predictors of survival following cardiac arrest in patients undergoing non-cardiac surgery, survival was seen to be lower in patients who experienced an arrest during non-standard working hours (18). This was attributed to reduced staff available to respond to cardiac arrests during off-hours.

Type of anesthesia and surgery

General anesthesia was associated with more deaths than regional anesthesia. Most of the deceased patients originated from general surgery (24.6%), neurosurgery (17.8%), and cardiothoracic (14.4%) departments. These surgeries are typically performed under general anesthesia. Very sick patients tend to be operated under general anesthesia. Similar findings were seen in the study done in Brazil (2). However, as stated earlier, this study cannot conclusively relate mortality to general anesthesia without analyzing and factoring other associated circumstances.

Most cardiac arrests occurred during maintenance of anesthesia (45.8%). A significant proportion of patients had a cardiac arrest at reception (12.7%); this may point toward pre-operative optimization of patients and delays in surgical intervention. Meanwhile, 24.6% of the patients had a cardiac arrest at recovery, and a lack of critical care unit beds and advanced post-operative care may have contributed to mortality in this group of patients.

Completeness of WHO checklist

The WHO surgical safety checklist is an evidence-based tool to reduce morbidity and mortality associated with surgery. It is recommended for use in all surgeries in all WHO regions (12). It is estimated that half million mortalities annually can be mitigated through global implementation of the checklist (13). In this study, the WHO safety checklist implementation was found to be low (39.0%) among the mortalities. This shows that implementation has remained low, as previously found in a study by Epiu et al., wherein the compliance rate at KNH was found to be 19% (24). Advocacy for use of surgical safety checklist is needed.

Study limitations

There is no real-time electronic data recording system in use at KNH operating theaters. The study therefore depended on deceased patient record retrieval by the hospital's health information systems officer; 18.6% of the patients' records were missing, but the missing records were randomly distributed over a 5-year period, thus reducing bias. Computation of the crude mortality

rate used all 145 reported mortalities to avoid bias. Age- and sex-adjusted death rates were computed using the available 118 patient records, and this may have introduced some bias.

The findings of the study are institutional-based and therefore are not representative of the intra-operative mortality trends in Kenya.

Conclusion

Theater mortality trend in KNH shows a declining trend. Risk factors include extremes of age, emergency surgery, increasing ASA class, off working hours, and need for CCU admission. Advocacy for use of surgical safety checklist is needed.

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