Blood Loss and Transfusion during Open Femur Fracture Surgeries at Moi Teaching and Referral Hospital, Eldoret, Kenya

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Blood Loss and Transfusion during Open Femur Fracture Surgeries at Moi Teaching and Referral Hospital, Eldoret, Kenya

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Abstract- Fractures of the femur due to increased road traffic accidents are on the rise and lead among orthopedic trauma conditions at Moi Teaching and Referral Hospital (MTRH). The best treatment is open surgery with fixation and stabilization using implants, mostly because fractures are either old or due to lack of equipment for closed or percutaneous surgery, leading to blood loss necessitating transfusion. MTRH experiences excessive blood cross-match relative to actual transfusion, wasting reagents and blood. There is a paucity of publications on factors associated with blood loss and the transfusion pattern in open femur fracture surgeries.The main objective was to determine factors affecting blood loss and transfusion during open femoral fracture surgeries at MTRH, Eldoret. A cross sectional study conducted at MTRH on adult patients undergoing open femur fracture surgeries between February 2022 and January 2023 on a sample of 172 patients using interviewer administered pretested structured questionnaire. The results showed that the Age range: 18-92 years, mean 47.3 ±20.3 years, majority male (71.5%). Blood loss: 45-3960 mL, mean 1274.1 ±714 mL. Cross-matched all, but only 19.8% transfused (CTR: 6.7:1). BTR: 19.8%, mostly 2 units. Transfusion reasons: visual estimation (58.8%), low hemoglobin (41.2%). AO fracture 31: 51.7%. IM SIGN nail: 37.2%, PFNA: 33.1%. Spinal anesthesia: 82.6%, diathermy in all. Consultants led 83.7%, registrars 5.2%. Surgeries: >2 hours (41.9%), incision 15-25 cm (69.8%).

This concludes that blood loss was high, with excessive cross-matching and wastage of blood indicated by a high CTR, while transfusion rates were low and primarily determined by anaesthetists' visual estimation. Factors contributing to blood loss included timing of surgery, fracture complexity, and surgery duration. From the study, prompt surgery to minimize blood loss, anticipation of significant blood loss in complex cases, selective cross-matching, transfusion only for patients with low haemoglobin levels, and early identification and mitigation of factors contributing to blood loss and transfusion.

I. Introduction

In developing countries, femoral fractures represent a significant burden on healthcare systems, particularly in emergency departments where orthopaedic surgeons encounter these injuries regularly (Agarwal-Harding et al., 2015) . These fractures can result from various traumatic events, with road traffic accidents, falls from heights, and gunshot wounds being common causes. The incidence of femoral fractures varies across regions, with Tanzania reporting an annual rate ranging from 2.1 to 18.4 per 100,000 people (Conway et al., 2019).

The prevalence of femoral fractures is closely linked to the epidemiology of trauma in each country. In Kenya, for example, more than 3,000 individuals succumb to trauma-related injuries each year, with a significant proportion attributed to road traffic accidents (Opondo & Kiprop, 2018). Globally, the impact of traffic accidents is staggering, with over 1.3 million fatalities annually, with the majority occurring in low- and middle-income nations (WHO, 2022). Femoral fractures resulting from such accidents often lead to substantial mortality and morbidity rates, especially when considering the associated complications and long-term sequelae (Opondo & Kiprop, 2018).

The etiology of femoral fractures exhibits a bimodal distribution, with peaks observed in different age groups. Young individuals typically experience high-energy injuries, such as those sustained in motor vehicle accidents, resulting in femoral fractures (Dim et al., 2012). Conversely, older patients may suffer fractures due to low-energy mechanisms, often associated with conditions like osteoporosis or multiple myeloma(Stevenson et al., 2014). These fractures can manifest as simple, wedge, or complex fractures, each requiring tailored management strategies (Meinberg et al., 2018).

The preferred method of treatment for femoral shaft fractures in adults is intramedullary nailing, a procedure associated with favorable outcomes when performed promptly and accurately. However, in resource-constrained settings, such as many healthcare facilities in low- and middle-income countries, intramedullary nailing may be performed without access to essential equipment like traction tables or fluoroscopy machines, necessitating alternative approaches that may increase the risk of intraoperative complications(Cai et al., 2023).

Orthopedic surgeries, including those for femoral fractures, are often accompanied by significant blood loss, leading to postoperative anemia and the need for blood transfusions (Giribabu et al., 2024). Blood loss during surgery is influenced by various factors, including surgical technique, patient characteristics, and the duration of the operation (Gerdessen et al., 2021). Quantifying blood loss accurately is challenging due to the absence of standardized protocols, although methods such as direct measurement and hematocrit changes are commonly employed.

Despite advances in surgical techniques and perioperative care, blood transfusion practices remain variable and subjective, contributing to issues such as blood shortages and unnecessary transfusions (Elmi et al., 2016). At Moi Teaching and Referral Hospital (MTRH), like many other healthcare facilities in similar settings, the management of femoral fractures presents unique challenges, including unpredictable blood loss and transfusion requirements. Improving transfusion practices requires a comprehensive understanding of factors affecting blood loss and transfusion patterns during open femoral fracture surgeries, which is currently lacking in the local context.

Post-operative anemia is a common complication following open femur surgeries due to intraoperative blood loss. Anemia after major orthopedic surgery like open reduction and internal fixation (ORIF) of femur fractures is associated with longer hospital stays, infections, decreased physical function, slower healing, and even mortality(Koch et al., 2015). The need for blood and blood components at MTRH is rising due to an increase in orthopedic trauma cases from accidents, and the transfusion process remains subjective, leading to periodic shortages.

The Orthopaedic Trauma Department at MTRH faces challenges of unnecessary blood transfusions, unpredictable blood supply, and increased demand due to rising accident cases (Ngetich, 2021). Data from MTRH shows a significant number of femur fracture patients receiving blood transfusions, often beyond necessity, leading to wastage(Adegboye, Kadir, et al., 2018). Limited local data on blood loss and transfusion patterns during open femur surgeries highlights the need for research to tailor transfusion practices to the hospital's setup and patient population. Establishing specific transfusion protocols for orthopedic patients at MTRH is crucial for enhancing patient care and optimizing blood utilization in surgical settings.

This study is justified by the fact that Femoral fractures, common at MTRH due to high-energy trauma, pose significant complications with a high incidence rate globally and in low to middle-income countries. Surgical management is standard, often necessitating blood transfusions due to intraoperative blood loss, yet local research on perioperative blood loss and transfusion patterns is lacking. Understanding factors influencing blood loss in open femoral fracture surgeries is crucial for surgeons to minimize risks, informing postoperative transfusion decisions and guiding the development of transfusion algorithms. Limited local research data underscores the need for guidelines formulation on blood transfusion during these surgeries, crucial for optimizing blood utilization and minimizing wastage or adverse effects on patients and operation costs.

Femur Anatomy

The femur, recognized as the body's strongest, longest, and heaviest bone, plays a pivotal role in weight-bearing and maintaining gait stability (Moore et al., 2014). Anatomically, it features a pyramidal neck connecting the head and trochanteric region, encompassing the greater and lesser trochanters (Salminen et al., 2000). The angle of inclination, approximately 128 degrees between the neck and shaft, varies with age and gender, gradually decreasing over time (Fischer et al., 2019). Proximally, the femoral head attaches to the pelvis's acetabulum via the ligamentum teres, while distally, the femur's medial and lateral condyles articulate with the tibial epicondyles in the knee joint, forming synovial joints cushioned by cartilage to reduce friction and optimize movement (Li et al., 2021). Blood supply to the femur is provided by the medial and lateral circumflex arteries, supplemented by the fovea artery to the head and perforating branches of the deep femoral artery to the shaft and distal femur (Li et al., 2021). The knee joint, formed by the distal femur and proximal tibia, is stabilized by ligaments and menisci, with the anterior and posterior cruciate ligaments permitting rotational movement while preventing tibial displacements (Shahibullah et al., 2023)

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Femur Fractures and Classification

The classification and characteristics of femur fractures vary across demographics and locations along the bone. High-energy fractures in young individuals often result from accidents or falls from heights, while in elderly women, fractures occur due to minor falls (Agarwal-Harding et al., 2015). Proximal femur fractures, categorized as intra-capsular or extra capsular, are graded using systems like the Garden, Pauwel's, and AO classifications (Kazley et al., 2018). Intertrochanteric fractures, comprising a significant portion of hip fractures, have a lower risk of complications like avascular necrosis due to their trabecular structure and blood supply (Vicaş et al., 2020). Sub trochanteric fractures, occurring between the lesser trochanter and femoral shaft isthmus, are challenging to treat due to muscular forces (Kanakaris et al., 2015; Kokkalis et al., 2018). Femoral shaft fractures, classified by the AO alphanumeric system, and distal femoral fractures, categorized by the AO-OTA system, aid in treatment decisions despite interobserver discrepancies and reliability issues (Benchoufi et al., 2020).

Management of Femur Fractures in Adults

In the absence of high surgical risks and severe comorbidities, all adult femur fractures are treated operatively to facilitate early ambulation and improve patient well-being (Capalbo et al., 2012). Treatment modalities vary depending on factors such as age, activity level, and fracture pattern. For femoral neck fractures in elderly patients, hemiarthroplasty or total hip arthroplasty is preferred, while younger patients often undergo fixation with multiple cannulated screws or sliding hip screws (Zhao et al., 2020). Surgical management is standard for intertrochanteric fractures, with options including intramedullary nails, extra medullary sliding screw systems, or prostheses, chosen based on fracture stability and patient characteristics. Sub trochanteric fractures commonly result in non-union or malunion, emphasizing the importance of appropriate reduction and fixation, with intramedullary implants showing higher success rates (Zhao et al., 2020). Intramedullary nailing is the preferred treatment for femoral shaft fractures in adults, offering early mobilization and rehabilitation, especially in mature skeletally patients (Lucatelli et al., 2018). Distal femur fractures present challenges, with treatment options ranging from operative fixation to non-operative management based on fracture type and patient factors (Gangavalli & Nwachuku, 2016). Surgical goals include restoring anatomical and mechanical alignment to facilitate early mobilization and reduce the risk of post-traumatic arthritis (Begum et al., 2021)

Quantifying Blood Loss during Femur Fracture Surgeries

Orthopedic surgeries, including those for femoral fractures, are associated with significant blood loss, leading to anemia and hemorrhagic shock, yet there's limited published data on blood loss throughout the intraoperative and postoperative periods (Allegranzi et al., 2016; Park et al., 2021). Estimates vary widely, with studies reporting average intraoperative blood loss ranging from 804ml to 1500ml for different procedures (Soleimani et al., 2016). Surgical blood loss can necessitate blood transfusions, but this carries risks and costs, emphasizing the importance of minimizing blood loss through various perioperative measures, such as meticulous hemostasis, diathermy use, patient positioning, and anesthesia (Rains et al., 2011). Accurate estimation of blood loss is crucial, and while various methods exist, colorimetric methods are considered the most accurate (Gerdessen et al., 2021)New mathematical models, such as Brecher's formula, provide rapid and unbiased estimations, aiding in transfusion management (Brecher et al., 1997). However, unnecessary blood transfusions contribute to resource depletion and financial burdens, highlighting the need for precise estimation methods and efficient blood management strategies.

Blood Transfusion Rate

A study in the USA found that implementing MSBOS reduced unnecessary crossmatching and blood wastage, with a decrease in the median number of monthly RBC units crossmatched and transfused after implementation (Woodrum et al., 2017). Additionally, a retrospective study in India showed high rates of unused cross-matched blood, with only 16.04% of total cross-matched blood being utilized (Raghuwanshi et al., 2017). Implementing institution-specific MSBOS-directed preoperative blood ordering guidelines led to reduced unnecessary orders and costs, with minimal impact on emergency release blood transfusions, as concluded by a study by (Frank et al., 2014). However, despite protocols on perioperative blood management standards in many developed countries, there is a lack of such protocol in orthopedic trauma surgery at MTRH.

Pattern of blood transfusion

Blood transfusion in orthopedic trauma is crucial but should be judiciously used based on individual patient needs(Yaddanapudi & Yaddanapudi, 2014). Transfusion rates vary across studies, with intraoperative assessment often driving transfusion decisions. Packed red blood cells (PRBCs) play a vital role in restoring blood volume and oxygen capacity, especially in cases of significant blood loss. However, guidelines on transfusion thresholds based on hemoglobin levels remain debated (Carson et al., 2011). Adherence to transfusion guidelines is inconsistent, highlighting the need for standardized practices (Yudelowitz et al., 2016). MTRH has implemented policy guidelines to ensure appropriate blood transfusion use, emphasizing conservative practices and thorough patient assessments.

Factors Affecting Blood Loss during Femur Fracture Surgeries

Age and sex: Gender and age influence intraoperative blood loss, with men experiencing greater blood loss compared to women. Elderly patients undergoing major surgery often have more comorbidities, fatal diseases, and poorer postoperative outcomes (Mistry et al., 2017). Females tend to receive more transfusions due to lower preoperative hemoglobin levels, while males typically experience more intraoperative blood loss (Shekhar et al., 2019).

Pattern of fracture: Fracture pattern and operative modality independently influence the rates of red blood cell (RBC) transfusion, with subtrochanteric or intertrochanteric fractures posing higher risks (Gowers et al., 2021). Long nails and unstable, comminuted fractures are associated with increased intraoperative bleeding compared to short nails and stable fractures, respectively (Shekhar et al., 2019).

Timing of surgery: Delaying hip fracture surgery beyond 24 hours is linked to increased morbidity and mortality, with early surgery associated with better outcomes (Klestil et al., 2018). Blood loss tends to increase with time since injury due to increased vascularity and prolonged operation times.

Length of operation: Longer surgical times are associated with increased blood loss, particularly in procedures lasting over 2 hours (M. E. Ugbeye et al., 2017). Prolonged operations, especially those conducted by untrained surgeons, result in greater intra- and postoperative blood loss.

Length of incision: Longer incisions lead to the formation of more tissue compartments, causing blood accumulation and subsequent increased blood loss (Chhabra et al., 2017).

Surgeon level of training and surgical technique: Surgeries performed by more experienced surgeons result in more blood loss due to the complexity of cases assigned to them (Shah et al., (2020).

Mode of anesthesia: Regional anesthesia reduces intraoperative blood loss, and proper patient positioning and avoidance of hypothermia are crucial in minimizing blood loss (Shah et al., 2020).

Preoperative Hb level: Higher preoperative hemoglobin levels are associated with increased blood loss, possibly due to larger hemoglobin content per ml of blood lost (Parish et al., 2017) Diathermy use: Diathermy use during surgeries such as femur open reduction and internal fixation (ORIF) reduces blood loss, incisional time, and postoperative pain (Kajja et al., 2010a)

Methodology

The study employed a cross-sectional study design, chosen for its ability to address all study objectives effectively by collecting data at a single point in time. The study took place at Moi Teaching and Referral Hospital (MTRH) Orthopaedic Wards, an ISO 9001:2015 certified hospital situated in Eldoret Town along Nandi Road, Uasin-Gishu County, approximately 310 kilometers northwest of Nairobi, serving as the headquarters of Uasin-Gishu County in the North Rift region of Western Kenya. MTRH operates a Blood Transfusion Unit (BTU), overseeing the distribution of packed red blood cells, platelets, fresh frozen plasma, and cryoprecipitate, with dedicated oversight by a haemovigilance officer and a transfusion committee to ensure safe and appropriate blood transfusion practices (MTRH, 2016).

The sampling frame included all admitted adult patients (18 years old and above) at MTRH, who had undergone open femur surgeries (voluntary written consent).

The minimum sample size was determined by the use of Fisher, *et al.* statistical formula with desired sample size (when population is greater than 10,000), Z, the standard normal deviation set at 1.96 which corresponds to 95% confidence level and p, a characteristic of the study population; prevalence of 48.2% from a prior study done at the Medical University of Vienna Austria in 2019, on Impact of Antiplatelet Therapies on Patients Outcome in Osteosynthetic Surgery of Proximal Femoral Fractures on 396 patients which showed that 48.2% had more than 1500mls of intraoperative blood loss and 51% had less than 1500mls of intraoperative blood loss during proximal femur osteosynthesis (Humenberger et al., 2019). The sample size was 172 participants, surveyed over one year.

Data Analysis and Management

Data analysis was done by Stata version 16 statistical software. Social demographics and clinical characteristics of patients was analyzed descriptively where categorical data such as sex, fracture classification, mode of anesthesia, and level of experience for lead surgeon experience was summarized as frequencies and their corresponding percentages.

While numerical data such as age, initial level of hemoglobin, length of surgery, time interval and length of skin incision was summarized as means/median and their corresponding standard deviations/ interquartile ranges. The other data was analyzed as per the objectives of the study outlined in table 1. :

Table 1: Objectives of study and variables analysed

Objective	Outcome	Independent	Statistical Test
One: To quantify the volume of blood loss during open femur fracture surgeries at MTRH	Blood loss. ***Binary categorical***	-	Proportion and frequency
Two: To establish cross-match transfusion ratio for patients undergoing open femur fracture surgeries at MTRH	Participants transfused and participants cross matched. ***Binary categorical***	-	Ratio
Three: To determine the blood transfusion rate in open femur fracture surgeries at MTRH	Participants transfused. ***Binary categorical***	-	Proportion
Four: To determine the factors affecting blood loss during open femur fracture surgeries at MTRH	Blood loss. ***Binary categorical***	Age, Length of surgery, Time interval, length of skin incision - ***Discrete*** Gender, Diathermy use, Fracture classification, anaesthesia mode, lead surgeon experience and haemoglobin level - ***Categorical***	T test/ Mann Whitney U Test – to compare discrete and binary categorical Chi square/ fishers exact tests – to compare categorical data. Binary logistic regression model – to factors associated with blood loss

Objective one: The amount of blood loss during open femur fracture surgery was summarized as means and corresponding standard deviation. Amount of blood loss was categorized into minimal blood loss (<1500mls) and severe blood loss (>1500mls) and then summarized as frequencies and their corresponding percentages.

Objective two: To determine the cross match transfusion ratio, the number of blood units cross-matched was divided by the number of blood units transfused to get a ratio.

Objective three: the rate of blood transfusion was determined by dividing the number of patient who received blood transfusion with the total number of participant in the study and reported as a percentage.

Objective four: At bivariate level Chi Square/ Fisher's exact test was used to assess association between dependent variable (severe blood loss) and independent variables, while *t*-test/ Mann Whitney U test was used to compare means/median between two categories of blood loss (<1500mls and >1500mls).

At multivariable level logistic was used to determine factors associated with blood loss. Researcher included all independent variables that had a *p*-value of 0.2 or less at bivariate level plus all demographic characteristics (age and Sex).

All statistical tests were performed at 95% level of confidence.

Results

Characteristics of patients

The age of patients ranged from 18 to 92 years with a mean of 47.3 ±20.3 years and a median of 45.5 (IQR 30, 63.5) years. Male patients were majority 123 (71.5%). Over half 89 (51.7%) of the fractures were classified as 31 according to AO classification. IM SIGN nail and PFNA were used in 64 (37.2%) and 57 (33.1%) of the fractures respectively. Spinal anesthesia was used among 142 (82.6%) of the total patients, however diathermy was used in all (100%) the surgeries. Lead surgeon in 144 (83.7%) of the surgeries was a consultant with only 9 (5.2%) surgeries having registrar as the lead surgeon. Most 72 (41.9%) of the surgeries lasted for more than two hours with majority 120 (69.8%) having an incision length of 15 – 25 cm. These results are shown in table 2.

Table 2: Characteristics of patients

Characteristic	Frequency	Percentage
Gender		
Male	123	71.5
Female	49	28.5
Time between injury & surgery in weeks		
<2	130	75.6
2 – 3	29	16.9
>3	13	7.6
Fracture type		
31	89	51.7
32	60	34.9
33	23	13.4
Fracture severity		
32/33A (simple)	28	16.3
32/33B (wedge)	30	17.4
32/33C (Multifragmented)	25	14.5
31	89	51.7
Implant used		
IM SIGN nail	64	37.2
PFNA	57	33.1
Bipolar	21	12.2
Distal femur plate	17	9.9
DHS	9	5.2
Cannulated screws	3	1.7
Angled Blade plate	1	0.6
Anesthesia mode		
General	30	17.4
Spinal	142	82.6
Used Diathermy	**172**	**100**
Lead surgeon		
Consultant	144	83.7
Registrar supervised by consultant	19	11.1
Registrar	9	5.2
Length of surgery in hours		
<1	8	4.6
1 – 2	92	53.5
>2	72	41.9
Length of incision in cm		
<15	16	9.3
15 – 25	120	69.8
>25	36	20.9

Volume of Blood Loss during Open Femur Fracture Surgeries at MTRH

On average, the blood loss during open femur fracture surgeries ranged from 45 to 3960 mls with a mean of 1274.1 ±714.2 mls and a median blood loss of 1080 (IQR 900, 1530) mls. The proportion of patients with severe blood loss of more than 1500ml was 26.7% (n=46). However, only 12(26.1%) of those with more than 1500ml blood loss got transfused. On average the blood loss in regard to Hb ranged from 0.1 to 8.8 with a mean of 2.8 ±1.6 g/dl and a median of 2.4 (IQR 2, 3.4). While the change in hematocrit ranged from 0.1 to 21.5 with a mean of 7.3 ±4.1 and a median of 6.3 (IQR 4.5, 9.4). These results are shown in table 3.

Table 3: Quantifying Blood Loss

Characteristic	N	Mean (SD)	Median (IQR)	Range
Implant used				
IM SIGN nail	64	1105.2(828.1)	1305(922.5, 2115)	135 – 3690
PFNA	57	1188.2(618.3)	1080(945, 1440)	135 – 3960
Bipolar	21	1073.6(467.1)	1035(855, 1170)	360 – 2340
Distal femur plate	17	1093.2(590.3)	1035(630, 1350)	45 – 2250
DHS	9	970(827)	990(405, 1035)	180 – 2925
Cannulated screws	3	1095(382.7)	945(810, 1530)	810 – 1530
Angled Blade plate	1	2205	2205	2205 – 2205
Fracture type				
31	89	1132.6(602.1)	1080(855 – 1305)	135 – 3960
32	60	1523.3(830.3)	1327.5(945, 2115)	135 – 3690
33	23	1171.9(636.2)	1080(630, 1530)	45 – 2295
Fracture severity	s			
32/33A (simple)	28	1296.9(645.4)	1282.5(832.5, 1552.5)	495 – 3240
32/33B (wedge)	30	1462.5(958.9)	1147.5(900, 2160)	45 – 3690
32/33C (Multifragmented)	25	1526.4(734.7)	13501080, 2115)	450 – 2880
31	89	1132.6(602.1)	1080(855, 1305)	135 – 3960

Cross-Match Transfusion Ratio for Patients Undergoing Open Femur Fracture Surgeries at MTRH

Blood cross-match was done to all patients (172) undergoing open femur fracture surgery, however only 34(19.8%) of them underwent transfusion giving a cross-match transfusion ratio of 5.5:1.

Blood Transfusion Rate in Open Femur Fracture Surgeries at MTRH

The blood transfusion rate in the study population was 19.8% (n=34), where 19 got 1 unit each, 12 got 2 units and 3 got 3 units each; however majority (98.8%, n=170) had 2 units ordered. More than half 20 (58.8%) of the patients had blood transfusion due to anesthetist's visual estimation followed by those who were transfused due to Low Hb 14 (41.2%).

Table 4: Blood transfusion

Characteristic	Frequency	Percentage
Transfusion		
No	138	80.2
Yes	34	19.8
Reason for transfusion		
Anesthetist visual Estimation	20	58.8
Low HB	14	41.2
Units of blood requested		
2	170	98.8
3	2	1.2
Units transfused		
0	138	80.2
1	19	11
2	12	7
3	3	1.7

Factors Affecting Blood Loss during Open Femur Fracture Surgeries at MTRH

On average those who had blood loss of more than 1500ml were by statistics significantly (*p*=0.034) younger (median 36 (IQR: 24, 62) years) than those with blood loss of 1500ml or less (median 47 (IQR: 32. 65) years). Males had higher proportion 35 (28.5%) of those with high blood loss compared to females 11 (22.4%) though the difference in proportion was not statistically significant. The proportion of patients with blood loss of more than 1500ml statistically increased significantly (*p*=0.017) with the time between injury and surgery, where those who took three or more weeks before surgery had 8 (61.5%) of patients with more than 1500ml blood loss compared to 8 (27.6%) and 30 (23.1%) among those with period of 2-3 and below 2 weeks respectively. Also, the proportion of patients with blood loss of more than 1500ml increased with the severity of injury, where those with 32/33C had higher proportion 24 (40%) of patients with more than 1500ml blood loss compared to 11 (36.7%) and 9 (32.1%) among those with 32/33B and 32/33A respectively though the difference was not statistically significant (*p*=0.054).

Table 5: Blood loss by patient characteristics

Characteristic	Blood loss ≤1500	>1500	*p*-value
Age			
Median (IQR	47 (32, 65)	36 (24, 62)	0.034[w]
Range	18 – 92	18 – 87	
Gender			
Male	88 (71.5%)	35 (28.5%)	0.422[c]
Female	38 (77.6%)	11 (22.4%)	
Time between injury & surgery in weeks			
<2	100 (76.9%)	30 (23.1%)	0.017[f]
2 – 3	21 (72.4%)	8 (27.6%)	
>3	5 (38.5%)	8 (61.5%)	
Fracture type			
31	73 (82%)	16 (18%)	0.012[c]
33	17 (73.9%)	6 (26.1%)	
32	36 (60%)	24 (40%)	
Fracture severity			
32/33A (simple)	19 (67.9%)	9(32.1%)	0.054[c]
32/33B (wedge)	19(63.3%)	11(36.7%)	
32/33C (Multifragmented)	15(60%)	10(40%)	
31	73(82%)	16(18%)	
Anesthesia mode			
General	19 (63.3%)	11 (36.7%)	0.177[c]
Spinal	107 (75.3%)	35 (24.7%)	
Lead surgeon			
Consultant	103 (71.5%)	41 (28.5%)	0.556[f]
Registrar	7 (77.8%)	2 (22.2%)	
Registrar supervised by consultant	16 (84.2%)	3 (15.8%)	
Length of surgery in hours			
<1	8 (100%)	0	<0.001[f]
1 – 2	76 (82.6%)	16 (17.4%)	
>2	42 (58.3%)	30 (41.7%)	
Length of incision in cm			
<15	11 (68.7%)	5 (31.3)	0.051[f]
15 – 25	94 (78.3%)	26 (21.7%)	
>25	21 (58.3%)	15 (41.7%)	

[c] Chi Square test
[f] Fisher's exact test
[w] Wilcoxon rank-sum test

The factors that were independently associated with blood loss were age, time between injury and surgery, fracture type, length of surgery in hours. All these were statistically significant ($p<0.05$).

Table 6: Association between blood loss by patient characteristics

Characteristic	Blood loss ≤1500	>1500	uOR	95%CI	aOR	95%CI
Age						
Median (IQR	47(32, 65)	36(24, 62)	0.98	0.97-1.01	0.99	0.97-1.02
Range	18 – 92	18 – 87				
Gender						
Male	88 (71.5%)	35 (28.5%)	Ref		Ref	
Female	38 (77.6%)	11 (22.4%)	0.73	0.33-1.58	0.91	0.37-2.25
Time between injury & surgery in weeks						
<2	100 (76.9%)	30 (23.1%)	Ref		Ref	

2 – 3	21 (72.4%)	8 (27.6%)	1.27	0.51-3.16	1.64	0.55-4.87
>3	5 (38.5%)	8 (61.5%)	5.33	1.62-17.52	**7.13**	**1.81-28.0**
Fracture type						
31	73 (82%)	16 (18%)	Ref		Ref	
32	36 (60%)	24 (40%)	3.04	1.44-6.43	**3.02**	**1.03-8.79**
33	17 (73.9%)	6 (26.1%)	1.61	0.55-4.73	1.28	0.36-4.56
Anesthesia mode						
General	19 (63.3%)	11 (36.7%)	Ref		Ref	
Spinal	107 (75.3%)	35 (24.7%)	0.56	0.25-1.30	0.85	0.31-2.33
Lead surgeon						
Consultant	103 (71.5%)	41 (28.5%)	Ref		Ref	
Registrar	7 (77.8%)	2 (22.2%)	0.47	0.13-1.70	0.47	0.11-1.96
Registrar supervised by consultant	16 (84.2%)	3 (15.8%)	0.72	0.14-3.60	0.55	0.09-3.13
Length of surgery in hours						
≤2	76 (82.6%)	16 (17.4%)	Ref		Ref	
>2	42 (58.3%)	30 (41.7%)	3.75	1.84-7.63	**3.31**	**1.42-7.75**
Length of incision in cm						
<15	11 (68.7%)	5 (31.3)	Ref		Ref	
15 – 25	94 (78.3%)	26 (21.7%)	0.61	0.19-1.91	0.50	0.14-1.79
>25	21 (58.3%)	15 (41.7%)	1.57	0.45-5.47	0.59	0.14-2.49

[c] Chi Square test
[f] Fisher's exact test
[w] Wilcoxon rank-sum test

The factors that were independently associated with blood loss were time between injury and surgery, fracture type, length of surgery in hours. Where, those whose time from injury to surgery was more than three weeks were 7.1 times more likely to lose more than 1500ml of blood compared to those stayed less than 2 weeks holding age, sex, fracture type, anesthesia mode, surgeon's length of surgery and length of incision constant. Holding other factors in the model constant, those whose surgery took more than 2 hours were 3.3 times more likely to lose more than 1500ml of blood compared to those whose took 2 or less than 2 hours. While those with fracture type 32 were 3 times more likely to lose more blood (>1500ml) compared to fracture type 31 holding age, sex, time from injury to surgery, anesthesia mode, surgeon length of surgery and length of incision constant.

Discussions

Demographics

The age of patients ranged from 18 to 92 years with a mean of 47.3 ±20.3 years and a median of 45.5 (IQR: 30, 63.5) years. Male patients were majority 123 (71.5%). This is in agreement with existing literature. This concurs with findings by Ayumba and colleagues, where they found that majority of patients were males in their study among patients with post-traumatic exposed bones (Ayumba et al., 2015). Kinyanjui reported 80% of the patients he studied were male (Kinyanjui, 2011) and Kajja and colleagues reported 72% in his study were male (Kajja et al., 2010b). Males who participated in the study conducted at MTRH in this local society are typically the family's primary breadwinners; as a result, they are more likely to be involved in high-energy trauma, such as motor vehicle accidents, particularly motorbike accidents, while they go about their income-generating activities. These results are related to the high mobility levels of people in their third and fourth decades, which increases their risk of injury

Over half (51.7%) of the fractures were classified as 31 according to AO classification. IM SIGN nail and PFNA were used in 64 (37.2%) and 57 (33.1%) of the fractures respectively. Spinal anaesthesia was used among 142 (82.6%) of the total patients, however diathermy was used in all (100%) the surgeries. Lead surgeon in 144 (83.7%) of the surgeries was a consultant with only 9 (5.2%) surgeries having registrar as the lead surgeon. Most 72 (41.9%) of the surgeries lasted for more than two hours with majority 120 (69.8%) having an incision length of 15 – 25 cm. All these factors affect blood loss during surgical procedures as will be discussed in this chapter.

Volume Of Blood Loss During Open Femur Fracture Surgeries At MTRH

On average, the blood loss during open femur fracture surgeries ranged from 45 to 3960 mls with a mean of 1274.1 ±714.2 mls and a median blood loss of 1080 (IQR: 900, 1530) mls. The average blood loss is equivalent 2.8g/dl when using the Brecher method of blood loss estimation. This is lower than what Kirii found in 70 patients undergoing open femur shaft fracture nailing in KNH. He observed a blood loss of 1485(3.3g/dl) (KIRII, 2019).This lower blood loss can be attributed to use of diathermy in all patients in this study. In another study (Mulago) looking at different femoral fracture surgery, Kinyanjui had an average blood loss of 910.1mls equivalent to 2.02 g/dl (Kinyanjui, 2011). Kajja and colleagues found a blood loss of 1490mls (3.31) in a study done in Mulago Hospital where they used Brecher formula to calculate blood loss three days after open intramedullary nailing of femur fractures (Kajja et al., 2010b).Another similar study was done in Pakistan (Lieurance et al., 1992) and they found a blood loss of 1276mls (2.8g/dl) which concurs with finding in this study. The proportion of patients with severe blood loss of more than 1500ml was 26.7% (n=46). However, only 12 (26.1%) of those with more than 1500ml blood loss got transfused. On average the blood loss in regard to Hb ranged from 0.1 to 8.8 with a mean of 2.8 ±1.6 g/dl and a median of 2.4 (IQR: 2, 3.4), while the change in hematocrit ranged from 0.1 to 21.5 with a mean of 7.3 ±4.1 and a median of 6.3 (IQR: 4.5, 9.4).

The length of the injury before surgery was a significant predictor of blood loss, with each extra day of injury increasing the blood loss. Kabazzi at Mulago Hospital had similar observation in that he noted duration of injury prior to surgery was a major predictor of blood loss, with each additional day of injury increasing the blood loss by 0.03g/dl where he was researching on effectiveness of single dose preoperative intravenous tranexamic acid on reduction of perioperative blood loss in open intramedullary nail fixation of femoral shaft fractures (Kabazzi, 2019). This is in agreement with the findings of a research by Kinyanjui, that examined blood loss during (ORIF) of isolated closed femoral fractures at Mulago Hospital and found that older fractures experienced greater intraoperative blood loss (Kinyanjui, 2011). In an effort to reduce the fracture, more extensive tissue striping of highly vascularized fibrous tissue and callus is responsible for the increased blood loss (Browner, 2009)

This study has demonstrated that 41.7 % of patients who took more than 2hours intraoperatively bled more than 1500mls as compared to patients (17.4%) who took less than 2 hours in which the blood loss was less than 1500mls which was statistically significant(p=0.001).

Kabazzi also demonstrated that the length of the procedure was a key factor in predicting blood loss, with each additional hour of the procedure resulting in a 0.66g/dl increase in blood loss (Kabazzi, 2019). Similar to this finding, Kinyanjui found that overall blood loss rose as intraoperative time increased (Kinyanjui, 2011).

According to Ugbeye and colleagues, the total hip arthroplasties performed at the National Orthopaedic Hospital in Lagos that took longer than average (>2 hours) to complete (p = 0.003) resulting in more intra- and post-operative blood loss compared to the surgeries that took less than 2 hours (p = 0.014) (M. Ugbeye et al., 2017). In addition, Kirii also found out that surgeries that took more than 2 hours had an average blood loss of 3.3g/dl as compared to surgeries which took less than 2 hours in which blood loss was 3.2g/dl which was not statistically significant(p=0.344) (KIRII, 2019) . Choi and colleagues showed similar outcomes in spinal deformity surgery (p=0.00) (Choi et al., 2017).

Cross-match transfusion ratio for patients undergoing open femur fracture surgeries at MTRH

Blood cross-match was done to all patients undergoing open femur fracture surgery, however only 34(19.8%) of them underwent transfusion giving a cross-match transfusion ratio of 5.1:1.

The number of units of blood cross matched was 346 but only 52 units were transfused. This concurs with a study done by Kirii at KNH where he found cross-match to transfusion ratio of 4.5:1(KIRII, 2019).Another study done in Iran by Soleimanha and colleagues also found a cross-match transfusion ratio of 4.6:1(Soleimanha et al., 2016) in femur surgeries.

The C/T ratio, which measures how efficiently blood is ordered, should ideally be less than 2.5. Blood wastage is regarded as considerably high when the ratio is greater than 2.5.A cross-match to transfusion ratio of 5.1:1at MTRH is very high and this means there was excessive blood ordering for transfusion. This calls for MSBOS schedule to reduce blood wastage as documented by (Hasan et al., 2018a). This group of authors in their study demonstrated that overall C/T ration in orthopaedic surgeries was 4.87:1 and concluded that their findings revealed considerable wastage of blood components and non-compliance with blood ordering regulations hence large-scale prospective studies are therefore required to establish MSBOS and assure its compliance (Hasan et al., 2018b).

Implementing the suggested MSBOS plan will assist standardize the blood ordering schedule, lessen the workload of the blood bank staff, and lower the cost of care for the patient in our resource-constrained setting (Adegboye, and, et al., 2018).

Blood transfusion rate in open femur fracture surgeries at MTRH

The blood transfusion rate in the study population was 19.8% (n=34), where 19 got 1 unit each, 12 got 2 units and 3 got 3 units each, however majority (98.8%, n=170) had 2 units ordered. More than half (58.8%) of the patients had blood transfusion due to intraoperative visual estimation by anaesthetist followed by those who were transfused due to Low preoperative Hb (41.2%).

Transfusion rate in this study contrasts with other studies done elsewhere. Transfusion rate in open diaphyseal femur fracture intramedullary nailing surgeries at KNH is 35% and this is according to Kirii (KIRII, 2019).A similar study done by Kajja and colleagues demonstrated a blood transfusion rate of 27.5% during open femur surgeries (Kajja et al., 2010b).

According to a study done by Wertheimer and colleagues in 2018 at Monash University Australia on fractures of the femur and blood transfusions, they found a transfusion rate of 36% (Wertheimer et al., 2018).A similar study done by Abbas and colleagues in 2014 at Aga Khan University Hospital, Karachi, Pakistan on transfusion practices in orthopedic patients found a transfusion rate of 35% (Abbas et al., 2014). Soleimanha and colleagues found a transfusion rate of 36.5% in orthopaedic surgeries and 49 % for femur surgeries (Soleimanha et al., 2016).A study done in Quebec Canada has shown a transfusion rate of 29% during elective orthopaedic surgeries (Vuille-Lessard et al., 2010).

Factors Affecting Blood Loss during Open Femur Fracture Surgeries at MTRH

On average those who had blood loss of more than 1500ml were by statistics significantly (*p*=0.034) younger (median 36 (IQR: 24, 62) years) than those with blood loss of 1500ml or less (median 47 (IQR: 32, 65) years). In this study the median age was 47 years and a larger percentage sustained femoral shaft fractures which were fixed by IM SIGN nail (37.2%) and PFNA (33.1%).
IM SIGN nail and PFNA had the most blood loss, with means of 1105.2 (SD: 828.1) mls and 1188.2 (SD: 618.3) mls respectively. Femoral shaft fractures also had the highest blood loss (1523mls). Kirii also had similar findings (Kirii, 2019).This finding concurs with that in a study done by Kinyanjui where he demonstrated that blood loss grew linearly with age up to 45 years old, after which point it started to decline and the explanation was the fact that K-nailing or SIGN-nailing was used on the majority of patients in the younger age group and also a greater volume of blood was lost as a result of SIGN-nailing (mean: 1451.13 mls) (Kinyanjui, 2011).
Patients who were more than 50 years with neck of femur fractures underwent bipolar hemiarthroplasty (12.2%).This was associated with a slightly low blood loss (mean: 1073.6 (SD: 467.1) mls). According to Kinyanjui, hemiarthroplasty was performed on the majority of patients over the age of 55 and that the procedure had a significantly lower blood loss (mean: 741.50mls) (Kinyanjui, 2011).

Males had higher proportion (28.5%) of those with high blood loss compared to females (22.4%) thought the difference in proportion was not statistically significant. This concurs with other studies done elsewhere. Shekhar and colleagues also documented similar findings(L. Shekhar et al., 2019) and they concur also with Hu and colleagues (Hu et al., 2018).This can be explained by the fact that men have more muscles than fat and large bodies and heavy and thick bones which tend to bleed more. The proportion of patients with blood loss of more than 1500ml increased significantly (*p*=0.017) with the time between injury and surgery with average of 10 days time between injury and surgery. Most of the times this delay is caused by lack of financial ability to procure implants and and pay for theatre fees.

Those who took three or more than weeks before surgery had 61.5% of patients with more than 1500ml blood loss compared to 27.6% and 23.1% among those with period of 2-3 and below 2 weeks respectively. These findings concur with those in studies done by Kinyanjui and Kiiri. The latter noted that blood loss increased linearly with increasing duration from injury date (Kinyanjui, 2011). Kirii found out that surgeries done more than a month since date of injury had an average blood loss of 2000mls and operations done less than 2weeks since date of injury had an average blood loss of 1200mls (Kirii, 2019).

Kajja and colleagues, and even Muriithi had similar outcomes in their studies (Kajja et al, 2010) (Muriithi, 2013). This is because these fractures often require more time to operate on and have partially malunited or and have fibrous bone as well as more vascular new bone at the fracture site, which causes more bleeding. Additionally, anatomical reduction requires time since soft tissues have typically contracted in older fractures.

Also, the proportion of patients with blood loss of more than 1500ml increased with the severity of injury, where those with 32/33C had higher proportion (40%) of patients with more than 1500ml blood loss compared to 36.7% and 32.1% among those with 32/33B and 32/33A respectively though the difference was not statistically significant (*p*=0.054).

According to Kabazzi Blood loss for the AO Type C fracture pattern was 0.55 g/dl higher than for the Type A fracture. Even though it was not statistically significant (*p*=0.717), type B fractures lost more blood than type A fractures did (Kabazzi, 2019). These results concur with those of Kajja and colleagues who also reported higher blood loss with type B (*p*= 0.01) and C (*p*= 0.01) fracture patterns (Kajja et al, 2010). According to Kinyanjui comminuted fractures lost more blood than uncomplicated fractures did, but the difference was not statistically significant (Kinyanjui, 2011).

The findings in this study concur with a studies done by Kinyanjui and Kiiri who found that the more comminuted and complex the fracture was the more the blood loss (KIRII, 2019). Kirii also noted that, compared to uncomplicated fractures, where blood loss was 900ml, comminuted fractures resulted in blood loss of up to 2550ml (Kirii, 2019).

In this study comminuted (32C/33C) fractures had mean of 1526.4 (SD: 734.7) mls of blood loss and wedge (32B/33B) fractures had mean blood loss of 1462.5 (SD: 958.9) mls followed by simple (32A/33A) fractures that had mean of 1296.9 (SD: 645.4) mls. This is because reducing and fixing a more severely comminuted femur fracture requires more technical skill and takes longer than usual. As a result, there is a higher risk of damaging the blood vessels in the endosteal and periosteal system. This may also be due to extensive soft tissue injury and increased surgical time in trying to obtain anatomical reduction in such fractures.

Femoral shaft fractures also bled more than proximal and distal femur fractures. Proximal fractures (31) had mean of 1132.6 (SD: 602.1) mls of blood loss and distal fractures (33) had mean of 1171.9 (SD: 636.2) mls. Femoral shaft fractures (32) bled more with mean of 1523.3 (SD: 830.3) mls with a difference of approximately 370mls more and this concurs with a study done by Kirii where he found an average of 1500mls blood loss during open intramedullary nailing of femoral shaft fractures (Kirii, 2019).This is because femur shaft fractures most of them are complex and require longer incision with more soft tissue opening with sign nail and more time to fix them as compared to proximal and distal fractures. Kinyanjui found an average blood loss of 1405mls with sign nail fixation and mean surgery time of 2hours (Kinyanjui, 2011).

In terms of the implants used, Angled blade plate had the highest blood loss of 2205 mls and this is because this device is used to fix severely comminuted intertrochanteric and subtrochanteric fractures. This finding concurs with those in a study done by Kinyanjui in Uganda at Mulago Hospital where he found out that angled blade plate incurred the highest amount of blood loss average of 1581mls followed by SIGN nail at 1451mls (Kinyanjui, 2011).

The most common used implant was Intramedullary SIGN nail at 37% followed by PFNA at 33% and least used implant was angled blade plate in which implants are rarely used because of development of more modern implants such as PFNA nails. Intramedullary SIGN nail had mean blood loss of 1105.2 (SD: 828.1) mls and PFNA had mean of 1188.2 (SD: 618.3) mls. This finding contrasts with that of Kirii where the blood loss was 1500mls (Kirii, 2019).

The least blood loss was seen in DHS fixation which had mean of 970 (SD: 827) mls with cannulated screws with mean of 1095 (SD: 328.7) mls. This is because the incision used during DHS fixation is small compared to shaft fractures fixation and also it takes shorter time to fix. This contrasts with a study done by Kinyanjui where DHS incurred a blood loss of 642.5mls and the mean duration of surgery was 135minutes (Kinyanjui, 2011).

Anaesthesia mode used in 82.5%% of the patients was spinal anaesthesia. About 36.7% done under general anaesthesia bled more than 1500mls as compare to spinal anaesthesia where 24.7% had blood loss more than 1500mls.This findings concur with those in a study done by Muriithi (Muriithi, 2013) and also Kirii (Kirii, 2019).According to Kinyanjui in comparison to general anesthesia, which resulted in a mean blood loss of 944 ml, spinal anesthesia resulted in a mean blood loss of 650 ml (Kinyanjui, 2011). This is in agreement with findings from other researchers, and it can be attributed to the regional hypotensive effects of spinal anesthesia brought on by sympathetic nerve blockade, which results in reduced bleeding at the site of the surgery. It has been discovered that hypotensive anesthesia reduces blood loss (Tegegne et al., 2021).

Consultants did majority of the surgeries (83.7%).Registrars alone did 5.2% of the surgeries and registrars supervised by consultants did 11%. Consultants had the largest number (28.5%)of patients bleeding more than 1500mls while registrars alone had 22.2% and registrars supervised by a consultant had 15.8%. This contrasts with other studies done elsewhere. Kinyanjui noted that there was minimal blood loss in surgeries done by consultants (mean of 606mls) when compared to operations done by registrars (1038mls)(Kinyanjui, 2011). Kirii had similar findings where surgeries done by consultants and senior registrars had more blood loss as compared to surgeries done by junior registrars (Kirii, 2019).This can be attributed to consultants doing complex cases and registrar doing uncomplicated or simple cases and also more surgeries in MTRH are done by consultants especially surgeries of the proximal and distal femur fractures.

Majority of surgeries took 1 to 2 hours (53.5%) and only 4.6% took less than 1 hour. Surgeries which took longer than 2hours had 41.7% of patients with average blood loss more than 1500mls and surgeries that took less than 2 hours had 17.4% with average blood loss more than 1500mls.This shows that the longer the surgery takes the more the blood loss. This can be explained by the fact that the longer the surgery takes the more the bleeding from the small blood vessels in the muscles and also the bone marrow. Findings in this study are in agreement with other studies. Kigera found that surgeries that took less than 90 minutes had an average haemoglobin drop of 4.1g/dl and those that took more than 90minutes had an haemoglobin drop of 4.6g/dl (Kigera, 2014).

Kabazzi also demonstrated that the length of the procedure was a key factor in predicting blood loss, with each additional hour of the procedure resulting in a median of 0.66g/dl (IQR: 0.45, 0.87) increase in blood loss (Kabazzi, 2019). Also in agreement with this finding, Kinyanjui found that overall blood loss rose as intraoperative time increased (Kinyanjui, 2011). According to Ugbeye and colleagues, the total hip arthroplasties performed at the National Orthopaedic Hospital in Lagos that took longer than average (>2 hours) to complete ($p = 0.003$) resulting in more intra- and post-operative blood loss compared to the surgeries that took less than 2 hours ($p = 0.014$) (M. Ugbeye et al., 2017). In addition, Kirii also found out that surgeries that took more than 2 hours had an average blood loss of 3.3g/dl as compared to surgeries which took less than 2 hours in which blood loss was 3.2g/dl which was not statistically significant (p=0.344) (Kirii, 2019) . Choi and colleagues showed similar outcomes in spinal deformity surgery (p=0.00) (Choi et al., 2017).

Less than half (41.7%) of patients with more than 25cm of skin incision had more than 1500mls of blood loss while in the 15 to 25cm group 21.7% had more than 1500mls and in the less than 15cm group 31.3% had had more than 1500mls of blood loss. This demonstrates that the longer the skin incision the more the blood loss. This findings have been backed up by other studies. Kirii reported that longer incisions (>25cm) had more blood loss (3g/dl) as compared to incisions less than 25cm which had an haemoglobin drop of 2.2g/dl (Kirii, 2019).The reason for this is that the longer the incision the more the tissue planes and compartments are penetrated thus blood accumulates in these compartments and also bleeding from the skin itself. Miao and colleagues also had similar findings (Miao et al., 2015).

In this study all the surgeries were done by using diathermy. It has been shown from the previous studies that diathermy reduces intraoperative bleeding by achieving haemostasis. Kirii demonstrated that there was reduced blood loss (3.2g/dl) in surgeries in which diathermy was used as compared to the group in which diathermy was not used (3.4g/dl) (Kirii, 2019).This finding concurs with those in studies done by Kajja and colleagues, and Kinyanjui (Kajja, 2010). Incisional blood loss, healing time, and postoperative pain are all decreased when using electrocautery to make skin incisions (Afuwape et al., 2015).

CONCLUSION

The majority of patients were middle-aged, socioeconomically active males. The mean blood loss during open femur fracture surgeries was 1274.1 mL (SD: 714.2) at MTRH, consistent with existing literature. The cross-match to transfusion ratio (CTR) was 5.1:1, indicating excessive cross-matching and wastage of blood and reagents compared to the international guideline of less than 2.5. The blood transfusion rate was 19.8%, with the most common reason being the anaesthetist's visual estimation. Factors contributing significantly to blood loss included the time between injury and surgery, fracture complexity, and surgery duration.

Recommendations include minimizing blood loss during surgery through timely and meticulous procedures, reducing the CTR to meet international standards, and controlling the blood transfusion rate by using scientific methods rather than visual estimations. Orthopaedic surgeons should address factors that contribute to blood loss and mitigate them appropriately. Further studies are recommended on implementing blood type and screen policies and formulating a perioperative blood management protocol for open fracture surgery at MTRH.

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