Can Relative Blood Loss and Operative Time Predict Prolonged Length of Stay following Total Joint Arthroplasty? A Retrospective Study from Single Center in Saudi Arabia

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ABSTRACT

Background: Total joint arthroplasty still causes a lot of blood loss, and many patients require blood transfusions thereafter. Blood transfusions can increase the risk of surgical site infection and periprosthetic joint infection, which can lengthen hospital stays and have a negative impact on patient outcomes.

Objective: This study aimed to examine if relative blood loss and operative time could predict the postoperative increased length of stay following total joint arthroplasty.

Patients and methods: A total of 187 procedures done during 2018–2021 were collected. Any revision case or any patient with hematological disorders was excluded. This led to a cohort of 181 procedures. The following data were collected: age, height, weight, body mass index (BMI), sex, procedure, surgery start time, surgery end time, preoperative hemoglobin and hematocrit levels, postoperative hemoglobin and hematocrit levels, number of packed red blood cells (PRBCs) transfused and the volume of each unit, and the length of stay (LOS).

Results: In our study, age ($p = 0.027$, odds ratio = 1.076) and relative blood loss ($p = 0.038$, odds ratio = 1.036) were predictors of prolonged LOS. Similarly, there was a significant association between age, operative time ($p < 0.01$), and blood loss ($p < 0.001$) and LOS.

Conclusion: The operative time, relative blood loss, and age were found to significantly affect the LOS. However, no significant association was found between LOS and gender or BMI.

Keywords: Blood loss, Total joint arthroplasty, Length of stay.

INTRODUCTION

Osteoarthritis is one of the most common chronic diseases [(1)]. Over 80% of its patients present with some degree of movement limitation, and 40% of these individuals rate their quality of life as fair or poor [(2)]. When the disease progresses to advanced stages and the conservative management fails, total joint arthroplasty (TJA) is an excellent choice to decrease the pain and improve the quality of life [(2)].

TJA is performed on a large number of patients annually. It is a well-described and safe treatment. The mean length of stay (LOS) following TJA surgery is around 3 days [(3)]. The literature shows that 30% of the cost of TJA is associated with the hospital room [(4)]. Decreasing the LOS helps in decreasing the cost, improving efficacy, and freeing up resources, which will help decrease patient waiting time to receive the treatment. Identified predicators of prolonged LOS are age over 64 years, operating time, American Society of Anesthesiologists score of 2 or greater, and comorbid conditions [(1,2, 5–8)].

This study aimed to examine if relative blood loss and operative time could predict the postoperative increased LOS following TJA. To our knowledge, this is the first study in Saudi Arabia with this aim.

PATIENTS AND METHODS

The present study uses patient-specific measure of relative blood loss, which is calculated as a percentage by dividing the intraoperative blood loss by the estimated preoperative total blood volume. This patient-specific measure may describe more accurately the acceptable level of blood loss. Furthermore, the measurement of the relative blood loss is easy and requires few resources [(6)].

This study is a retrospective review of our institute's electronic system of TJA patients, which was performed to identify patients who underwent primary unilateral total knee replacement, bilateral total knee arthroplasty, or total hip arthroplasty from 2018 to 2021. A total of 187 procedures were identified. Any revision case or any patient with bleeding disorder or missing data was excluded. This resulted in a cohort of 181 procedures.

The electronic files for the patients undergoing the procedure were reviewed in detail to extract data pertaining to the study: age, height, weight, body mass index (BMI), sex, procedure, surgery start time, surgery end time, preoperative hemoglobin and hematocrit (Hct) levels, postoperative hemoglobin and hematocrit levels, number of packed red blood cells (PRBCs) transfused and the volume of each unit, and the LOS. LOS was defined as the number of nights the patient was admitted from the date of surgery to the date of discharge.

For the postoperative hemoglobin and hematocrit, we tried to collect the reading at the 3rd day postoperatively. If not available, we selected the 2nd day postoperative reading, and if not available we selected the 1st day postoperative reading.

Our institute uses allogeneic blood for transfusion. The volume of each unit is variable and recorded for each dispensed unit from the blood bank. The decision to give blood transfusion is physician dependent, with general rules as hemoglobin drop below 8 g/L or signs and symptoms of postoperative anemia.

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LOS was classified as normal LOS when 3 days or less and prolonged LOS when more than 3 days.

Surgical procedures:

A standard technique was used in all cases, performed by two different teams. The unilateral total knee replacement (TKR) was performed under spinal/epidural anesthesia, and a tourniquet was inflated 100 mmHg above systolic blood pressure in all the patients. An anterior midline skin incision and a medial parapatellar approach were performed. Components were fixed with cement fixation. The tourniquet was deflated before closure to achieve hemostasis, and closure by layers was performed.

The bilateral TKR was performed under general anesthesia. Then, the knees were replaced sequentially by the same technique as unilateral TKR.

The total hip arthroplasty (THA) was performed under general anesthesia, with the patient in lateral position and the hip approached by the lateral approach. All the patients received uncemented femoral and acetabular components.

In all the cases, intraoperative blood loss was estimated by the attending surgeon at the end of surgery. Start time of surgery was recorded at the start of skin incision and the end time of surgery was recorded at the end of skin closure.

Formulas used:

To overcome the undervalued and inaccurate nature of the estimated blood loss by the attending surgery, blood loss was calculated using the following formulas [7]:

Total RBC loss (mL) = (Uncompensated RBC loss (mL) ± ***("±" or "+" only??)*** Compensated RBC loss (mL))

Uncompensated RBC loss (mL) = (Initial RBC (mL) – Final RBC (mL))

Compensated RBC loss = (Sum of RBCs received from the various sources of transfusion)

Initial RBC = (Estimated blood volume (mL)) x (Final Hct level (%)) at Day 1

Final RBC = (Estimated blood volume (mL)) x (Final Hct level (%)) at Day 3

Estimated blood volume (mL) =

Women: (Body surface area (m^2)) x 2430

Men: (Body surface area (m^2)) x 2530

Body surface area (m^2) = 0.0235 x (height (cm)) 0.42246 x (weight (kg)) 0.51456

Then, to obtain a result with blood loss at an Hct level of 35 percent,

Total blood loss (TBL) (mL) = (Total RBC loss (mL))/0.35.

Relative blood loss (RBL) was calculated as follows:

RBL (%) = intraoperative blood loss (mL) x 100/estimated blood volume (mL)

Ethical consent:

An approval of the study was obtained from Taif University (Saudi Arabia) Academic and Ethical Committee. Every patient signed an informed written consent for acceptance of the operation. This work was carried out in accordance with the Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Statistical analysis:

Data analysis was performed using Statistical Package for the Social Sciences, SPSS, 23rd version. Frequency and percentages were used to display categorical variables. Mean, standard deviation, and range were used to present continuous variables. Independent *t*-test was used to test for comparison of means. Multivariate logistic regression was utilized to predict risk factors for prolonged LOS. Level of significance was set at 0.05.

RESULTS

A total of 181 patients were included in the study. Figure 1 shows the patients' gender. 43 of the patients were males, and 138 were females.

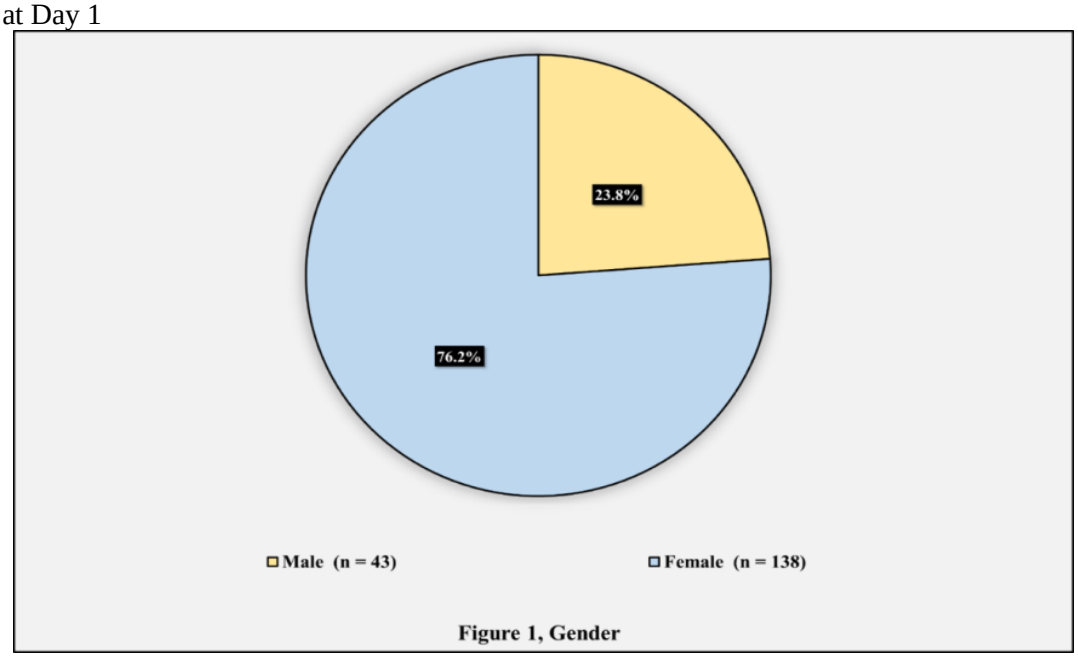

Figure (1): Gender of the patients.

Figure 2 displays the procedure which the participants had undergone. 165 had a unilateral total knee arthroplasty (TKA), 10 had a bilateral TKA, and 6 had THA.

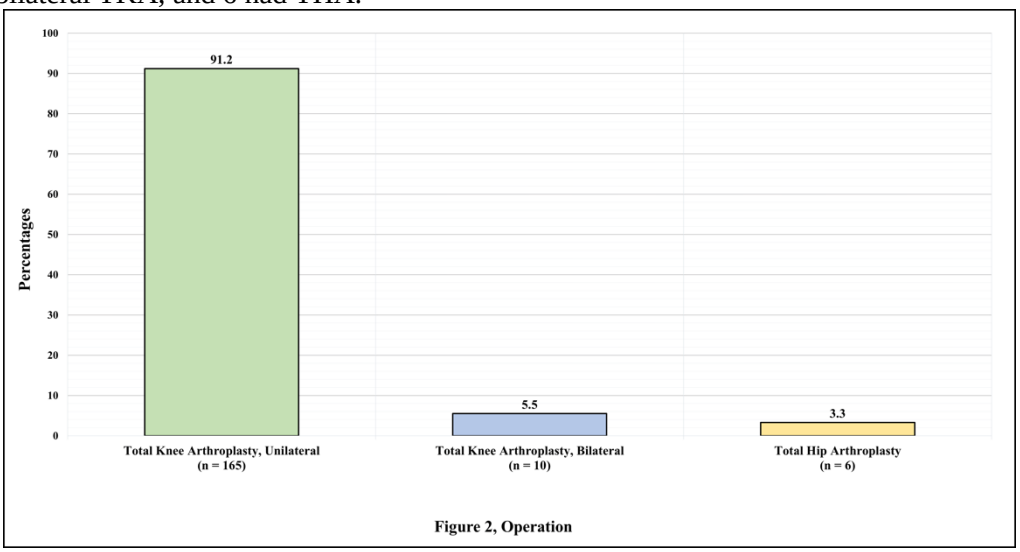

Figure (2): Percent of patients as regard the type of the operation

Table 1 demonstrates the age and BMI of the patients.

Table (1): Age and BMI of the patients (*n* = 181)

	N	**%**
BMI		
Underweight	2	1.10
Normal weight	12	6.63
Overweight	43	23.76
Obese	124	68.51
Age		
Mean	63.31	
Standard deviation	7.68	
Minimum	24	
Maximum	83	

Figure 3 illustrates the postoperative LOS for the patients. 152 of the patients had a normal LOS (3 days or less), while 29 had a prolonged LOS (more than 3 days).

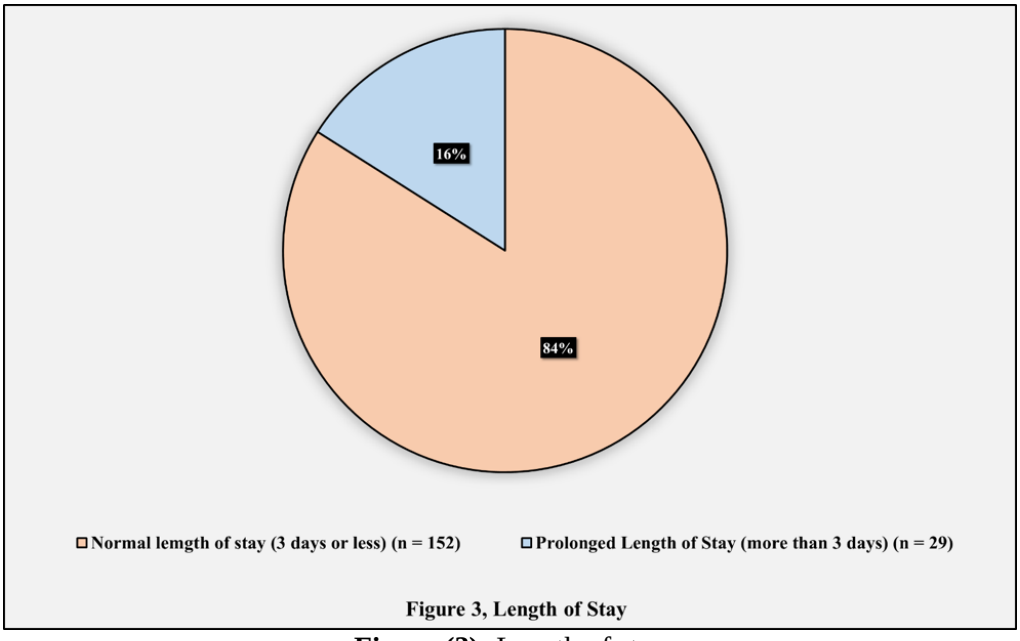

Figure (3): Length of stay

Table 2 presents the operation and blood loss assessment. Concerning the blood transfusion, 6 (3.31%) patients received PRBCs.

Table (2): Operation and blood loss assessment

Item	Mean	Standard deviation
Operation		
Operation time (in minutes)	140.92	47.39
Length of stay (in days)	3.21	0.96
Blood transfusion		
6 patients received PRBCs (among the six, 3 received 1 unit of PRBCs and 3 received 2 units of PRBCs)		
Transfused volume	569.00	225.97
Blood loss		
Intraoperative blood loss	764.05	558.60
Relative blood loss	16.32	11.84

Table 3 shows the factors associated with LOS. Those with prolonged LOS had a significantly higher mean of operation time, intraoperative blood loss, and RBL compared to those with normal LOS.

Table (3): Factors associated with length of stay

Factor	Length of stay		*p* value
	Normal length of stay	Prolonged length of stay	
Operation time (mean, standard deviation)	137.16 ± 43.95	160.62 ± 59.47	0.014*
Intra-operative blood loss (mean, standard deviation)	711.17 ± 442.5	1041.22 ± 924.76	0.003*
Relative blood loss (mean, standard deviation)	15.1 ± 9.1	22.71 ± 20.08	0.001*

Table 4 displays the multivariate logistic regression determining factors predicting prolonged LOS. Age and RBL predicted higher rate of prolonged LOS. Gender, BMI, procedure, and operation time were not observed to significantly influence LOS.

Table (4): Multivariate logistic regression (factors predicting prolonged length of stay)

Factor	*P*-value	Odds ratio	Confidence interval	
Gender (male versus female)	0.058	0.287	0.079	1.041
Age	0.027*	1.076	1.008	1.149
BMI (underweight is the reference)				
Normal weight	0.110	0.049	0.001	1.989
Overweight	0.096	0.063	0.002	1.636
Obese	0.160	0.104	0.004	2.435
Operation time	0.355	1.005	0.994	1.017
Procedure (total knee arthroplasty, unilateral is the reference)				
Total knee arthroplasty, bilateral	0.140	4.497	0.611	33.103
Total hip arthroplasty	0.101	7.938	0.668	94.282
Relative blood loss	0.038*	1.036	1.002	1.071

DISCUSSION

This study aimed to examine how relative blood loss and operative time could predict the postoperative LOS following TJA. To our knowledge, this is the first study in Saudi Arabia that had this aim.

In this study, the average postoperative LOS was found to be 3.21 (±0.96) days. The majority of our patients (84%) had a normal LOS with 3 days or less, while only 16% had a prolonged LOS with more than 3 days. Our findings were consistent with the study of **Kirkland *et al.*** [3] where the average LOS was found to be 3.6 (±2.4) days. This, however, opposed the findings of **Song *et al.*** [9] where the average LOS was found to be 8.3 (±4.3) days. This variation in the average postoperative LOS might be partly explained by the experience of the surgical team performing the operations as well as the skills of nurse facility and therapist, which provide the postoperative care and rehabilitation. Moreover, other factors like the absence of concomitant comorbidities, the physical wellbeing, and the different discharging criteria were identified in previous studies as contributing factors and hence should not be ignored [9-10].

In the study of **Song *et al.*** [9], the mean operative time was found to be 89.3 (±21.5), while the average blood loss was found to be 219.8 (±120.5) mL. Those findings were lower than the findings of our study where the mean operative time was found to be 137.16 (±43.95), and the average blood loss was 711.17.8 (±442.5) mL. This variation in the operative time and intraoperative blood loss might, again, be attributed to surgical factors like the experience of surgeons performing the operations and patient factors like the presence of concomitant comorbidities that predispose the patients to bleeding and/or operative issues.

Inneh *et al.* [11] **and Foote *et al.*** [12] stated in their studies that the longer the operative time was, the higher the postoperative LOS would be. They thus suggested a positive correlation between operative time and the expected LOS. That correlation is consistent with the findings of our study in which a significant prolongation of postoperative LOS in patients who had longer operative time was identified. In previous studies, this phenomenon was attributed to the ischemia secondary to the tourniquet used during the operation, which subsequently increases the local/systemic rate of infection, delays wound healing, and weakens the muscles mediating postoperative rehabilitation, resulting eventually in prolonged LOS [13–15]. Moreover, prolonged operative time is associated with blood loss necessitating transfusion and prolonged exposure to Foley catheter, which, respectively, place the patient at risk of allergic reactions and infection, prolonging the LOS[16].

In this study, a significant association between increasing blood loss and prolongation of LOS was observed. This finding is consistent with the study of **Song *et al.*** [9] where an increased intraoperative blood loss was found to prolong the postoperative LOS. **Song *et al.*** [9] assumed that increased blood loss promotes the sensations of weakness, which in turn interferes with the early initiation of rehabilitation, thus prolonging the LOS. Although a direct correlation between increasing intraoperative blood loss and prolongation of LOS was established, one disadvantage to consider in regard to this association is that no well-defined incremental prolongation of LOS per quantified amount of blood loss has been investigated. This aspect is worth considering and needs to be studied more broadly in future researches in an attempt to precisely identify to what extent blood loss can prolong the LOS. In our study, we found that intraoperative blood loss can predict the LOS; this renders paths open for future researches to investigate further and dig deeper in this aspect.

No significant association between gender and prolonged LOS was seen in this study. This is in contrast to the findings of **Inneh *et al.*** [11], **Mathijssen *et al.*** [17], **and Whitlock *et al.*** [18], where female patients tended to have prolonged LOS compared to their male counterparts. They attribute such tendency to the higher prevalence of obesity, postoperative complications, and postoperative transfusions among female patients. However, this is consistent with the findings of **Newman *et al.*** [19] **and Halawi *et al.*** [20], where no significant prolongation of LOS was observed in either gender. Additionally, in our study, the BMI was also not associated with prolonged LOS, as no significant difference in the LOS was observed among underweight, normal weight, overweight, or obese patients.

In conformity with the studies of **Maiorano *et al.*** [21], **Ong *et al.*** [22], **Jonas *et al.*** [23] **and Tan *et al.*** [24], our study found a significant association between advancement of age and prolongation of LOS. Previous studies suggested that elderly patients (>65 years of age) often have their physical wellbeing deteriorated, tend to develop postoperative complications more frequently, and usually live alone and thus are in need for continuous support from a caregiver [17, 25, 26]. In our study, age was found to be a predictive factor of prolonged LOS.

LIMITATIONS

The data of this study was collected from one medical center. Therefore, the results of this study might be biased. Furthermore, the majority of our sample were female, and most of them underwent a unilateral TKR; thus, the results elicited may not apply accurately with male patients and for patients who undergo another type of TJA.

CONCLUSION AND RECOMMENDATIONS

In our study, the operative time, relative blood loss, and age were found to significantly affect the LOS. However, no significant association was found between LOS and gender or BMI.

We recommend studying the effect of relative blood loss and operative time more comprehensively with data covering several hospital centers, the different types of

TJA, and both genders equally to better analyze the correlation between these factors and LOS.

Conflict of Interests: The author declares no conflict of interests.

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