Predictors of blood transfusion following total knee replacement at a tertiary care center in Central Saudi Arabia

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ABSTRACT

الأهداف: إيجاد نسبة نقل الدم والعوامل المؤثرة عليه للمرضى اللذين خضعوا لعملية استبدال مفصل الركبة.

الطريقة: شملت هذه الدراسة 462 مريضاً أجريت لهم عملية استبدال أولي لمفصل الركبة في مستشفى الملك فهد بالحرس الوطني في الرياض، المملكة العربية السعودية. خضعت النتائج للأساليب الإحصائية المناسبة لإيجاد العوامل المؤثرة على نقل الدم.

النتائج: أظهرت الدراسة أن معدل نقل الدم بعد عملية استبدال مفصل الركبة هو 35.3%. كما بينت أن العوامل المرتبطة بارتفاع هذه النسبة هي مايلي استبدال مفصل الركبتين اليمنى واليسرى خلال نفس العملية، انخفاض مستوى الهيموجلوبين قبل العملية، و فقد كمية كبيرة من الدم خلال العملية.

الخاتمة: تصحيح مستوى الهيموجلوبين قبل الجراحة والسيطرة الكافية على الدم المفقود خلال العملية وتجنب عمل جراحة للركبتين في وقت واحد قد يقلل من معدل نقل الدم بعد هذا النوع من العمليات.

Objectives: To examine the incidence and predictors of blood transfusion following total knee replacement (TKR).

Methods: A retrospective study on 462 patients of primary TKR at National Guard Hospital, Riyadh, Kingdom of Saudi Arabia. Descriptive statistics were compared by blood transfusion status and significant variables were further included in the multivariable model.

Results: Overall transfusion rate following TKR was 35.3%. Regression analyses identified bilateral surgery, low preoperative hemoglobin (Hb) level, and high amount of blood loss as predictors of blood transfusion.

Conclusion: Correction of Hb level prior to surgery, careful hemostasis, and avoiding bilateral surgery may reduce the rate of blood transfusion following TKR.

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Total knee replacement (TKR) is a widely used elective procedure and one of the most common procedures performed in orthopedic departments. In 2010, more than half a million operations were carried out in the United States.[1] Total knee replacement is needed to treat and improve a number of medical conditions involving the knee, including knee osteoarthritis (OA), a common condition among older adults and considered to be the leading cause for TKR.[2,3] As with other major surgeries, there are several complications during and after TKR including thromboembolism, persistent pain, stiffness, and blood transfusion.[4-6] The need of blood transfusion following the surgery is also a concern for both patients and surgeons. Incidence rates of blood transfusion following TKR have been reported to range between 8-18% according to studies from developed countries and several factors were found associated with increased risk of blood transfusion.[7-11] These include patient-related factors (gender, body

mass index [BMI], preoperative hemoglobin [Hb] level, American Society of Anesthesiologist [ASA] score, and certain medical conditions) and surgery-associated factors (operation time and amount of blood loss).[7, 10-13] Although blood transfusion can save patients' lives, it has several complications that are associated with high risk of morbidity and mortality, including hemolytic reactions, transfusion-related lung injury (TRALI), and transmission of pathogens and infections.[11,14-16] Published literatures regarding the incidence rates of blood transfusion following TKR and its predictors were mostly limited to unilateral surgeries and their results appear to be highly variable. Moreover, the incidence rates of blood transfusion following TKR and its predictors have not been examined in the Saudi population. This is an important issue as 13% of Saudi adults have knee OA and many of them may undergo TKR.[17] Therefore, this study aims to fill the knowledge gap on blood transfusion following TKR by estimating its incidence rate and key predictors following both unilateral and bilateral TKR. Identifying the key predictors, especially those preventable, will contribute to improving TKR outcomes and reduce patients' complications.

Methods. This study is a retrospective study of all adult patients (age ≥18 at time of surgery) who had a primary TKR procedure between January 2010 and August 2015 at National Guard Hospital, Riyadh, Kingdom of Saudi Arabia (KSA). National Guard Hospital is a tertiary care hospital with 690 beds that serves mainly the eastern region of Riyadh and the National Guard employees and their families. Patients with hematological disorder, and all revision and trauma cases were excluded from the study. Subjects were entered the cohort at the date of the primary TKR surgery (index date) and followed-up for 10 days after the surgery. Data pertaining to baseline clinical and demographics characteristics (age in years at surgery time, gender, and BMI), co-morbidities (hypertension, diabetes mellitus, and heart diseases), preoperative Hb level as well as ASA score were extracted from medical charts and Hospital Health Information System (HIS). At the end of follow-up, information related to the amount of blood loss (intraoperative and postoperative), surgery related data (anesthetic technique and whether the surgery is unilateral or bilateral), and whether the subject has received blood transfusion were extracted from medical charts and HIS. All surgeries were carried out by utilizing the medial parapatellar approach to the knee, with application of tourniquets. Tranexamic acid was not routinely used. Post operatively, surgical drains were kept for an average of 2-3 days.

Statistical analysis. Data were analyzed using The Statistical Analysis Software SAS version 9.2. (SAS Institute Inc., Cary, NC, USA) All categorical demographics data were summarized and reported as proportions and were compared across study groups using Chi-square tests. All continuous variables were summarized and reported as means and standard deviations, and were compared across study groups using Independent T-test. The incidence rate of blood transfusion was calculated as the proportion of subjects who had blood transfusion divided by the total number of subjects included in the study. The incidence rate was summarized and reported in terms of proportion with its corresponding 95% confidence interval (CI). To determine the predictors of blood transfusion, significant variables ($p \leq 0.05$) were included in logistic regression model. Logistic regression analysis was utilized by the relationship between blood transfusion and key potential predictors including preoperative Hb level, total amount of blood loss, whether the surgery is unilateral or bilateral (type of surgery), ASA score, as well as anesthesia technique. All results were reported in terms of odds ratio (OR) and the corresponding 95% CI. All statistical tests were declared significant at a level of 0.05 or <0.05.

Ethics, consent, and permissions. The institutional review board (IRB) of King Abdullah International Medical Research Center (KAIMRC), Riyadh, KSA approved the study

Results. The study included 462 cases of primary TKR surgery between January 2010 and August 2015, all of them survived the perioperative time. A few cases were excluded mainly due to lack of clear documentation. The demographic and baseline clinical characteristic of all study cohorts are summarized in **Table 1**. The sample included mostly females, representing over 77% of all patients. At time of the surgery, patients' mean age was 64.59 (±8.91) years while the BMI was 34.73 (±5.97) kg/m^2. The means of preoperative Hb level was 12.93 (±1.36) gm/dl and the total amount of blood loss

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was 832.67 (±475.03) ml. The study included both unilateral and bilateral TKR surgeries. The unilateral cases were 386 and 76 cases were performed bilaterally.

Incidence rate. The overall incidence rate of blood transfusion following TKR surgery was 35.3% (163 out of 462) with 95% CI of 30.95, 39.7. The incidence rate of blood transfusion following unilateral TKR was (27.7%) and bilateral TKR was (73.7%) (**Table 2**).

Table 1 - Demographic and baseline clinical characteristic of all study cohorts 2010-2015.

Variables	Statistics (n= 462)
Number of cases	462
Number of blood transfusion post operatively	163
Age (Mean ± SD)	64.59 (±8.91)
Gender (%)	
Male	106 (22.94)
Female	356 (77.1)
BMI in kg/m^2 (Mean ± SD)	34.73 (±5.97)
Hypertension (%)	
Yes	303 (65.6)
No	159 (34.4)
Heart disease (%)	
Yes	33 (7.1)
No	429 (92.9)
Diabetes mellitus (%)	
Yes	206 (44.6)
No	256 (55.4)
Type of surgery (%)	
Unilateral	386 (83.6)
Bilateral	76 (16.6)
Anesthesia technique (%)	
Regional	260 (56.3)
General	40 (8.7)
Combined	162 (35.1)
ASA classification (%)	
ASA 1	21 (4.6)
ASA 2	293 (63.4)
ASA 3	146 (31.6)
ASA 4	2 (0.4)
Preoperative Hb level (Mean ± SD)	12.93 (±1.36)
Intraoperative amount of blood loss (Mean ± SD)	241.56 (±137.04)
Postoperative amount of blood loss (Mean ± SD)	596.29 (±447.24)
Total amount of blood loss (Mean ± SD)	832.67 (±475.03)

SD - standard deviation, BMI - body mass index, ASA - classification American Society of Anesthesiologist Classification

Table 2 - Incidence rate of blood transfusion following primary total knee replacement.

Surgeries	Incidence Rate	95% LCL	95% UCL
Overall	35.3	30.95	39.7
Type of surgery (%)			
Unilateral	27.72	23.26	23.26
Bilateral	73.68	63.78	63.78

LCL - lower control limit, UCL - upper control limit

There was no major post-surgical bleeding documented among the cases included in this study.

Predictors of blood transfusion. Low preoperative Hb level, high amount of blood loss, bilateral surgery, high ASA score, as well as general anesthesia technique were significantly ($p \leq 0.05$) associated with an increase in the blood transfusion rate in the univariate analysis (**Table 3**). However, bilateral surgery, low preoperative Hb level, and high amount of blood loss remain significant in the logistic regression model. Bilateral TKR was associated with a great increase in the blood transfusion rate compared with unilateral TKR with OR: 12.89, and 95% CI: 5.04-33.01. High amount of blood loss (OR 1.303, 95% CI 1.098, 1.546) and low preoperative Hb level (OR 2.60, 95% CI 1.90, 3.56) showed an increase of receiving blood transfusion (**Table 4**).

Discussion. This study included mostly older females, considering that older women are more likely to be affected by knee OA.[2,18] The high BMI presented in this study was expected due to the strong association between high BMI and the risk for developing OA.[19] Our study suggests that the overall incidence rate of blood transfusion following TKR is high. This is particularly true when compared with published literatures where the rates are at least 50% less than our estimate.[7-11] One important factor leading to such high rate is the inclusion of subjects with bilateral TKR. It is difficult to determine the result of our findings regarding the overall incidence rate of blood transfusion following both unilateral and bilateral TKR. However, the transfusion rate of unilateral TKR in our study, were 1.5 times higher than the other studies.[7-11] Furthermore, our findings suggest that bilateral surgery is associated with a very high incidence rate of blood transfusion. This is particularly true when compared with Fabi et al[20] study where the rate was 64% less than our estimate. Another reason might be due to a lower threshold for the blood transfusion among our surgeons. The decision of blood transfusion depends on patient's characteristics, Hb level, and the patient's status that depend mainly on physician's judgment.[21,22] Patients with hematological disorders were excluded from the study as they have different criteria for blood transfusion at the present hospital. The results from previous studies[7,10-13] regarding the predictors of blood transfusion following TKR appear to be highly variable.A study conducted by Carling et al[11] identified low BMI, low preoperative Hb, and long operation time as key predictors of blood transfusion following TKR. Hart et al[7] study reported age, female gender, BMI of <30 kg/m^2, preoperative low Hb level, and ASA class of >2 to be associated with

increased risk of blood transfusion. In our study, there was no correlation between age, gender, and BMI with the incidence rate of blood transfusion. As for the ASA score, all patients with ASA class of 4 in our study have received blood transfusion. This may be due to the fact that patients with ASA class of 4 have disabling life-threatening conditions that would make them less able to tolerate high amount of blood loss.

Low preoperative Hb level, high amount of blood loss, bilateral surgery, high ASA score, as well as general

Table 3 - Blood transfusion following primary total knee replacement and the factors associated with it.

Variables	Received BT n(%) total 163	No BT n(%) total 296	*P*-value
Age group			
≤55	28 (6.1)	44 (9.6)	0.0964†
56-65	50 (10.9)	124 (27.2)	
66-75	63 (13.7)	101 (22.0)	
≥76	22 (4.8)	27 (5.9)	
Gender			
Male	33 (7.2)	71 (15.5)	0.4150
Female	130 (28.3)	225 (49.2)	
BMI in kg/m²			
Normal	4 (0.9)	13 (2.8)	0.4528
Overweight	34 (7.4)	53 (11.6)	
Obese	124 (27.1)	230 (50.2)	
Hypertension			
Yes	113 (24.6)	189 (41.2)	0.2368
No	50 (10.9)	107 (23.3)	
Heart disease			
Yes	15 (3.3)	17 (3.7)	0.1637
No	148 (32.3)	279 (60.8)	
Diabetes mellitus			
	77 (16.8)	128 (27.9)	0.4099
Yes	86 (18.7)	168 (36.6)	
No			
Type of surgery			
Unilateral	107 (23.3)	276 (60.1)	<0.0001
Bilateral	56 (12.2)	20 (4.4)	
Anesthesia technique			
Regional	83 (18.1)	176 (38.3)	0.0180
General	22 (4.8)	18 (3.9)	
Combined	58 (12.6)	102 (22.2)	
ASA classification (N%)			
ASA 1	6 (1.3)	14 (3.05)	0.0302
ASA 2	93 (20.3)	199 (43.4)	
ASA 3	62 (13.6)	83 (18.1)	
ASA 4	2 (0.4)	0 (0.0)	
Preoperative Hb level (Mean ± SD)	12.3356 (±1.3521)	13.2429 (±1.2489)	<0.0001‡
Total amount of blood loss (Mean ± Std. Deviation)	993.9 (±666.2)	747.4 (±306.1)	0.0035

BMI body mass index - ASA classification American society of anesthesiologist classificatio, SD - standard deviation, BT - blood transfusion, † Chi-square test in all below, ‡T-test in all below

Table 4 - Predictors of blood transfusion following primary total knee replacement.

Predictors	Odd ratio	95% LCI	95% UCI
Bilateral versus unilateral	12.893	5.036	33.007
Preoperative Hb level	2.60	1.90	3.56
Total amount of blood loss (200 ml increment)	1.303	1.098	1.546

LCL - lower control limit, UCL - upper control limit

anesthesia technique were significantly ($p \leq 0.05$) associated with increased risk of blood transfusion in the univariate analysis while bilateral surgery, low preoperative Hb level, and high amount of blood loss remained significant predictors in the multivariate analysis.

Patients who underwent bilateral TKR were over 12 times more likely to receive blood transfusion postoperatively than patients who underwent unilateral TKR adjusting for other model covariates. Although patients prefer to do simultaneous bilateral TKR when both knees are affected to avoid multiple hospital admissions, 2 operations, repeated anesthesia, and long overall recovery time, simultaneous bilateral TKR is associated with a very high risk of complications including blood transfusion.[20] This is mainly due to the fact that operating on both knees increases the intraoperative and postoperative amount of blood loss, which affects the hemodynamic state of the patient and increases the need of blood transfusion to restore the baseline Hb level.

Patients with low preoperative Hb level was 2.6 more likely to receive blood transfusion and those who lost high amount of blood was 1.3. This was expected, as low preoperative Hb level and high amount of blood loss have a direct effect on the postoperative Hb level, which is mainly used to determine the need of blood transfusion. While TKR is an elective procedure, the correction of Hb level prior to the surgery is available and can contribute to lowering the transfusion rate. Careful hemostasis and techniques that have been proved to lower the perioperative amount of blood loss (local infiltration of anesthesia and tranexamic acid use) can also contribute to lowering the transfusion rate.[23,24]

Study limitations. of this study. One key limitation is that it is conducted only in one of the tertiary care centers in Riyadh, which may affect the generalizability of the study. There were also some missing values related to the postoperative amount of blood loss that could possibly have influenced the result. However, strengths of the present study include investigating the incidence and predictors of blood transfusion following both unilateral and bilateral TKR.

In conclusion, The estimated rates of blood transfusion are much higher than any previously published study. Bilateral surgery, low preoperative Hb level, and high amount of blood loss were found to be key predictors of blood transfusion. Correction of Hb level prior to surgery, careful hemostasis, and avoiding bilateral surgery may reduce the rate of blood transfusion following TKR. Quality improvement programs may use these findings to guide initiatives aimed to improve surgery outcomes and reduce patients' complications.

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