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# An insight into the utilization of allogenic blood transfusion and factors affecting blood transfusion in total knee replacement surgery in a tertiary care hospital in Eastern India

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**Abstract:**

**BACKGROUND:** Significant blood loss and requirement of allogenic blood transfusion during or after total knee replacement (TKR) have been reported. Incidence of blood transfusion in TKR is highly variable and depends on several factors. We investigated the blood utilization in patients undergoing TKR in our hospital and depicted the important risk factors that determine the need of allogenic blood transfusion in primary unilateral TKR.

**MATERIALS AND METHODS:** The study included 1241 consecutive patients undergoing primary unilateral total knee arthroplasty. All the surgeries were performed by a single surgical team of orthopedists following standard procedure. Patient and disease details were obtained from patient file and hospital information system. Compatibility test was performed in blood bank before blood reservation following mandatory guidelines. Details of test, blood issue, and blood transfusion were documented in the blood bank.

**RESULTS:** Of 1241 enrolled patients, 1069 (86.2%) were female. The median age of patients was 66 years with mean preoperative hemoglobin of 9.9 g/dL. Allogenic blood transfused was needed in 223 (17.9%) patients. Diabetes mellitus, hypertension, thyroid disorders, and chronic heart diseases were the major comorbid conditions. Risk factors such as gender, American Society of Anesthesiologists score, preoperative hemoglobin, and intraoperative and postoperative blood losses were significantly associated with blood transfusion.

**CONCLUSION:** The risk factors determining blood transfusion in TKR vary between studies, however, all centers should establish standard operating procedures describing the surgical procedure and transfusion support in TKR. In addition, each center may develop specific blood management strategy to rationalize blood transfusion in TKR and overall successful care in TKR.

**Keywords:**

Allogenic blood transfusion, osteoarthritis, preoperative hemoglobin, total knee arthroplasty, total knee replacement

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## Introduction

Significant blood loss and subsequent requirement of allogenic blood transfusion during or after total knee replacement (TKR) surgeries have been reported by previous authors.[1-4] TKR is performed to treat various joint pathologies, the common being osteoarthritis, rheumatoid or inflammatory arthritis, osteonecrosis, and posttraumatic degenerative joint diseases.[2,3] In addition to the inherent side effect of blood transfusion such as alloimmunization, transfusion-transmitted infections,



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hemolytic transfusion reactions, and allergic reactions, it also increases the risk of surgical site infection due to transfusion-related immunomodulation, prolonged hospital length of stay (LOS), and even mortality.[2-4] To prevent the risk of blood transfusion, various workers have developed perioperative blood management algorithm for rational utilization of blood and blood components in total knee arthroplasty (TKA).[4,5] The reported incidence of blood transfusion varies from 3.5% to 18.5%.[4] Bierbaum *et al*. reported a transfusion rate as high as 39% following TKA, with an increased risk of fluid overload, infection rate, and duration of hospitalization in patients who received allogenic blood.[6] Factors determining the need of blood transfusion have been discussed elaborately in the past. Some of these important factors included patient age, American Society of Anesthesiologists (ASA) grade, preoperative hemoglobin (Hb), associated medical comorbidities, and postoperative drainage volume.[6-12] Pierson *et al*. in 2004 calculated the Hb loss in routine primary TKA and found it to be 3.8 g/dL.[5]

Most Maximum Surgical Blood Ordering Schedule dictates reservation of blood, particularly packed red blood cell (PRBC) units before TKR. Ours being a tertiary care hospital with specialty knee and hip clinics, the number of patients referred for TKR is significantly high. As per our hospital protocol for every patient planned for TKR, a routine blood sample should be sent for reservation of two units of compatible PRBC in the blood bank. In this study, we aimed to investigate the blood utilization in patients undergoing TKR in our hospital and discuss the important risk factors determining the need of allogenic blood transfusion in primary unilateral TKR.

## Materials and Methods

The retrospective study included 1241 consecutive patients from January 2017 to February 2020 undergoing primary unilateral TKA. The study was conducted in the hospital blood center after obtaining ethical approval from the Institute Ethics Committee. All the surgeries were performed by a single surgical team of orthopedists following standard procedure. Patients with coagulopathies, hematological diseases, and trauma were excluded from the study. All surgeries were performed by using the medial parapatellar arthrotomy approach with application of pneumatic tourniquet before skin incision and released after cementing the prosthesis. Autologous blood and medications such as tranexamic acid and other hemostatic agents were not used in the patients. Postoperatively, a closed drainage system was used in all patients and kept for an average of 2–3 days.

Patient and disease details such as demographic profile, LOS, and clinical and surgical profiles including postoperative complications were obtained from patient file and hospital information system. Blood samples for blood grouping and crossmatching were sent to blood bank for mandatory compatibility test and blood reservation before surgery. Compatibility test was performed using automated column agglutination technology (Ortho Clinical Diagnostics, Raritan, New Jersey 08869, USA). Details of test, blood issue, and blood transfusion were documented in the blood bank. All transfusions were subjected to hemovigilance, and any adverse events observed during or after blood transfusion were investigated and documented.

Statistical analysis was done using the SPSS statistical package (version 13, IBM, 2015, Armonk, New York, USA). All results were calculated as mean ± standard deviation, and $P < 0.05$ was considered statistically significant. Demographic, clinical, and surgical variables were compared between transfused and nontransfused groups. Qualitative variables and quantitative variables were analyzed using the Chi-square test and *t*-test, respectively. Risk factors with $P < 0.05$ were statistically analyzed through multivariate logistic regression to identify the independent risk factor for blood transfusion. All results were reported in terms of odds ratio and corresponding 95% lower control limit and 95% upper control limit.

## Results

The study included 1241 patients, of which 172 (13.8%) were male and 1069 (86.2%) were female. The median age of patients was 66 years with a mean body mass index (BMI) of 31.6 kg/m$^2$. The mean preoperative Hb and platelet values in the enrolled patients were 9.9 g/dL

**Table 1: Demographic, clinical, and surgical characteristics of patients undergoing total knee replacement (n=1241)**

| Patient characteristics | Statistical values |
|---|---|
| Male patients, *n* (%) | 172 (13.8) |
| Female patients, *n* (%) | 1069 (86.2) |
| Age (years) (median) | 66 |
| Weight (kg), mean±SD | 67±13.2 |
| BMI (kg/m$^2$), mean±SD | 31.6±5.7 |
| Preoperative Hb (g/dL), mean±SD | 9.9±2.2 |
| Preoperative platelet (×10$^3$/μL), mean±SD | 186±18.3 |
| INR, mean±SD | 1.02±0.07 |
| Patients with comorbidities, *n* (%) | 1031 (83.1) |
| Duration of surgery (min), mean±SD | 116.4±41.7 |
| Intraoperative blood loss (mL), mean±SD | 236.5±147.3 |
| Postoperative blood loss (mL), mean±SD | 468.1±302.7 |
| Length of stay (days), mean±SD | 5.3±2.8 |

BMI=Body mass index, INR=International normalized ratio, SD=Standard deviation, Hb=Hemoglobin

and 186 × $10^3$/μL, respectively. While the mean operation time was 116.4 min;the intraoperative blood loss was 236.5 mL; the intraoperative blood loss was 236.5 mL. The mean LOS was observed to be 6.2 days [Table 1].

Allogenic blood transfused was needed in 223 (17.9%) patients, and among them, 83 (37.2%) patients received transfusion during surgery. Table 2 describes the risk factors affecting blood transfusion in TKR. A total of 759 (61.2%) patients were more than 60 years. Diabetes mellitus, hypertension, thyroid disorders, and chronic heart diseases were the major comorbid conditions observed in 1031 (83.1%) patients where the primary indication of TKR was osteoarthritis (93.3%); majority of patients belonged to ASA score 2 (65.4%). The operation time was <120 min in 1015 (81.8%) patients with intraoperative blood loss below 250 mL in 791 (63.7%) patients. Most of the TKR patients received spinal anesthesia (99.1%). Risk factors such as gender ($P$ = 0.0308), ASA score ($P$ = 0.0462), preoperative Hb values ($P$ = 0.0074), intraoperative blood loss ($P$ = 0.0296), and postoperative blood loss ($P$ = 0.0036) were significantly associated with blood transfusion. Table 3 depicts the multivariate logistic regression analysis to identify independent significant risk factors for blood transfusion in TKR. Gender ($P$ = 0.0317), preoperative Hb level ($P$ = 0.0001), increased volume of intraoperative blood loss ($P$ = 0.0301), and increased

**Table 2: Risk factors affecting blood transfusion in total knee replacement**

| Risk factors | Number of patients (*n*=1241), *n* (%) | Transfused patients (*n*=223), *n* (%) | Nontransfused patients (*n*=1018), *n* (%) | *P* |
|---|---|---|---|---|
| Male patient | 172 (13.9) | 41 (23.8) | 131 (76.2) | 0.0308 |
| Female patient | 1069 (86.1) | 182 (17.1) | 887 (82.9) | |
| Age ≤ 60 years | 482 (38.8) | 97 (20.1) | 385 (79.9) | 0.5162 |
| Age>60 years | 759 (61.2) | 126 (16.6) | 633 (83.4) | |
| BMI (kg/$m^2$) ≤30 | 343 (27.6) | 109 (31.8) | 234 (68.2) | 1.5762 |
| BMI (kg/$m^2$) >30 | 898 (72.4) | 114 (12.7) | 784 (87.3) | |
| Diabetic | 331 (26.7) | 101 (30.5) | 230 (69.5) | 0.9693 |
| Nondiabetic | 910 (73.3) | 122 (13.4) | 788 (86.6) | |
| Hypertensive | 711 (57.3) | 117 (16.5) | 594 (83.5) | 2.0232 |
| Nonhypertensive | 530 (42.7) | 106 (20) | 424 (80) | |
| Abnormal thyroid | 253 (20.4) | 37 (14.6) | 216 (85.4) | 0.7973 |
| Normal thyroid | 988 (79.6) | 130 (13.2) | 858 (86.8) | |
| Smoker | 153 (12.3) | 99 (64.7) | 54 (35.3) | 1.1247 |
| Nonsmoker | 1088 (87.7) | 124 (11.4) | 964 (88.6) | |
| Heart ailments | 96 (7.7) | 51 (53.1) | 45 (46.9) | 1.0219 |
| No heart ailments | 1145 (92.3) | 172 (15) | 973 (85) | |
| Osteoarthritis | 1158 (93.3) | 192 (16.6) | 966 (83.4) | 1.9291 |
| RA | 83 (6.7) | 31 (37.3) | 52 (62.7) | |
| ASA classification 1 | 66 (5.3) | 35 (53) | 31 (47) | 0.0462 |
| ASA classification 2 | 811 (65.4) | 117 (14.4) | 694 (85.6) | |
| ASA classification 3 | 359 (28.9) | 67 (18.7) | 292 (81.3) | |
| ASA classification 4 | 5 (0.4) | 4 (80) | 1 (20) | |
| Antiplatelet drugs | 59 (4.7) | 21 (36.6) | 38 (53.4) | 0.7462 |
| No antiplatelet drugs | 1182 | 202 (17.1) | 980 (82.9) | |
| Preoperative Hb ≤ 10 g/dL | 922 (74.3) | 189 (20.5) | 733 (79.5) | 0.0074 |
| Preoperative Hb>10 g/dL | 319 (25.7) | 34 (10.7) | 285 (89.3) | |
| Preoperative PLT ≤ 150×$10^3$/μL | 1204 (97) | 195 (16.2) | 1009 (83.8) | 0.4238 |
| Preoperative PLT>150×$10^3$/μL | 37 (3) | 28 (75.7) | 9 (24.3) | |
| INR ≤ 1.5 | 1205 (97.1) | 201 (16.7) | 1004 (83.3) | 0.6925 |
| INR>1.5 | 36 (2.9) | 22 (61.1) | 14 (38.9) | |
| Duration of surgery ≤ 120 min | 1015 (81.8) | 177 (17.4) | 838 (82.6) | 0.3023 |
| Duration of surgery>120 min | 226 (18.2) | 46 (20.4) | 180 (79.6) | |
| Intraoperative blood loss ≤ 250 mL | 791 (63.7) | 128 (16.2) | 663 (83.8) | 0.0296 |
| Intraoperative blood loss>250 mL | 450 (36.3) | 95 (21.1) | 355 (78.9) | |
| Postoperative blood loss ≤ 500 mL | 811 (65.4) | 127 (15.7) | 684 (84.3) | 0.0036 |
| Postoperative blood loss>500 mL | 430 (34.6) | 96 (22.3) | 334 (77.7) | |
| Spinal anesthesia | 1230 (99.1) | 220 (17.9) | 1010 (82.1) | 0.4198 |
| General anesthesia | 11 (0.9) | 3 (27.3) | 8 (72.7) | |

BMI=Body mass index, RA=Rheumatoid arthritis, ASA=American Society of Anesthesiologists, Hb=Hemoglobin, PLT=Platelet, INR=International normalized ratio

**Table 3: Multivariate logistic regression analysis to identify independent significant risk factors for blood transfusion in total knee replacement**

| Significant risk factors | OR | 95% LCL | 95% UCL | *P* |
|---|---|---|---|---|
| Gender | 1.525 | 1.038 | 2.242 | 0.0317 |
| ASA classification | 1.885 | 1.379 | 2.709 | 0.1413 |
| Preoperative Hb | 2.161 | 1.463 | 3.192 | 0.0001 |
| Intraoperative blood loss | 1.721 | 0.937 | 2.969 | 0.0301 |
| Postoperative blood loss | 1.646 | 0.880 | 2.868 | 0.0038 |

LCL=Lower control limit, UCL=Upper control limit, ASA=American Society of Anesthesiologists, OR=Odds ratio, Hb=Hemoglobin

volume of postoperative blood loss ($P$ = 0.0038) were independent risk factors for allogenic blood transfusion. On analyzing the predictors of intraoperative and postoperative blood transfusion, gender ($P$ = 0.0003), preoperative Hb ($P$ < 0.001), and intraoperative blood loss ($P$ = 0.0061) were independent predictors of intraoperative blood transfusion. Factors such as preoperative Hb ($P$ = 0.032) and postoperative blood loss ($P$ = 0.0245) were independent predictors of postoperative blood transfusion [Table 1].

## Discussion and Conclusion

The past two decades have observed a significant increase in the number of patients undergoing TKR. Due to various underlying risk factors, blood transfusion is often needed in TKR which at times makes the overall treatment more complicated adding more burden to the blood bank inventory.[5,6,12] The present study witnessed an increased number of elderly females undergoing TKR. The median age was 66 years, with female patients as high as 86.2%. This is due to the fact that the most common indication of TKR is osteoarthritis which commonly affects the elderly population. Women are more affected and burdened by osteoarthritis of the knee than men, and the causes mainly include anatomic differences, previous trauma, genetic causes, and hormonal issues.[13-19] While Song *et al*. observed that 82.1% of their Chinese patients were females with a mean age of 67.4 years; Al-Turki *et al*. in their Saudi patients reported 77.1% females with a mean age of 64.59 years; Al-Turki *et al*. in their Saudi patients reported 77.1% of females with a mean age of 64.59 years.[11,12] The mean weight and BMI of our enrolled patients were 67 kg and 31.6 kg/m$^2$, respectively. The prevalence of obesity has been growing alarmingly in the world and is now a key factor for knee osteoarthritis.[20,21] Felson *et al*. reported that obese individuals have a 1.5–2 times risk of developing knee osteoarthritis compared to their leaner counterparts.[22] Fowler-Brown *et al*. also found that a 5 kg/m$^2$ increase in BMI was associated with a 32% increase in the probability of osteoarthritis.[23] Similarly, Larson *et al*. and Al-Turki *et al*. observed high BMI in their TKR patient populations.[11,24]

The 2009 Nationwide Inpatient Sample (NIS) data of the USA revealed that most patients who underwent TKR were elderly women and the most common comorbid conditions included hypertension (67.8%), diabetes (20.0%), and obesity (19.8%), chronic renal disease at 14.7%, and depression at 11.8%. In addition, the data mentioned that over 85% of patients had at least one comorbidity and these increasing numbers of medical comorbidities were associated with incremental increase in LOS and use of hospital resources.[25] Similarly, other authors also observed an association between comorbidities and higher LOS. The major comorbidities we observed were obesity (72.4%), hypertension (57.3%), diabetes (26.7%), thyroid disorders (20.4%), and chronic heart diseases (7.7%). Single or multiple comorbidities were observed in over 83% of patients. Although the average LOS was estimated to be 5.3 days, patients with 3 or more comorbidities had a mean LOS of 6.7 days.[26,27]

As high as 94.3% of our patients belonged to ASA classification 2 and 3, and this explained that most of them had mild-to-severe systemic diseases.[28] Associations between ASA scores and specific surgical complications and outcomes have been reported in the literature.[29,30] Previous workers reported a significant correlation of ASA scores with operating times, hospital LOS, postoperative infection rates, overall morbidity, and mortality rates.[7,31,32] Al-Turki *et al*. found similar data like ours and they reported 63.4% and 31.6% of patients under ASA categories 2 and 3, respectively.[11]

In the current study, the mean preoperative Hb was 9.9 g/dL which was lower than values described by Song *et al*. in their Chinese patients or Al-Turki *et al*. and Larson *et al*. in their Saudi and American patients, respectively.[11,12,24] These variations may be attributed to average low Hb in our Indian patients, particularly the elderly female population which was also observed by previous Indian authors.[33,34] We also observed that 74.3% of our TKR patients were admitted with Hb ≤10 g/dL. Since the allogenic blood transfusion trigger was a Hb level <9 g/dL as per the institutional protocol, therefore 57 (6.9%) of these patients received blood transfusion before or during operation.

The present investigation reviewed in detail the surgical factors that determine the outcome of TKR surgeries. Data relating to average operation time and intraoperative and postoperative blood losses could be compared with those reported by others.[11,12,24] Several studies have reported the range of blood loss between 1000 and 1790 mL in TKR surgery.[35,36] According to published literature, total blood loss could be visible or hidden. Approximately 50% of blood loss occurs during the postoperative period and the hidden blood loss was

estimated to be 38% by Li *et al*.[37] Likewise, we observed that in 34.6% of patients, the postoperative blood loss was >500 mL. Multiple previous studies have shown that spinal anesthesia reduces the incidence of postoperative complications, morbidities, and mortalities.[38-40] We also found that more than 99% of patients received spinal anesthesia during surgery. General anesthesia was opted for those patients who had problems with coagulation, spine, or cardiac functions.

The incidence of blood transfusion in the present study was estimated to be 17.9%, and majority of transfused patients (62.8%) received blood postoperatively. The need for blood transfusion in TKR depends on multiple factors. While Al-turki *et al*. reported 163 (35.3%) patients receiving blood transfusion; Song *et al*. and Larson *et al*., respectively, observed a 19.4% and 45.7% incidence of blood transfusion in their patients.[11,12,24] Cardozo *et al*. observed a low incidence rate of 10.9% and concluded that patients with fall in Hb >20% or Hb value <9 g/dL after surgery may need blood transfusion, particularly when accompanied by major symptoms of tissue hypoperfusion.[41] In this context, Liu *et al*. described in detail the blood management strategies in TKR and advised restrictive blood transfusion in these patients by adhering to evidence-based transfusion guidelines and utilization of appropriate transfusion triggers. They recommended transfusion in patients with Hb <7 g/dL and Hb <8 g/dL in setting of cardiac diseases or specific patient situation where additional oxygen-carrying capacity is needed.[42] We observed that factors relating to patient and surgery such as gender, ASA score, preoperative Hb, and both intraoperative and postoperative blood losses were significantly associated with blood transfusion ($P < 0.05$). Previous studies showed that gender and old age have been associated with blood transfusion.[43,44] Song *et al*. reported variables such as gender, preoperative Hb, and intraoperative blood loss as significant determinants of blood transfusion which is consistent with our findings.[12] It has also been observed that patients with a preoperative Hb level <13 g/dL are at a fourfold higher risk of having transfusion and bleeding and clotting disorders are independent risk factors for blood transfusion.[45,46] Low preoperative Hb, high amount blood loss, bilateral surgery, high ASA score, and general anesthesia techniques were significantly associated with blood transfusion as per Al-Turki *et al*.[11] It was reported that ASA scores are correlated with total blood loss during surgery and are significant variables associated with blood transfusion.[32] We investigated that gender, preoperative Hb, and increased volume of intraoperative and postoperative blood losses were independent risk factors for allogenic blood transfusion. Song *et al*. reported preoperative Hb levels and intraoperative blood loss as the independent risk factors for blood transfusion.[12] Previous authors also documented weight, age >75 years, male gender, hypertension, and BMI as risk factors of blood transfusion.[47,48] We analyzed the predictors of intraoperative and postoperative blood transfusion and found gender, preoperative Hb, and intraoperative blood loss as independent predictors of intraoperative blood transfusion and factors such as preoperative Hb and postoperative blood loss as independent predictors of postoperative blood transfusion. Likewise, Song *et al*. reported prolonged APTT, low preoperative Hb, and increased blood loss as independent predictors for intraoperative transfusion and female gender and postoperative low Hb as independent predictors of postoperative blood transfusion.[12]

Although the risk factors determining blood transfusion in TKR vary from study to study, gender, preoperative low Hb level, and blood loss during or after surgery are common ones in the literature. More prospective, multicentric, and large studies are needed to accurately assess the risk factors determining allogenic blood transfusion in TKR. Moreover, all centers should establish standard operating procedures describing the surgical procedure and transfusion support in TKR. Each center may develop specific blood management strategy which at recent times is considered as a critical component of successful care in TKR.

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## Conflicts of interest
There are no conflicts of interest.

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