RESEARCH ARTICLE

Operative Time Directly Correlates with Blood Loss and Need for Blood Transfusion in Total Joint Arthroplasty

David Ross, DO; Omer Erkocak, MD; Mohammad R. Rasouli, MD; Javad Parvizi, MD, FRCS

Research performed at Rothman Institute of Orthopaedic Surgery, Philadelphia, PA, USA

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Abstract

Background: Allogeneic blood transfusion in patients undergoing total joint arthroplasty (TJA) has been shown to negatively affect patient outcomes. This study aimed to examine if there is a correlation between operative time and the need for allogeneic blood transfusions during TJA.

Methods: We performed a retrospective review of 866 patients who underwent primary TJA during a one-year period at our institution. Logistic regression was performed to identify the association between operative time and need for allogeneic blood transfusion, controlling for other patient and surgical factors. Multiple linear regression analysis was also performed to see how the same factors affected CBL.

Results: Of the 866 cases, 13%(115) were simultaneous bilateral. 52%(449) of patients received preoperative autologous blood donation. The average operative time for unilateral and bilateral patients was 74.1±(33.9) and 132.6±(36.0) minutes, respectively. Average CBL for unilateral patients was 2120mL±(1208) and 4051mL±(1311) for bilateral cases. The average number of allogeneic transfusions was also higher within the bilateral group (0.49 vs 1.15 units). Multivariate analysis indicated that duration of surgery (odds ratio [OR]:1.35 per 15 minutes) and bilateral TJA (OR: 2.97) increase the risk of allogeneic blood transfusion, while patients having total knee arthroplasty are less likely to receive allogeneic blood transfusion (OR: 0.50). CBL also increased significantly with surgical duration (211.5 mL per 15 minutes).

Conclusion: A subgroup analysis confirmed that there was a correlation between operative time and need for allogeneic transfusion following unilateral TJA. Expeditious surgery can minimize blood loss and subsequent need for blood transfusion and its associated adverse consequences.

Level of evidence: III

Keywords: Arthroplasty, Hip, Knee, Operative time, Outcomes, Transfusion

Introduction

Due to its immense success, total joint arthroplasty (TJA), is performed on a large number of patients annually (1, 2). Total hip and knee arthroplasty, despite being routine procedures, are associated with substantial blood loss (3). A considerable portion of patients, between 51% to 87% by report, become anemic postoperatively (4). In addition, up to 20% of patients may need allogeneic blood transfusion in the perioperative period (5).

The adverse effects of allogeneic blood transfusion in general, and on the outcome of TJA patients in particular, have been well defined (6, 7). It has been demonstrated

Corresponding Author: Javad Parvizi, The Rothman Institute at Thomas Jefferson University, Philadelphia, PA, USA
Email: research@rothmaninstitute.com

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that allogeneic blood transfusion increases all-time mortality and the risk of subsequent surgical site infection, and prolongs the average length of hospital stay (8-11). In addition, general complications of allogeneic blood transfusion include the transmission of blood-borne infections, transfusion-related and allergic reactions, and immune-modulatory effects (8).

Therefore, an effort should be made to minimize perioperative blood loss and consequently allogeneic blood transfusion in TJA cases through the adjustment of modifiable risk factors. One of these factors is operative time; however, the correlation between operative time, amount of blood loss, and the need for allogeneic blood transfusion has not been well defined for TJA procedures (12). This study was conceived to investigate if operative time is a predictor of blood loss and need for allogeneic blood transfusion during TJA, and how increasing the duration of operation affects the need for allogeneic blood transfusion in TJA cases.

Materials and Methods

A retrospective review of our institutional database of TJA patients was performed to identify patients who underwent primary TJA during a one-year period between October 2005 and October 2006. A total of 1,071 patients underwent primary total knee arthroplasty (TKA) and 1,119 underwent primary total hip arthroplasty (THA) for a total of 2,190 surgeries, including 275 bilateral cases. The medical records of these patients were reviewed in detail to extract data pertinent to this study, which included demographic information, history of bleeding disorders, blood loss (calculated as well estimated), intraoperative blood salvage, blood transfusion, and details of comorbidities including anemia.

Patients with a bleeding disorder or missing important data were excluded, leaving a final cohort of 866 patients undergoing 981 TJAs between October 2005 and October 2006. Among this cohort, 503 (58%) of patients were women, with a mean age of 64 years (range, 24 to 93 years) and 363 (42%) were men, with a mean age of 60 years (range, 20 to 90 years). Our final cohort consisted of 408 (47%) patients who underwent TKA and 458 (53%) patients who underwent THA. Eighty-three (20%) of the TKA patients and 32 (7%) of the THA patients had simultaneous bilateral surgery.

At our institution, the decision to transfuse allogeneic blood intraoperatively is at the discretion of the attending surgeon or anesthesiologist. Operative time was defined as the time from incision to the completion of skin closure. Blood loss estimates for TJA are given by the attending surgeon, surgical fellow, or anesthesiologist at the conclusion of surgery. Due to the undervalued and inaccurate nature of these estimates, blood loss was calculated for this study using the following validated formula (13):

Total red blood cell (RBC) loss (mL) =
[Uncompensated RBC loss (mL)] + [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)] × [Initial hematocrit (Hct) level (%)] at Day - 1
Final RBC = [Estimated blood volume (mL)] × [Final Hct level (%)] at Day + 3
Estimated blood volume (mL) =
Women: [Body surface area (m^2)] × 2430
Men: [Body surface area (m^2)] × 2530
Body surface area (m^2) = .0235 × [height (cm)]$^{0.42246}$ × [Weight (kg)]$^{0.51456}$
Total blood loss (mL) = [Total RBC loss (mL)] / 0.35

After consulting with the blood bank at our institution, we used 275 mL/unit as the average volume for each allogeneic transfusion, and 325 mL/unit was used as the average volume for autologous transfusions. Intraoperatively-salvaged blood was transfused at 135 mL/unit.

At our institution, the care of all patients undergoing TJA is protocol-based, which includes the anesthesia and surgical techniques as well as postoperative anticoagulation prophylaxis and rehabilitation. All patients undergoing TJA at our institution during the year of this study received low-dose coumadin for anticoagulation. All TKA cases were performed through medial parapatellar arthrotomy with the use of cement fixation. The THA cases were done using the lateral approach with the patient in supine position, and all patients received uncemented femoral and acetabular components.

The decision to give a patient a transfusion in the postoperative period is at the discretion of the internist and the treating surgeon, with some general rules that apply to all patients. Anyone with signs and symptoms of postoperative anemia such as sustained tachycardia, lassitude that interferes with rehabilitation, and patients with cardiovascular disease in whom hemoglobin falls below 8 gr/L are usually given transfusion.

Statistical Analysis

Logistic regression analysis was performed to identify the association between operative time and the need for allogeneic blood transfusion. The association between operative time and the need for autologous and intraoperative blood salvage transfusion was also identified. We controlled for surgical factors such as hip versus knee joint and unilateral versus bilateral surgery, and for demographic factors including age, body mass index (BMI), and sex. Multiple linear regression analysis was performed to identify the relationship between operative time and calculated blood loss (CBL), controlling for the previously described surgical and demographic factors. A subgroup analysis was performed within the unilateral and bilateral cohorts, looking at the association between operative time and units of allogeneic blood transfused.

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Results

Out of the 866 cases, 115 (13%) were simultaneous bilateral procedures. The types of anesthesia were general in 40 patients (4.6%) and regional (spinal) in 826 (95.4%) patients. Within the unilateral group, the mean operative time for TKA patients was 74.5±28.8 minutes and 73.7±37.2 minutes for unilateral THA patients. The average CBL was 2120±1208 mL and 4051±1311 mL for the unilateral and bilateral cases, respectively. The mean CBL for unilateral TKA patients was 1896±1016 mL and 2291±1309 mL for unilateral THA patients.

Overall, 219 patients (25.3%) received at least one unit of intraoperative allogeneic blood transfusion. Pre-donated autologous blood was administered to 449 patients (51.8%), and blood collected using an intraoperative salvage system was re-infused in 18 patients (2.1%). Ninety-seven patients (21.6%) who received autologous transfusion also received allogeneic transfusion.

Of the patients receiving allogeneic transfusion, 154 (70.3%) underwent a unilateral procedure and 65 (29.7%) underwent simultaneous bilateral procedures, with mean operative times of 92.6 (±48.2) and 137.1±34.3 minutes, respectively. One hundred fifteen patients (53%) receiving allogeneic blood underwent THA and 104 (47%) underwent TKA. Patients undergoing unilateral TJA who received at least one unit of allogeneic transfusion had an average CBL of 3607.2±1476.2 mL and those receiving bilateral procedures had an average CBL of 4752.2±1198.1 mL.

Multivariate analysis indicated that duration of surgery (odds ratio [OR]: 1.35 per 15 minutes, *P<0.001*) and undergoing bilateral TJA (OR: 2.97, *P<0.001*) increased the patient's chances of receiving allogeneic transfusion. Age (OR: 1.06, *P<0.001*) and female sex (OR: 2.61, *P <0.001*) also increased the patient's chances of undergoing allogeneic transfusion [Table 1]. Patients undergoing TKA (OR: 0.50, *P<0.001*) were less likely to receive an allogeneic transfusion. CBL increased significantly with operative time (211.5 mL per 15 minutes, *P<0.001*) [Table 2].

Subgroup analysis indicated that duration of surgery significantly increased the patient's chance of receiving an allogeneic transfusion within the unilateral group (OR: 1.31, *P<0.001*).This correlation was also observed for the bilateral TJA patients, but it did not reach statistical significance (OR: 1.13, *P=0.13*) [Table 3].

Table 1. Logistic Regression Analysis Showing the Likelihood for Need of Allogeneic Blood Transfusion

	OR	95% CI	*P-value*
Duration of Surgery (15 minute intervals)	1.35	1.25 - 1.46	<0.001
Age	1.06	1.04 - 1.07	<0.001
BMI	0.99	0.96 - 1.02	0.32
Female	2.61	1.77 - 3.85	<0.001
Knee	0.50	0.38 - 0.74	<0.001
Bilateral	2.97	1.73 - 5.12	<0.001

*OR: odds ratio; 95% CI: 95% confidence interval

Table 2. Linear Regression Showing Variable Effects on Calculated Blood Loss

	Estimate (mL)	Standard Error	*P-value*
Intercept	624.58	217.61	0.004
Duration of Surgery (per minute)	14.10	1.12	<0.001
Age	10.01	3.19	0.002
Knee	-408.39	79.68	<0.001
Bilateral	1257.61	131.10	<0.001

Table 3. Logistic Regression Subgroup Analysis of the Likelihood of Need for Allogeneic Transfusion against Surgical Duration in Unilateral and Bilateral Patients

	OR	95% CI	*P-value*
Unilateral Duration (15 minutes)	1.31	1.21 – 1.41	<0.001
Bilateral Duration (15 minutes)	1.13	0.96 – 1.33	0.13

*OR: odds ratio; 95% CI: 95% confidence interval

Discussion

Major orthopedic procedures such as TJA are usually associated with significant blood loss due to extensive soft tissue release and bone cuts, and the transfusion of allogeneic blood is not uncommon (8, 13-16). Conservation of blood has become a priority during all surgical procedures because of the shortages of donor blood, the risks associated with the use of allogeneic blood products, and the costs of these products (14, 17-22). Although numerous advances in surgical technique and measures to prevent perioperative complications have been implemented, blood transfusion due to intraoperative blood loss is still a major concern during TJA procedures (21-23).

It has been shown that several factors may influence perioperative blood loss in these patients including sex, age, physical status of the patient, hypertension, BMI, coagulation factors, type of anesthesia, and type of surgical procedure (24-28). Operative time may also directly influence blood loss and subsequent need for blood transfusion (18, 29-32). Considering the deleterious effects of allogeneic transfusions, minimizing intraoperative blood loss may prevent many unnecessary blood transfusions and subsequent complications (33). Furthermore, a more accurate prediction of operative time and blood loss could help the surgeon and anaesthesiologist improve perioperative blood management. Although there have been several studies to analyze factors affecting blood loss in TJA (24-28,32,34), review of the literature did not reveal any study specifically analyzing the relationship between operative time and the need for allogenic blood in patients undergoing these procedures.

The relationship between operative time and blood loss has been investigated in the context of spinal surgery (30, 35, 36). In scoliosis surgery, Brodsky et al. found that operative time, and not performing surgery under hypotensive anesthesia, was an important factor determining blood loss (35). In another study by Zheng et al., degenerative scoliosis surgery was associated with more intraoperative blood loss due to long operative time (30). Similarly, Fosco et al. observed a significantly greater risk of blood transfusions in female patients, who have low preoperative Hb rates, longer surgical times, and multiple fused spinal levels (36). However, according to their study, sex and levels surgically fused were more significant determinants of the need of blood transfusion than the duration of surgery. In another study that examined blood loss and transfusion requirements in musculoskeletal tumor surgeries, Kawai et al. found a significant correlation between total blood loss and operative time (37).

Previous reports regarding operative time and blood loss in patients undergoing TJA showed no real consensus, with some studies supporting a relationship between the two (18, 29, 31) and others not (32, 34). To determine the correlation between allogeneic transfusion and wound healing disturbances, Weber et al. performed an observational study in 444 patients scheduled for elective primary hip surgery (18). According to their study, a longer surgery time was correlated with higher blood loss and a high rate of transfusion. In a prospective study that analyzed various factors affecting blood loss in primary uncomplicated cemented TKA, Prasad et al. also found a significant positive correlation between the total blood loss and total surgical time (31). It has also been demonstrated that significantly greater blood loss during revision surgery is because of prolonged operative time and the need for extensile exposure (29). The results from our study are consistent with the findings of the above-mentioned reports.

Not all studies, however, suggest a positive correlation between duration of surgery and blood loss. Cushner and Friedman, in their study involving 112 primary TKA, concluded that age, diagnosis, operative time, and tourniqet time were not related to blood loss following TKA (34). In a prospective study from our institution to evaluate the safety and efficacy of the minimally invasive TKA approach against the standard TKA approach, Kolisek et al. reported a longer operative time for a minimally invasive TKA than for a standard TKA (32). However, the rate of blood loss in both groups was similar.

Our study has several limitations that should be noted. Our study population was selected from one high volume center and may not represent the general TJA population. In this study, we included patients operated on by several surgeons and surgical fellows, and there was variability in incision size and soft tissue dissection, as well as approach to hemostasis during surgery. At our institution there is no rigid protocol for blood transfusion. Most surgeons and internists at our institution, however, abide by some general rules, which are highlighted in the Methods section. The lack of a protocol for transfusion may have introduced some confounding variables. In addition, the majority of patients in this study underwent surgery under regional anesthesia and hence our findings may not be applicable to patients receiving general anesthesia.

Despite the aformentioned limitations, this study demonstrates that there is a direct correlation between operative time and blood loss and the need for subsequent blood transfusion. We found that for every 15 minutes in operative time the blood loss increases on average by 211.5 mL. In view of this important problem, part of blood management in TJA procedures must be directed toward reduction of surgical blood loss and implementation of blood preservation measures during surgery. The most important aspect of TJA, however, is obeying the basic principles of surgery: minimizing soft tissue dissection, achieving excellent hemostasis, and performing the surgery in the most expeditious but safest manner possible.

David Ross DO
Omer Erkocak MD
Javad Parvizi MD FRCS
The Rothman Institute at Thomas Jefferson University, Philadelphia, PA, USA

Mohammad R. Rasouli MD
Sina Trauma and Surgery Research Center, Tehran University of Medical Sciences, Tehran, Iran

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