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Predictors and Complications of Blood Transfusion in Total Hip and Knee Arthroplasty

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ABSTRACT

Perioperative patient optimization can minimize the need for blood transfusions in patients undergoing total hip arthroplasty (THA) and total knee arthroplasty (TKA). The purpose of this study was to determine predictors and complications of transfusions. This retrospective review analyzed 1795 patients who underwent primary THA and TKA at our institution between January 2011 and December 2012. Of the 1573 patients ultimately included the rates of transfusion were 9.27% in TKA and 26.6% in THA. Significant predictors for transfusion include: preoperative hemoglobin, age, female gender, body mass index, creatinine, TKA, operating room time, operative blood loss, and intra-operative fluids. The DVT rate was comparable, but deep surgical site infection rate among transfused patients was 2.4% compared to 0.5% in non-transfused patients ($P = 0.0065$).

Total hip and total knee arthroplasty (THA and TKA) are among the most common and successful orthopedic surgical procedures performed today. Their frequency is only expected to increase in the coming decades with growth projections nearing 137% and 601% for THA and TKA between 2005 and 2030 [1]. Increased focus has been directed toward peri-operative complications including blood loss and the decision regarding when to transfuse patients throughout the perioperative period. Blood transfusion is not without risks, including the potential for blood-borne infection, allergic reaction and transfusion reactions [2–4]. Furthermore, red blood cell (RBC) transfusion adds significant cost to the healthcare system [5–8] which will likely increase as demand continues to grow. Orthopedic procedures consume a significant portion of the donated blood supply with THA and TKA representing an estimated 4.6% and 1.6%, respectively, of all units transfused [9]. Previously published data have identified several potential predictors of transfusion in total joint patients, including: preoperative hemoglobin (Hgb) concentration, weight, age, estimated blood loss (EBL) and aspirin use [4,7,10–12]. Identification of predictors of transfusion will allow physicians to better optimize patients during the preoperative period in an effort to reduce the need for transfusion and its associated complications. The goal of this study is to identify both predictors and complications associated with blood transfusion in THA and TKA.

Methods

Under institutional review board (IRB) approval, a retrospective chart review was performed of clinical records from 1795 patients who underwent THA or TKA at our institution between January 1, 2011 and December 31, 2012. Data were collected from 6 fellowship trained surgeons at 2 academically affiliated hospitals. Five independent reviewers collected all data and performed extensive chart reviews. After excluding patients who underwent bilateral procedure, partial arthroplasty or revision surgery, a total of 1573 patients were ultimately included in the statistical analysis. Of the 1573 patients ultimately included in the study 949 patients underwent TKA and 624 patients THA.

Gender, age, body mass index (BMI), preoperative Hgb, preoperative creatinine, operating room time, estimated blood loss (EBL) and intravenous fluid (IVF) were examined for their relationship to blood transfusion in the perioperative period. Primary outcome variables related to complications included deep vein thrombosis (DVT), pulmonary embolism (PE) and infection. Patients received pharmacologic VTE prophylaxis beginning the morning after surgery with either enoxaparin (40 mg subcutaneous [SQ] daily for 21 days for THA patients, 30 mg SQ twice daily for 14 days for TKA patients) or rivaroxaban (10 mg oral daily for 35 days for THA patients, 10 mg oral daily for 12 days for TKA patients). Prior to February 2012, our institution administered enoxaparin for routine VTE prophylaxis after primary THA and TKA. In February 2012, our institution changed the VTE prophylaxis protocol to include the routine use of rivaroxaban. Patients with renal insufficiency are routinely placed on enoxaparin,

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due to the medical team's greater familiarity with this medication in these situations. Patients in both groups wore thromboembolism-deterrent stockings until 2 weeks post-operatively and wore intermittent pneumatic compression devices during their hospital stay. Both groups received 24 hours of post-operative antibiotics.

Logistic regression models were used to evaluate variables predictive of transfusion and a stepwise logistic model determined the best-fit multivariate model. A Wilcoxon two-sample test, a Spearman's correlation and a linear regression were used to analyze the number of units transfused. Chi-squared tests were used to analyze differences in complications among the transfused and non-transfused groups. A priori alpha (α) = 0.05.

Results

Currently there are a variety of criteria used for calculating preoperative risk for adverse cardiac and pulmonary events preoperatively, including the revised cardiac risk index (RCRI) and cardiopulmonary risk index. Rather than focusing on cumulative risk assessment, we focused on individual variables including: age, gender, BMI, pre-operative Hbg, and preoperative creatinine. The final study group was 66.3% female. The average age was 66.2 years [standard deviation (SD) = 10.71], BMI = 31.94 kg/m^2 [SD = 6.89], pre-operative Hgb = 13.17 mg/dL [SD = 1.53], creatinine = 0.95 mg/dL [SD = 0.89], OR time = 169 minutes [SD = 40], EBL = 180 mL [SD = 245] and IVF = 2052 mL [SD = 749] (Fig. 1).

Of the 1573 patients included in the study 949 patients underwent TKA and 624 patients THA. Eighty-eight (9.27%) TKA patients received a blood transfusion compared to 166 (26.6%) THA patients (Fig. 2). Significant predictors for transfusion are hemoglobin (odds ratio (OR) = 0.62 [95% CI, 0.53–0.76, P = 0.001]), age (OR = 1.45 [1.19–1.77, P = 0.001]), female gender (OR = 2.60 [1.55–4.43, P = 0.001]), BMI (OR = 0.84 [0.72–0.98, P = 0.027]). Also, preoperative creatinine (OR = 1.35 [1.05–1.74, P = 0.020]), TKA (OR = 0.39 [0.25–0.63, P = 0.001]), operating room time (OR = 1.25 [1.05–1.74, P = 0.029]), EBL (OR = 1.14 [1.06–1.24, P = 0.001]), intra-operative fluids (OR = 1.04 [1.01–1.07, P = 0.012]) were all found to be predictive of transfusion (Fig. 3).

	Number (N)	Transfusion	Rate (%)
Knee	949	88	9.27
Hip	624	166	26.6
Total	1573	254	16.2

Fig. 2. Overall transfusion rates among total hip and total knee arthroplasty patients.

Stepwise logistic regression modeling calculated the odds ratio for transfusion associated with each variable (Fig. 3). Deep vein thrombosis (DVT) rate was 1.99% and 2.27% in transfused and non-transfused patients, respectively and was not statistically significant (P = 0.938). However, the deep surgical site infection (DSSI) rate among transfused patients was 2.4% compared to 0.5% in non-transfused patients (P = 0.0065) (Fig. 4).

Discussion

Despite several studies reporting on transfusion rates in TKA and THA, there is substantial variability in reported rates. Rate for TKA ranges from 3 to 67% and for THA from 4 to 68% [2,4,7,12–15]. One reason for the extreme variability in transfusion rates may be associated with the relative lack of clear consensus regarding the appropriate indications for transfusion. At our institution, we transfuse patients who are symptomatic with hemoglobin less than 8 mg/dL and asymptomatic with hemoglobin less than 7 mg/dL. During the time period of our study, the clinical indications to transfuse packed red blood cells at our institution did not change, nor does it appear that the change in pharmacologic VTE prophylaxis to

	Number (N)	Mean	Standard Deviation
Female Gender	1001	66.3%	
Age (years)	1573	66.2	10.71
BMI (kg/m^2)	1573	31.94	6.89
Hemoglobin (mg/dL)	1484	13.17	1.53
Creatinine (mg/dL)	1465	0.95	0.89
Operating Room Time (min)	1568	169	40
Estimated Blood Loss (mL)	978	180	245
Intravenous Fluid (mL)	972	2052	749

Fig. 1. Demographic and patient characteristics included in the study population.

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	Odds Ratio (95% CI)	Change	P-Value
Female Gender	2.60 (1.55-4.34)	--	0.001
Age	1.45 (1.19-1.77)	Δ10 years	0.001
BMI	0.84 (0.72-0.98)	Δ5 kg/m^2	0.027
Preoperative Hemoglobin	0.62 (0.53-0.76)	Δ1 mg/dL	0.001
Preoperative Creatinine	1.35 (1.05-1.74)	Δ1 mg/dL	0.020
OR Time	1.25 (1.02-1.52)	Δ40 minutes	0.029
Estimated Blood Loss	1.14 (1.06-1.24)	Δ100 mL	0.001
Intravenous Fluid	1.04 (1.01-1.07)	Δ100 mL	0.012

Fig. 3. Stepwise logistic regression model indicated the odds ratio for transfusion associated with each variable. Female gender, age, and decreased preoperative hemoglobin were found to be significant positive predictors of transfusion as were preoperative creatinine, OR time, EBL and intravenous fluid. Change indicates the unit change associated with each OR, such that an increase in Hgb by 1 mg/dL would decrease transfusion with a predicted OR of 0.62.

rivaroxaban changed our transfusion rates. The rates of blood transfusion at our institution were 9.27% in TKA and 26.6% in THA. Compared to reported studies this is relatively low for TKA but relatively high for THA. Browne et al reported there was a 17% increase in transfusion rates at their institution over a 4 year period of time despite efforts to decrease those rates [7].

Increased age, female gender and BMI were found to be predictive of transfusions which is consistent with previously published reports [10–12]. Furthermore, rates of transfusion increased with longer OR time, EBL and intraoperative fluids, which is also consistent with previously reported data [12,16]. With better understanding of potential preoperative indicators of transfusion, future efforts can focus on decreasing the effects of these risk factors on postoperative outcome and need for blood transfusion. Other work has suggested a variety of methods to reduce postoperative transfusion rates including preoperative administration of erythropoietin and iron supplementation [13,17,18].

The total cost of providing care to patients receiving transfusions has been repeatedly shown to be higher than those not requiring transfusion [5–8]. We did not include a financial analysis in this review. Other studies have attributed increased rates of transfusions with increased length of stay, although our data did not show a significant difference [2,7,14].

The DVT rate was 1.99% and 2.27% in transfused and non-transfused patients, respectively and was not statistically significant ($P = 0.938$). Rates of DVT in our study correlate closely with larger studies currently [19]. In our study, symptomatic DVT rates were similar regardless of transfusion. All of our patients were placed on DVT prophylaxis on post-operative day one. Although not included in this study, an *ad hoc* follow-up analysis comparing the DVT rate between patients in this study receiving enoxaparin versus rivaroxaban we found no statistical difference between the two and no difference in transfusion rates.

	Transfused (n = 254)	Non -transfused (n = 1319)	p-value
DVT	5 (1.97%)	30 (2.27%)	0.944
DSSI	6 (2.4%)	6 (0.5%)	0.0065

Fig. 4. Rate of complications among transfused patients. There was no statistically significant difference in rate of DVT between transfused and non-transfused patients. However, DSSI rates were slightly higher in transfused patients and this difference was significant. *P*-values shown are indicative of differences between transfused and non-transfused patients (DVT – deep vein thrombus, DSSI – deep surgical site infection).

Deep surgical site infection (DSSI) rates were statistically higher in the transfused patients, which could be explained by the fact that greater wound drainage not only increases blood loss and potential transfusion but also the potential risk for infection. Our DSSI rates for transfused patients were 2.4% compared to 0.5% in non-transfused patients ($P = 0.0065$). Bierbaum et al reported infection rates of 7% in transfused patients and 3% in non-transfused patients, although the authors still noted a significant difference [2]. Rosencher et al performed a prospective survey of 225 centers looking at blood management techniques in THA and TKA and noted an overall infection rate of 8% in non-transfused patients and 11% in those transfused with allogenic-only blood products [14]. These studies took into account overall infection rate. Our data looked specifically at DSSI which required return to the operating room for irrigation and debridement, polyethylene exchange or revision arthroplasty. Additional analysis will be needed to better determine the underlying factors in all cause infection rates.

Strengths of this particular study stem from the relatively larger study population compared with previously released reports [11,20]. Despite the relatively larger study size and the significance of our results, this study has several limitations. This is inherently limited by the retrospective nature of the study and the completeness of information included accurately in patient charts during review. The fact that the data were taken from two academically affiliated hospitals lends itself to variation in transfusion practice and organization culture. The latter point may also be considered a strength in the sense that the data were collected from a large urban tertiary care center and a suburban community hospital, which makes the cumulative results more broadly generalizable.

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Summary

Transfusion among TKA and THA patients is relatively common even with modern surgical techniques. Our data allow physicians to identify at risk patients and modify preoperative, intraoperative and postoperative planning in an effort to reduce rates of transfusion. Additionally, clinicians can now have a more informed discussion with their patients regarding the potential likelihood of transfusion in a given patient. At our institution this discussion takes place during the consent process at the pre-operative visit and when there is concern for increased risk of transfusion patients are referred to our perioperative optimization clinic for additional evaluation. Further study is needed to distinguish the relationship between preoperative predictors of transfusion and postoperative use of chemical venous thromboembolism (VTE) prophylaxis and their relationship to transfusion rate.

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