



Predictive and protective factors for allogenic blood transfusion in total knee arthroplasty. A retrospective cohort study

Douglas Mello Pavão^{a,b,*}, Erica Maciel Heringer^a, Giancarlo Jório Almeida^a,
José Leonardo Rocha de Faria^a, Rodrigo Sattamini Pires e Albuquerque^a,
Eduardo Branco de Sousa^a, Pedro José Labronici^b

^a National Institute of Traumatology and Orthopaedics (INTO), Rio de Janeiro, Brazil

^b Federal Fluminense University (UFF), Niterói, Brazil

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ABSTRACT

Background: This study aimed to identify the predictive and protective factors of blood transfusion in patients undergoing total knee arthroplasty (TKA) and therefore determine the profile of patients with low and high risk of blood transfusion after arthroplasty.

Methods: We conducted a retrospective study with all patients who underwent primary TKA between January 2017 and December 2019 (n = 1.028 patients) in our institution. Information about allogenic transfusion was collected from medical records to determine the incidence, the predictive and protective factors of blood transfusion. All cases of blood transfusions were documented as well the number of units and the moment of each transfusion. We performed univariate and multivariate logistic regression analyses to identify the independent risk and protective factors.

Results: The total transfusion rate was 11%, 1.1% at intraoperative and 9.9% at postoperative period. The independent risk factors for transfusion were female gender (OR 1.64), older age (>55yo, OR > 2) higher surgical risk (ASA III, OR 3.07), lower preoperative hemoglobin levels (p = 0.024), post-traumatic arthritis (OR 4.11) and use of postoperative drains (OR 1.81) The protective factors for transfusion were male gender (OR 0.60), obesity (IMC >30, OR 0.60) and use of intravenous tranexamic acid intraoperatively (OR 0.40).

Conclusions: We conclude that in addition to the well-established risk factors for blood transfusion such as advanced age, low hemoglobin levels and high surgical risk, we can add post-fracture arthroplasty, non-use of tranexamic acid and the use of postoperative joint drain.

1. Introduction

Total knee arthroplasty (TKA) is performed worldwide in the treatment of severe osteoarthritis, and perioperative bleeding is an important morbidity factor, especially when it leads to blood transfusion.¹

Older studies evidenced that total blood loss after TKA reached up to 2000 mL,^{2,3} while allogeneic blood transfusion rates varied between 10%⁴ and 35%.⁵ More recent studies report blood losses around 900–1200 mL⁶ and blood transfusion rates ranging from 1%^{6,7} to 5.1%.⁸ Bleeding control measures in TKA have evolved with the use of venous and topical tranexamic acid,⁹ optimized tourniquet or even without tourniquet use.^{1,7,10–12} Oral and periarticular injection of tranexamic acid, as well as the use of bone wax, have been studied as alternatives to

reduce blood loss.^{13–15}

Despite increasingly low blood transfusion rates are reported in TKA after the development of the so called modern perioperative blood loss control techniques,⁹ an eventual need for blood transfusion is still a common cause of surgery postponement and suspension, causing inconvenience to the patient and compromising surgeries flow. Although several risk factors, such as low levels of previous hemoglobin, coagulopathies and bilateral surgeries¹⁶ are known, we believe that current blood control protocols may have influenced on the panorama about the predictive and protective factors for blood transfusion in TKA surgeries performed today.

This study aimed to identify the predictive and protective factors of blood transfusion in patients undergoing TKA and therefore determine

* Corresponding author. Knee Surgery Center – INTO, Av. Brasil, 500 - Caju, Rio de Janeiro, RJ, CEP: 20940-070, Brazil.

E-mail address: drdougaspavao@gmail.com (D.M. Pavão).

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the profile of patients with low and high risk of blood transfusion after arthroplasty.

2. Methods

We retrospectively evaluated the medical records of patients undergoing primary TKA in our institute from January 2017 to December 2019. Revision surgeries were excluded. The project was approved by the Institutional Ethics Board and registered in the National Registry of Clinical Trials.

Patients were divided in two cohorts, one who received blood transfusion and other that did not. Age, sex, body mass index, American Society of Anesthesiology (ASA) index, comorbidities as diabetes mellitus, systemic chronic hypertension, hematological and rheumatological diseases, and cancer were evaluated. Preoperative hemoglobin levels, intravenous use of TXA, tourniquet use, and postoperative joint drain use were also recorded. In the case of blood transfusion, the number of bags and the moment of transfusion were identified.

We have some standardized routines in our institute, described below. All patients in which the intravenous tranexamic acid regimen was adopted, the dose used was 1 g, regardless of the patient's weight. Hemoglobin levels below 8 mg/dl or symptoms of anemia were considered as blood transfusion criteria. The capsular suture technique was always the same, with the knee flexed and non-continuous stitches.

Categorical demographic data such as proportions were compared using the Chi-Square test. Continuous variables were presented as mean plus standard deviation and compared by independent *t*-test.

Blood transfusion rate was calculated as the proportion of transfused patients divided by the total number of TKA performed during the study period. We used a confidence interval (CI) of 95%, considering a statistically significant difference when the *p*-value was lower than 0.05. We analyzed the Odds Ratio (OR) for the need of blood transfusion pre- and postoperatively for each studied variable. Odds Ratio and its 95% CI between predictive variables and the outcomes were calculated using Microsoft Excel 365®.

3. Results

Our search identified 1.350 patients undergoing primary TKA in our institution from January 2017 to December 2019. We excluded 332 patients which underwent revision TKA, and hence 1.028 patients were included for the medical records evaluation. The stratification of the main variables analyzed according to age is listed in Table 1.

The statistical analysis of the variables is presented at Table 2.

Most of the patients studied were between 61 and 70 years old (45%), and 71 and 80 years old (35.7%). Our first analysis evidenced statistically significant differences between patients who did and did not receive blood transfusions. Patients who received blood transfusions were older ($p < 0.0001$), female ($p = 0.04$), with lower bone mass index ($p = 0.021$), higher ASA ($p = 0.0002$), lower preoperative hemoglobin levels ($p = 0.024$), did not use postoperative aspirative joint drains ($p = 0.01$) and did not use of tranexamic acid intraoperatively ($p < 0.0001$). Tourniquet use and presence of comorbidities did not demonstrate statistical association with blood transfusion. Despite significantly lower preoperative hemoglobin levels in the transfused group, we could not determine the minimum hemoglobin value related to increased risk of blood transfusion.

We complemented the data analysis by determining the OR of each variable (Table 3).

The female gender showed a bigger risk of transfusion (OR 1.64) while de male gender was a protective factor (OR 0.60). Surgeries performed due to trauma sequelae had a higher transfusion rate when compared to those performed for primary osteoarthritis (OR 4.23). Rheumatoid arthritis also showed to be primarily a risk factor, but with a non-significant confidence interval (OR 1.53 CI - 0.72 – 3.19). Interestingly, obese patients had fewer transfusions than non-obese patients, with an OR of 0.52. The surgical classification of risk ASA 3 was shown to be related to transfusion when compared to ASA 2 with OR 3.07.

The use of intravenous tranexamic acid proved to be a protective factor, with an OR of 0.41. Tourniquet use at first suggested being a risk factor (OR 1.15), however, without statistical significance. The use of aspirative joint drain was related to a higher rate of transfusion (OR 1.81).

In our sample, tumors, hematological and rheumatological diseases did not show statistical significance as well as hypertension and diabetes.

Regarding the timing of blood transfusion, the rate was significantly higher postoperatively than intraoperatively ($p < 0.0001$).

4. Discussion

Our main finding was that the use of preoperative tranexamic acid was confirmed as an excellent protective factor against blood transfusion and, conversely, the use of aspirative joint drain and post-traumatic osteoarthritis as risk factors, in addition to the other well-established predictive and protective factors as hemoglobin levels, surgical risk and age. In addition, we identified in our institution the profile of the patient most likely to need blood transfusion in the postoperative

Table 1

Stratification of the main variables analyzed according to age. Results are shown in absolute numbers and percentages. BMI: bone mass index; ASA: American Society Anesthesiology score; yo: years old.

Demography/Age	<50 yo	51-60 yo	61-70 yo	71-80 yo	>80 yo	Total	Demography/Age	<50 yo	51-60 yo	61-70 yo	71-80 yo
Total	10	1%	108	11%	467	45%	364	35%	79	8%	1028
Male	3	30%	38	35%	133	28%	84	23%	22	28%	280
Female	7	70%	70	65%	334	72%	280	77%	57	72%	748
Indication											
Primary Osteoarthritis	4	40%	87	81%	435	93%	355	98%	76	96%	957
Rheumatoid Arthritis	5	50%	17	16%	27	6%	8	2%	2	3%	59
Post traumatic Osteoarthritis	1	10%	4	4%	5	1%	1	0%	1	1%	12
Surgical Risk											
Obesity (BMI >30)	4	40%	77	71%	325	70%	225	62%	47	59%	678
Non Obesity	6	60%	31	29%	142	30%	139	38%	32	41%	350
ASA 1	0	0%	5	5%	11	2%	3	1%	1	1%	20
ASA 2	9	90%	101	94%	427	91%	329	90%	72	91%	938
ASA 3	1	10%	2	2%	29	6%	32	9%	6	8%	70
Intraoperative Measures											
Intravenous Tranexamic Acid	6	60%	77	71%	325	70%	245	67%	45	57%	698
Tourniquet use	8	80%	90	83%	363	78%	289	79%	58	73%	808
Postoperative Joint Drain	9	90%	73	68%	315	67%	249	68%	48	61%	694
Outcome											
Required Transfusion	2	20%	6	6%	37	8%	51	14%	18	23%	114

Table 2Statistical analysis of the analyzed variables. TXA: tranexamic acid; ASA: American Society Anesthesiology; *Student *t*-test; #Chi-square test.

Variables	Total of patients (n = 1028)	Not transfused (n = 914)	Transfused (n = 114)	p value
Age (years)	69.26 ± 8.1	68.86 ± 7.89	72.4 ± 9.08	<0.0001*
BMI (kg/m ²)	32.56 ± 5.92	32.76 ± 5.78	30.92 ± 6.78	0.021*
Preoperative hemoglobin (g/dL)	13.52 ± 4.87	13.64 ± 5.14	12.55 ± 1.2	0.024*
Gender				0.04*
Male	280	258	22	
Female	748	656	92	
Cause				0.025#
Osteoarthritis	957	856	101	
Rheumatic Arthritis	59	50	9	
Post fracture	12	8	4	
Intravenous TXA				<0.0001*
yes	698	642	56	
no	330	272	58	
Tourniquet Use				0.62*
yes	808	716	92	
no	220	198	22	
Postoperative joint drain				0.01*
yes	694	605	89	
no	334	309	25	
ASA score				0.0002#
1	20	19	1	
2	938	843	95	
3	70	52	18	
Hipertension				0.55*
yes	894	797	97	
no	134	117	17	
Diabetes				0.51*
yes	309	278	31	
no	719	636	83	
Rheumatologic disease				0.3*
yes	66	56	10	
no	962	858	104	
Hematological disease				0.19*
yes	14	11	3	
no	1014	903	111	
Neoplastic disease				1.0*
yes	18	16	2	
no	1010	898	112	

Table 3

Odds Ratio for receiving blood transfusion. BMI: bone mass index; ASA: American Society Anesthesiology; TXA: tranexamic acid; CI: confidence interval.

Odds Ratio for receiving blood transfusion	OR	CI 95% -	CI 95% +
Male	0.60	0.37	0.98
Female	1.64	1.01	2.67
BMI > / = 30	0.51	0.34	0.77
Systemic Arterial Hypertension	0.83	0.483	1.45
Diabetes Mellitus	0.85	0.55	1.32
Hematological Diseases	2.21	0.61	8.07
Rheumatological Diseases	1.47	0.72	2.97
Neoplastic Diseases	1.00	0.22	4.41
ASA score 1	0.41	0.05	3.14
ASA score 2	0.42	0.24	0.72
ASA score 3	3.10	1.74	5.52
Primary Osteoarthritis	0.52	0.27	0.99
Rheumatoid Arthritis	1.48	0.70	3.09
Post-traumatic Osteoarthritis	4.11	1.22	13.90
Intravenous TXA Use	0.40	0.27	0.60
Postoperative Joint Drain	1.81	1.14	2.89
Tourniquet Use	1.15	0.70	1.89

period, in addition to bringing more results and corroborating those existing in the literature on the subject.

Although blood transfusion does not affect health related to quality of life and functional outcomes following TKA,¹⁷ patients who receive blood transfusion demonstrate a significantly higher rate of complications such as pneumonia, urinary tract infection, septic shock and deep vein thrombosis.^{18,19} We believe that knowledge of the predictive and protective factors of transfusion allows for individualized pre-, intra- and postoperative care that minimizes this need.

Our current transfusion rate (about 11%) was lower than those found by Mozella et al. 2020²⁰ (about 33%), who evaluated patients operated on from 2010 to 2013 in a different scenario, when the current strategies of bleeding control were not yet well established. It is noteworthy the high rate of blood transfusion reported. Although within their values are in the average of published articles evaluating patients undergoing TKA at the time of the study development,²¹ they found much higher blood

transfusion rates than the reported in more recent studies, where the tranexamic acid scheme is frequently adopted.⁹

Low hemoglobin levels, high surgical risk²⁰ and advanced age²² are well-established predictors of blood transfusion in the literature. Gender and body mass index presents conflicting results.^{23–26}

Hu et al. (2018)²⁷ found higher rates of blood loss and blood transfusions in men which contrasts with our finding, that shows higher rate of blood transfusion in women.

In our study, we found obesity as a protective factor for the need for postoperative blood transfusion. Such findings are in line with Nicholas et al. (2016),²⁸ who show lower rates of blood transfusion in hip and knee arthroplasties in obese patients.

Our results showed the intravenous tranexamic acid use as a protective factor for blood transfusion while the use of aspirative joint drain as a risk, which is in line with the recent literature.^{9,29–32}

About the tourniquet use, a meta-analysis from 2019³³ concluded that the use of tourniquet does not significantly decrease total blood loss or the rate of transfusion, although it can decrease intra-operative blood loss and time of operation. Those results are in accordance with our findings in regards of rate of blood transfusion.

Post-traumatic arthritis confirmed to be a risk factor compared to primary osteoarthritis, in accordance to the current literature.³⁴

As a strong point of the study, we can highlight the significant number of patients evaluated in the same center using the same intra and postoperative protocols.

As a weak point, we highlight the retrospective nature of the research and the fact that patients were operated by different staff.

5. Conclusion

We concluded that in addition to the well-established risk factors for blood transfusion such as advanced age, low hemoglobin levels and high ASA score, we can add post-fracture arthroplasty, non-use of tranexamic acid and the use of aspirative joint drain. Young male obese patients with non traumatic osteoarthritis, surgical risk grades one or two, higher hemoglobin levels, operated under tranexamic acid scheme and without aspirative drain have a very small risk of requiring a blood transfusion. On the other hand, older women with post-traumatic osteoarthritis,

surgical risk greater than or equal to three, low hemoglobin and operated without the use of tranexamic acid and with aspirative joint drain are at high risk of hemotransfusion.

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Informed consent (patient/guardian)

Informed consent was obtained from all individual participants included in the study.

Institutional ethical committee approval

The project was approved by the Institutional Review Board (CAEE #44131421.8.0000.5273) and registered in the Brazilian Registry of Clinical Trials (ReBEC, #RBR-2fmytmx).

Authors' contributions

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by all authors. The first draft of the manuscript was written by Douglas Pavão and all authors commented on previous versions of the manuscript.

Consent to publish

All authors have read and approved to publish the final manuscript.

Declaration of competing interest

The authors declare that they have no conflict of interest.

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