HHS Public Access

Author manuscript

J Arthroplasty. Author manuscript; available in PMC 2024 August 20.

Published in final edited form as:

J Arthroplasty. 2020 September ; 35(9): 2367–2374. doi:10.1016/j.arth.2020.04.029.

Tranexamic Acid Does Not Reduce the Risk of Transfusion in Rheumatoid Arthritis Patients Undergoing Total Joint Arthroplasty

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Abstract

Background: Patients with rheumatoid arthritis (RA) receive transfusions more often than patients with osteoarthritis following lower extremity total joint arthroplasty (TJA), but mitigating factors are not described. Tranexamic acid (TXA) is widely used to reduce blood loss in patients undergoing TJA, but its effect on transfusion rates in patients with RA has not been studied.

Methods: We retrospectively reviewed data from a prospectively collected cohort of patients with RA undergoing TJA. Disease activity measured by Clinical Disease Activity Index, patient-reported outcome measures, and serologies was obtained. Baseline characteristics were summarized and compared. Transfusion requirements and TXA usage were obtained from chart review. Logistic regression was used to determine factors associated with transfusion in RA patients undergoing TJA.

Results: The cohort included 252 patients, mostly women with longstanding RA and end-stage arthritis requiring TJA. In multivariate analysis, 1 g/dL decrease in baseline hemoglobin (odds ratio [OR] = 0.394, 95% confidence interval [CI] [0.232, 0.669], $P = .001$), 1-minute increase in surgical duration (OR = 1.022, 95% CI [1.008, 1.037], $P = .003$), and 1-point increase in Clinical Disease Activity Index (OR = 1.079, 95% CI [1.001, 1.162]) were associated with increased risk of transfusion. TXA use was not associated with decreased risk of postoperative transfusion.

Conclusions: Preoperative health optimization should include assessment and treatment of anemia in RA patients before TJA, as preoperative hemoglobin level is the main risk factor for postoperative transfusion. Increased disease activity and increased surgical time were independent

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One or more of the authors of this paper have disclosed potential or pertinent conflicts of interest, which may include receipt of payment, either direct or indirect, institutional support, or association with an entity in the biomedical field which may be perceived to have potential conflict of interest with this work. For full disclosure statements refer to https://doi.org/10.1016/j.arth.2020.04.029.

risk factors for postoperative transfusion but are less modifiable. While TXA did not decrease transfusion risk in this population, a prospective trial is needed to confirm this.

Level of Evidence: IV.

Keywords

total knee arthroplasty; total hip arthroplasty; tranexamic acid; rheumatoid arthritis; postoperative transfusion; perioperative management

Despite the widespread use of disease modifying antirheumatic drugs and biologics, rheumatoid arthritis (RA) patients commonly develop advanced arthritis and joint damage, associated pain and dysfunction, and undergo total joint arthroplasty (TJA) surgery at relatively high utilization rates, estimated at 4.5 per 100,000 persons in 2005 [1]. The perioperative management of these patients can be challenging given the systemic inflammatory nature of the disease and associated increased readmission rates, health-care resource utilization, and periprosthetic infection. RA patients undergoing total hip arthroplasty (THA) and total knee arthroplasty (TKA) have long-standing disease, and most patients have moderate to high disease activity at the time of surgery [2]. In addition, complications, including infection and transfusion, are higher compared with patients with osteoarthritis (OA) [3,4].

Anemia occurs in 30%−60% of RA patients and more often in those with severe joint damage [5]. The etiology is typically multifactorial but may be because of iron deficiency or anemia of chronic disease secondary to active inflammatory disease [5–8]. The presence of anemia increases the risk of allogenic transfusion at the time of surgery, and transfusion may increase the risk of perioperative infection, which may contribute to the higher rate of PJI found in RA patients undergoing TJA [3–5,9,10]. Factors contributing to transfusion risk for patients with RA such as increased disease activity are not clearly defined.

Tranexamic acid (TXA) is an antifibrinolytic drug that reversibly binds to plasminogen and prevents the binding of plasmin to fibrin, thus inhibiting clot degradation [11]. TXA has gained widespread use in THA/TKA, and multiple studies have shown its efficacy in reducing postoperative transfusion by decreasing intraoperative blood loss [11–18]. However, these studies focus on patients with OA, and for this reason, the efficacy of TXA to reduce transfusion rates in patients with RA has not been reported. In addition, prior studies have reported on risk factors for transfusion for patients in a RA cohort undergoing TJA but did not include the use of TXA [7,19]. Additionally, recent clinical practice guidelines have given strong recommendations for the use of TXA for the reduction of blood loss and transfusion requirements following TKA/THA, but its efficacy in RA is not known [16]. The purpose of this study was 2-fold; determine the risk factors for transfusion in patients with RA undergoing TJA and describe the use of TXA in RA patients undergoing TJA.

Materials and Methods

Study Design

We retrospectively reviewed data from a prospective observational cohort in the RA Perioperative Flare Study. Eligible patients with RA were ≥18 years of age and were undergoing THA/TKA between October 2013 and November 2018 at a tertiary care musculoskeletal center. Patients were identified via electronic medical record screening, recruited, and enrolled as previously outlined and summarized below [2]. Participants were enrolled before surgery at either their preoperative visit or day of surgery. Baseline evaluation included both physician and patient-reported outcome measures as well as laboratory evaluation including hemoglobin (Hb). Demographics, RA characteristics, and disease activity were collected prospectively. The primary aim was to describe TXA use in RA. The secondary aim was to describe transfusion risk factors in patients with RA; postoperative Hb, operative blood loss, transfusion-related data, and TXA use were obtained by retrospective chart review.

All participants gave informed consent, and the study was approved by the Hospital for Special Surgery Institutional Review Board (#2014-233).

Participants

Participants' diagnosis of RA was confirmed using the American College of Rheumatology/European League Against Rheumatism 2010 or 1987 criteria or physical exam by one of the authors (S.M.G.) at the time of study enrollment. Rheumatologists outside of the study institution managing study patients were contacted if needed to confirm the diagnosis. Patients in whom the diagnosis of RA could not be confirmed, patients with another rheumatic disease, or patients undergoing revision or emergency surgery were excluded. These patients were enrolled into the prospective cohort, and this study used de-identified data. All participants underwent THA/TKA utilizing a posterolateral approach to the hip and a medial parapatellar approach to the knee was used in the majority of cases. Thirty-six surgeons contributed cases to the cohort.

Data Collection

Baseline demographic data collected prospectively included age at surgery, gender, date of surgery, surgery type (THA or TKA), RA criteria, disease activity, and relevant risk factors, comorbidities, and past medical history that includes prior transfusion, deep vein thrombosis, pulmonary embolism, cerebrovascular accident, malignancy, hormone therapy, and myocardial infarction. Complete blood count to include Hb, erythrocyte sedimentation rate (ESR), C-reactive protein, and serologies were systematically drawn preoperatively. For our secondary aim, surgical data was collected by retrospective chart review and included duration of surgery (minutes) and estimated blood loss (EBL, mL). TXA dosing and route were recorded (IV vs topical). IV TXA was dosed at 1000 mg in 10 mL (100 mg/mL) of normal saline and administered at 1 mL over 10 minutes. Topical TXA was dosed at 3000 mg in 10 mL (300 mg/mL) and applied topically. For TKA, patients who received IV TXA did so prior to inflation of the tourniquet. For THA, IV TXA was administered prior to skin incision. Topical TXA was administered following placement of all components prior to

closure for both THA and TKA. Some patients who received IV TXA dose were re-dosed 3 hours postoperatively based on changes in institutional protocol. TXA use and transfusion were at the discretion of the operating surgeon and were not protocolized.

Postoperative Hb throughout the participants' hospital stay was recorded and was followed until an increase or stability was documented per standard of care. Hb at the time of transfusion, the number of transfusions (mL), postoperative day of transfusion, indication for transfusion, and symptoms at the time of transfusion were recorded. Primary transfusion indications included Hb < 7 mg/dL, symptomatic Hb < 8 mg/dL, and excessive surgical blood loss at the surgeon's discretion.

Institutional protocol uses an absolute transfusion trigger of Hb < 7 mg/dL, and any patient reaching this threshold was transfused. Transfusions are also performed at the discretion of the surgeon, and the chart documentation reflects the rationale as described by the surgical team and was recorded. These included symptoms of acute blood loss anemia such as postoperative fatigue, hypotension, or a down-trending repeat laboratory results.

RA outcome measures: RA disease activity was measured utilizing the Disease Activity Score (DAS28-ESR) and Clinical Disease Activity Index (CDAI), both of which are composite measures of disease activity. The DAS28-ESR is scored from 0–9.4 and interpreted as remission (DAS28 < 2.6), low disease activity (2.6 ≤ DAS28 ≤ 3.2), moderate disease activity (3.2 ≤ DAS28 ≤ 5.1), and high activity (DAS28 > 5.1) [20]. The CDAI score ranges between 0 and 76 with a CDAI ≤2.8 representing remission, 2.8 ≤ CDAI ≤ 10 representing low disease activity, 10 ≤ CDAI ≤22 moderate disease activity, and CDAI >22 as high disease activity [20]. The Multidimensional Health Assessment Questionnaire (MDHAQ) assesses functional status in RA patients and uses 10 items to assess activities of daily living as well as the ability to walk 2 miles and participate in sports and recreational activities [21]. The MDHAQ is scored from 0 to 3 with a score of 3 indicating the most impairment.

Arthroplasty outcome measures: Patient-reported outcome measures included the Hip Disability and Osteoarthritis Outcomes Score (HOOS), Knee Injury and Osteoarthritis Outcomes Score (KOOS), and MDHAQ. The HOOS is a hip specific measure scored from 0 to 100 across 40 items in 5 different domains with a higher score indicating better status [22] and in widespread use after THA and TKA. The KOOS is a knee outcome measure with the same domains as HOOS but contains 42 items and is scored similarly from 0 to 100 [23].

Missing Data

Among the total of 252 patients, 19 (7.5%) patients did not have transfusion information. Baseline characteristics of these patients were compared with rest of 233 patients who had data available to evaluate bias. All of the patients had TXA administration status available.

Data Analysis

Baseline characteristics were summarized as frequencies and percentages for categorical variables and mean and standard deviation for continuous variables. Categorical variables were compared using Chi-squared or Fisher's exact test. Continuous variables were

compared using 2-sample t-test or Wilcoxon rank-sum test. Logistic Regression analysis was performed to explore the relationship between posttransfusion (Yes or No) and predictors (including diagnosis of RA or OA, TXA received or not). Characteristics of the patients undergoing THA vs TKA were compared, as well as those who did/did not receive TXA. Multiple comparisons of proportions with Bonferroni correction were performed for patients who received TXA to compare between groups. Predictors that were found statistically significant ($P < .05$) in the univariate analysis were included in the multivariate analysis. The final models for multivariate analysis were chosen using backward selection method. TXA, CDAI, and DAS28 were forced into the final model during the model selection. Associations between preoperative Hb and CDAI, and DAS28 were also calculated. Because all 3 variables were not normally distributed by the Shapiro-Wilk test, Spearman correlation coefficients (SCC) were calculated. Values are reported as mean and standard deviation unless otherwise noted. This study was supported by the Clinical Translational Science Center (UL1-TR002384), Clinical Translational Science Award (# UL1TR001866), and the Accelerated Medicines Partnership (UH2-AR067691).

Results

Baseline Characteristics

Two hundred fifty-two patients were included in the study, and baseline characteristics are outlined in Table 1. The study population was predominantly women (83.3%), with a prolonged disease duration (14.1 ± 12 years) and average age of 62.7 ± 11.0 years. At the time of surgery, patients had moderate active disease as measured by the mean DAS28-ESR (3.7 ± 1.3) and CDAI (18.4 ± 10.9). One hundred forty-six participants (57.9%) underwent TKA while 106 participants (42.1%) underwent THA. Patients undergoing THA had a shorter duration of RA (12.4 ± 12.1 vs 15.3 ± 11.8 years, P value = .02), had shorter surgery duration (87.9 minutes ± 30.9 vs 95.7 ± 33.9, P value = .03), and less frequently received TXA [55.7%] vs 71.9%). There was no difference in preoperative Hb for patients undergoing THA vs TKA (12.9 ± 1.7 vs 12.6 ± 1.4 mg/dL, (overall mean 12.8 ± 1.5 8 mg/dL) $P = .25$), and EBL did not differ (THA 180.5 ± 50.5 mL vs TKA 195.7 ± 75.1 mL, P value 0.09). Medications were not different between the groups (Appendix I).

One hundred sixty-four participants (65.1%) received TXA, whereas 88 (34.9%) did not. Among the 164 patients who received TXA, 122 patients (74.4%) received IV TXA, and 42 (25.6%) patients received topical TXA. Among the 122 patients who received IV TXA, the majority (69.7%) of them were re-dosed.

Twenty-six participants (11.2%) required transfusion following surgery with nearly half (n = 12, 46.2%) with a Hb less than 8 mg/dL. There was no indication for transfusion listed for 2 (0.8%) patients. Overall, patients who received TXA had a lower preoperative Hb (12.6 ± 1.4 vs 13.1 ± 1.9 mg/dL, $P = .01$) and had a longer duration of surgery (93.8 ± 31.0 vs 86.7 ± 39.2 minutes, $P = .01$). Patients who had TXA were more likely to have postoperative transfusions than those who did not receive TXA (14.0% vs 4.4%, $P = .03$). Patients who received TXA were more likely to require a transfusion because of symptomatic Hb < 8 mg/dL ($P = .001$) compared with patients who did not receive TXA. Additionally, these patients were less likely to be transfused for hypotension (7.0% vs 0.0%, $P = .04$) compared

with patients who did not receive TXA. Patients who underwent TKA were more likely to require a transfusion for symptomatic Hb < 8 mg/dL (7.5% vs 0.9%, $P = .02$) compared with patients who underwent THA. Equal proportions of patients undergoing either THA or TKA received transfusions for Hb < 7 mg/dL, hypotension, extensive surgical blood loss, or fatigue.

Patients who did not have postoperative transfusion information available had a longer disease duration (21.3 ± 10.2 vs 13.5 ± 12.0 years, $P = .02$) compared with the remainder of patients, but no other statistically significant differences in baseline characteristics were found.

EBL was not significantly different between those who received TXA and those who did not (190.3 ± 68.7 vs 183.6 ± 52.9, $P = .93$).

Predictors of Transfusion

In the univariate analysis, patients who did not receive TXA had a decreased risk of transfusion (OR = 0.279, $P = .04$) (Table 2).

Predictors associated with a decreased risk of postoperative transfusion included baseline Hb ($P = .0001$) and HOOS/KOOS pain score ($P = .04$); predictors associated with an increased risk of postoperative transfusion included blood loss ($P = .001$), duration of surgery ($P = .0006$), baseline CDAI ($P = .01$), and ESR ($P = .02$). (Table 2).

The multivariate analysis included significant predictors from the univariate analysis. After adjustment for baseline CDAI, preoperative Hb, duration of surgery, TXA administration, and baseline DAS28-ESR, with TXA administration and baseline DAS28-ESR were forced into the mode as variables of interest, we found baseline CDAI, preoperative Hb, and surgery duration were statistically significant predictors of postoperative transfusion (Table 3).

Specifically, a one unit increase in CDAI at baseline was associated with increased risk of transfusion (OR = 1.113, 95% CI [1.024, 1.208], $P = .01$), a 1 g/dL increase in hemoglobin was associated with decreased risk of transfusion (OR = 0.347, 95% CI [0.191, 0.632], $P = .001$) and a 1 minute unit increase in duration of surgery was associated with increased risk of transfusion (OR = 1.028, 95% CI [1.011, 1.045], $P = .001$). Neither the administration of TXA nor the preoperative DAS28 were independently predictive of postoperative transfusion.

In addition, lower preoperative Hb was associated with higher disease activity (both CDAI [SCC = 0.017, $P = .03$] and DAS28 [SCC = −0.43, $P < .0001$]).

Discussion

This is the first study to describe the use of TXA in patients with RA. Surprisingly, although TXA has been shown to be effective in reducing transfusions in multiple prior studies, in our study of RA patients undergoing THA/TKA, we did not observe a lower transfusion rate in patients who received TXA, which may be because of the underlying disease process

itself or because of baseline anemia in these patients [11–17]. In this RA cohort of patients undergoing TJA, decreased preoperative Hb, increased duration of surgery, and higher RA disease activity were all associated with increased risk of transfusion.

We found low preoperative Hb was a risk factor for postoperative transfusion, and TXA may not prevent transfusion, which is supported by several studies. Bini et al [24] reported on 10,518 patients who underwent TKA, with TXA being administered in 2556 patients and reported that patients who received TXA were less likely to receive a postoperative transfusion; however, further analysis showed that patients with a preoperative Hb under 12.9 g/dL had an increased odds ratio for transfusion. In contrast to our findings, Bini et al [24], did not find duration of surgery to be associated with an increased risk of transfusion; moreover, the preoperative diagnosis (RA vs OA) was not reported.

Similarly, others have also reported that low preoperative Hb is associated with increased risk of transfusion in patients with RA. Ogbemudia et al [7] reported a transfusion rate of 21% in 349 patients with RA undergoing THA/TKA. The study authors found that patients with a Hb less than 90.0 g/L required a transfusion and that for each 1 g/L increase in the preoperative Hb, there was a 8.3% decrease in the probability of transfusion [7]. The study also reported a higher transfusion rate for THA but did not report on the use of TXA [7]. Salt et al [19] retrospectively reviewed demographic risk factors for transfusion in 3270 patients with RA undergoing THA/TKA and found a transfusion rate of 19.9% and an increased risk of transfusion for females and those with a history of anemia.

We did not find surgery type or gender as a risk factor for transfusion though the majority of our cohort was female; therefore, it would be difficult to conclude on the impact of gender. In addition, our transfusion rate was lower at 11.2%.

We found that preoperative Hb was inversely correlated with RA disease activity, demonstrating that patients with high disease activity are at risk for anemia, and both anemia of chronic disease and iron deficiency anemia are reported in RA [8]. Low preoperative Hb may be a modifiable risk factor, and both iron replacement or erythropoietin administration may be utilized to optimize anemia but have to be balanced by a potential increase in postoperative thrombotic events [5,25,26].

Our study has several limitations. The use of TXA was analyzed retrospectively, and the groups were not matched in several key variables including BMI, preoperative Hb, and baseline C-reactive protein; however, this is similar to previous published cohort studies [24]. In addition, use of TXA was not random, and patients who did not receive TXA had a nonclinically relevant higher baseline Hb, and these patients may have been selected out of TXA administration, biasing our results. Additionally, this cohort includes patients in which the institutional protocol for TXA was not fully implemented as well as the indications and exclusion criteria for its use, and patients with lower preoperative Hb may have missed TXA administration. Patients may also not have received TXA because of additional co-morbidities in which it was felt that TXA administration was not safe. Nonetheless, cases were recruited and enrolled consecutively, and the RA characteristics including disease activity were collected prospectively, strengthening the analysis of these factors. Lastly, as

the use of TXA was retrospectively analyzed, no power analysis was performed, and we may be unable to detect a difference in transfusion rate. Our results suggest that patients with a higher preoperative Hb may not benefit from TXA administration, especially as we did not find a difference in operative blood loss. We did not collect information regarding drain outputs as the use of drains are variable at our institution. We also note the discordance between DAS-ESR and CDAI, but the underestimation of disease activity at low DAS-ESR scores is well recognized and may contribute to this result [27,28]. As with any observational study, there may be unmeasured confounders.

We did not assess the risk of cardiovascular events such as myocardial infarction or ischemic stroke, pulmonary embolus, or deep venous thrombosis following TXA in this study. Studies have assessed the safety of TXA for use in THA/TKA [29–31]. Patients with RA however may be at increased risk; both the efficacy and the safety of TXA remains an area of future research for this patient population [32].

Conclusion

In conclusion, premedical optimization should include assessment and treatment of anemia in patients with RA who undergo THA/TKA. This is important as TXA did not result in a lower transfusion rate for this subpopulation of RA patients in this study. Decreased preoperative Hb may be a modifiable risk factor, whereas increased disease activity as measured by CDAI and increased surgical time were risk factors for postoperative transfusion but may be more difficult to change in these patients with long-standing RA. Future studies should prospectively assess the use of TXA in patients with RA.

Acknowledgments

This study was supported by the Clinical Translational Science Center (UL1-TR002384), Clinical Translational Science Award (# UL1TR001866), and the Accelerated Medicines Partnership (UH2-AR067691).

Appendix

Appendix I

Baseline Characteristics of Patients Undergoing Either Total Hip Arthroplasty or Total Knee Arthroplasty.

Characteristic	Hip N = 102	Knee N = 146	Combined N = 252	*P* Value
Age, y (mean ± SD)	61.5 ± 12.9	63.6 ± 9.4	62.7 ± 11.0	0.42
Female, n (%)	82 (78.1)	127 (87.0)	209 (83.3)	0.06
BMI, (mean ± SD)	28.9 ± 6.9	29.5 ± 6.7	29.3 ± 6.8	0.48
Duration_diag (mean ± SD)	12.4 ± 12.1	15.3 ± 11.8	14.1 ± 12.0	0.02
Race, n (%)				0.59
White	83 (78.3)	103 (2.9)	186 (73.8)	
Black	10 (9.4)	17 (11.6)	27 (10.7)	
Asian	2 (1.9)	4 (2.7)	6 (2.4)	
Other	11 (10.4)	22 (15.1)	33 (2.4)	
Smoking, n (%)	51 (53.7)	64 (50.0)	115 (51.6)	0.59

Characteristic	Hip N = 102	Knee N = 146	Combined N = 252	*P* Value
Education, n (%)				0.94
Less than College	13 (13.8)	18 (14.2)	31 (14.0)	
College or above	81 (86.2)	109 (85.8)	190 (86.0)	
Employment, n (%)				0.71
Employed	36 (38.3)	48 (38.1)	84 (38.2)	
Unemployed, Disabled or retire	52 (55.3)	73 (57.9)	125 (56.8)	
Other	6 (6.4)	5 (4.0)	11 (5.0)	
Ethnicity, n (%)				0.87
Hispanic or Latino	8 (8.1)	10 (7.5)	18 (7.7)	
Not Hispanic or Latino	90 (90.9)	121 (90.3)	211 (90.6)	
Do not wish to answer	1 (1.0)	3 (2.2)	4 (1.7)	
Criteria, n (%)				0.13
Meet both criteria	35 (38.0)	66 (47.8)	101 (43.9)	
1987	15 (16.3)	17 (12.3)	32 (13.9)	
2010	19 (20.7)	35 (25.4)	54 (23.5)	
Does not meet criteria	23 (25.0)	20 (14.5)	43 (18.7)	
Medication, n (%)				
NSAIDs	53 (52.5)	82 (60.7)	135 (57.2)	0.2
Steroids	37 (35.9)	50 (36.2)	87 (36.1)	0.96
Methotrexate	57 (55.3)	60 (43.8)	117 (48.8)	0.08
DMARD	29 (28.2)	41 (30.2)	70 (29.3)	0.74
Opioids	35 (34.3)	53 (39.0)	88 (37.0)	0.46
Biologic	50 (48.5)	78 (57.4)	128 (53.6)	0.18
Received TXA (IV or topical), n (%)	59 (55.7)	105 (71.9)	164 (65.1)	0.01
Preop hemoglobin, (mean ± SD)	12.9 ± 1.7	12.6 ± 1.4	12.8 ± 1.5	0.25
Platelet count (mean ± SD)	257.6 ± 76.7	276.0 ± 76.9	268.0 ± 77.1	0.08
Hx of previous transfusion n (%)	2 (2.0)	7 (5.3)	9 (3.9)	0.31
Hx of DVT n (%)	6 (5.9)	5 (3.8)	11 (4.7)	0.54
Hx of PE n (%)	2 (2.0)	2 (1.5)	4 (1.7)	1
Hx of CVA n (%)	7 (6.9)	3 (2.3)	10 (4.3)	0.11
Hx of Stroke n (%)	5 (4.9)	2 (1.5)	7 (3.0)	0.24
Hx of Malignancy n (%)	10 (9.8)	11 (8.4)	21 (9.0)	0.71
Hx of Hormone Therapy, n (%)	10 (9.8)	10 (7.6)	20 (8.6)	0.56
History of Myocardial Infraction n (%)	0 (0)	2 (1.5)	2 (0.9)	0.51
Estimated blood loss, mL (mean ± SD)	180.5 ± 50.5	195.7 ± 75.1	188.8 ± 65.3	0.09
IV TXA dose (mean ± SD)	972.2 ± 107.4	995.0 ± 44.7	986.8 ± 74.1	0.1
Topical TXA dose (mean ± SD)	3000.0 ± 0.0	2888.9 ± 400.3	2928.6 ± 323.3	0.29
Surgery Duration, min (mean ± SD)	87.9 ± 30.9	95.7 ± 33.9	92.4 ± 32.8	0.03
Post op transfusion needed?, Yes n (%)	9 (8.8)	17 (13.0)	26 (11.2)	0.32
Indication, n (%)				
Hemoglobin < 7	3 (2.8)	2 (1.4)	5 (2.0)	0.65
Hemoglobin <8	1 (0.9)	11 (7.5)	12 (4.8)	0.02

Characteristic	Hip N = 102	Knee N = 146	Combined N = 252	*P* Value
Hypotensive	2 (1.9)	1 (0.7)	3 (1.2)	0.57
Extensive surgical blood loss	0 (0)	2 (1.4)	2 (0.8)	0.51
Fatigue	1 (0.9)	1 (0.7)	2 (0.8)	1
MDHAQ, (mean ± SD)	3.8 ± 1.7	3.8 ± 1.7	3.8 ± 1.7	0.53
DAS28 – ESR, (mean ± SD)	3.6 ± 1.3	3.7 ± 1.3	3.7 ± 1.3	0.43
BL CDAI, (mean ± SD)	18.3 ± 10.2	18.6 ± 11.4	18.4 ± 10.9	0.73
ESR result (mean ± SD)	19.6 ± 20.1	21.0 ± 19.4	20.4 ± 19.7	0.28
CRP result (mean ± SD)	1.6 ± 2.3	1.7 ± 2.7	1.7 ± 2.5	0.85
CCP raw (mean ± SD)	213.8 ± 515.5	155.8 ± 101.8	178.2 ± 329.1	0.98
RF raw (mean ± SD)	246.8 ± 392.4	439.0 ± 705.7	362.5 ± 605.9	0.23
Pain score at baseline (mean ± SD)	40.1 ± 22.8	40.4 ± 18.4	40.3 ± 20.1	0.77
Function score at baseline (mean ± SD)	43.4 ± 22.1	48.6 ± 20.0	46.2 ± 21.1	0.08
Length of stay (mean ± SD)	73.3 ± 38.2	87.8 ± 34.6	81.8 ± 36.7	0.0001

BMI, body mass index; RA, rheumatoid arthritis; TXA, Tranexamic acid; DVT, deep vein thrombosis; PE, pulmonary embolism; CVA, cerebrovascular accident; CRP, C-reactive protein; ESR, erythrocyte sedimentation rate; CDAI, Clinical Disease Activity Index; MDHAQ, Multidimensional Health Assessment Questionnaire; DAS, Disease Activity Score; DMARDs, disease modifying antirheumatic drugs; THA, total hip arthroplasty; TKA, total knee arthroplasty.

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Table 1

Baseline Characteristics for Patients who Received Tranexamic Acid (TXA) and Did Not Receive TXA.

Characteristic	Received TXA N = 164	Did Not Receive TXA N = 88	Combined	*P* Value
Age, y (mean ± SD)	62.7 ± 10.5	62.9 ± 11.9	62.7 ± 11.0	0.72
Female, n (%)	141 (86.5)	68 (77.3)	209 (83.3)	0.06
BMI, (mean ± SD)	29.5 ± 7.1	28.8 ± 6.2	29.3 ± 6.8	0.62
RA Duration (mean ± SD)	13.4 ± 11.9	15.3 ± 12.2	14.1 ± 12.0	0.22
Type of surgery, n (%)				0.01
TKA	105 (64.0)	41 (46.6)	146 (57.9)	
THA	59 (36.0)	47 (53.4)	106 (42.1)	
Race, n (%)				0.95
White	122 (74.4)	64 (72.7)	186 (73.8)	
Black	18 (11.0)	9 (10.2)	27 (10.7)	
Asian	4 (2.4)	2 (2.3)	6 (2.4)	
Other	20 (12.2)	13 (14.8)	33 (2.4)	
Smoking, n (%)	77 (54.6)	38 (46.3)	115 (51.6)	0.23
Education, n (%)				0.51
Less than College	18 (12.9)	13 (16.1)	31 (14.0)	
College or above	122 (87.1)	68 (84.0)	190 (86.0)	
Employment, n (%)				0.34
Employed	58 (41.7)	26 (32.1)	84 (38.2)	
Unemployed, Disabled, or Retired	75 (54.0)	50 (61.7)	125 (56.8)	
Other	6 (4.3)	5 (6.2)	11 (5.0)	
Ethnicity, n (%)				0.67
Hispanic or Latino	10 (6.7)	8 (9.6)	18 (7.7)	
Not Hispanic or Latino	137 (91.3)	74 (89.2)	211 (90.6)	
Do not wish to answer	3 (2.0)	1 (1.2)	4 (1.7)	
Criteria, n (%)				0.09
Meet both criteria	73 (46.5)	28 (38.4)	101 (43.9)	
1987	19 (12.1)	13 (17.8)	32 (13.9)	
2010	41 (26.1)	13 (17.8)	54 (23.5)	

Characteristic	Received TXA N = 164	Did Not Receive TXA N = 88	Combined	*P* Value
Does not meet criteria	24 (15.3)	19 (26.0)	43 (18.7)	
Medication, n (%)				
NSAIDs	94 (61.8)	41 (48.8)	135 (57.2)	0.06
Steroids	56 (35.9)	31 (36.5)	87 (36.1)	0.93
Methotrexate	74 (47.4)	43 (51.2)	117 (48.8)	0.58
DMARD	45 (29.0)	25 (29.8)	70 (29.3)	0.91
Opioids	57 (37.0)	31 (36.9)	88 (37.0)	0.98
Biologic	86 (55.5)	42 (50.0)	128 (53.6)	0.42
Preop hemoglobin, g/dL (mean ± SD)	12.6 ± 1.4	13.1 ± 1.9	12.8 ± 1.5	0.01
Platelet count (mean ± SD)	271.8 ± 76.6	256.0 ± 78.3	268.0 ± 77.1	0.19
Hx of previous transfusion, n (%)	5 (3.1)	4 (5.8)	9 (3.9)	0.46
Hx of DVT, n (%)	5 (3.1)	6 (8.7)	11 (4.7)	0.09
Hx of PE, n (%)	2 (1.2)	2 (2.9)	4 (1.7)	0.58
Hx of CVA, n (%)	7 (4.3)	3 (4.4)	10 (4.3)	0.98
Hx of stroke, n (%)	4 (2.4)	3 (4.4)	7 (3.0)	0.43
Hx of malignancy, n (%)	15 (9.2)	6 (8.7)	21 (9.0)	0.91
Hx of hormone therapy, n (%)	16 (9.8)	4 (5.8)	20 (8.6)	0.32
History of myocardial infraction, n (%)	2 (1.2)	0 (0)	2 (0.9)	1
Estimated blood loss, mL (mean ± SD)	190.3 ± 68.7	183.6 ± 52.9	188.8 ± 65.3	0.93
IV TXA dose (mean ± SD)	986.8 ± 74.1	-	986.8 ± 74.1	-
Topical TXA dose (mean ± SD)	2928.6 ± 323.3	-	2928.6 ± 323.3	-
Surgery duration, min (mean ± SD)	93.8 ± 31.0	86.7 ± 39.2	92.4 ± 32.8	0.01
Post op transfusion needed?, Yes n (%)	23 (14.0)	3 (4.4)	26 (11.2)	0.03
Indication, n (%)				
Hemoglobin <7	5 (3.1)	0 (0)	5 (2.0)	0.17
Hemoglobin <8	12 (7.3)	0 (0)	12 (4.8)	0.01
Hypotensive	0 (0)	3 (3.4)	3 (1.2)	0.04
Extensive surgical blood loss	2 (1.2)	0 (0)	2 (0.8)	0.54
Fatigue	2 (1.2)	0 (0)	2 (0.8)	0.54
MDHAQ, (mean ± SD)	3.8 ± 1.8	3.8 ± 1.7	3.8 ± 1.7	0.98
DAS28 – ESR, (mean ± SD)	3.8 ± 1.3	3.5 ± 1.2	3.7 ± 1.3	0.21

Characteristic	Received TXA N = 164	Did Not Receive TXA N = 88	Combined	*P* Value
CDAI, (mean ± SD)	18.7 ± 11.5	17.8 ± 9.4	18.4 ± 10.9	0.86
ESR result (mean ± SD)	20.5 ± 18.8	20.4 ± 21.5	20.4 ± 19.7	0.29
CRP result (mean ± SD)	1.6 ± 2.3	1.9 ± 2.9	1.7 ± 2.5	0.62
CCP raw (mean ± SD)	199.3 ± 393.8	134.8 ± 101.8	178.2 ± 329.1	0.09
RF raw (mean ± SD)	345.6 ± 558.9	404.6 ± 719.6	362.5 ± 605.9	0.94
Pain score at baseline (mean ± SD)	40.3 ± 20.6	40.3 ± 19.2	40.3 ± 20.1	0.82
Function score at baseline (mean ± SD)	45.8 ± 22.1	47.0 ± 19.4	46.2 ± 21.1	0.69
Length of stay (mean ± SD)	83.3 ± 40.2	78.8 ± 28.3	81.8 ± 36.7	0.62

BMI, body mass index; RA, rheumatoid arthritis; TXA, Tranexamic acid; DVT, deep vein thrombosis; PE, pulmonary embolism; CVA, cerebrovascular accident; CRP, C-reactive protein; ESR, erythrocyte sedimentation rate; CDAI, Clinical Disease Activity Index; MDHAQ, Multidimensional Health Assessment Questionnaire; DAS, Disease Activity Score; DMARDs, disease modifying antirheumatic drugs; THA, total hip arthroplasty; TKA, total knee arthroplasty; CCP, cyclic citrullinated peptide; RF, rheumatoid factor; NSAID, nonsteroidal anti-inflammatory drug.

Table 2

Univariate Analysis for Transfusion Predictors.

Univariate Variable	Subcategory	Odds Ratio (95% CI)	*P* Value
Age		1.010 (0.973, 1.050)	0.59
Gender	Female vs Male	2.89 (0.656, 12.734)	0.16
Race	Asian vs White	4.361 (0.746, 25.504)	0.12
	Black vs White	1.744 (0.537, 5.672)	0.77
	Other vs White	0.671 (0147, 3.064)	0.19
Ethnicity	Hispanic or Latino vs Not Hispanic or Latino	0.675 (0.115, 3.976)	0.81
BMI		0.957 (0.897, 1.022)	0.19
Have you ever smoked cigarettes	No vs Yes	0.679 (0.280, 1.645)	0.39
Highest Level of education completed	College or above vs Less than college	0.343 (0.527, 165.517)	0.13
Employment Status	Employed vs Unemployed or Disabled or Retired	0.797 (0.326, 1.951)	0.68
	Other vs Unemployed or Disabled or Retired	0.315 (0.015, 6.476)	0.5
RA Criteria	1987 Criteria vs Meets Both Criteria	0.356 (0.077, 1.648)	0.51
	2010 Criteria vs Meets Both Criteria	0.454 (0.142, 1.448)	0.75
TXA	No vs Yes	0.279 (0.081, 0.961)	0.04
Type of Surgery	THA vs TKA	0.649 (0.277, 1.523)	0.32
NSAIDs	No vs Yes	0.857 (0.367, 2.004)	0.72
Opioid	No vs Yes	0.718 (0.309, 1.668)	0.44
Methotrexate	No vs Yes	2.169 (0.894, 5.259)	0.09
Steroids	No vs Yes	0.701 (0.302, 1.628)	0.41
Biologic	No vs Yes	0.592 (0.250, 1.404)	0.23
Other DMARD	No vs Yes	1.374 (0.522, 3.614)	0.52
Prior Transfusion	No vs Yes	0.420 (0.082, 2.138)	0.3
Prior DVT	No vs Yes	3.106 (0.157, 61.557)	0.46
History of PE	No vs Yes	1.171 (0.044, 31.481)	0.92
History of CVA	No vs Yes	1.136 (0.138, 9.349)	0.91
History of Stroke	No vs Yes	0.746 (0.086, 6.450)	0.79
History of Malignancy	No vs Yes	0.730 (0.20, 2.669)	0.63
History of Hormone Therapy	No vs Yes	2.526 (0.324, 19.689)	0.38

Univariate Variable	Subcategory	Odds Ratio (95% CI)	*P* Value
History of Myocardial Infraction	No vs Yes	0.644 (0.015, 27.105)	0.82
Hemoglobin at baseline		0.559 (0.417, 0.749)	0.0001
Platelet count		1.002 (0.997, 1.007)	0.53
Estimated blood loss		1.010 (1.004, 1.017)	0.001
IV TXA dose		1.035 (0.057, 18.848)	0.98
Topical TXA dose		0.999 (0.997, 1.001)	0.24
Duration of Surgery		1.018 (1.008, 1.029)	0.0006
HOOS/KOOS pain at baseline		0.974 (0.949, 0.999)	0.04
HOOS/KOOS function at baseline		0.993 (0.971, 1.014)	0.5
Duration of disease		1.030 (0.997, 1.063)	0.08
MDHAQ at baseline		0.978 (0.756, 1.265)	0.86
DAS28-ESR at baseline		1.370 (0.962, 1.951)	0.08
CDAI at baseline		1.048 (1.011, 1.087)	0.01
CRP result at baseline		0.964 (0.793, 1.171)	0.71
ESR result at baseline		1.023 (1.004, 1.042)	0.02
CCP Raw at baseline		1.0 (0.998, 1.002)	0.91
RF Raw at baseline		1.0 (0.999, 1.001)	0.99

BMI, body mass index; RA, rheumatoid arthritis; TXA, Tranexamic acid; DVT, deep vein thrombosis; PE, pulmonary embolism; CVA, cerebrovascular accident; CRP, C-reactive protein; ESR, erythrocyte sedimentation rate; CDAI, Clinical Disease Activity Index; MDHAQ, Multidimensional Health Assessment Questionnaire; DAS, Disease Activity Score; DMARDs, disease modifying antirheumatic drugs; THA, total hip arthroplasty; TKA, total knee arthroplasty; HOOS, Hip Disability and Osteoarthritis Outcomes Score; KOOS, Knee Injury and Osteoarthritis Outcomes Score.

Table 3

Multivariate Analysis for Transfusion Predictors.

Multivariate Variable	Odds Ratio (95% CI)	*P* Value
TXA, No vs Yes	0.585 (0.068, 5.06)	0.63
Baseline CDAI	1.079 (1.001, 1.162)	0.04
Baseline DAS28 – ESR	0.666 (0.313, 1.416)	0.29
Baseline Hemoglobin	0.394 (0.232, 0.669)	0.001
Duration of Surgery	1.022 (1.008, 1.037)	0.003

TXA, Tranexamic acid; CDAI, Clinical Disease Activity Index; DAS, Disease Activity Score; ESR, erythrocyte sedimentation rate.