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ORIGINAL ARTICLE

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The use of tranexamic acid in patients submitted to primary total hip and knee arthroplasty: a single-center retrospective observational study

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ABSTRACT

Introduction: This study aimed to determine the efficacy of intravenous tranexamic acid (TXA) in change in hemoglobin levels and need of red blood cell (RCB) transfusion following total hip arthroplasty (THA) and total knee arthroplasty (TNA) when compared with non-tranexamic acid treatment.

Material and methods: We retrospectively reviewed 33 hips and 44 knees between January 2023 and December 2023. Outcome measures were hemoglobin drop (among postoperative first day), need of RBC transfusion, number of RBC units, hemoglobin levels among preoperative, and postoperative 1, 2, and 5 day.

Results: Among THA patients, use of TXA compared to the non-TXA group was associated with a reduced need for RBC transfusion (12.5% vs. 32.0%; $p = 0.496$). Drop in hemoglobin levels within the first postoperative day was significantly greater in the non-TXA group (2.4 ± 1.12) compared to the TXA group (1.48 ± 0.53; $p = 0.032$). Among TKA patients, drop in hemoglobin levels on the first postoperative day was significantly smaller in the TXA group (1.05) than in the non-TXA group (2.31), with a significant p-value of < 0.001, with the need of RBC transfusion at 20% vs. 83.3%, respectively ($p < 0.001$).

Conclusion: Our study supports the use of TXA as an effective measure to reduce the need for RBC transfusion in patients undergoing THA and TKA. The findings suggest that TXA may contribute to better postoperative outcomes by maintaining higher hemoglobin levels and reducing the need for transfusion.

Keywords: intravenous tranexamic acid; total hip arthroplasty; total knee arthroplasty; blood loss

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Introduction

The use of lower limb total joint arthroplasty has seen a notable rise in popularity owing to its efficacy in managing advanced joint ailments. There has been a significant increase in the number of patients receiving total hip arthroplasty (THA) and total knee arthroplasty (TKA) in recent years. Approximately 500 million individuals worldwide were affected by osteoarthritis in 2017, according to estimates [1]. Osteoarthritis is a prevalent degenerative joint condition that mostly affects those over the age 65 and above, reaching a rate of up to 50% [2]. Osteoarthritis is a significant cause for visits to family physicians and is responsible for over 50% of all prescriptions for nonsteroidal anti-inflammatory drugs [3]. The presence of arthritis in the knee and hip joints may significantly hinder activities such as walking, ascending stairs, and performing self-care tasks. Osteoarthritis, particularly in the hip and knee, has a significant impact on an individual's physical, emotional, and social

well-being [4]. The rising longevity of people is related to the growing occurrence of osteoarthritis [5]. Ensuring optimal care for osteoarthritis is crucial for improving the quality of life of middle-aged and older adults. Both THA and TKA have shown substantial effectiveness in reducing pain and enhancing functional rehabilitation in persons with severe knee and hip problems. However, the study of managing postoperative complications after THA and TKA has been a significant area of research in recent years.

Multiple studies have shown a correlation between significant blood loss and the use of transfusions in the perioperative period, leading to the future occurrence of complications following surgery [6–9]. An extensive retrospective analysis of more than 1,013,024 patients in the United States revealed a decrease in the transfusion rate for both first and subsequent total hip and knee replacement procedures between 2010 and 2015 [10]. Blood transfusions not only heighten the likelihood of an immunological reaction and transfer of diseases but also increase the likelihood of difficulties before and after surgery, as well as the expenses linked to hospitalization. Prior research has shown that the use of allogeneic blood transfusion, which involves using blood from a different donor, might lead to notable negative consequences. These complications include infection at the surgical site and adjacent artificial joints, deep vein thrombosis after surgery, as well as increased risks of illness and death after surgery [11–13]. Elderly adults, especially females, who have additional health conditions such as blood clotting disorders, a higher American Society of Anesthesiologists (ASA) grade, lower levels of preoperative hemoglobin, and greater postoperative drainage volume, are more likely to need a blood transfusion after orthopedic surgeries [14–16]. Enhanced implementation of patient blood management strategies and the use of tranexamic acid (TXA) may substantially reduce the need for blood transfusion. TXA is a synthetic chemical synthesized from amino acids that inhibits the degradation of blood clots by temporarily blocking the site where lysine attaches to the fibrinogen molecule. This hindrance impedes the transformation of fibrinogen into fibrinolytic enzymes — fibrinolysis [17]. The decay rate of TXA in the joint fluid is around 3 hours [18]. Several studies have shown the effectiveness and safety of intravenous TXA in the treatment of TKA and THA; however, it has not yet been widely adopted as the standard practice.

The purpose of this study was to determine the efficacy of intravenous TXA in change in hemoglobin (Hgb) levels and need of red blood cell (RCB) transfusion following THA and TKA when compared with non-TXA treatment.

Material and methods

A retrospective study was conducted at Department of Trauma and Orthopedic Surgery in City Hospital of Ruda Slaska (Poland). Individuals aged 18 years or older were included in evaluation for the study if they had received only IV (intravenous) TXA ordered by a single surgeon who performed their THA or TKA from January 2023 to December 2023. Approval for the study was granted by the Institutional Review Board of Polish Society of Disaster Medicine (Decision No. 03.12.2023. IRB). The study was conducted in accordance with the principles of the Declaration of Helsinki. A total of 77 patients with degenerative changes of the knee or hip who underwent THA or TKA between January 2023 and December 2023 were enrolled in this retrospective study. Only patients with complete dataset and a minimum 24-hour hospital stay were included. Patients who were aged under 18 years, with allergy to tranexamic acid, preoperative renal or hepatic dysfunction, known bleeding disorders or preoperative coagulation anomalies, anticoagulant or aspirin-like medication and long acting NSAID medication. Short acting NSAID's were discontinued at least 24 hours before surgery.

Data were collected from electronic medical records. Patients' charts were screened for demographics (age, sex), patient comorbidities, whether TXA was received and route of administration, type of surgery, Hgb values at baseline and following surgery (postoperative day 1, 3 and 5), RBC transfusions, and units of RBCs transfused.

Tranexamic acid, when administered, was given intravenously maximum 1g dose within one hour prior to incision. Contraindications for the use of TXA were prior history of transient ischemic attack (TIA) or stroke, or history of cardiac or vascular stents or thrombosis. No patient received topical or oral TXA.

The primary outcome was to evaluate the change in Hgb levels from preoperative TKA or THA to first measured postoperative Hgb within 24 hours. Secondary outcomes were the proportion of patients who underwent RBC transfusion during hospitalization and number of RBC units transfused during hospitalization.

Statistical analysis

Demographic data were compared between patients who received TXA and those who did not. The normality of data distribution was evaluated using the Shapiro-Wilk test. Normally distributed continuous data are expressed as mean ± SD (standard deviation) and were compared using Student's t test. Non-normally distributed

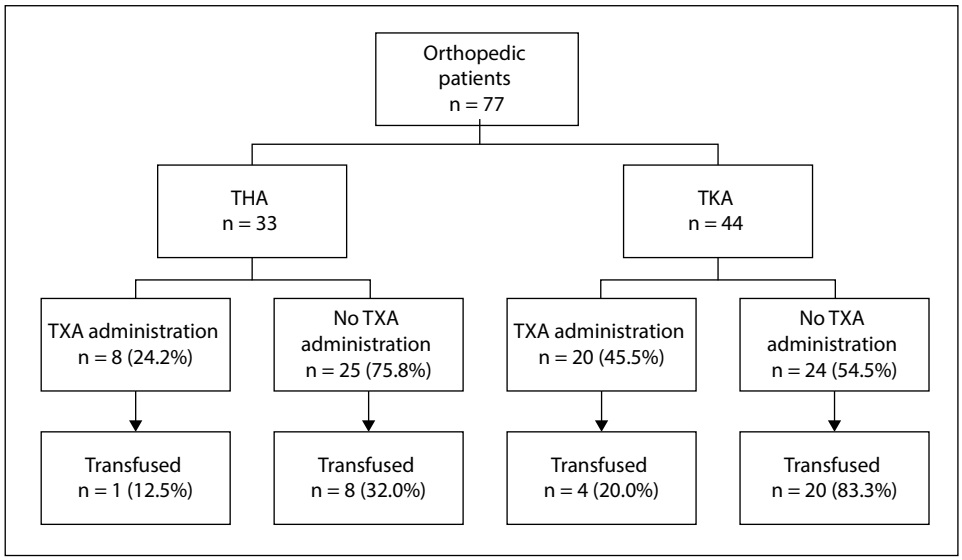

Figure 1. Transfusion rates by surgery type and TXA administration

continuous data are presented as mean (SD) and were compared using the Mann–Whitney U test. Categorical data are expressed as frequencies and percentages and were compared using the Pearson chi-square test or Fisher's exact test. Multivariate logistic regression analysis was con- ducted to identify factors associated with perioperative blood transfusion. A stepwise logistic model was used to determine the best-fit multivariate model. All statistical analyses were performed using Stata software version 18 (StataCorp, College Station, TX, USA). Statistical significance was set at $p < 0.05$ (two-sided).

Results

Overall, 33 patients were undergoing THA and 44 patients underwent TKA surgery (Fig. 1).

Total hip arthroplasty

Detailed distribution of patient demographics and characteristics is presented in Table 1. Comparison of demographic and clinical parameters between the TXA group (n = 8) and the non-TXA group (n = 25) revealed no significant differences in sex distribution, mean age, or the presence of comorbidities such as hypertension, diabetes mellitus (DM), ischemic heart disease, thrombosis, obesity, lung disease, hypercholesterolemia, or cardiac arrhythmia, with all p-values above 0.05.

The proportion of patients requiring RBC transfusion during hospital stay was 12.5% (1 patient) in the TXA group compared to 32.0% (8 patients) in the non-TXA group, which was not statistically significant ($p = 0.496$). The mean number of RBC units received in transfused patients was similar between the groups, with 2.0 ± 0.1 in the TXA group and 2.25 ± 1.23 in the non-TXA group ($p = 0.278$).

The analysis of RBC units transfused during hospitalization showed that 87.5% of the TXA group did not receive any transfusion compared to 68.0% of the non-TXA group, which was not statistically significant ($p = 0.394$). No patients in either group received 1 or 3 units of blood, with p-values of 1.0. A comparison of those who received 2 units showed no significant difference between groups (12.5% in the TXA group vs. 28.0% in the non-TXA group, $p = 0.643$). One patient in the non-TXA group received 4 units of RBC, but this was also not statistically significant ($p = 1.0$).

Mean hemoglobin levels preoperatively and on postoperative day 1 and day 2 showed no significant differences between the TXA and non-TXA groups (Fig. 2). However, the drop in hemoglobin levels within the first postoperative day was significantly greater in the non-TXA group (2.4 ± 1.12) compared to the TXA group (1.48 ± 0.53), with a p-value of 0.032. On postoperative day 5, the mean hemoglobin level was lower in the TXA group (9.63 ± 1.19) compared to the non-TXA group (10.4 ± 1.19), but this difference was not statistically significant ($p = 0.109$).

Total knee arthroplasty

The assessment of the characteristics and clinical outcomes between the TXA group (n = 20) and the non-TXA group (n = 24) indicated no significant difference in

Table 1. Baseline characteristics of THA patients

Parameter	TXA group (n = 8)	Non-TXA group (n = 25)	p-value
Sex, n (%)			
Male	6 (75.0%)	15 (60.0%)	0.443
Age (years), mean (SD)	68.88 ± 8.12	68.04 ± 10.01	0.613
Comorbidities, n(%)			
Hypertension	5 (62.5%)	20 (80.0%)	0.315
Diabetes mellitus	4 (50.0%)	8 (32.0%)	0.420
Ischemic heart disease	0 (0.0%)	4 (16.0%)	0.550
Thrombosis	0 (0.0%)	0 (0.0%)	1.0
Obesity	0 (0.0%)	3 (12.0%)	0.560
Lung disease	0 (0.0%)	0 (0.0%)	1.0
Hypercholesterolemia	0 (0.0%)	0 (0.0%)	1.0
Cardiac arrythmia	0 (0.0%)	0 (0.0%)	1.0
RBC transfusion during hospital stay (or to day 30), n (%)	1 (12.5%)	8 (32.0%)	0.496
RBC units received in transfused patients, mean (SD)	2.0 ± 0.1	2.25 ± 1.23	0.278
RBC units transfused during hospitalization, n (%)			
0	7 (87.5%)	17 (68.0%)	0.394
1	0 (0.0%)	0 (0.0%)	1.0
2	1 (12.5%)	7 (28.0%)	0.643
3	0 (0.0%)	0 (0.0%)	1.0
4	0 (0.0%)	1 (4.0%)	1.0
Hemoglobin, g/dL, mean (SD)			
Hemoglobin preop.	13.44 ± 1.13	13.84 ± 1.13	0.344
Hemoglobin postop. Day 1	11.96 ± 1.44	11.44 ± 1.44	0.355
Delta 1 day	**1.48 (0.53)**	**2.4 (1.12)**	**0.032**
Hemoglobin postop. Day 2	10.86 ± 1.39	10.54 ± 1.39	0.501
Hemoglobin postop. Day 5	9.63 ± 1.19	10.4 ± 1.19	0.109

SD — standard deviation; RBC — red blood cells; TXA — tranexamic acid

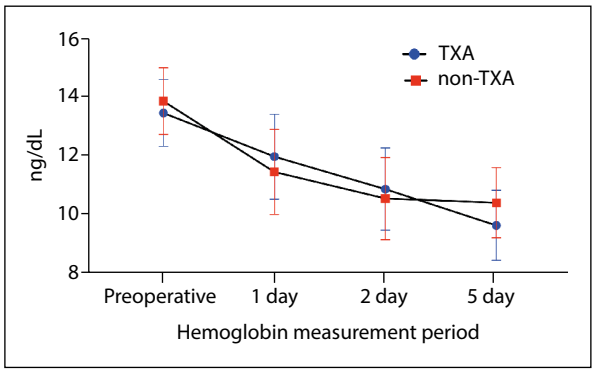

Figure 2. Comparison of the preoperative, postoperative day, second and fifth postoperative day hemoglobin levels after total hip arthroplasty

gender distribution, with males comprising 20.0% and 25.0% of the respective groups (p = 0.694; Table 2). Age comparison revealed no considerable difference, with mean ages being 69.3 years for the TXA group and 71.42 years for the non-TXA group (p = 0.198). When evaluating comorbid conditions, the incidence of hypertension, diabetes mellitus, ischemic heart disease, thrombosis, obesity, lung disease, hypercholesterolemia, and cardiac arrhythmia showed no statistical discrepancy between the two groups, with p-values ranging from 0.054 to 1.0.

A notable finding was the requirement for RBC transfusion during the hospital stay, with the TXA group having a significantly lower percentage (20.0%)

Table 2. Baseline characteristics of TKA patients

Parameter	TXA group (n = 20)	Non-TXA group (n = 24)	p-value
Sex, n (%)			
Male	4 (20.0%)	6 (25.0%)	0.694
Age (years), mean (SD)	69.3 ± 7.2	71.42 ± 7.2	0.198
Comorbidities, n (%)			
Hypertension	12 (60.0%)	16 (66.7%)	0.084
Diabetes mellitus	3 (15.0%)	7 (29.2%)	0.054
Ischemic heart disease	1 (5.0%)	1 (4.2%)	1.0
Thrombosis	0 (0.0%)	0 (0.0%)	1.0
Obesity	2 (10.0%)	1 (4.2%)	0.848
Lung disease	0 (0.0%)	2 (8.3%)	0.101
Hypercholesterolemia	3 (15.0%)	5 (20.8%)	0.617
Cardiac arrythmia	3 (15.0%)	2 (8.3%)	0.810
RBC transfusion during hospital stay (or to day 30), n(%)	4 (20.0%)	20 (83.3%)	< 0.001
Mean number of RBC units received in transfused patients, mean (SD)	2.25 ± 0.78	2.15 ± 0.68	< 0.001
RBC units transfused during hospitalization, n (%)			
0 units	16 (80.0%)	4 (16.7%)	< 0.001
1 unit	0 (0.0%)	1 (4.2%)	1.0
2 units	3 (15.0%)	17 (70.8%)	< 0.001
3 units	1 (5.0%)	0 (0.0%)	0.455
4 units	0 (0.0%)	2 (8.3%)	0.493
Hemoglobin, g/dL, mean (SD)			
Hemoglobin preop.	13.44 ± 1.15	13.33 ± 1.13	0.524
Hemoglobin postop. Day 1	12.39 ± 1.31	11.52 ± 1.29	< 0.001
Delta 1 day	1.05 (0.74)	2.31 (0.92)	< 0.001
Hemoglobin postop. Day 2	11.22 ± 1.28	10.33 ± 1.27	< 0.001
Hemoglobin postop. Day 5	10.21 ± 1.17	9.85 ± 1.16	0.053

SD — standard deviation; RBC — red blood cells; TXA — tranexamic acid

compared to the non-TXA group (83.3%), which was highly significant ($p < 0.001$). Furthermore, the average number of RBC units received by those who were transfused was not significantly different between the groups ($p < 0.001$).

In-depth analysis of the RBC units transfused revealed that 80.0% of the TXA group did not need any transfusion compared to only 16.7% in the non-TXA group, showing a significant difference ($p < 0.001$). For patients who received two units of blood, there was a stark contrast with 15.0% in the TXA group against 70.8% in the non-TXA group ($p < 0.001$). There was no statistical significance in the comparison of 3 and 4 units transfused across the groups ($p = 0.455$ and $p = 0.493$, respectively).

Hemoglobin levels prior to surgery were comparable between both groups ($p = 0.524$; Fig. 3). However, the drop in hemoglobin levels on the first postoperative day was significantly smaller in the TXA group (1.05) than in the non-TXA group (2.31), with a significant p-value of < 0.001. Hemoglobin levels on the second postoperative day and fifth postoperative day also demonstrated a significant difference ($p < 0.001$ and $p = 0.053$, respectively), with the TXA group maintaining higher levels.

Discussion

The utilization of TXA in THA and TKA has been the subject of extensive research due to its potential

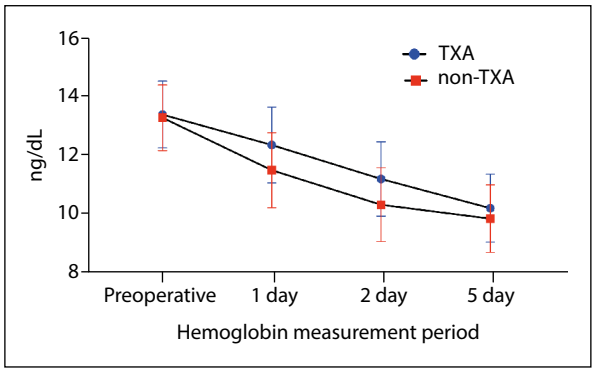

Figure 3. Comparison of the preoperative, postoperative day, second and fifth postoperative day hemoglobin levels after total knee arthroplasty

to reduce perioperative blood loss and the need for transfusion. Our study's findings contribute to the growing body of evidence supporting the efficacy of TXA in this context.

The mechanism of action of TXA is highly specific to the preservation of the clotting matrix, making it an invaluable agent in surgeries where blood conservation is critical [19]. Unlike other antifibrinolytic agents, TXA does not have a prothrombotic effect, meaning it does not increase the risk of developing blood clots that can lead to conditions such as deep vein thrombosis or pulmonary embolism [20]. This specificity allows TXA to be used in a controlled manner, targeting the fibrinolytic pathway without tipping the balance towards excessive clot formation [21].

In the context of surgical procedures, especially those with a high risk of bleeding such as THA and TKA, the administration of TXA can be a crucial intervention [22, 23]. By maintaining clot integrity during and after surgery, TXA reduces the need for blood transfusions, which are associated with risks and additional costs. Allogeneic blood transfusion is known to increase the risk of surgical site infection, as well as other long-term hospitalization and death consequences. Numerous studies have shown that the use of TXA in TKA, THA and other forms of surgery is not only a successful means of reducing total blood loss but also healthcare expenses while maintaining patient safety [24–26]. The pharmacological action of TXA, therefore, makes it a targeted and effective means to manage hemostasis in clinical practice.

The observed reduction in the incidence of RBC transfusion in patients receiving TXA aligns with the body of research indicating TXA's efficacy in minimizing perioperative blood loss [27, 28]. Such reductions have been noted not only in elective orthopedic surgeries but also in cases of trauma and significant hemorrhage [29, 30], highlighting TXA's broad applicability. In our analysis, we observed that the TXA group had a significantly lower incidence of RBC transfusion during hospital stay compared to the non-TXA group. This is consistent with previous studies that have shown TXA to reduce bleeding during and after orthopedic surgeries. Notably, the average number of RBC units required by patients who did receive a transfusion did not differ significantly between the groups, suggesting that while TXA may reduce the likelihood of needing a transfusion, it may not influence the quantity of blood required once transfusion is deemed necessary.

A critical observation was the significant difference in the delta of hemoglobin levels from preoperative to postoperative Day 1, with the TXA group experiencing a smaller decrease. This suggests that TXA not only reduces the risk of transfusion but also mitigates the drop in hemoglobin levels, which is an important consideration for patient recovery and postoperative outcomes.

There are several limitations to this study. A limitation of the study is its single-center retrospective nature, as well as the lack of data on blood loss parameters during the procedure. Our sample size was small, and the results may have been biased. A larger randomized prospective trial is required to further improve the relevant experiments to determine the efficacy and safety of TXA in the perioperative period of THA and TKA.

Conclusion

In conclusion, our study supports the use of TXA as an effective measure to reduce the need for RBC transfusion in patients undergoing THA and TKA. The findings suggest that TXA may contribute to better postoperative outcomes by maintaining higher hemoglobin levels and reducing the need for transfusion, which can also be beneficial from an economic standpoint given the costs associated with blood products and transfusion-related complications. Future prospective studies with larger sample sizes and diverse patient populations are warranted to confirm these results and to explore the optimal dosing and timing of TXA administration in the context of orthopedic surgery.

Article information

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