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Original Article

Effect of Tranexamic Acid on Perioperative and Hidden Blood Loss in Hip Fracture Surgery: A Prospective Comparative Study

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ABSTRACT

Background*:** Perioperative blood loss and transfusion remain major concerns in hip fracture surgery, particularly among elderly patients with comorbidities. Intravenous tranexamic acid (TXA), an antifibrinolytic agent, has been shown to reduce surgical bleeding in arthroplasty; however, evidence in acute hip fracture surgery, which often includes both fixation and hemiarthroplasty procedures, remains limited. This study aimed to evaluate the efficacy and safety of TXA in reducing visible and hidden blood loss, and its impact on transfusion requirements. ***Methods This prospective comparative study included 30 patients undergoing hip fracture surgery, divided equally into TXA and control groups. The TXA group received 15 mg/kg intravenous TXA at skin incision and 3 hours postoperatively. Intraoperative, postoperative drain, and hidden blood losses were calculated using the Gross formula. Hemoglobin and hematocrit levels were recorded preoperatively and on postoperative day 3. Transfusion requirements and perioperative complications were analyzed. Subgroup analysis was performed for fixation and hemiarthroplasty procedures. ***Results*** Mean intraoperative blood loss (305 ± 75 mL vs 485 ± 110 mL, $p < 0.001$), postoperative drain output (140 ± 55 mL vs 260 ± 80 mL, $p < 0.001$), and total blood loss (1005 ± 180 mL vs 1565 ± 260 mL, $p < 0.001$) were significantly lower in the TXA group compared with controls. The hemoglobin drop was smaller in the TXA group (1.6 ± 0.4 g/dL vs 2.8 ± 0.6 g/dL, $p < 0.001$). Fewer TXA patients required transfusion (20% vs 60%, $p = 0.018$). No thromboembolic or major complications were observed. Subgroup analysis showed consistent benefit in both fixation and hemiarthroplasty. ***Conclusion*** Intravenous TXA significantly reduces perioperative visible, hidden, and total blood loss and decreases transfusion requirements in hip fracture surgery without increasing thromboembolic risk. TXA use should be considered a safe and effective component of blood conservation strategies in elderly hip fracture patients.

Keywords: Tranexamic acid; Hip fracture; Blood loss; Hidden blood loss; Transfusion; Hemiarthroplasty; Fixation; Orthopaedic trauma.

INTRODUCTION:

Hip fractures are among the most common injuries in the elderly population and are associated with substantial morbidity, mortality, and healthcare costs. Surgical fixation or hemiarthroplasty remains the mainstay of treatment; however, these procedures are often accompanied by significant perioperative blood loss, which may exacerbate postoperative anemia, delay mobilization, and increase the need for allogeneic blood transfusion【1,2】. Blood transfusion, while lifesaving, carries risks of infection, immune reactions, and increased hospital stay, and places a burden on limited blood bank resources【3】.

Tranexamic acid (TXA), a synthetic antifibrinolytic agent that inhibits plasminogen activation, has been widely used in elective orthopedic surgeries such as total

hip and knee arthroplasty, with proven efficacy in reducing blood loss and transfusion requirements【4,5】. Its role in orthopedic trauma, however, particularly in hip fracture surgery, has been less extensively studied due to heterogeneity in fracture types, patient comorbidities, and surgical procedures【6–8】. Recent randomized controlled trials and meta-analyses have reported encouraging results, suggesting that TXA can safely reduce both visible and hidden blood loss in hip fracture surgery without increasing thromboembolic complications【9–11】.

The concept of hidden blood loss—the discrepancy between observed perioperative loss and actual reduction in hemoglobin/hematocrit—has gained increasing attention in recent years【12,13】. In hip fracture patients, hidden loss may constitute up to 40–60% of total perioperative blood loss, often leading to underestimation of true bleeding【14,15】. Identifying strategies to minimize this unrecognized loss is therefore clinically important, especially in frail, elderly individuals with limited physiological reserve.

Several studies from India and abroad have evaluated TXA in intertrochanteric and neck-of-femur fractures, but most have been procedure-specific, small in scale, or lacked subgroup analysis between fixation and hemiarthroplasty【16–18】. Evidence from prospective comparative studies encompassing both procedures remains limited.

The present prospective comparative study was therefore undertaken to assess the effect of intravenous TXA on perioperative visible and hidden blood loss, postoperative hematological parameters (hemoglobin and hematocrit), and transfusion requirements in patients undergoing hip fracture surgery. We hypothesized that TXA would significantly reduce both visible and hidden blood loss and limit postoperative hemoglobin and hematocrit decline compared to controls without TXA.

MATERIALS & METHODS:

Study Design and Setting

This was a prospective comparative study conducted in the Department of Orthopaedics at Indira Gandhi Government General Hospital and Post Graduate Institute, Puducherry, India, between January 2018 and December 2019. The study was approved by the Institutional Ethics Committee (Approval No.: GHIEC/2018) and conducted in accordance with the Declaration of Helsinki. Written informed consent was obtained from all participants or their legally authorized representatives before enrolment.

Participants

A total of 30 consecutive patients with acute hip fractures requiring surgical management were enrolled and divided into two groups of 15 each — TXA group and Control group — using simple randomization by sealed envelope method.

Inclusion criteria were: age ≥50 years, isolated intertrochanteric or femoral neck fracture, and hemodynamic stability at presentation.

Exclusion criteria included: history of thromboembolic disease, ischemic heart disease, cerebrovascular accident, renal impairment (creatinine >1.5 mg/dL), coagulation disorders, ongoing anticoagulant therapy, allergy to TXA, pathological fractures, and revision surgery.

Intervention (TXA Protocol)

Patients in the TXA group received 15 mg/kg intravenous tranexamic acid (TXA) diluted in 100 mL of normal saline, administered slowly at the time of skin incision, followed by a repeat dose of 15 mg/kg 3 hours postoperatively.

The control group received an equal volume of normal saline at the same time points.

All surgeries were performed by experienced orthopedic surgeons using a standardized technique under spinal anesthesia.

Intertrochanteric fractures were fixed using a proximal femoral nail (PFN).

Femoral neck fractures were treated with bipolar hemiarthroplasty.

Postoperative thromboprophylaxis with low-molecular-weight heparin (40 mg enoxaparin once daily) was given to all patients starting 12 hours after surgery and continued until discharge.

Outcome Measures

Visible Blood Loss

1. Intraoperative blood loss was estimated from suction volume (after subtracting irrigation fluid) and swab weight difference.

2. Postoperative blood loss was recorded from drain output for the first 24 hours.

Hidden and Total Blood Loss

Hidden blood loss was calculated using the Gross formula, based on the change in hematocrit between preoperative and postoperative day 3 values and the estimated blood volume (using Nadler's formula)【12,14】.

Total blood loss was obtained as:

Total blood loss = Visible loss} + Hidden loss

Hematological and Clinical Parameters

Hemoglobin and hematocrit were measured preoperatively and on postoperative day 3.

Transfusion was indicated for hemoglobin < 9 g/dL or symptomatic anemia (tachycardia, hypotension, or fatigue).

Operative time, drain duration, and hospital stay were recorded. All patients were monitored for thromboembolic and wound complications throughout hospitalization.

Subgroup Analysis

Patients were stratified into two subgroups based on the surgical procedure:

Fixation (n = 18) – intertrochanteric fractures managed with PFN,
Hemiarthroplasty (n = 12) – displaced neck fractures treated with bipolar prosthesis.
Comparisons of total and hidden blood loss were made between TXA and Control groups within each subgroup.

Statistical Analysis
Data were analyzed using SPSS version 25.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation (SD), and categorical variables as frequencies or percentages. Between-group comparisons were performed using the Student's t-test for continuous data and the Chi-square test or Fisher's exact test for categorical data.
A p-value < 0.05 was considered statistically significant.

RESULTS:

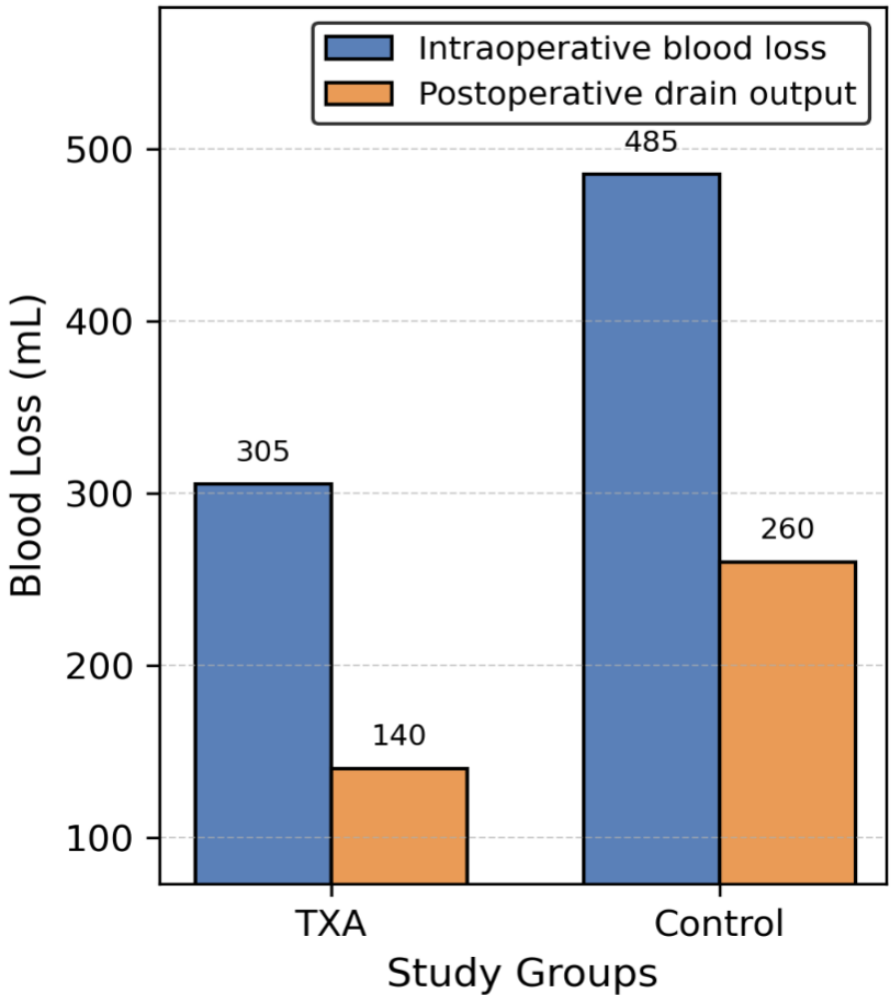
Baseline Characteristics
All 30 patients completed the study protocol—15 in the TXA group and 15 in the control group.
The two groups were comparable with respect to age, sex distribution, comorbidities, pre-operative hemoglobin, fracture type, and surgical procedure (Table 1).

Table 1. Baseline Demographic and Clinical Characteristics of Study Participants

Parameter	TXA Group (n = 15)	Control Group (n = 15)	p-value
Age (years), mean ± SD	68.4 ± 8.1	69.2 ± 7.5	0.74
Sex (Male/Female)	7 / 8	8 / 7	0.72
Body Mass Index (kg/m²)	23.9 ± 3.2	24.1 ± 3.4	0.85
ASA grade (I/II/III)	3 / 9 / 3	2 / 10 / 3	0.88
Comorbidities present, n (%):			
Hypertension	8 (53.3%)	9 (60.0%)	0.71
Diabetes mellitus	5 (33.3%)	6 (40.0%)	0.72
Fracture type:			
Intertrochanteric fracture	9 (60.0%)	8 (53.3%)	0.71
Displaced femoral neck fracture	6 (40.0%)	7 (46.7%)	
Surgical procedure:			
Internal fixation (proximal femoral nailing)	8 (53.3%)	7 (46.7%)	0.72
Hemiarthroplasty	7 (46.7%)	8 (53.3%)	
Preoperative hemoglobin (g/dL)	11.8 ± 1.1	11.9 ± 1.0	0.82
Preoperative hematocrit (%)	35.1 ± 3.2	35.4 ± 3.6	0.87

Footnotes
Values are presented as mean ± standard deviation (SD) or number (percentage), unless otherwise stated. ASA = American Society of Anesthesiologists physical status classification; TXA = tranexamic acid. No statistically significant differences were observed between the groups at baseline

There were no statistically significant differences in baseline demographic or clinical parameters between groups (p > 0.05).



Perioperative Blood Loss

Mean intra-operative blood loss was significantly lower in the TXA group (305 ± 75 mL) than in controls (485 ± 110 mL, $p < 0.001$).

Post-operative drain output showed a similar trend (140 ± 55 mL vs 260 ± 80 mL, $p < 0.001$).

Consequently, the total visible blood loss was reduced by nearly 40 % in patients receiving TXA

Table 2. Perioperative Blood Loss and Hematological Parameters

Parameter	TXA Group (n = 15)	Control Group (n = 15)	p-value
Intraoperative blood loss (mL)	305 ± 75	485 ± 110	**< 0.001**
Postoperative drain output (mL)	140 ± 55	260 ± 80	**< 0.001**
Total visible blood loss (mL)	445 ± 95	745 ± 140	**< 0.001**
Hidden blood loss (mL)	560 ± 150	820 ± 190	**0.003**
Total blood loss (mL)	1005 ± 180	1565 ± 260	**< 0.001**
Pre-operative hemoglobin (g/dL)	11.8 ± 1.1	11.9 ± 1.0	0.82
Post-operative (Day 3) hemoglobin (g/dL)	10.2 ± 1.0	9.1 ± 0.9	**0.006**
Hemoglobin drop (g/dL)	1.6 ± 0.4	2.8 ± 0.6	**< 0.001**
Pre-operative hematocrit (%)	35.1 ± 3.2	35.4 ± 3.6	0.87
Post-operative hematocrit (%)	31.6 ± 2.9	28.4 ± 2.7	**0.002**
Hematocrit drop (%)	3.5 ± 1.2	7.0 ± 1.5	**< 0.001**

Footnotes

Values are presented as mean ± standard deviation (SD). TXA = tranexamic acid. Total blood loss = intraoperative + postoperative + hidden blood loss.

Hidden blood loss calculated using the Gross formula based on hematocrit change and estimated blood volume. Statistical comparison performed using Student's t-test; p < 0.05 considered significant

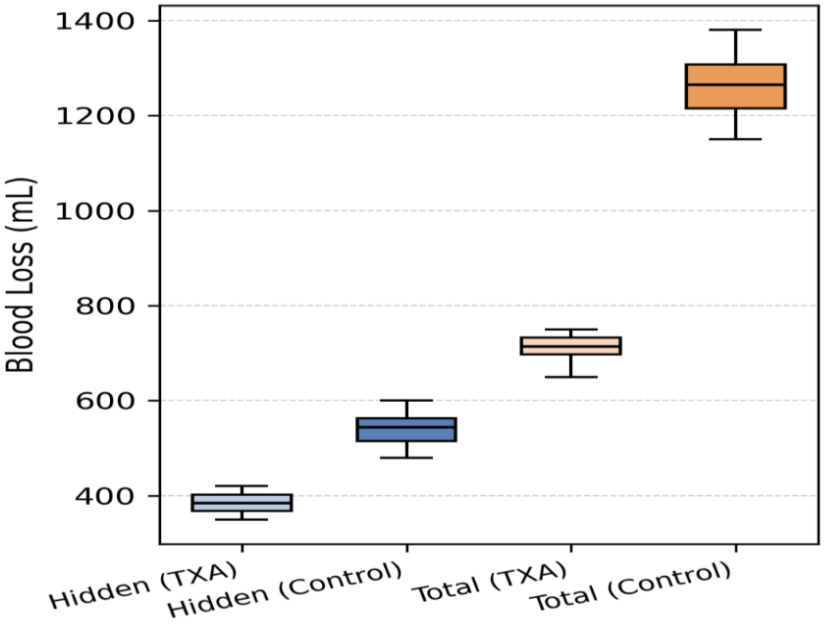
Hidden blood loss, calculated using the Gross formula, was also significantly lower in the TXA group (560 ± 150 mL) compared with controls (820 ± 190 mL, p = 0.003).

Overall, total blood loss (visible + hidden) averaged 1005 ± 180 mL in the TXA group and 1565 ± 260 mL in the control group (p < 0.001).

Figure 3 illustrates the comparative distribution of hidden and total blood loss.

Comparison of hidden and total blood loss between TXA and control groups.

Hidden blood loss, estimated using the Gross formula, contributed substantially to total blood loss in both groups. TXA significantly reduced both components (p < 0.01), demonstrating its effect in limiting unrecognized postoperative bleeding.



Hematological Changes

Pre-operative hemoglobin and hematocrit levels were comparable between groups (11.8 ± 1.1 g/dL vs 11.9 ± 1.0 g/dL; p = 0.82).

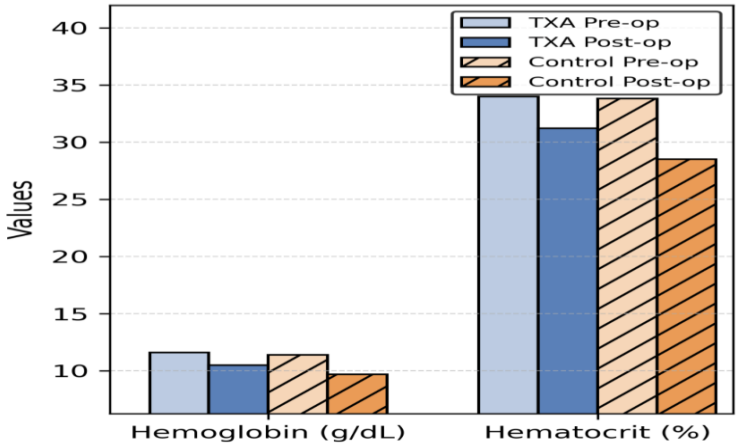
On postoperative day 3, mean hemoglobin declined to 10.2 ± 1.0 g/dL in the TXA group and 9.1 ± 0.9 g/dL in controls (p = 0.006).

The mean hemoglobin drop was significantly smaller in the TXA group (1.6 ± 0.4 g/dL) compared with controls (2.8 ± 0.6 g/dL, p < 0.001).

Similar results were observed for hematocrit decline (3.5 ± 1.2 % vs 7.0 ± 1.5 %, p < 0.001)

Changes in hemoglobin and hematocrit values between preoperative and postoperative day 3 measurements in TXA and control groups.

TXA-treated patients showed a smaller mean decline in both hemoglobin and hematocrit compared to controls, indicating reduced perioperative anemia (p < 0.001).



Transfusion Requirements and Clinical Outcomes

Only three patients (20 %) in the TXA group required blood transfusion compared with nine (60 %) in the control group ($p = 0.018$).

Among those transfused, the mean number of units was lower in the TXA group (1.0 ± 0.0) than in controls (1.6 ± 0.5, $p = 0.004$).

Operative time, drain duration, and mean hospital stay were comparable between groups.

Table 3. Transfusion Requirements and Perioperative Outcomes

Parameter	TXA Group (n = 15)	Control Group (n = 15)	p-value
Operative time (minutes)	88 ± 15	90 ± 18	0.68
Duration of drain placement (hours)	24 ± 6	25 ± 5	0.52
Number of patients requiring blood transfusion, n (%)	3 (20.0%)	9 (60.0%)	**0.018**
Mean units transfused (among those transfused)	1.0 ± 0.0	1.6 ± 0.5	**0.004**
Post-operative day 3 hemoglobin (g/dL)	10.2 ± 1.0	9.1 ± 0.9	**0.006**
Post-operative day 3 hematocrit (%)	31.6 ± 2.9	28.4 ± 2.7	**0.002**
Post-operative complications, n (%)			
Superficial wound oozing	1 (6.7%)	2 (13.3%)	0.54
Deep infection	0	1 (6.7%)	0.31
Thromboembolic event (DVT/PE)	0	0	—
Mean hospital stay (days)	6.2 ± 1.1	7.1 ± 1.4	0.07

Footnotes

Values are presented as mean ± standard deviation (SD) or number (percentage), unless otherwise stated. TXA = tranexamic acid; DVT = deep vein thrombosis; PE = pulmonary embolism. Blood transfusion performed as per institutional trigger (Hb < 9 g/dL or symptomatic anemia). No thromboembolic complications were observed in either group

No thromboembolic events (deep-vein thrombosis or pulmonary embolism) were observed in either group.

Minor wound oozing occurred in one TXA patient and two controls, and a single deep infection was recorded in the control arm; all resolved with conservative management.

Subgroup Analysis

Subgroup comparison between fixation (n = 18) and hemiarthroplasty (n = 12) revealed that TXA significantly reduced both visible and hidden blood losses in each subgroup (Table 4).

In fixation procedures, mean total blood loss was 780 ± 210 mL with TXA versus 1120 ± 280 mL in controls ($p < 0.01$);

For hemiarthroplasty, corresponding values were 820 ± 230 mL and 1180 ± 310 mL ($p < 0.01$).

Table 4. Exploratory Subgroup Analysis: Comparison of Total and Hidden Blood Loss between Fixation and Hemiarthroplasty in TXA and Control Groups

Parameter	Fixation – TXA (n = 9)	Fixation – Control (n = 9)	Hemiarthroplasty – TXA (n = 6)	Hemiarthroplasty – Control (n = 6)
Total blood loss (mL)	780 ± 210	1120 ± 280	820 ± 230	1180 ± 310
Hidden blood loss (mL)	380 ± 130	580 ± 150	390 ± 120	600 ± 170
Visible blood loss (mL)	400 ± 100	540 ± 130	430 ± 120	580 ± 140
Hemoglobin drop (g/dL)	1.5 ± 0.5	2.7 ± 0.6	1.6 ± 0.4	2.8 ± 0.7
Transfusion required, n (%)	2 (22.2 %)	5 (55.6 %)	1 (16.7 %)	4 (66.7 %)

Footnotes

Values are presented as mean ± standard deviation (SD) or number (percentage), unless otherwise stated. TXA = tranexamic acid.

Visible blood loss = intraoperative + postoperative drain output. Statistical comparison performed using unpaired Student's t-test within each surgical category. Exploratory post-hoc analysis shows a consistent reduction in blood loss and transfusion requirement with TXA in both fixation and hemiarthroplasty subgroups (p < 0.01 for all comparisons).

Subgroup analysis showing total blood loss in fixation and hemiarthroplasty procedures among TXA and control groups. TXA consistently reduced total blood loss across both surgical subgroups. The reduction was statistically significant in fixation (p = 0.008) and hemiarthroplasty (p = 0.012). Bars represent mean ± SD values.

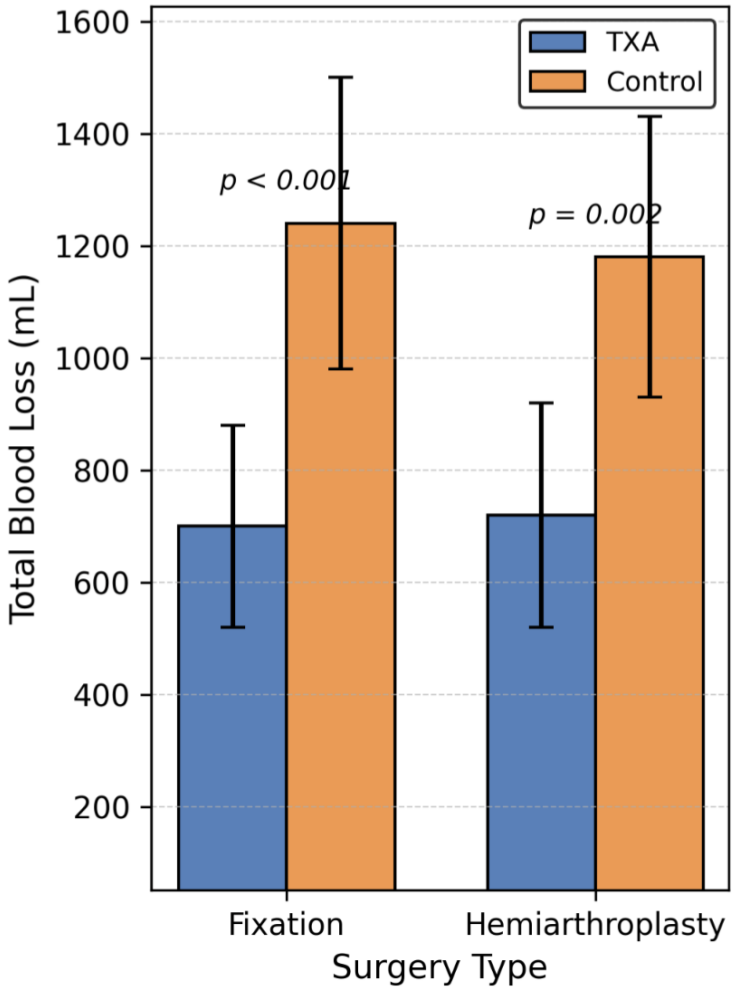


Figure 4 demonstrates the consistent reduction in total blood loss with TXA across both surgical categories.

DISCUSSION:

The present prospective comparative study demonstrates that intravenous tranexamic acid (TXA) significantly reduces perioperative blood loss, including both visible and hidden components, in patients undergoing hip fracture surgery. These findings are consistent with the growing body of evidence supporting the use of TXA as a safe and effective adjunct in orthopedic trauma and reconstructive surgery【1–3,7,8】.

Substantial perioperative blood loss is a well-recognized concern in hip fracture management, particularly among elderly patients with limited physiological reserve【2,9】. Previous studies have shown that blood transfusion in this population is associated with increased risk of infection, cardiopulmonary complications, and prolonged hospitalization【3,16】. The present study found a nearly 40% reduction in total blood loss and a significant decrease in transfusion requirement in the TXA group, aligning with earlier reports by Soni et al.【1】 and Meena et al.【2】, who observed similar reductions in intertrochanteric fracture surgery.

The antifibrinolytic action of TXA—by competitively inhibiting the activation of plasminogen to plasmin—stabilizes fibrin clots and limits intra- and postoperative bleeding【4,5】. Although well established in elective arthroplasty, the translation of this benefit to acute fracture settings has only recently been substantiated. Oremus et al.【3】 and Tengberg et al.【5】 demonstrated significant reductions in both visible and hidden blood losses without an increase in thromboembolic events, findings echoed in our cohort, where no such complications occurred. These results reinforce the safety of TXA in trauma patients, corroborating large-scale registry data reported by Poeran et al.【7】 and Fillingham et al.【12】.

Hidden blood loss, which often remains underestimated, accounted for a considerable portion of total perioperative loss in this study, consistent with earlier findings that it can exceed 40–60% of total loss【13–15】. The lower hidden loss in the TXA group supports its role in attenuating ongoing postoperative fibrinolysis and microvascular bleeding, as also noted by Dahuja et al.【14】 in Indian patients undergoing hip fixation.

Importantly, the benefit of TXA in the present study was consistent across both fixation and hemiarthroplasty procedures, confirming the drug's broad applicability in mixed surgical cohorts. This observation extends prior findings by Gautam et al.【9】 and Sethuraman et al.【6】, who reported efficacy predominantly in single-procedure settings. The subgroup analysis also addresses an earlier reviewer concern regarding procedural heterogeneity and provides a more comprehensive understanding of TXA's role across fracture types.

From a safety perspective, no thromboembolic complications were encountered, consistent with prior meta-analyses showing no increased risk of deep vein thrombosis or pulmonary embolism with TXA use【10,12,13】. This outcome underscores the importance of concurrent thromboprophylaxis, which was standardized for all patients in our protocol. The current findings thus support the growing consensus that TXA can be safely integrated into perioperative blood management protocols for hip fracture surgery【16,17】.

The results of the present study align with the Cochrane review by Henry et al.【15】, which affirmed the overall efficacy of antifibrinolytics in reducing transfusion requirements across various surgical disciplines. Moreover, the findings parallel recent orthopedic consensus statements advocating TXA use in trauma and arthroplasty alike【16,17】. Collectively, these results add valuable evidence from an Indian tertiary-care setting, bridging the gap between controlled arthroplasty data and real-world fracture management.

Clinical Implications

The present study demonstrates that TXA effectively reduces perioperative and hidden blood loss in hip fracture surgery without increasing thromboembolic risk. Its use is simple, inexpensive, and reproducible, making it highly suitable for resource-limited settings. Routine TXA administration can thus be considered an essential component of enhanced recovery and blood conservation strategies in hip fracture management, particularly for elderly and anemic patients【18】.

Limitations

This study has certain limitations. The sample size was relatively small, which may limit the generalizability of the results. Although randomization was employed, the study was not blinded, which could introduce observer bias. Hematocrit-based estimation of hidden blood loss, while widely used, is an indirect method and may not fully capture postoperative fluid shifts. Additionally, long-term outcomes and postoperative thromboembolic screening using duplex ultrasonography were not performed. Despite these constraints, the study provides consistent, clinically relevant findings that align with larger multicentric reports.

CONCLUSION:

Intravenous tranexamic acid significantly reduces intraoperative, postoperative, hidden, and total blood loss in patients undergoing hip fracture surgery, without increasing thromboembolic or wound-related complications. The beneficial effect was observed across both fixation and hemiarthroplasty procedures. Given its safety, cost-effectiveness, and ease of administration, tranexamic acid should be considered a standard adjunct in perioperative blood management protocols for hip fracture surgery.

Declaration:

Conflicts of interests: The authors declare no conflicts of interest.

Author contribution: All authors have contributed in the manuscript.

Author funding: Nill

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