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Original Research Article

Bloodless Backtrack: Tranexamic Acid as a Perioperative Blood Conservation Strategy in Revision Lumbar Interbody Fusion Surgery

Kora Sai Sujith[1], Penchala Pradeep Batta[2], Ananth Raj Sharma Vinjamuri[3]

[1]Senior Consultant, Department of Orthopaedics, KIMS-Saveera hospitals, Anantapur, Andhra Pradesh, India

[2]Associate Professor, Department of Emergency Medicine, Kanachur Institute of Medical Sciences, Mangalore, Karnataka, India

[3]Associate Professor, Department of Orthopaedics, Kerala Medical College, Mangode, Palakkad, Kerala, India

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Corresponding Author: Dr. Kora Sai Sujith

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Abstract:

Background: Revision spinal fusion surgeries such as transforaminal lumbar interbody fusion and posterior lumbar interbody fusion are associated with considerable blood loss because of fibrosis, distorted anatomy and prolonged operative dissection. Tranexamic acid may reduce perioperative bleeding by inhibiting fibrinolysis.

Aim: To compare perioperative and postoperative blood loss in revision spinal fusion surgeries with and without tranexamic acid administration.

Methods: This retrospective comparative case-control study included 50 patients who underwent revision lumbar spinal fusion surgery at Apollo Main Hospital, Chennai, from 2017 to 2019. Patients were divided into tranexamic acid and control groups. Intraoperative estimated blood loss, postoperative drain output, total blood loss, percentage total blood volume loss, haemoglobin fall and blood transfusion requirement were compared between groups. Correlation of blood loss with age, sex, number of levels fused and duration of surgery was assessed.

Results: Tranexamic acid administration was associated with significantly lower intraoperative blood loss, postoperative drain output, total blood loss and percentage total blood volume loss. The need for blood transfusion was also lower in the tranexamic acid group. Duration of surgery and number of levels fused showed positive correlation with blood loss.

Conclusion: Tranexamic acid reduced blood loss and transfusion requirement in revision spinal fusion surgery.

Keywords: Tranexamic Acid; Revision Spinal Fusion; TLIF; PLIF; Perioperative Blood Loss.

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Introduction

Revision lumbar spinal fusion procedures such as transforaminal lumbar interbody fusion (TLIF) and posterior lumbar interbody fusion (PLIF) are technically demanding surgeries because of epidural fibrosis, distorted anatomy, prolonged operative time, multilevel instrumentation and difficulty in tissue dissection. These factors commonly increase intraoperative blood loss, postoperative drain output, fall in haemoglobin and requirement for allogeneic blood transfusion [1]. Excessive blood loss may further increase morbidity by causing haemodynamic instability, transfusion-related complications, delayed mobilisation and prolonged hospital stay. Tranexamic acid (TXA), a synthetic lysine analogue, acts by inhibiting plasminogen activation and stabilising formed fibrin clot, thereby reducing surgical bleeding [1]. Recent evidence in spinal surgery, including PLIF and adult spinal procedures, has shown that TXA significantly reduces intraoperative blood loss, total blood loss, postoperative drainage volume and transfusion requirement without a clear increase in thromboembolic events [2, 3]. However, evidence specifically focused on revision spinal fusion remains limited, where bleeding risk is expected to be higher than primary surgery. Hence, the present retrospective comparative case-control study was undertaken to evaluate whether TXA administration decreases calculated percentage total blood volume loss, perioperative blood loss and transfusion requirement in revision spinal fusion surgeries performed for failed back surgery syndrome [4]. The aim of the study was to compare perioperative and postoperative blood loss between patients receiving TXA and those not receiving TXA during revision TLIF/PLIF procedures.

Methods

This retrospective comparative case-control study was conducted to evaluate the effect of tranexamic acid administration on perioperative and postoperative blood loss in patients who underwent revision spinal fusion surgeries. The study was carried out at Apollo Main Hospital, Chennai, over a study period from January 2017 to December 2019. Medical records of patients who underwent revision lumbar spinal fusion procedures, including transforaminal lumbar interbody fusion and posterior lumbar interbody fusion, for failed back surgery syndrome were reviewed. All surgeries were performed by a single spine surgeon, thereby reducing inter-surgeon variability in operative technique and perioperative decision-making. A total of 50 patients who fulfilled the eligibility criteria were included in the study. Patients were divided into two groups based on whether tranexamic acid was administered or not during surgery. The tranexamic acid group included patients who received intravenous tranexamic acid as part of perioperative blood conservation protocol, whereas the control group included patients who underwent similar revision spinal fusion procedures without tranexamic acid administration.

Patients of either sex who underwent revision spinal fusion surgery during the study period and had complete perioperative and postoperative records were included. Revision procedures included cases performed for recurrent disc prolapse, implant failure, pseudoarthrosis, adjacent segment disease, persistent instability or failed back surgery syndrome requiring TLIF or PLIF. Patients with incomplete records, known bleeding disorders, chronic anticoagulant therapy that could not be appropriately withheld, severe hepatic or renal dysfunction, history of thromboembolic disease, hypersensitivity to tranexamic acid, infection-related surgery, trauma, malignancy or combined anterior and posterior staged procedures were excluded. The following data were collected from hospital records: age, sex, diagnosis, indication for revision surgery, number of vertebral levels fused, duration of surgery, use or non-use of tranexamic acid, intraoperative estimated blood loss, postoperative drain output, haemoglobin values, need for blood transfusion and postoperative complications. Estimated blood loss was obtained from anaesthesia and operative records, while postoperative blood loss was assessed using drain output recorded during the postoperative period. Total blood loss was calculated by combining intraoperative and postoperative blood loss. Percentage total blood volume loss was calculated using estimated blood volume based on patient characteristics and the measured perioperative blood loss.

The primary outcome measure was the difference in percentage total blood volume loss between patients who received tranexamic acid and those who did not. Secondary outcome measures included intraoperative estimated blood loss, postoperative drain output, total calculated blood loss, fall in haemoglobin level, requirement for packed red blood cell transfusion and association of blood loss with clinical and operative factors. The collected data were entered into Microsoft Excel and analysed using appropriate statistical software. Continuous variables such as age, duration of surgery, estimated blood loss, postoperative drain output, total blood loss and percentage total blood volume loss were expressed as mean and standard deviation. Categorical variables such as sex, number of levels fused, tranexamic acid use and transfusion requirement were expressed as frequency and percentage. Mean blood loss parameters between the tranexamic acid and control groups were compared using independent t-test or Mann–Whitney U test, depending on data distribution. Chi-square test or Fisher's exact test was used for categorical variables. Correlation analysis was performed to assess the relationship between percentage total blood volume loss and factors such as age, sex, number of levels fused and length of operation. A p-value of less than 0.05 was considered statistically significant.

Results

The present retrospective comparative study included 50 patients who underwent revision spinal fusion surgery, with 25 patients in the TXA group and 25 patients in the control group. Both groups were comparable with respect to age, sex distribution, body weight, number of levels fused and duration of surgery, with no statistically significant difference between the groups, as shown in Table 1. Intraoperative estimated blood loss was significantly lower in the TXA group compared with the control group, 620.4 ± 178.5 mL versus 948.6 ± 246.7 mL, respectively. Postoperative drain output and total blood loss were also significantly reduced among patients who received TXA, as presented in Table 2. The mean percentage total blood volume loss was 18.2 ± 4.7% in the TXA group compared with 28.5 ± 6.3% in the control group, which was statistically significant. Blood transfusion requirement was also lower in the TXA group, with 24% requiring transfusion compared with 60% in the control group, as shown in Table 3. Correlation analysis showed that number of levels fused and duration of surgery had significant positive correlation with percentage total blood volume loss, whereas TXA administration showed a significant negative correlation, as shown in Table 4.

Table 1: Baseline demographic and operative characteristics of study participants			
Variable	**TXA group**	**Control group**	**p-value**
Age, years*	52.4 ± 9.6	54.1 ± 10.2	0.548
Male**	15 (60.0)	14 (56.0)	0.774
Female**	10 (40.0)	11 (44.0)	0.774
Body weight, kg*	68.3 ± 8.7	69.5 ± 9.1	0.635
Two-level fusion**	16 (64.0)	15 (60.0)	0.771
Three-level fusion, n (%)	9 (36.0)	10 (40.0)	0.771
Duration of surgery, minutes*	214.6 ± 38.2	221.8 ± 41.5	0.526
*mean ± SD; ** n (%)			

Table 2: Comparison of perioperative and postoperative blood loss in mL				
Blood loss parameter	**TXA group**	**Control group**	**Difference**	**p-value**
Intraoperative estimated loss	620.4 ± 178.5	948.6 ± 246.7	328.2	<0.001
Postoperative drain output	238.8 ± 96.4	412.5 ± 138.2	173.7	<0.001
Total blood loss	859.2 ± 214.7	1361.1 ± 318.5	501.9	<0.001
Fall in haemoglobin, g/dL	1.6 ± 0.5	2.4 ± 0.7	0.8	<0.001

Table 3: Percentage total blood volume loss and transfusion requirement			
Variable	**TXA group**	**Control group**	**p-value**
Estimated blood volume, mL*	4720.5 ± 524.6	4788.3 ± 548.2	0.657
Percentage total blood volume loss*	18.2 ± 4.7	28.5 ± 6.3	<0.001
Blood transfusion requirement, n (%)	6 (24.0)	15 (60.0)	0.01
Mean units transfused per patient	0.4 ± 0.7	1.2 ± 1.0	0.002
≥2 units transfusion, n (%)	2 (8.0)	8 (32.0)	0.034
* mean ± SD			

Table 4: Correlation of clinical and operative variables with percentage total blood volume loss			
Variable	**Correlation coefficient (r)**	**p-value**	**Interpretation**
Age	0.12	0.405	No significant correlation
Sex	0.08	0.578	
Number of levels fused	0.46	0.001	Significant positive correlation
Duration of surgery	0.52	<0.001	
TXA administration	-0.61	<0.001	Significant negative correlation

Discussion:

The present study demonstrated that tranexamic acid administration was associated with a significant reduction in intraoperative estimated blood loss, postoperative drain output, total calculated blood loss and percentage total blood volume loss in revision spinal fusion surgeries. Revision TLIF and PLIF are usually more haemorrhagic than primary lumbar fusion because the surgeon has to work through scarred planes, epidural fibrosis, distorted anatomy, previous implant tracks and altered paraspinal muscle vascularity. These factors increase venous oozing and prolong operative time, making blood conservation clinically important. In the present study, patients who received TXA had lower mean intraoperative blood loss and postoperative drainage than controls, supporting the hypothesis that antifibrinolytic therapy was useful even in complex revision settings. Similar findings were reported by Luan et al., who observed that TXA reduced intraoperative blood loss, total blood loss, drainage volume and transfusion events in PLIF patients [1]. Luo et al. also reported that TXA was effective and safe in TLIF, with reduction in blood loss-related outcomes [5]. Thus, although most available evidence comes from primary degenerative lumbar fusion, the direction of benefit in the present revision cohort was consistent with the broader spinal fusion literature.

The lower postoperative drain output observed in the TXA group was an important finding because postoperative bleeding is often underestimated when only intraoperative estimated blood loss is considered. Hidden blood loss, wound ooze and drain loss may contribute substantially to haemoglobin fall after posterior lumbar surgery. TXA acts by reversibly blocking lysine-binding sites on plasminogen, thereby inhibiting conversion to plasmin and preventing fibrin degradation. This mechanism stabilises formed clot rather than producing a direct procoagulant effect, explaining why it is useful in surgeries where tissue trauma activates fibrinolysis. In the present study, the fall in haemoglobin was lower in the TXA group, suggesting that reduction in measured blood loss was clinically reflected in postoperative

haematological status. He et al. reported that TXA reduced intraoperative haemorrhage after TLIF and supported enhanced recovery by improving early postoperative mobilisation [6]. Xiao et al., in a meta-analysis of lumbar surgery, concluded that TXA reduced postoperative blood loss, total blood loss, intraoperative blood loss, drainage volume, transfusion rate and transfusion volume [7]. These findings support the present observation that the benefit of TXA extended beyond the operative field and continued into the early postoperative period.

The present study also showed a significantly lower transfusion requirement in the TXA group. This is clinically relevant because allogeneic blood transfusion in spine surgery is associated with increased cost, transfusion reactions, immunomodulation, infection risk and delayed recovery. In revision fusion, transfusion avoidance is particularly valuable because these patients may already have comorbidities, prior surgical morbidity and prolonged operative exposure. The present study found that 24% of patients in the TXA group required transfusion compared with 60% in the control group, indicating a meaningful reduction in blood product utilisation. Kanhangad et al. similarly observed that TXA reduced intraoperative blood loss, intraoperative transfusion need, postoperative haemoglobin drop and surgical drain output in spine surgery [8]. Network meta-analysis by Cao et al. further supported the role of TXA in spinal surgery, although it highlighted variation in route, timing and dosage across studies [2]. More recently, Shi et al. reported that intravenous TXA was associated with decreased total blood loss and transfusion requirement in multilevel spine surgery, with dose-related differences in effect [9]. Taken together, these data suggest that TXA may be particularly useful in patients undergoing multilevel or revision procedures, where the baseline risk of transfusion is high.

Correlation analysis in the present study showed that number of levels fused and duration of surgery were positively associated with percentage total blood volume loss, whereas TXA administration showed a significant negative correlation. This supports the practical observation that blood loss in revision lumbar fusion is not determined by one factor alone but by operative complexity, exposure time, number of decorticated surfaces, extent of decompression and technical difficulty. Longer procedures increase cumulative venous oozing, while multilevel fusion increases cancellous bone bleeding and paraspinal soft tissue trauma. The negative correlation with TXA use suggests that antifibrinolytic therapy remained protective even when these operative factors were considered. Kushioka et al. demonstrated that high-dose TXA significantly reduced both intraoperative and postoperative blood loss in PLIF without reported complications [10]. Yamanouchi et al., in a recent systematic review, concluded that TXA reduced intraoperative and overall blood loss in spinal surgery without increasing complication risk, although heterogeneity among studies remained a limitation [3]. Akosman et al. also reported moderate evidence that high-dose TXA did not increase medical complications and could reduce transfusion requirement in major spine surgery [11]. These reports strengthen the interpretation that TXA is useful as part of a broader blood conservation protocol, especially when revision surgery is expected to be prolonged or multilevel.

Safety remains an important concern when TXA is used in spine surgery, especially in older patients or those with cardiovascular risk factors. In the present study, no increase in clinically evident thromboembolic complications was observed in the TXA group; however, the retrospective nature and small sample size limited the ability to detect rare adverse events. Current literature generally supports the safety of TXA in spinal surgery when contraindications such as active thromboembolic disease, severe renal impairment, seizure risk and hypersensitivity are considered. Deng et al. reported that intravenous TXA was more effective than topical TXA in producing haemostatic effect during spinal surgery [12]. Xie et al. reported that topical TXA did not significantly reduce postoperative blood loss compared with intravenous TXA, indicating that route selection may influence outcomes [13]. The present study had some limitations. It was retrospective, non-randomised, single-surgeon and single-centre in design, with a relatively small sample size. Dosing details, drain removal protocols and transfusion thresholds may also have influenced outcomes. Despite these limitations, the findings suggested that TXA administration significantly reduced perioperative and postoperative blood loss in revision TLIF/PLIF and may be considered a useful, safe and cost-effective blood conservation strategy in carefully selected revision spinal fusion patients.

Conclusion

Tranexamic acid administration was associated with a significant reduction in perioperative and postoperative blood loss among patients undergoing revision lumbar spinal fusion surgeries, including TLIF and PLIF. Patients who received TXA showed lower intraoperative estimated blood loss, reduced postoperative drain output, lower total calculated blood loss, lesser percentage total blood volume loss and decreased requirement for blood transfusion compared with patients who did not receive TXA. These findings suggest that TXA is a useful blood conservation strategy in revision spinal fusion, where surgical dissection is technically difficult and bleeding risk is high due to scar tissue, epidural fibrosis and prolonged operative time. However, this

study had limitations. It was retrospective in design, had a small sample size and was conducted at a single centre by a single surgeon. Randomisation was not performed, and TXA dose variation, transfusion thresholds and hidden blood loss could have influenced results. Larger prospective randomized studies are needed.

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