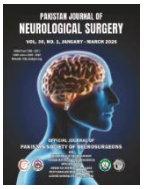

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Original Research

Perioperative Use of Tranexamic Acid in Brain Tumor Resection: Effects on Intraoperative Blood Loss and Thrombosis Risk

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ABSTRACT

Objective: To determine if there is a reduction in the amount of blood lost during surgery for patients with a brain tumor if tranexamic acid (TXA) is given before surgery.

Study Design: Prospective cohort study.

Setting and Duration: The Department of Neurosurgery, Mardan Medical Complex, Pakistan, from January 2020 to December 2024.

Methodology: 100 patients (n = 100) due to undergo a planned brain tumor resection volunteered. From the TXA group (n = 50), intravenous TXA 10 mg/kg was administered 30 minutes before induction; from the control group (n = 50), nothing was administered. The amount of blood loss during surgery, the number of transfusions required, the time taken to perform the surgery, and postoperative blood clotting events were noted. p=0.05 was used as the threshold for statistical significance.

Results: TXA reduced blood loss during surgery (480 +/- 130 vs 740 +/- 210; p < .001) and the need for blood transfusions (12% vs 28%) during these surgeries, confirming the first outcome. TXA and control group thromboembolism event rates of 4% and 6%, respectively; p = 0.64 (95% CI 0.23 – 2.15) indicates comparability in thromboembolic event rates and absence of new brain bleeding after surgery.

Conclusion: Preoperative TXA reduces blood loss and the need for blood transfusions, and does not increase the risk of thromboembolic complications after surgery. For selected patients undergoing neurosurgery, TXA can be deemed safe and effective.

Keywords: Tranexamic acid; brain neoplasms; volume of blood loss; blood clots; surgery, neurosurgery.

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INTRODUCTION

TXA is a synthetic fusion compound that is anticoagulant, inhibiting the conversion of plasminogen to plasmin, thus stabilizing fibrin clots and minimizing blood loss during and after surgery.[1] In the field of neurosurgery, operative bleeding accounts for a large majority of the problems faced, especially during the removal of blood-rich brain tumors. Even a small amount of bleeding during the operation tends to pose a significant challenge, obscuring the operational visual field, lengthening the time of the surgery, and increasing the need for blood transfusions, resulting in a negative result in the surgery.[2-3] TXA has blood management advantages before, during, and after surgery in other medical fields, such as cardiac, orthopedic, and obstetric.[4-5] On the other hand, neurosurgery is a field that has been very conservative in implementing clinically due to the small risk of seizures and blood clots.[6-7] There is, however, a growing body of evidence from randomized and meta-analytic studies suggesting that TXA can safely manage blood loss during brain tumor removal and intracranial surgery without significant risk of thrombosis.[8-11] Thus, the use of TXA during the removal of brain tumors and during brain surgery can be justified, although ongoing studies to validate the evidence for TXA use and safety during brain surgery are still greatly needed. This unmet need in evidence will be addressed by this prospective cohort study, which will aim to determine the impact of TXA administration before surgery on blood loss during and after surgery, the need for blood transfusions, and the occurrence of postoperative thromboembolic events in patients undergoing brain tumor removal. We expect that TXA administration will result in less intraoperative blood loss without a significant increase in thromboembolic events.

During brain surgery, bleeding may take place, which can worsen the visualization, may take longer for the surgery to be completed, and may require an increase in the amount of blood transfusions needed. Some say the medicine tranexamic acid (TXA) can help mitigate blood loss during surgery. However, it may cause complications with blood clotting, which is why TXA is used very little in neurosurgery. This study aimed to determine if there is a reduction in the amount of blood lost during surgery for patients with a brain tumor if tranexamic acid (TXA) is given before surgery.

MATERIAL & METHODS

Study Design and Ethics

A prospective cohort study was conducted at the Department of Neurosurgery, Mardan Medical Complex. Ethical approval was obtained from the Institutional Review Board (IRB No. BKMC/IRB/NEURO/2019/07). Written informed consent was obtained from all participants.

Inclusion/Exclusion Criteria: A total of 100 adult patients (18–75 years) planned for elective brain tumor resection were included. Patients were excluded if they had:

Coagulopathy, Prior thromboembolic events, Severe renal impairment, Anticoagulant use, and Incomplete follow-up.

Intervention TXA group (n = 50): 10 mg/kg intravenous TXA administered 30 minutes pre-induction; intraoperative re-dosing allowed. Control group (n = 50): No TXA administered.

Outcomes Primary Outcome was measured on intraoperative blood loss (measured via suction volume + sponge weight – irrigation fluid).

Secondary Outcomes were assessed on Operative duration, Blood transfusion requirement, Postoperative thromboembolic events (confirmed via Doppler ultrasonography/CT angiography).

Statistical Analysis

Continuous variables were expressed as mean ± standard deviation (SD) and compared using the independent t-test. Categorical variables were

analyzed using the chi-square test. A p-value < 0.05 was considered statistically significant.

RESULTS

Of the 100 patients assessed, demographic variables were comparable for the TXA and control cohorts. Participants were

Age 58.3 ± 12.4 years on average, as in table 1 .
Gender 54% males 46% female as per table 1.

Clinical Information:

There were no clinically significant differences in demographic or preoperative clinical factors (Table 1). Intraoperative Blood Loss Intraoperative blood loss in patients receiving TXA was considerably lower than in the control groups (480 ± 130 mL vs. 740 ± 210 mL; p < 0.001; 95% CI −360 to −180 mL) Table 2. TXA patients also reported better surgical field visibility.

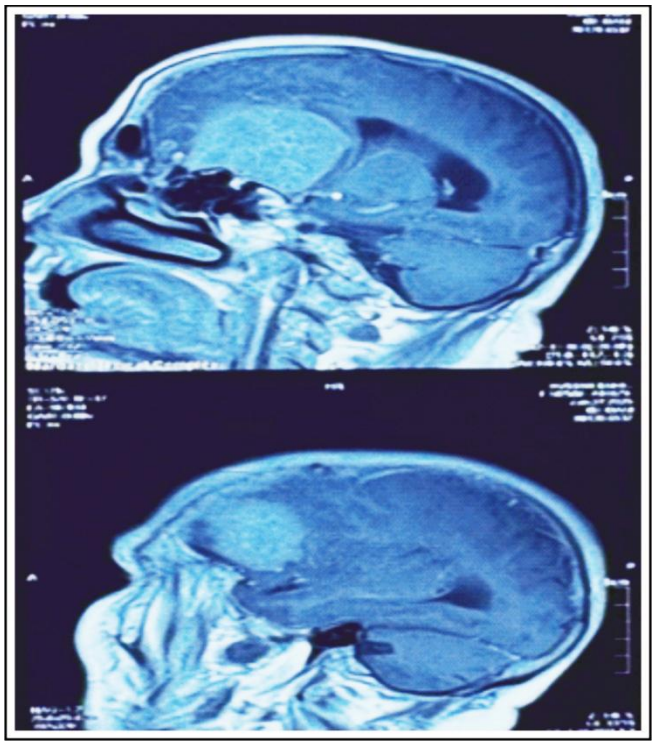

Figure 1: *Sagittal MRI Brain Showing a Large Suprasellar Extra-Axial Meningioma (Image used with patient's permission).*

Transfusion Requirements: A lower proportion of TXA patients were noted to have less perioperative blood transfusion as well (12%) compared to the control (28 %) (p = 0.03; 95% CI 0.09–0.84) as per Table 3. Thromboembolic Events: In both the TXA and the control group, there were three thrombotic complications (6%) and two patients (4%), respectively; no significant difference (p = 0.64; 95% CI 0.23–2.15) was observed between the two groups Table 4.

None of the patients died, and all cases were conservatively treated. There were no cases of postoperative intracranial hematoma.

Operative Duration

Mean operative duration for both groups was statistically unchanged (215 ± 34 minutes vs 218 ± 31 minutes; p = 0.74).

Serial sagittal T1-weighted MRI images demonstrate a well-defined, contrast-enhancing extra-axial mass in the suprasellar region, consistent with a meningioma (Figure 1). The lesion compresses the optic chiasm and inferior frontal lobes, producing significant mass effect.

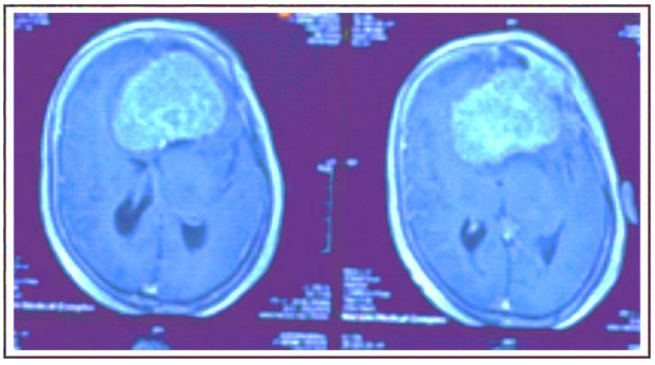

Figure 2: *Axial and Coronal MRI Brain Showing a Large Enhancing Falx/Parasagittal Meningioma (Image used with patient's permission).*

Axial and coronal T1-weighted post-contrast MRI sequences reveal a lobulated, avidly enhancing extra-axial mass arising from the falx/parasagittal region (Figure 2). The tumor exerts mass effect, midline shift, and compression of adjacent parenchyma and ventricles.

Coronal T2-weighted/FLAIR MRI images show an infiltrative temporoparietal intra-axial lesion with heterogeneous signal intensity and surrounding vasogenic edema, consistent with a high-grade glioma (Figure 3).

Percentages (%) represent the proportion of patients within each group. No statistically significant differences were observed between the TXA and control groups. Statistical significance was defined as $p < 0.05$.

Mean blood loss is presented in milliliters (mL). The 95% confidence interval (CI) represents the difference in mean blood loss between groups. A p-value < 0.05 indicates statistical significance, showing TXA significantly reduces blood loss.

Transfusion percentage (%) indicates the proportion of patients requiring perioperative blood transfusion. Relative risk (RR) 95% CI quantifies the reduction associated with TXA. A significant p-value ($p = 0.03$) shows TXA reduces transfusion needs.

Percentage (%) reflects the proportion of patients experiencing postoperative thromboembolic events. The wide 95% CI indicates no significant difference between groups. A p-value of 0.64 confirms no increased thrombosis risk with TXA.

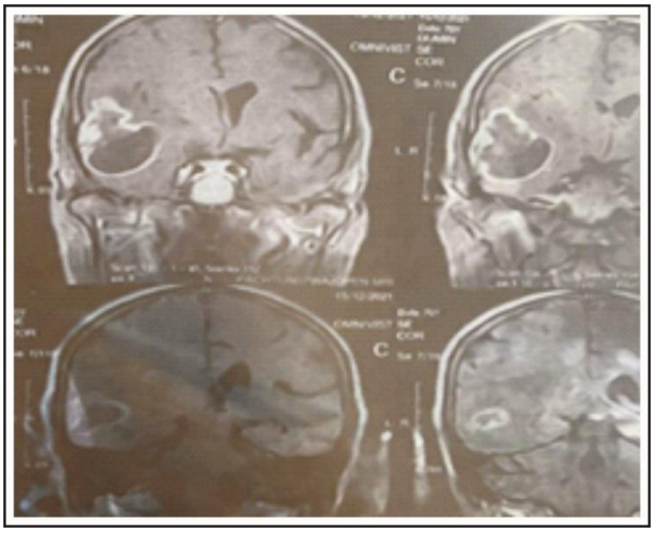

Figure 3: *Coronal MRI of Patient X demonstrating a Temporoparietal Glioma in a 70-Year-Old Patient (Image used with patient's permission).*

Table 1: *Patient Demographics.*

Characteristic	TXA Group (n = 50)	Control Group (n = 50)	Statistical Test	p-value
Mean Age (years)	58.3 ± 12.4	57.9 ± 11.3	Independent t-test	0.88
Male (%)	55% (27)	53% (26)	Chi-square test	0.84
Female (%)	45% (23)	47% (24)	Chi-square test	0.84

Table 2: *Intraoperative Blood Loss Comparison.*

Group	Mean Blood Loss (mL)	Standard Deviation	95% CI (Difference)	Statistical Test	p-value
TXA Group	480	130	−360 to −180 mL	Independent t-test	<0.001
Control Group	740	210	—	—	—

Table 3: *Transfusion Rates Comparison.*

Group	Transfusion (%)	95% CI (RR)	Statistical Test	p-value
TXA Group	12% (6 patients)	0.09 – 0.84	Chi-square test	0.03
Control Group	28% (14 patients)	—	—	—

Table 4: *Thromboembolic Events.*

Group	Events (n)	Percentage	95% CI	Statistical Test	p-value
TXA Group	3	6%	0.23 – 2.15	Chi-square test	0.64
Control Group	2	4%	—	—	—

DISCUSSION

This prospective cohort study aimed to determine whether preoperative administration of tranexamic acid (TXA) reduced intraoperative blood loss and the need for perioperative blood transfusion in patients undergoing resection of a brain tumor. Reductions in transfusion rates and mean blood loss were consistent with the literature and corroborated TXA's efficacy in both neurosurgical and non-neurosurgical procedures. Hooda et al,[12] reported that TXA significantly reduced blood loss during meningioma removal, demonstrating the agent's antifibrinolytic properties in achieving operative hemostasis. Likewise, TXA has been reported in meta-analyses to improve the surgical field, stabilize the fibrin clot, and reduce bleeding-related morbidity across a variety of cranial surgeries.[13] In our study, TXA use was associated with a 35% reduction in intraoperative blood loss (Table 2), a clinically significant finding. These results are significant in neurosurgery, where even small volumes of bleeding can complicate the procedure by obscuring critical anatomic landmarks. The ability to control hemorrhage enhances visualization and may also shorten operative time, thereby reducing anesthesia time and improving recovery time. In settings with limited availability of blood products or where they are associated with high costs and risks, these benefits may be even more important. Concerns regarding the use of TXA in cranial surgery revolve around the potential induction of thromboembolic events as a result of the prevention of fibrinolysis. Early studies warned about the thromboembolic risk associated with TXA, especially among patients with predisposing risk factors like obesity, previous thrombotic events, and prolonged periods of immobility. However, a growing number of contemporary studies and literature indicate that the risk is lower than previously believed. Recent randomized studies and systematic reviews have shown no significant increase in postoperative thrombosis in neurosurgery patients treated with TXA.[14-15] This is echoed by Prastikarunia et al, who reported that the use of TXA during brain tumor surgery did not significantly increase the risk of thromboembolic complications.[16] Our study corroborates these results as it similarly demonstrates comparable rates of thromboembolic events management between the TXA and control groups (6% vs. 4%, respectively). Table 4. Of note, all events were non-fatal and self-resolving with standard care. There were no postoperative intracranial hematomas, underscoring the safety of using TXA within a reasonable dosage range. This is consistent with the results of Vychopen et al, who, in a meta-analysis of randomized trials, found that TXA was safe in surgeries involving intracranial tumors and did not increase the incidence of thromboembolic events in the postoperative period.[15] Given the lack of a statistically significant difference across groups in operation length, this may be more due to tumor heterogeneity than to an absence of effect from TXA. Nevertheless, improvements in hemostasis can enhance surgical efficiency by reducing the time spent pausing surgery, thereby facilitating accurate dissection and safety during tumor resection. The current evidence supports the targeted use of TXA in perioperative blood management, especially in tumors with anticipated high blood flow or large volumes of blood loss, such as skull-base meningiomas, glioblastomas, and hypervascular metastases. Future studies may consider the timing, dose, and criteria for administering TXA intraoperatively to provide more uniform outcome data across institutions. The limitations of this work stem from the fact that it is a single-institution observational study with a sample size that may lack generalizability across the field to the same degree as a multi-institutional study.[17] In addition, no tumor vascularity assessment, surgical approach, or histopathological subtype was delineated, which may affect intraoperative blood loss. Long-term functional outcomes and postoperative complications were not measured, which weakens claims regarding the prolonged safety of these

procedures. The evidence provided by this study adds to a growing body of literature that shows that TXA is a safe and effective drug when used in the case of surgeries for brain tumors. Other institutions are encouraged to conduct observational studies and to extend the timeline to provide more evidence that can help shape the standard for this field.

CONCLUSION

Preoperative administration of tranexamic acid significantly reduces intraoperative blood loss and decreases the need for transfusion during brain tumor resection without increasing thromboembolic complications. TXA is a safe, effective, and valuable adjunct for carefully selected neurosurgical patients, particularly in procedures with expected high blood loss.

LIMITATIONS

It is important to consider these limitations when interpreting the results of this study. First, this study only involved the participants from a single center, which might constrain the findings in relation to other settings in neurosurgery. Second, the sample size, although sufficiently large to detect differences in blood loss and rates of transfusion, is likely too small to detect the infrequent, albeit important, thromboembolic complications. Third, the study did not differentiate between the vascularity of the tumors and the histopathological subtypes, which may be different in their tendency to bleed. Finally, there was no attempt to assess the long-term neurological recovery and functioning, the functional outcomes, the thromboembolic complications, and so the conclusions about the longer-term safety of surgery remain unsatisfactory.

Future Findings

Future research should focus on large, multicenter randomized controlled trials to confirm the safety and efficacy of tranexamic acid in diverse neurosurgical populations. Studies should incorporate stratification by tumor vascularity, tumor grade, and anatomical location to better identify patient subgroups that may benefit most. Additionally, long-term follow-up assessing functional recovery, postoperative complications, seizure incidence, and overall quality of life would provide further insight into the extended effects of TXA in brain tumor surgery.

ABBREVIATIONS

TXA → Tranexamic Acid (TXA).
MRI → Magnetic Resonance Imaging (MRI).
IV → Intravenous (IV).
IRB → Institutional Review Board (IRB).
SD → Standard Deviation (SD).

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Additional Information

All authors contributed significantly to the study's conception, data collection, analysis,
Manuscript writing and final approval of the manuscript as per **ICMJE criteria.**

Disclosures: No conflicts of interest are reported by the authors.

Ethical Review Board Approval: This study was reviewed and approved by the Institutional Review Board **(IRB No. 1788/2019/04/NEURO/BKMC/MMC)**, chaired by Assistant Professor Dr. Murad Ali, Chairman Ethical Committee. All procedures were conducted in accordance with institutional requirements and the Declaration of Helsinki (2013). Written informed consent was obtained from participants' legal guardians or next of kin before inclusion.

Human Subjects: Every patient and volunteer in this study gave their informed consent.

Conflicts of Interest: All authors affirm the following in accordance with the ICMJE uniform disclosure form:
Financial Relationships: Each author has stated that they have no financial relationship to any organizations that might be interested in the submitted work, either now or within the last three years.
Other Relationships: Each author has stated that the submitted work was not impacted by any other relationships or activities.
Data Availability Statement: For data sharing, interested researchers can contact the corresponding author.
Funding: None.

Patient Permission Statement

Written informed consent for the use of anonymized clinical images and data was obtained from the patient's legal guardian. All identifying details have been removed to ensure confidentiality.

AUTHORS CONTRIBUTIONS

Sr.#	Author's Full Name	Intellectual Contribution to Paper in Terms of:
1.	Naeem Ul Haq	1. Study design and methodology.
2.	Syed Nasir Sha	2. Paper writing.
3.	Gohar Ali	3 Analysis of data and interpretation of results Editing and quality insurer.
4.	Musawir Khan	4. Data collection and calculation.
5.	Muhammad Ishaq	5. Literature review and referencing.