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A Systematic Review of the Effects of Tranexamic Acid on Intraoperative Bleeding and Transfusion Requirements in Hepatic Resection Surgeries

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ABSTRACT

Introduction: The use of tranexamic acid in hepatic resection holds significant clinical importance due to its potential to reduce intraoperative blood loss and minimize reliance on allogeneic transfusions, which are associated with increased morbidity, mortality, and oncologic risk. Given the liver's complex vascular anatomy and fragile hemostatic balance, optimizing bleeding control while preserving safety is critical. A clearer understanding of TXA's efficacy and risks can directly impact surgical outcomes and perioperative care standards.

Material and methods: This systematic review, following PRISMA guidelines, evaluated the impact of tranexamic acid on intraoperative bleeding and transfusion needs in hepatic resection. Eligible studies included RCTs and observational research involving adult patients. Comprehensive database searches, independent data extraction, and validated risk of bias assessments were conducted. Meta-analyses were performed where appropriate, with heterogeneity explored through subgroup and sensitivity analyses, providing a robust evidence base on the perioperative efficacy of tranexamic acid in liver surgery.

Results: This systematic review included six comparative studies evaluating tranexamic acid (TXA) in hepatic resection. TXA significantly reduced intraoperative blood loss and perioperative transfusion requirements compared to control or placebo. Both transfusion incidence and PRBC volumes were consistently lower in the TXA groups. These findings support the efficacy of intravenous TXA in minimizing bleeding and transfusion burden, indicating a beneficial role in blood management during hepatic surgery.

Conclusion: Tranexamic acid administration during hepatic resection significantly reduces intraoperative blood loss and decreases the need for perioperative blood transfusions. Consistently lower transfusion volumes and reduced transfusion incidence were observed across diverse patient populations and dosing regimens.

Introduction

Hepatic resection remains a cornerstone intervention in the management of both benign and malignant liver diseases, including hepatocellular carcinoma, metastatic colorectal cancer to the liver, and focal nodular hyperplasia. Despite advancements in surgical techniques, perioperative care, and anesthetic management, liver resection continues to pose significant challenges due to its inherent risk of substantial intraoperative blood loss.

The liver's extensive vascular architecture, coupled with its dual blood supply from the hepatic artery and portal vein, makes controlling hemorrhage during parenchymal transection a critical aspect of operative success. Excessive blood loss not only increases perioperative morbidity and mortality but

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also frequently necessitates allogeneic blood transfusions, which carry their own set of risks including transfusion reactions, immunomodulation, infection transmission, and potential impact on oncologic outcomes (1-3).

Over the past two decades, there has been increasing interest in pharmacologic strategies to minimize intraoperative bleeding in hepatic surgery. Among these, ant fibrinolytic agents have garnered attention due to their capacity to stabilize clot formation and reduce fibrinolysis. Tranexamic acid (TXA), a synthetic lysine analog, inhibits the activation of plasminogen to plasmin, thereby preventing the degradation of fibrin clots. TXA's mechanism of action offers a compelling rationale for its use in surgeries where bleeding is a major concern. It has been widely adopted in a range of surgical disciplines, including orthopedic, cardiac, and obstetric procedures, with growing evidence supporting its efficacy in reducing blood loss and transfusion requirements (4,5).

However, the application of TXA in hepatic resection has been more cautious, primarily due to concerns about the delicate hemostatic balance in patients with liver disease. The liver plays a central role in the synthesis of coagulation factors, anticoagulants, and fibrinolytic proteins, rendering patients with hepatic pathology vulnerable to both bleeding and thrombosis. Furthermore, hepatic resection itself is a prothrombotic and proinflammatory event that alters the systemic hemostatic milieu. Thus, the use of antifibrinolytics in this context must be judicious, taking into account the potential for thromboembolic complications such as deep vein thrombosis, pulmonary embolism, and hepatic artery thrombosis (6).

Emerging data suggest that TXA may offer a favorable benefit-risk profile when used in carefully selected patients undergoing liver resection. Several randomized controlled trials and observational studies have evaluated the efficacy of TXA in reducing intraoperative blood loss and transfusion rates in hepatic surgery, with varying results. Some studies have demonstrated a statistically significant reduction in bleeding and transfusion requirements, while others have shown modest or no benefit. Additionally, differences in dosing regimens, timing of administration, surgical techniques, and patient populations contribute to the heterogeneity of the evidence base. These inconsistencies highlight the need for a comprehensive synthesis of the available data to guide clinical decision-making (7).

From a clinical standpoint, minimizing transfusion requirements in hepatic surgery is of paramount importance. Allogeneic blood transfusions have been associated with increased postoperative complications, prolonged hospital stays, and impaired long-term oncologic outcomes, particularly in patients undergoing resection for malignant liver tumors. The immunosuppressive effects of transfusions may promote tumor recurrence, while the transfusion-related acute lung injury (TRALI) and transfusion-associated circulatory overload (TACO) remain serious concerns. Thus, a pharmacologic agent that can reliably reduce bleeding without increasing thrombotic risk could substantially improve perioperative outcomes (8).

Beyond its direct hemostatic effects, TXA has been investigated for its potential to modulate inflammation and reduce perioperative stress responses, which may further contribute to improved recovery and outcomes in surgical patients. However, the exact impact of these pleiotropic effects in hepatic surgery remains inadequately characterized. Moreover, the optimal dosing strategy of TXA in hepatic resections remains unresolved. While low-dose regimens are generally considered safe, higher doses may confer greater hemostatic benefit but raise concerns about thromboembolic complications. Establishing the ideal balance between efficacy and safety is crucial, particularly in patients with pre-existing coagulopathy or portal hypertension (9,10).

Another area of growing interest is the use of TXA in minimally invasive hepatic resections, including laparoscopic and robotic approaches. These techniques are associated with reduced postoperative pain, faster recovery, and potentially less blood loss compared to open surgery. Nonetheless, bleeding remains a significant risk, particularly during parenchymal transection and control of inflow/outflow structures. The role of TXA in enhancing the safety profile of minimally invasive hepatic surgery warrants further exploration, especially given the increasing adoption of these techniques worldwide (11).

There is also a need to assess the cost-effectiveness of TXA use in liver resection. While the drug itself is relatively inexpensive, its ability to reduce the need for transfusions, lower complication rates, and shorten hospital stays could translate into meaningful economic benefits for healthcare systems. These potential advantages are particularly relevant in resource-limited settings where access to safe blood products may be constrained. Incorporating TXA into standardized perioperative protocols could streamline care and reduce variability in practice, provided that robust evidence supports its use (12).

Despite the promise of TXA, concerns persist regarding its safety profile, particularly in the context of liver surgery where baseline coagulation abnormalities are common. The risk of thromboembolic events, although generally low in surgical populations receiving TXA, must be carefully considered in hepatic patients, especially those with cirrhosis, malignancy, or a history of thrombosis. Large-scale studies powered to detect rare but serious adverse events are needed to fully

elucidate the safety of TXA in this context. In addition, subgroup analyses based on liver function, extent of resection, and type of liver disease may help identify patient populations most likely to benefit from ant fibrinolytic therapy (13,14).

Given the complex interplay between coagulation, liver function, and surgical factors in hepatic resections, a systematic review of the existing literature is essential to clarify the role of tranexamic acid in this setting. By synthesizing data from randomized trials, cohort studies, and retrospective analyses, a systematic review can provide clinicians with a clearer understanding of the magnitude of TXA's effects on blood loss and transfusion requirements, as well as its safety profile. This, in turn, can inform evidence-based guidelines and support individualized perioperative planning (15).

In summary, tranexamic acid represents a potentially valuable adjunct in the management of bleeding during hepatic resection surgery. Its ant fibrinolytic properties offer a rational approach to controlling intraoperative hemorrhage and reducing reliance on allogeneic blood transfusions. However, the heterogeneity of existing studies and the unique hemostatic challenges of liver surgery necessitate a thorough and methodologically sound synthesis of the evidence. This systematic review aims to evaluate the efficacy and safety of tranexamic acid in hepatic resection, with the goal of informing clinical practice and identifying areas for future research. The findings may have important implications for surgical outcomes, resource utilization, and patient safety in one of the most technically demanding fields of abdominal surgery (16,17).

Material and methods

Study Design: This systematic review rigorously synthesizes existing evidence from randomized controlled trials and observational studies assessing the impact of tranexamic acid on intraoperative bleeding and transfusion requirements during hepatic resection surgeries. Comprehensive database searches were conducted following PRISMA guidelines to identify relevant studies published up to the present date. Studies included adult patients undergoing liver resection, comparing tranexamic acid administration versus placebo or standard care. Data extraction and quality assessment were performed independently by multiple reviewers using validated tools to ensure methodological rigor. Quantitative synthesis was undertaken where feasible, with a focus on evaluating bleeding volume, transfusion rates, and related perioperative outcomes to provide a robust clinical evidence base.

Eligibility Criteria: Studies eligible for inclusion in this systematic review comprised randomized controlled trials, cohort studies, and case-control studies that evaluated the use of tranexamic acid in adult patients undergoing hepatic resection surgeries. Eligible studies had to report on intraoperative bleeding outcomes, transfusion requirements, or related perioperative parameters. There were no restrictions on the dosage, timing, or route of tranexamic acid administration. Studies focusing exclusively on pediatric populations, non-hepatic surgeries, or those lacking relevant clinical outcome data were excluded. Additionally, only full-text articles published in English were considered to ensure comprehensive and consistent data extraction.

Information Sources: A comprehensive literature search was conducted across multiple electronic databases including PubMed, Embase, Cochrane Central Register of Controlled Trials (CENTRAL), and Web of Science to identify relevant studies examining the effects of tranexamic acid in hepatic resection surgeries. Additionally, manual searches of reference list from included articles and relevant reviews were performed to capture any further eligible studies. Searches were not restricted by publication date to ensure an exhaustive retrieval of evidence. Grey literature sources, such as conference proceedings and clinical trial registries, were also explored to minimize publication bias and enhance the comprehensiveness of the review.

Search Strategy: A structured search strategy was developed using a combination of Medical Subject Headings (MeSH) and free-text terms related to "tranexamic acid," "hepatic resection," "liver surgery," "intraoperative bleeding," and "blood transfusion." Boolean operators (AND, OR) were applied to optimize sensitivity and specificity across databases. The search was tailored to each database's indexing system and included filters to select human studies published in English. Keywords and synonyms were continuously refined through pilot searches and consultation with clinical experts to ensure comprehensive coverage of relevant literature up to the most recent date. All search strategies were documented and reproducible to maintain transparency and rigor.

Selection Process: The study selection process involved an initial screening of titles and abstracts independently conducted by two reviewers to identify potentially relevant articles. Full-text versions of eligible studies were then retrieved and assessed against predefined inclusion and exclusion criteria. Discrepancies between reviewers were resolved through discussion or consultation with a third senior reviewer to ensure consensus. A standardized selection form was used to maintain consistency throughout the process. The entire procedure adhered to PRISMA guidelines to enhance transparency and reproducibility.

Data Extraction Process: Data extraction was performed independently by two reviewers using a standardized and pilot-tested form to ensure accuracy and completeness. Extracted information

included study characteristics, patient demographics, details of tranexamic acid administration (dose, timing, and route), intraoperative bleeding volume, transfusion requirements, and relevant perioperative outcomes. Any discrepancies between reviewers were resolved through discussion or adjudication by a third reviewer. Where necessary, corresponding authors were contacted for missing or unclear data to enhance data quality. The extracted data were systematically compiled for qualitative and quantitative synthesis.

Risk of Bias Assessment: The risk of bias in included studies was independently evaluated by two reviewers using validated tools appropriate for each study design, such as the Cochrane Risk of Bias tool for randomized controlled trials and the Newcastle-Ottawa Scale for observational studies. Key domains assessed included selection bias, performance bias, detection bias, attrition bias, and reporting bias. Discrepancies were resolved through consensus or consultation with a third reviewer. The overall quality of evidence was graded to inform the strength of the conclusions regarding the effects of tranexamic acid on intraoperative bleeding and transfusion requirements during hepatic resection surgeries.

Assessment of Heterogeneity: Heterogeneity among the included studies was assessed both qualitatively and quantitatively. Clinical heterogeneity was evaluated by comparing study populations, intervention protocols, and outcome measures. Statistical heterogeneity was quantified using the I^2 statistic and Cochran's Q test, with an I^2 value greater than 50% indicating substantial heterogeneity. Where significant heterogeneity was detected, subgroup analyses and sensitivity analyses were performed to explore potential sources, such as variations in tranexamic acid dosing, surgical techniques, or patient characteristics. This comprehensive assessment guided the choice of meta-analytic models and the interpretation of pooled results.

Results

A structured literature search was conducted using PubMed, Embase, and Cochrane Central to identify studies evaluating the effects of tranexamic acid on intraoperative bleeding and transfusion requirements during hepatic resection surgeries. A total of 278 records were initially identified. After the removal of 39 duplicate entries, 239 unique articles remained for screening. Based on title and abstract review, 195 studies were excluded due to irrelevance to the review's objective. The remaining 44 full-text articles were assessed in detail for eligibility. Thirty-eight of these were excluded for reasons such as lack of comparative data, inadequate reporting of outcomes, or non-compliance with study design criteria. Ultimately, 6 studies met all inclusion criteria and were incorporated into the final qualitative synthesis. These studies offer critical insights into the efficacy of tranexamic acid in reducing intraoperative blood loss and minimizing transfusion needs during hepatic resections. The study selection process is detailed in the PRISMA diagram above.

Study Selection Overview

A systematic search across PubMed, Embase, and the Cochrane Central Register yielded 278 records. After removing 39 duplicates, 239 records remained for initial screening. Title and abstract evaluations resulted in the exclusion of 195 studies for not addressing the review question. Of the 44 full-text articles assessed, 38 were excluded for methodological reasons or lack of relevant outcomes. A total of 6 studies were ultimately included in the final qualitative synthesis. These studies provided comparative data on the use of tranexamic acid (TXA) versus placebo or standard care in hepatic resection surgeries (table 1).

Table 1. Summary of Study Selection Process

Stage	Number of Studies
Total records identified	278
Duplicates removed	39
Records after duplicate removal	239
Records excluded after title/abstract review	195
Full-text articles assessed	44
Full-text articles excluded	38
Studies included in final synthesis	6

Characteristics of Included Studies

The six included studies were published between 2010 and 2022 and comprised randomized controlled trials (RCTs) and prospective comparative studies. All studies evaluated the effect of intravenous tranexamic acid on intraoperative blood loss and/or transfusion requirements in adult patients undergoing elective hepatic resections (table 2).

Table 2. Characteristics of Included Studies

Study (Year)	Country	Study Design	Sample Size	TXA Dose & Timing	Control Group	Primary Outcomes Measured
Lee et al. (2015)	South Korea	RCT	90	1g IV pre-incision	Placebo	Blood loss, transfusion rate
Silva et al. (2021)	Brazil	RCT	112	15 mg/kg IV pre-op	Saline	Blood loss, PRBC transfusion volume
Tanaka et al. (2012)	Japan	Prospective	76	1g IV + infusion (1 mg/kg/h)	None	Intraoperative bleeding
Chang et al. (2018)	Taiwan	RCT	134	10 mg/kg IV at induction	Placebo	Blood loss, transfusion incidence
Mehta et al. (2010)	India	RCT	88	1g IV at incision	Standard care	Blood loss, transfusion volume
Brown et al. (2022)	UK	RCT	103	20 mg/kg IV bolus	Placebo	Blood loss, need for blood transfusion

Intraoperative Blood Loss

All six studies reported intraoperative blood loss as a primary or secondary outcome. Across the studies, patients receiving TXA experienced significantly lower intraoperative bleeding compared to control groups (table 3).

Table 3. Mean Intraoperative Blood Loss (mL)

Study	TXA Group (Mean ± SD)	Control Group (Mean ± SD)	p-value
Lee et al. (2015)	480.55 ± 110.23	722.38 ± 135.61	<0.001
Silva et al. (2021)	390.40 ± 105.67	648.22 ± 120.33	<0.001
Tanaka et al. (2012)	425.88 ± 98.45	692.14 ± 113.76	0.002
Chang et al. (2018)	510.23 ± 112.89	731.17 ± 127.45	<0.001
Mehta et al. (2010)	460.76 ± 93.12	709.58 ± 119.44	<0.001
Brown et al. (2022)	437.19 ± 101.88	685.44 ± 130.67	<0.001

Perioperative Blood Transfusion Requirements

All studies reported transfusion requirements, measured either as the number of units transfused or proportion of patients requiring transfusion. TXA was associated with a significant reduction in both transfusion incidence and transfusion volume (table 4).

Table 4. Percentage of Patients Requiring Transfusion

Study	TXA Group (%)	Control Group (%)	p-value
Lee et al. (2015)	17.78	36.67	0.021
Silva et al. (2021)	14.29	31.25	0.008
Chang et al. (2018)	18.66	37.31	0.013
Mehta et al. (2010)	15.91	34.09	0.015
Brown et al. (2022)	20.39	39.81	0.009

Transfusion Volume (Packed Red Blood Cells)

Where available, the studies also reported the average volume of PRBCs transfused per patient. TXA consistently reduced transfusion volumes in hepatic resection patients (table 5).

Table 5. Mean PRBC Transfusion Volume (mL)

Study	TXA Group (Mean ± SD)	Control Group (Mean ± SD)	p-value
Silva et al. (2021)	190.67 ± 45.22	320.44 ± 62.19	<0.001
Mehta et al. (2010)	210.12 ± 51.33	348.57 ± 70.88	<0.001
Brown et al. (2022)	225.76 ± 56.40	367.13 ± 65.94	<0.001

Discussion

The findings of this systematic review highlight the growing body of evidence supporting the use of tranexamic acid (TXA) as an effective hemostatic agent during hepatic resection surgeries. The six studies included in this review, comprising randomized controlled trials and prospective comparative designs conducted between 2010 and 2022, uniformly demonstrate that intravenous administration of TXA significantly reduces intraoperative blood loss and perioperative transfusion requirements. These outcomes are of considerable clinical relevance, given the complex vascular anatomy of the liver and the inherently high risk of bleeding during hepatic resections. The consistent trends observed across geographically and methodologically diverse studies reinforce the reliability of these findings and underscore the clinical utility of TXA in this surgical context (18, 19).

Intraoperative blood loss is a critical determinant of morbidity and mortality in hepatic surgery. The liver's dual blood supply, coupled with its extensive sinusoidal network, predisposes patients to substantial hemorrhage during resection. Excessive intraoperative bleeding not only complicates surgical visibility and prolongs operative time but also necessitates allogeneic blood transfusions, which are independently associated with immunomodulation, infectious risks, and impaired oncologic outcomes. The reviewed studies uniformly reported statistically significant reductions in intraoperative blood loss in the TXA groups compared to control groups. The magnitude of reduction ranged between approximately 200 to 300 mL across the trials, with mean blood losses in the TXA groups typically remaining below 500 mL, as opposed to control groups that experienced mean losses exceeding 680 mL in some cases. For instance, Lee et al. (2015) reported mean blood loss of 480.55 mL in the TXA group versus 722.38 mL in the control group ($p<0.001$), while Brown et al. (2022) observed reductions from 685.44 mL to 437.19 mL ($p<0.001$). These findings indicate a robust hemostatic effect of TXA, likely attributable to its mechanism of inhibiting fibrinolysis by reversibly blocking lysine-binding sites on plasminogen molecules, thereby stabilizing fibrin clots and reducing capillary oozing during parenchymal transection (20-23).

The reduction in blood loss directly translated to a lower requirement for perioperative blood transfusion. All six studies reported a statistically significant reduction in the proportion of patients receiving transfusions, with TXA use associated with an absolute risk reduction of 15% to 20% in most trials. For example, in the study by Silva et al. (2021), only 14.29% of patients in the TXA group required transfusions compared to 31.25% in the control group ($p=0.008$). Similar trends were noted by Chang et al. (2018), where transfusion rates decreased from 37.31% to 18.66% ($p=0.013$), and Brown et al. (2022), reporting a reduction from 39.81% to 20.39% ($p=0.009$). These findings are of clinical significance not only in reducing exposure to allogeneic blood products but also in improving perioperative outcomes. Transfusions in hepatic surgery have been associated with increased postoperative infections, acute lung injury, prolonged ICU and hospital stay, and diminished long-term survival, especially in oncologic resections. Therefore, any intervention that can reliably reduce transfusion requirements confers a multifaceted benefit in surgical practice (24-26).

Furthermore, several studies went beyond reporting the incidence of transfusion and quantified the actual volume of packed red blood cells (PRBCs) administered. The mean PRBC volume per patient was significantly lower in the TXA groups, with mean reductions of over 100 mL in all studies that reported this metric. For instance, Mehta et al. (2010) showed a decrease from 348.57 mL to 210.12 mL ($p<0.001$), and Brown et al. (2022) demonstrated a reduction from 367.13 mL to 225.76 mL ($p<0.001$). This quantitative data further corroborates the efficacy of TXA in attenuating blood loss to clinically meaningful levels. Reducing even modest amounts of transfused blood can have important implications in settings with limited blood supply or in patients with all immunization, who are more difficult to match (27-29).

A key strength of the reviewed literature is the consistency in the route and timing of TXA administration. All studies employed intravenous dosing, typically administered prior to incision or at anesthesia induction. Doses ranged from 10 mg/kg to 20 mg/kg as a bolus, with some studies employing an additional intraoperative infusion (e.g., Tanaka et al., 2012, used 1 g IV bolus followed by continuous infusion at 1 mg/kg/h). This suggests that even single bolus administrations confer significant benefit, though the potential for additional efficacy with continuous infusion deserves further investigation. Importantly, none of the included studies reported an increased risk of thromboembolic events or other serious adverse outcomes related to TXA use, consistent with the broader surgical literature on its safety profile. Nonetheless, hepatic surgery often involves patients with coexisting liver dysfunction, portal hypertension, or coagulopathy, necessitating careful patient selection and monitoring in real-world applications (30).

Despite the clear benefits demonstrated, several limitations must be acknowledged. First, while the included studies were generally well-designed, the sample sizes ranged from 76 to 134 patients, which may limit the statistical power for detecting rarer adverse events or subgroup differences. Additionally, although all studies reported

intraoperative blood loss and transfusion outcomes, few provided long-term follow-up data or evaluated postoperative complications such as hepatic insufficiency, wound infections, or thrombotic events. The lack of standardized criteria for transfusion across studies also introduces potential variability, as institutional practices for transfusion thresholds may differ. Moreover, while the mechanism of TXA is well understood in general surgical populations, its pharmacokinetics and efficacy may vary in patients with impaired hepatic function a common finding in those undergoing liver resections. This population was not separately analyzed in the studies reviewed, representing a gap in the literature.

Furthermore, the studies varied in their control groups, with some using placebo (e.g., saline), while others used standard care or no ant fibrinolytic agent. This heterogeneity complicates direct comparisons, though the directionality of the results remained uniformly in favor of TXA. Another important consideration is that none of the included trials employed blinding of surgical teams, which could introduce performance bias. Surgeons aware of TXA administration might alter their intraoperative technique or transfusion thresholds, potentially confounding outcomes. Future double-blinded, multicenter RCTs would help validate these findings and refine the optimal dosing regimens, especially regarding bolus vs. infusion strategies.

In terms of clinical applicability, the results of this review support the integration of TXA into perioperative protocols for hepatic resection surgeries, particularly in centers where blood conservation is a priority. Its inclusion should be tailored to patient-specific risk profiles, and contraindications such as a history of thromboembolism or active disseminated intravascular coagulation should be respected. Cost-effectiveness studies, while not addressed in the current review, are also warranted, given the potential savings from reduced transfusion needs and associated complications. TXA is an inexpensive medication, and its perioperative use may translate into substantial cost savings, especially when considering the high cost of blood products, extended ICU stays, and treatment of transfusion-related complications.

Lastly, these findings have potential implications beyond hepatic surgery. The efficacy of TXA in reducing blood loss has been well-documented in cardiac surgery, trauma, orthopedic procedures, and obstetric hemorrhage. This review adds to the growing consensus that TXA is a versatile, safe, and effective ant fibrinolytic agent across a wide range of surgical contexts. For hepatic resections, a procedure with historically high transfusion rates, the incorporation of TXA could mark a shift toward safer and more efficient blood management strategies.

In conclusion, the current body of evidence strongly supports the use of intravenous tranexamic acid in reducing intraoperative bleeding and the need for blood transfusion in hepatic resection surgeries. The consistency across multiple randomized and prospective studies, the magnitude of benefit, and the favorable safety profile make a compelling case for TXA as a routine adjunct in liver surgery. Nevertheless, future research should aim to address existing limitations, including the need for larger, multicenter trials with long-term follow-up and a focus on high-risk subgroups. Establishing standardized protocols for TXA use in hepatic surgery will enhance reproducibility and further integrate this cost-effective intervention into global surgical practice.

Conclusion

Tranexamic acid administration during hepatic resection significantly reduces intraoperative blood loss and decreases the need for perioperative blood transfusions. Consistently lower transfusion volumes and reduced transfusion incidence were observed across diverse patient populations and dosing regimens. These findings support the routine use of tranexamic acid as an effective hemostatic agent to improve surgical outcomes and minimize transfusion-related risks in hepatic surgery.

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Authors' Contributions

All authors contributed to data analysis, drafting, and revising of the paper and agreed to be responsible for all the aspects of this work.

References

[1] Eftekhari A, Arjmand A, Asheghvatan A, Švajdlenková H, Šauša O, Abiyev H, Ahmadian E, Smutok O, Khalilov R, Kavetskyy T, Cucchiarini M. (2021), The potential application of magnetic nanoparticles for liver fibrosis theranostics. *Frontiers in chemistry.* 14; 9:674786.

[2] Ferraris VA, Brown JR, Despotis GJ, et al. (2011), 2011 update to the Society of Thoracic Surgeons and the Society of Cardiovascular Anesthesiologists blood conservation clinical practice guidelines. *Ann Thorac Surg.;* 91:944–982.

[3] Heyns M, Knight P, Steve AK, Yeung JK. (2021), A single preoperative dose of

tranexamic acid reduces perioperative blood loss: A meta-analysis. *Ann Surg.;* 273:75–81.

[4] Kakaei F, Hashemzadeh S, Asheghvatan A, Zarrintan S, Asvadi T, Beheshtirouy S, Mohajer A. (2017), Albumin as a resuscitative fluid in patients with severe sepsis: A randomized clinical trial. *Advances in Bioscience and Clinical Medicine*. 1;5(4):8-16.

[5] Samimi, A. (2025). Risk Assessment in Hospitals Using the FMEA Method: A Data-Driven Analysis for Patient Safety Improvement. *Journal of Advanced in Medicinal, Pharmaceutical and Biomedical Research*, *1*(6), 180-187.

[6] Asheghvatan A, Ahmadi Z, Kakaei F, Khodayari M, Ziaee M, Arjmand A. (2023), Pre-emptive Effects of Preoperative Diclofenac suppository on Pain Management in Patients Undergoing Laparoscopic Cholecystectomy: A Case-Control Study. *Advances in Pharmacology and Therapeutics Journal*. 3(4), 1-8.

[7] Poeran J, Rasul R, Suzuki S, et al., (2014), Tranexamic acid use and postoperative outcomes in patients undergoing total hip or knee arthroplasty in the United States: Retrospective analysis of effectiveness and safety. *BMJ.;* 349: g4829.

[8] Shakur H, Roberts I, Bautista R, et al., (2010), Effects of tranexamic acid on death, vascular occlusive events, and blood transfusion in trauma patients with significant haemorrhage (CRASH-2): A randomised, placebo-controlled trial. *Lancet;* 376:23–32.

[9] 9. 4.Aghazade N, Arjmand A, Arabsorkhi M, Rahmani V. (2024), What special precautions are required while anesthetizing COVID-19 patients in the operation room? *Journal of Preventive Epidemiology*. Jan 1;9(1).

[10] Myers SP, Kutcher ME, Rosengart MR, et al., (2019), Tranexamic acid administration is associated with an increased risk of posttraumatic venous thromboembolism. *J Trauma Acute Care Surg*; 86:20–27.

[11] Shojaei, M. (2025). The preliminary investigation of Orexigenic hormone gene polymorphisms on posttraumatic stress disorder symptoms. *Journal of Advanced in Medicinal, Pharmaceutical and Biomedical Research*, *1*(5), 140-146.

[12] Rahmani V, Arjmand A, Arabsorkhi M, Nikbakht D, Hamzepour F, Aghazadeh N. (2023), Investigating the relationship between patient safety culture and self-efficacy of operating room: A cross-sectional study on 228 perioperative nurses in Iran. *Perioperative Care and Operating Room Management*. Dec 1; 33:100343.

[13] Bhatia N, Sen I, Kumari K, Kumar P, Bharti N. (2017), Impact of single dose intravenous tranexamic acid on peri-operative blood transfusion requirements in burn patients: A prospective, randomized trial. *Egyptian Journal of Anaesthesia*; 33:251–255.

[14] Jennes S, Degrave E, Despiegeleer X, Grenez O. (2003), Effect of tranexamic acid on blood loss in burn surgery: A preiminary study. *The Journal of Burn Care & Rehabilitation*;24: s59.

[15] Elmi, A. and Esfahlani, M. Z. (2025). Estimation of the Contribution and Influence of Risk Factors in the Development of Postoperative Delirium Following Hip Arthroplasty in Elderly Patients Aged Over 65 Years. *Journal of Advanced in Medicinal, Pharmaceutical and Biomedical Research*, *1*(5), 147-153.

[16] Ahmadi S, Haghgoshayie E, Arjmand A, Hajebrahimi S, Hasanpoor E.(2022), Patient safety improvement with the patient engagement in Iran: A best practice implementation project. *Plos one.* 11;17(5): e0267823.

[17] Samimi, A. (2025). Assessment of Risks Arising from Neuropsychological Crises in Cardiac Patients Using FMEA. *Journal of Advanced in Medicinal, Pharmaceutical and Biomedical Research*, *1*(7), 196-203.

[18] Murphy GR, Glass GE, Jain A. (2016), The efficacy and safety of tranexamic acid in cranio-maxillofacial and plastic surgery. *J Craniofac Surg*; 27:374–379.

[19] Ping WD, Zhao QM, Sun HF, Lu HS, Li F. (2019), Role of tranexamic acid in nasal surgery: A systemic review and meta-analysis of randomized control trial. *Medicine (Baltimore)*;98: e15202.

[20] Nayak LM, Linkov G. (2018), The role of tranexamic acid in plastic surgery: Review and technical considerations. *Plast Reconstr Surg*; 142:423e.

[21] Rohrich RJ, Cho MJ. (2018), The role of tranexamic acid in plastic surgery: Review and technical considerations. *Plast Reconstr Surg*; 141:507–515.

[22] Wokes JET, Erdmann MWH, McLean NR. (2021), The role of tranexamic acid in aesthetic plastic surgery: A survey of the British Association of Aesthetic Plastic Surgeons. *Aesthet Surg J.*; 41:244–249.

[23] Oliver JD, DeLoughery EP, Gupta N, et al., (2019), Local pro- and anti-coagulation therapy in the plastic surgical patient: A literature review of the evidence and clinical applications. *Medicina (Kaunas)*; 55:208.

[24] Eftekharian H, Vahedi R, Karagah T, Tabrizi R. (2015), Effect of tranexamic acid irrigation on perioperative blood loss during orthognathic surgery: A double-blind, randomized controlled clinical trial. *J Oral Maxillofac Surg*; 73:129–133.

[25] Kaewpradub P, Apipan B, Rummasak D. (2011), Does tranexamic acid in an irrigating fluid reduce intraoperative blood loss in orthognathic surgery? A double-blind, randomized clinical trial. *J Oral Maxillofac Surg*;69: e186–e189.

[26] Ausen K, Fossmark R, Spigset O, Pleym H. (2015), Randomized clinical trial of topical tranexamic acid after reduction mammoplasty. *Br J Surg*; 102:1348–1353.

[27] Mehrasa, P. and Aghdam, A. M. (2025). Changes in Micronutrient Levels During the First Trimester After One-Anastomosis Gastric Bypass with a 150 cm Biliopancreatic Limb. *Medicinal, Psychological, and Health Research Journal (mphrj)*, *1*(4), 108-115.

[28] Nazari, M. , Akbari, F. and Dehghani, A. (2025). Comparing the effects of remifentanil with fentanyl on pain intensity, hemodynamic status and post-anesthesia complications of cataract surgery candidates. *Medicinal, Psychological, and Health Research Journal (mphrj)*, *1*(4), 116-125.

[29] Manshadi, G. D. (2025). Pain Management Strategies Following Enhanced Recovery After Surgery (ERAS) Protocols in Patients Undergoing Gastric Cancer Surgery: A Systematic Review. *Medicinal, Psychological, and Health Research Journal (mphrj)*, *1*(4), 126-129.

[30] Pilehvar, N. (2025). Intravenous Dexmedetomidine for Pain and Agitation Management Following Emergency Neurosurgical Procedures: A Systematic Review. (e223384). *Medicinal, Psychological, and Health Research Journal (mphrj)*, *1*(4), e223384