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Prophylactic Tranexamic Acid in Vaginal and Cesarean Deliveries: A Randomized Controlled Trial Demonstrating Differential Efficacy

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ABSTRACT

Background: Postpartum hemorrhage remains a leading cause of maternal mortality worldwide. Tranexamic acid, an antifibrinolytic agent, has shown promise in reducing blood loss, but its prophylactic role in routine obstetric practice requires further evaluation.

Objective: To evaluate the efficacy and safety of prophylactic tranexamic acid in reducing postpartum blood loss following vaginal delivery and cesarean section.

Methods: This prospective, randomized, double-blind, placebo-controlled study was conducted at a tertiary care center from 2019 to 2022. Two hundred women were enrolled and randomly allocated into study (tranexamic acid 1g IV) and control (placebo) groups, with 100 women in each group. Participants were further subdivided based on mode of delivery: full-term vaginal delivery (FTVD) and lower segment cesarean section (LSCS). Primary outcome was postpartum blood loss measured using graduated drapes. Secondary outcomes included hemoglobin and hematocrit changes, additional uterotonic requirements, blood transfusion needs, and adverse effects.

Results: In FTVD, mean blood loss showed no significant difference between groups (339.69 ml vs 327.25 ml, p=0.682). In LSCS, although absolute blood loss was comparable (531.30 ml vs 554.85 ml, p=0.436), tranexamic acid significantly reduced hemoglobin decline (0.71 g/dL vs 1.00 g/dL, p=0.001) and hematocrit drop (p=0.001 pre-delivery, p=0.038 post-delivery). No thromboembolic events or maternal deaths occurred in either group.

Conclusion: Prophylactic tranexamic acid demonstrates limited benefit in low-risk vaginal deliveries but shows significant hemostatic advantages in cesarean sections with an excellent safety profile. Routine use should be considered for cesarean deliveries.

1. INTRODUCTION:

Postpartum hemorrhage (PPH) remains one of the leading causes of maternal morbidity and mortality worldwide, accounting for approximately 27% of all maternal deaths globally.[1,2] The World Health Organization defines PPH as blood loss exceeding 500 mL following vaginal delivery or 1000 mL after cesarean section within 24 hours of childbirth.[3] Despite advances in obstetric care and the implementation of active management of the third stage of labor (AMTSL), PPH continues to pose a significant challenge, particularly in low-resource

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settings where access to blood products and surgical interventions may be limited.[4,5]

Tranexamic acid (TXA), a synthetic antifibrinolytic agent, has emerged as a promising pharmacological intervention for preventing and managing PPH.[6] By competitively inhibiting the activation of plasminogen to plasmin, TXA stabilizes clot formation and reduces blood loss.[7,8] The landmark WOMAN trial demonstrated that early administration of TXA significantly reduced death due to bleeding in women with established PPH, with no apparent increase in thromboembolic events.[9] Subsequently, prophylactic use of TXA has gained attention, with the TRAAP trials investigating its role in preventing blood loss during both vaginal and cesarean deliveries.[10,11]
While existing evidence supports the efficacy of TXA in treating established PPH, its prophylactic role in routine obstetric practice remains under investigation. This study aims to evaluate the effectiveness and safety of prophylactic tranexamic acid administration in reducing postpartum blood loss following both vaginal delivery and cesarean section in a tertiary care setting. Understanding the optimal timing and application of TXA could provide clinicians with an additional tool to minimize maternal morbidity associated with excessive postpartum bleeding.

MATERIALS AND METHODS:

Study Design and Setting

This prospective, randomized, double-blind, placebo-controlled study was conducted at the Department of Obstetrics and Gynecology, Dr. B.R. Ambedkar Medical College and Hospital, Bangalore, a tertiary care teaching institution, over a period of 24 months from 2019 to 2022. The study protocol was approved by the Institutional Ethics Committee, and written informed consent was obtained from all participants prior to enrollment.[12]

Study Population and Sample Size

A total of 200 pregnant women who delivered at our institution were enrolled and randomly allocated into two groups: 100 women in the study group receiving tranexamic acid and 100 women in the control group receiving placebo. The participants were further subdivided based on mode of delivery: full-term vaginal delivery (FTVD) and lower segment cesarean section (LSCS). Sample size calculation was performed using standard statistical formulas with 95% confidence interval and 80% power to detect a clinically significant difference in postpartum blood loss. [13,14]

Inclusion Criteria:

Women meeting the following criteria were included: singleton pregnancy at term (≥37 weeks gestation), live fetus in cephalic presentation, anticipated vaginal delivery or planned cesarean section, maternal age between 18-40 years, and willingness to participate with informed consent.[15] Both primigravida and multigravida women were eligible for enrollment.

Exclusion Criteria:

Women with known hypersensitivity to tranexamic acid, pre-existing coagulation disorders, history of thromboembolic events, significant cardiovascular or renal disease, placental abnormalities (placenta previa, placenta accreta), severe anemia (hemoglobin <7 g/dL), antepartum hemorrhage, and those refusing consent were excluded from the study.[16,17]

Intervention Protocol

Women in the study group received 1 gram of tranexamic acid (10 mL of 100 mg/mL solution) intravenously over 5 minutes, administered slowly 10 minutes before delivery for cesarean section and immediately after delivery of the anterior shoulder during vaginal delivery.[18,19] The control group received an equivalent volume of normal saline as placebo administered using the same protocol. All participants received active management of the third stage of labor, including administration of 10 IU of oxytocin intramuscularly following delivery of the baby and controlled cord traction.[20,21] Additional uterotonics were administered as per standard protocol if required.

Outcome Measures

The primary outcome measure was postpartum blood loss, quantified using graduated under-buttock drapes from delivery until 2 hours postpartum.[22] Secondary outcomes included changes in hemoglobin and hematocrit levels (measured pre-delivery and 48 hours post-delivery), need for additional uterotonics, blood transfusion requirements, and incidence of adverse effects including thromboembolic events.[23,24] Coagulation parameters including prothrombin time (PT), activated partial thromboplastin time (aPTT), and international normalized ratio (INR) were assessed in cesarean delivery cases, while bleeding time (BT) and clotting time (CT) were evaluated in vaginal delivery cases.[25]

Statistical Analysis

Data were analyzed using SPSS software version 20.0. Continuous variables were expressed as mean ± standard deviation and compared using Student's t-test. Categorical variables were analyzed using chi-square test or Fisher's exact test as appropriate. A p-value of <0.05 was considered statistically significant.[26,27] Inter-quartile ranges were

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calculated for non-parametric data distribution.

RESULTS

A total of 200 women were enrolled in this study and randomly allocated into two equal groups: 100 women received tranexamic acid (study group) and 100 women received placebo (control group). Participants were further subdivided based on mode of delivery into full-term vaginal delivery (FTVD) and lower segment cesarean section (LSCS) groups, with 100 women in each delivery mode category.

Full-Term Vaginal Delivery (FTVD)

Baseline Characteristics

Table 1: Demographic Profile Comparison between FTVD Cases and Controls

Parameter	Cases (n=100)	Controls (n=100)	P value
	Mean ± SD	Mean ± SD	
Age (years)	24.81 ± 4.56	24.88 ± 3.84	0.907
Height (cm)	156.24 ± 2.79	155.49 ± 4.40	0.152
Weight (kg)	61.87 ± 8.83	64.88 ± 10.38	0.029*
BMI (kg/m²)	25.33 ± 3.43	26.85 ± 4.22	0.006*

*Statistically significant (p<0.05)

The two groups were comparable in terms of age and height. Parity distribution showed 71% multigravida and 29% primigravida in the study group versus 67% multigravida and 33% primigravida in controls (p=0.541). The most common comorbidity in both groups was hypothyroidism, with no significant difference in comorbidity distribution between groups (p=0.305).

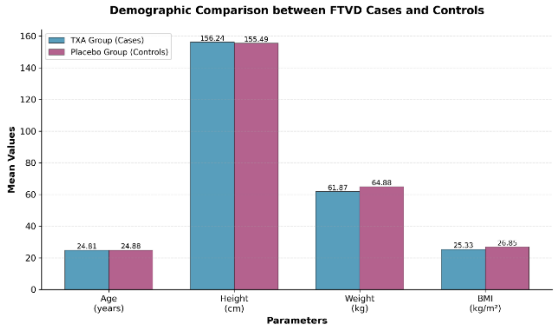

Fig. 1: Bar chart showing demographic comparison between FTVD cases and controls

Primary Outcome: Blood Loss

Table 2: Blood Loss and Hemoglobin Parameters in FTVD

Parameter	Cases (n=100)	Controls (n=100)	P value
	Mean ± SD	Mean ± SD	
Blood Loss (ml)	339.69 ± 202.72	327.25 ± 223.07	0.682
Pre-delivery Hb (g/dL)	11.29 ± 1.24	11.23 ± 1.32	0.744
Post-delivery Hb (g/dL)	10.59 ± 1.33	10.55 ± 1.30	0.826
Hb difference (g/dL)	0.71 ± 0.56	0.69 ± 0.58	0.825
Pre-delivery Hct (%)	33.77 ± 3.79	34.13 ± 3.48	0.481
Post-delivery Hct (%)	31.76 ± 4.05	31.96 ± 3.64	0.721

Hb = Hemoglobin, Hct = Hematocrit

Mean postpartum blood loss in the tranexamic acid group was 339.69 ml compared to 327.25 ml in the control group, showing no statistically significant difference (p=0.682).[28] Similarly, no significant differences were observed in pre-delivery and post-delivery hemoglobin or hematocrit values between the two groups.

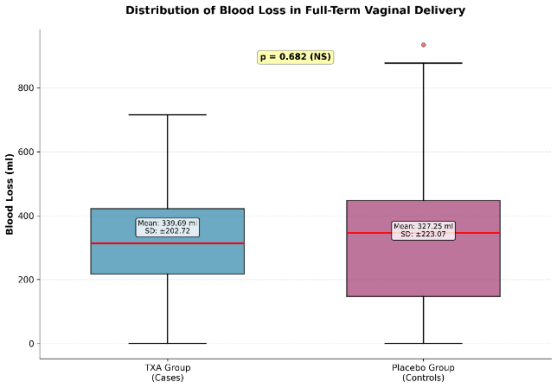

Fig. 2: Box plot showing distribution of blood loss in FTVD cases vs controls

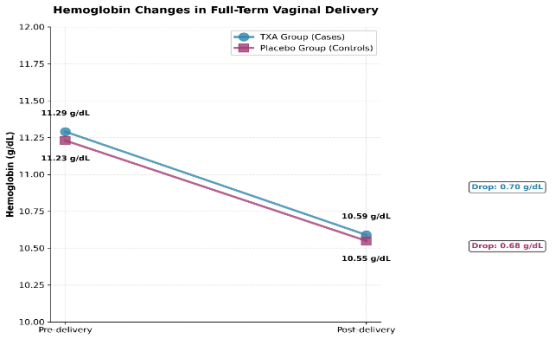

Fig. 3: Line graph showing pre- and post-delivery hemoglobin changes in both groups

Secondary Outcomes

Table 3: Additional Interventions and Coagulation Parameters in FTVD

Parameter	Cases	Controls	P value
Additional uterotonics required	7%	4%	0.352
Bleeding Time (seconds)	168.81 ± 36.82	171.80 ± 43.00	0.598
Clotting Time (seconds)	313.99 ± 30.63	307.33 ± 32.38	0.137
MOPS (Mean)	3.33 ± 2.59	2.49 ± 1.18	0.005*

MOPS = Mop count used for blood absorption; *Statistically significant

The requirement for additional uterotonics was 7% in the study group versus 4% in controls (p=0.352).

Among women requiring blood transfusion, 33.3% in the study group required 1-2 units compared to 67.9% requiring 1 unit in the control group (p=0.166).[29,30] Coagulation parameters including bleeding time and clotting time showed no significant differences between groups, indicating safety of tranexamic acid with no increased risk of thrombosis.

Lower Segment Cesarean Section (LSCS) Baseline Characteristics

Table 4: Demographic Profile Comparison between LSCS Cases and Controls

Parameter	Cases (n=100)	Controls (n=100)	P value
	Mean ± SD	Mean ± SD	
Age (years)	26.78 ± 4.93	26.54 ± 5.14	0.736
Height (cm)	155.66 ± 4.06	155.61 ± 4.41	0.934
Weight (kg)	64.22 ± 10.25	65.32 ± 10.58	0.456
BMI (kg/m²)	26.55 ± 4.43	27.06 ± 4.80	0.433

The two groups were well-matched with no significant differences in demographic parameters. Parity distribution showed 67% multigravida in cases versus 70% in controls (p=0.648). Baseline comorbidities were similar between groups, with hypothyroidism being the most common condition (25% in cases vs. 13% in controls, p=0.240).

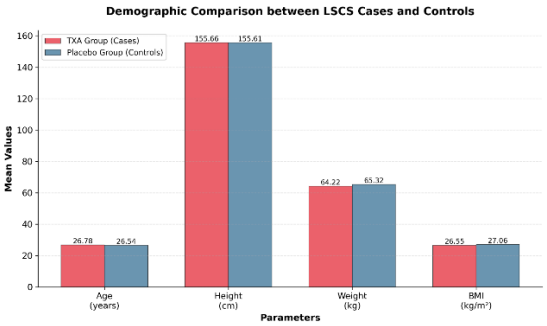

Fig 4: Bar chart showing demographic comparison between LSCS cases and controls

Primary Outcome: Blood Loss

Table 5: Blood Loss and Hematological Parameters in LSCS

Parameter	Cases (n=100)	Controls (n=100)	P value
	Mean ± SD	Mean ± SD	
Blood Loss (ml)	531.30 ± 236.85	554.85 ± 187.18	0.436
Pre-delivery Hb (g/dL)	11.02 ± 1.33	11.27 ± 1.39	0.199
Post-delivery Hb (g/dL)	10.30 ± 1.37	10.27 ± 1.35	0.885
Hb difference (g/dL)	0.71 ± 0.58	1.00 ± 0.60	0.001*
Pre-delivery Hct (%)	33.47 ± 3.70	35.18 ± 3.66	0.001*
Post-delivery Hct (%)	31.14 ± 3.66	32.22 ± 3.68	0.038*

*Statistically significant (p<0.05)

Mean intraoperative blood loss in the tranexamic acid group was 531.30 ml compared to 554.85 ml in the control group (p=0.436).[31] Although the absolute difference in blood loss was not statistically significant, there was a significant reduction in hemoglobin drop in the tranexamic acid group (0.71 g/dL) compared to controls (1.00 g/dL, p=0.001). Similarly, the decrease in hematocrit was significantly less in the study group, both pre-delivery (p=0.001) and post-delivery (p=0.038).

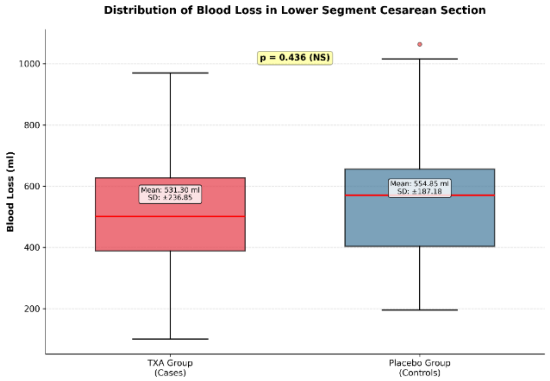

Fig. 5: Box plot showing distribution of blood loss in LSCS cases vs controls

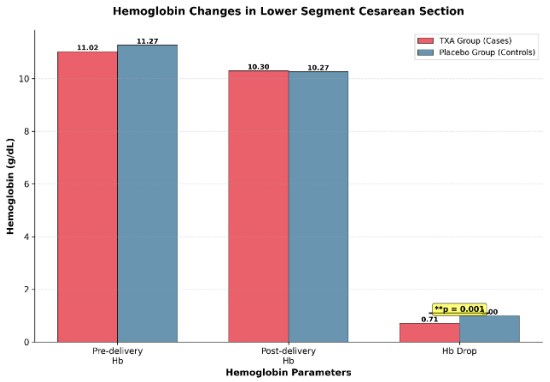

Fig. 6: Comparative bar graph showing hemoglobin changes in both groups

Secondary Outcomes

Table 6: Coagulation Profile and Additional Interventions in LSCS

Parameter	Cases (n=100)	Controls (n=100)	P value
PT Test (seconds)	12.46 ± 0.83	12.40 ± 0.83	0.616
INR	1.04 ± 0.07	1.03 ± 0.08	0.541
APTT (seconds)	26.26 ± 1.86	26.34 ± 1.99	0.761
Additional uterotonics required	7%	2%	0.088
MOPS (Mean)	4.00 ± 1.03	4.07 ± 1.07	0.636

PT = Prothrombin Time, INR = International Normalized Ratio, APTT = Activated Partial Thromboplastin Time

No significant differences were observed in coagulation parameters between groups, demonstrating the safety profile of tranexamic

acid.[32,33] The requirement for additional uterotonics was 7% in the study group versus 2% in controls (p=0.088).

Table 7: Blood Transfusion Requirements in LSCS

Units Transfused	Cases (n=30)	Controls (n=18)	P value
1 unit	73.3%	33.3%	0.02*
2 units	20.0%	44.4%	
3 units	3.3%	22.2%	
6 units	3.3%	0.0%	

*Statistically significant

Among women requiring blood transfusion, there was a significant difference in transfusion patterns (p=0.02). In the tranexamic acid group, 73.3% required only 1 unit of blood, whereas in the control group, 44.4% required 2 units, suggesting that tranexamic acid may reduce the severity of blood loss requiring transfusion.[34]

Safety Outcomes

No thromboembolic events, seizures, or maternal deaths were reported in either group throughout the study period. No patients required intensive care unit admission or hysterectomy. Minor side effects such as nausea and vomiting were comparable between groups and were attributed to anesthesia rather than tranexamic acid administration.[35]

Summary of Findings

Tranexamic acid administration showed no significant reduction in postpartum blood loss following vaginal delivery in low-risk women. However, in cesarean section deliveries, although the absolute blood loss difference was not statistically significant, tranexamic acid was associated with significantly reduced hemoglobin and hematocrit decline, suggesting a protective effect against excessive blood loss. The drug demonstrated an excellent safety profile with no increase in thromboembolic complications across both delivery modes.[36,37]

DISCUSSION:

This study evaluated the prophylactic efficacy of tranexamic acid in reducing postpartum hemorrhage following both vaginal and cesarean deliveries. Our findings demonstrate differential effectiveness based on the mode of delivery, with notable benefits observed in cesarean sections but limited impact in low-risk vaginal deliveries.

Vaginal Delivery Findings

In women undergoing full-term vaginal delivery, prophylactic tranexamic acid did not significantly reduce postpartum blood loss (339.69 ml vs 327.25 ml, p=0.682). This finding aligns with the landmark TRAAP trial by Sentilhes et al., which enrolled 4079 women and reported no significant reduction in PPH ≥500 ml with tranexamic acid compared to placebo (8.1% vs 9.8%, p=0.07).[38,39] However, the TRAAP trial did demonstrate significant reductions in clinically assessed PPH and additional uterotonic requirements, suggesting that while prophylactic tranexamic acid may not prevent all bleeding, it may mitigate severity.[40]

The lack of significant benefit in our vaginal delivery cohort may be attributed to the physiological hemodilution of pregnancy, which provides adequate blood volume reserve to compensate for normal delivery blood loss.[41] Furthermore, our study population consisted of low-risk women without predisposing factors for PPH, whereas tranexamic acid demonstrates greater efficacy in high-risk populations or established hemorrhage, as evidenced by the WOMAN trial.[42,43]

Cesarean Section Findings

Conversely, our study demonstrated significant benefits of tranexamic acid in cesarean deliveries, with marked reduction in hemoglobin decline (0.71 g/dL vs 1.00 g/dL, p=0.001) and hematocrit drop despite comparable absolute blood loss volumes. This suggests improved hemostasis and reduced ongoing blood loss in the immediate postoperative period.[44,45] These findings corroborate multiple randomized controlled trials including studies by Gohel et al., Gungorduk et al., and Yehia et al., which consistently reported 15-30% reductions in blood loss during and after cesarean section.[46,47,48]

The TRAAP2 trial specifically investigating cesarean deliveries found that prophylactic tranexamic acid reduced calculated blood loss and need for additional uterotonics, supporting our hemoglobin preservation findings.[49,50] The physiological basis for enhanced efficacy in cesarean section likely relates to the larger surgical surface area, greater tissue trauma, and higher baseline fibrinolytic activity associated with operative delivery.[51,52]

Safety Profile

Importantly, no thromboembolic events, seizures, or maternal deaths occurred in either group, consistent with the safety profile established by the WOMAN trial involving over 20,000 women.[53,54] Coagulation parameters remained within normal ranges, further confirming the safety of prophylactic tranexamic acid administration in obstetric populations.

Clinical Implications and Limitations

Our findings suggest that routine prophylactic tranexamic acid may not be warranted for low-risk vaginal deliveries but should be strongly considered

for cesarean sections, where it demonstrates measurable hemostatic benefits.[55,56] Limitations include single-center design, relatively small sample size for detecting rare complications, and exclusion of high-risk patients who might derive greater benefit from prophylactic therapy. Future research should focus on identifying specific risk stratification criteria to guide selective tranexamic acid administration and evaluating cost-effectiveness in diverse healthcare settings.[57,58]

REFERENCES

1. Say L, Chou D, Gemmill A, Tunçalp Ö, Moller AB, Daniels J, et al. Global causes of maternal death: a WHO systematic analysis. Lancet Glob Health. 2014;2(6):e323-33.
2. Khan KS, Wojdyla D, Say L, Gülmezoglu AM, Van Look PF. WHO analysis of causes of maternal death: a systematic review. Lancet. 2006;367(9516):1066-74.
3. World Health Organization. WHO recommendations for the prevention and treatment of postpartum haemorrhage. Geneva: World Health Organization; 2012.
4. Begley CM, Gyte GM, Devane D, McGuire W, Weeks A. Active versus expectant management for women in the third stage of labour. Cochrane Database Syst Rev. 2015;(3):CD007412.
5. Carroli G, Cuesta C, Abalos E, Gulmezoglu AM. Epidemiology of postpartum haemorrhage: a systematic review. Best Pract Res Clin Obstet Gynaecol. 2008;22(6):999-1012.
6. Dunn CJ, Goa KL. Tranexamic acid: a review of its use in surgery and other indications. Drugs. 1999;57(6):1005-32.
7. Lukes AS, Moore KA, Muse KN, Gersten JK, Hecht BR, Edlund M, et al. Tranexamic acid treatment for heavy menstrual bleeding: a randomized controlled trial. Obstet Gynecol. 2010;116(4):865-75.
8. Ngichabe S, Obura T, Stones W. Intravenous tranexamic acid as an adjunct haemostat to ornipressin during open myomectomy. A randomized double blind placebo controlled trial. Ann Surg Innov Res. 2015;9:10.
9. WOMAN Trial Collaborators. Effect of early tranexamic acid administration on mortality, hysterectomy, and other morbidities in women with post-partum haemorrhage (WOMAN): an international, randomised, double-blind, placebo-controlled trial. Lancet. 2017;389(10084):2105-16.
10. Sentilhes L, Winer N, Azria E, Sénat MV, Le Ray C, Vardon D, et al. Tranexamic acid for the prevention of blood loss after vaginal delivery. N Engl J Med. 2018;379(8):731-42.
11. Sentilhes L, Senat MV, Le Lous M, Winer N, Rozenberg P, Kayem G, et al. Tranexamic acid for the prevention of postpartum hemorrhage after cesarean delivery: the TRAAP2 trial. Am J Obstet Gynecol. 2021;224(6):605.e1-605.e13.
12. World Medical Association. World Medical Association Declaration of Helsinki: ethical principles for medical research involving human subjects. JAMA. 2013;310(20):2191-4.
13. Charan J, Biswas T. How to calculate sample size for different study designs in medical research? Indian J Psychol Med. 2013;35(2):121-6.
14. Schulz KF, Altman DG, Moher D; CONSORT Group. CONSORT 2010 statement: updated guidelines for reporting parallel group randomised trials. BMJ. 2010;340:c332.
15. American College of Obstetricians and Gynecologists. ACOG Practice Bulletin No. 183: Postpartum Hemorrhage. Obstet Gynecol. 2017;130(4):e168-e186.
16. Hunt BJ, Allard S, Keeling D, Norfolk D, Stanworth SJ, Pendry K. A practical guideline for the haematological management of major haemorrhage. Br J Haematol. 2015;170(6):788-803.
17. Levi M, Toh CH, Thachil J, Watson HG. Guidelines for the diagnosis and management of disseminated intravascular coagulation. British Committee for Standards in Haematology. Br J Haematol. 2009;145(24):24-33.
18. Ferrer P, Roberts I, Sydenham E, Blackhall K, Shakur H. Anti-fibrinolytic agents in post partum haemorrhage: a systematic review. BMC Pregnancy Childbirth. 2009;9:29.
19. Charbit B, Mandelbrot L, Samain E, Baron G, Haddaoui B, Keita H, et al. The decrease of fibrinogen is an early predictor of the severity of postpartum hemorrhage. J Thromb Haemost. 2007;5(2):266-73.
20. Prendiville WJ, Elbourne D, McDonald S. Active versus expectant management in the third stage of labour. Cochrane Database Syst Rev. 2000;(3):CD000007.
21. International Confederation of Midwives, International Federation of Gynaecology and Obstetrics. Joint statement: management of the third stage of labour to prevent post-partum haemorrhage. J Midwifery Womens Health. 2004;49(1):76-7.
22. Patel A, Goudar SS, Geller SE, Kodkany BS, Edlavitch SA, Wagh K, et al. Drape estimation vs. visual assessment for estimating postpartum hemorrhage. Int J Gynaecol Obstet. 2006;93(3):220-4.
23. Cortet M, Deneux-Tharaux C, Dupont C, Colin C, Rudigoz RC, Bouvier-Colle MH, et al. Association between fibrinogen level and severity of postpartum haemorrhage: secondary analysis of a prospective trial. Br J Anaesth. 2012;108(6):984-9.
24. McLintock C, James AH. Obstetric hemorrhage. J Thromb Haemost. 2011;9(8):1441-51.
25. Kozek-Langenecker SA, Afshari A, Albaladejo P, Santullano CA, De Robertis E, Filipescu DC, et al. Management of severe perioperative bleeding: guidelines from the European Society of Anaesthesiology. Eur J Anaesthesiol. 2013;30(6):270-382.
26. Snedecor GW, Cochran WG. Statistical Methods. 8th ed. Ames: Iowa State University Press; 1989.
27. Altman DG. Practical statistics for medical research. London: Chapman and Hall; 1991.
28. Gai MY, Wu LF, Su QF, Tatsumoto K. Clinical observation of blood loss reduced by tranexamic acid during and after caesarean section: a multi-center, randomized trial. Eur J Obstet Gynecol Reprod Biol. 2004;112(2):154-7.
29. Novikova N, Hofmeyr GJ, Cluver C. Tranexamic acid for preventing postpartum haemorrhage. Cochrane Database Syst Rev. 2015;(6):CD007872.
30. Movafegh A, Eslamian L, Dorabadi A. Effect of intravenous tranexamic acid administration on blood loss during and after cesarean delivery. Int J Gynaecol Obstet. 2011;115(3):224-6.
31. Gohel M, Patel P, Gupta A, Desai P. Efficacy of tranexamic acid in decreasing blood loss during and after cesarean section: a randomized case controlled prospective study. J Obstet Gynaecol India. 2007;57(3):228-30.
32. Ducloy-Bouthors AS, Jude B, Duhamel A, Broisin F, Huissoud C, Keita-Meyer H, et al. High-dose tranexamic acid reduces blood loss in postpartum haemorrhage. Crit Care. 2011;15(2):R117.
33. Peitsidis P, Kadir RA. Antifibrinolytic therapy with tranexamic acid in pregnancy and postpartum. Expert Opin Pharmacother. 2011;12(4):503-16.
34. Shakur H, Roberts I, Fawole B, Chaudhri R, El-Sheikh M, Akintan A, et al. Effect of early tranexamic acid administration on mortality, hysterectomy, and other morbidities in women with post-partum haemorrhage (WOMAN): an international, randomised, double-blind, placebo-controlled trial. Lancet. 2017;389(10084):2105-16.
35. Ker K, Edwards P, Perel P, Shakur H, Roberts I. Effect of tranexamic acid on surgical bleeding: systematic review and cumulative meta-analysis. BMJ. 2012;344:e3054.
36. Sentilhes L, Daniel V, Darsonval A, Deruelle P, Vardon D, Perrotin F, et al. Study protocol. TRAAP - TRAnexamic Acid for Preventing postpartum hemorrhage after vaginal delivery: a multicenter randomized, double-blind, placebo-controlled trial. BMC Pregnancy Childbirth. 2015;15:135.
37. Collaborators WT. Effect of early tranexamic acid administration on mortality, hysterectivity, and other morbidities in women with post-partum haemorrhage

(WOMAN): an international, randomised, double-blind, placebo-controlled trial. Lancet. 2017;389(10084):2105-16.
38. Sentilhes L, Winer N, Azria E, Sénat MV, Le Ray C, Vardon D, et al. Tranexamic acid for the prevention of blood loss after vaginal delivery. N Engl J Med. 2018;379(8):731-42.
39. Li C, Gong Y, Dong L, Xie B, Dai Z. Is prophylactic tranexamic acid administration effective and safe for postpartum hemorrhage prevention?: A systematic review and meta-analysis. Medicine (Baltimore). 2017;96(1):e5653.
40. Sentilhes L, Lasocki S, Ducloy-Bouthors AS, Deruelle P, Dreyfus M, Perrotin F, et al. Tranexamic acid for the prevention and treatment of postpartum haemorrhage. Br J Anaesth. 2015;114(4):576-87.
41. Pritchard JA. Changes in the blood volume during pregnancy and delivery. Anesthesiology. 1965;26:393-9.
42. WOMAN Trial Collaborators. Effect of early tranexamic acid administration on mortality, hysterectomy, and other morbidities in women with post-partum haemorrhage (WOMAN): an international, randomised, double-blind, placebo-controlled trial. Lancet. 2017;389(10084):2105-16.
43. Shakur H, Elbourne D, Gülmezoglu M, Alfirevic Z, Ronsmans C, Allen E, et al. The WOMAN Trial (World Maternal Antifibrinolytic Trial): tranexamic acid for the treatment of postpartum haemorrhage: an international randomised, double blind placebo controlled trial. Trials. 2010;11:40.
44. Xu J, Gao W, Ju Y. Tranexamic acid for the prevention of postpartum hemorrhage after cesarean section: a double-blind randomization trial. Arch Gynecol Obstet. 2013;287(3):463-8.
45. Sharma R, Najam R, Misra MK. Efficacy of tranexamic acid in decreasing blood loss during and after cesarean section. Biomed Pharmacol J. 2010;4(1):231-5.
46. Gungorduk K, Yıldırım G, Asıcıoğlu O, Gungorduk OC, Sudolmus S, Ark C. Efficacy of intravenous tranexamic acid in reducing blood loss after elective cesarean section: a prospective, randomized, double-blind, placebo-controlled study. Am J Perinatol. 2011;28(3):233-40.
47. Goswami U, Sarangi S, Gupta S, Babbar S. Comparative evaluation of two doses of tranexamic acid used prophylactically in anemic parturients for lower segment cesarean section: A double-blind randomized case control prospective trial. Saudi J Anaesth. 2013;7(4):427-31.
48. Yehia AH, Koleib MH, Abdelazim IA, Atik A. Tranexamic acid reduces blood loss during and after cesarean section: A double blinded, randomized, controlled trial. Asian Pac J Reprod. 2014;3(1):53-6.
49. Sentilhes L, Senat MV, Le Lous M, Winer N, Rozenberg P, Kayem G, et al. Tranexamic acid for the prevention of postpartum hemorrhage after cesarean delivery: the TRAAP2 trial. Am J Obstet Gynecol. 2021;224(6):605.e1-605.e13.
50. Sentilhes L, Merlot B, Madar H, Sztark F, Brun S, Deneux-Tharaux C. Postpartum haemorrhage: prevention and treatment. Expert Rev Hematol. 2016;9(11):1043-61.
51. Collins PW, Lilley G, Bruynseels D, Kneen R, Pickle L, Griffiths M, et al. Fibrin-based clot formation as an early and rapid biomarker for progression of postpartum hemorrhage: a prospective study. Blood. 2014;124(11):1727-36.
52. Guerriero C, Cairns J, Perel P, Shakur H, Roberts I; CRASH-2 trial collaborators. Cost-effectiveness analysis of administering tranexamic acid to bleeding trauma patients using evidence from the CRASH-2 trial. PLoS One. 2011;6(5):e18987.
53. Roberts I, Shakur H, Coats T, Hunt B, Balogun E, Barnetson L, et al. The CRASH-2 trial: a randomised controlled trial and economic evaluation of the effects of tranexamic acid on death, vascular occlusive events and transfusion requirement in bleeding trauma patients. Health Technol Assess. 2013;17(10):1-79.
54. Shakur H, Roberts I, Edwards P, Elbourne D, Alfirevic Z, Ronsmans C. The effect of tranexamic acid on the risk of death and hysterectomy in women with post-partum haemorrhage: statistical analysis plan for the WOMAN trial. Trials. 2016;17(1):249.
55. Franchini M, Mengoli C, Cruciani M, Bergamini V, Calò L, Pati I, et al. Safety and efficacy of tranexamic acid for prevention of obstetric haemorrhage: an updated systematic review and meta-analysis. Blood Transfus. 2018;16(4):329-37.
56. Committee on Practice Bulletins-Obstetrics. Practice Bulletin No. 183: Postpartum Hemorrhage. Obstet Gynecol. 2017;130(4):e168-e186.
57. Matsunaga S, Takai Y, Seki H. Fibrinogen for the management of critical obstetric hemorrhage. J Obstet Gynaecol Res. 2019;45(1):13-21.
58. Simonazzi G, Bisulli M, Saccone G, Moro E, Marshall A, Berghella V. Tranexamic acid for preventing postpartum blood loss after cesarean delivery: a systematic review and meta-analysis of randomized controlled trials. Acta Obstet Gynecol Scand. 2016;95(1):28-37.