Effect of Additional Administration of Topical Tranexamic Acid in Patients Undergoing Primary Total hip Arthroplasty Without Drainage

Jing Yao Jin
Chonnam National University Hwasun Hospital
Qing Song Li
Yanbian Hospital: Yanbian University Hospital
Taek Rim Yoon
Chonnam National University Hwasun Hospital
Sheng Yu Jin
Chonnam National University Hwasun Hospital
Min Gwang Kim
Chonnam National University Hwasun Hospital
Kyung-Soon Park (chiasma@hanmail.net)
Chonnam National University Hwasun Hospital https://orcid.org/0000-0002-5036-1803

Research article

Keywords: Tranexamic acid, Drainage, Total hip arthroplasty, Total blood loss

Posted Date: January 23rd, 2021

DOI: https://doi.org/10.21203/rs.3.rs-151736/v1

Abstract

Introduction: This study was designed to compare the clinical results of additional administration of topical tranexamic acid (TXA) with intravenous TXA (IV-TXA) and to determine its effect in patients undergoing primary total hip arthroplasty (THA) without drainage using propensity score matching analysis.

Methods: A total of 248 patients (248 hips) underwent primary THA from March 2016 to June 2018. Patients who received topical TXA and IV-TXA were included in the combined group (46 patients), and patients who received IV-TXA were included in the IV only group (202 patients). After propensity score matching, both groups consisted of 44 patients (88 patients in total). We compared the results of total blood loss (TBL), haemoglobin (Hb) level, Hb drop, and the incidence of deep vein thrombosis (DVT) and pulmonary embolism (PE).

Results: In the combined group, the TBL was 280.4 ± 64.2 mL, which was significantly lower than that in the IV only group (335.3 ± 75.3 mL; $p < 0.001$). From the preoperative period to 1-week postoperatively, Hb levels were not significantly different between the two groups. There was significantly more Hb drop in the IV only Group from immediate postoperative to postoperative day 3 (POD 3). In both groups, no patient presented with postoperative symptomatic DVT or PE.

Conclusion: In patients undergoing primary THA without drainage, combined use of IV-TXA and topical TXA can significantly decrease blood loss without influencing postoperative complications.

Introduction

Total hip arthroplasty (THA) is a common and effective orthopedic surgical procedure for patients with end-stage hip disease. However, it is associated with a significant amount of blood loss (approximately 700–2,000 mL); hence, several patients require postoperative blood transfusions, with a reported transfusion rate of 16–37% [1]. Furthermore, although the incidence is low, some serious complications related to transfusions have been reported, including volume overload, immunological reactions, intravascular hemolysis, infections, renal failure, and even death [2–4].

Notably, two main factors are known to contribute to substantial blood loss during THA: overt blood loss (OBL) caused by surgical trauma and hidden blood loss (HBL) caused by fibrinolysis. HBL accounts for approximately 60% of the total blood loss (TBL) [5]. To reduce blood loss, several blood-conserving techniques have been used, including autologous blood transfusion, application of autologous fibrin tissue adhesive, and use of hypotensive anesthesia. These techniques can reduce the risk of transfusion and infection rates. However, some techniques such as autologous blood transfusion are expensive [6–8]. Another method used to control intraoperative blood loss is the administration of antifibrinolytic agents, such as aprotinin, tranexamic acid (TXA), and epsilon-aminocaproic acid [9–11]. Of these agents, TXA has attracted the most attention due to its low cost and minimal complications.

TXA, a synthesized antifibrinolytic agent, competitively inhibits the activation of plasminogen by blocking lysine-binding sites and inhibiting clot breakdown, resulting in reduced blood loss and transfusion requirements [12]. Numerous studies have confirmed that TXA could effectively reduce blood loss and transfusion rates in patients undergoing THA without increasing the risk of complications such as deep vein thrombosis (DVT) and pulmonary embolism (PE). To confirm the efficacy and safety of TXA, these studies have evaluated the use of TXA via single or repeated intravenous (IV) administration, topical application, or IV administration combined with topical application [10, 13–18].

In all these studies, topical application was evaluated in patients undergoing surgery with drainage. Thus, the complete effect of topical TXA administration may have been diminished due to drainage. Therefore, to determine the complete effect of topical administration of TXA, we conducted this retrospective study to assess whether the additional administration of topical TXA with IV-TXA is more efficient than administration of single-dose IV-TXA in patients undergoing unilateral primary THA without drainage.

Methods

We retrospectively reviewed the collected registry data of 248 patients who underwent primary THA from March 2016 to June 2018. The patients who received topical TXA with IV-TXA were included in the combined group (46 patients), whereas patients who received IV-TXA only were included in the IV only group (202 patients). Patients who met the following inclusion criteria were included: (1) age ≥ 18 years, (2) diagnosis of osteoarthritis (OA) or osteonecrosis of the femoral head (ONFH), for which unilateral, 2-incision, minimally invasive THA without drainage was performed, and (3) use of IV-TXA only or a combination of topical TXA and IV-TXA. The preoperative exclusion criteria were as follows: (1) known allergy to TXA, (2) cardiovascular disease (history of angina, myocardial infarction, or atrial fibrillation), (3) cerebrovascular pathology (history of stroke), (4) thromboembolic disorders (history of DVT or PE), and (5) clotting disorders. Patients who underwent THA before September 2017 were not administered topical TXA during surgery, whereas patients treated during and after September 2017 were administered topical TXA to effectively reduce blood loss and postoperative complications. Since the additional administration of topical TXA depended only on the date of surgery, no patient selection bias was present. Four patients, two in each group, were lost to follow-up postoperatively.

Before propensity score matching (PSM) analysis, the combined group included 44 patients and the IV only group included 200 patients. To minimize the effect of possible confounding factors, both groups underwent PSM prior to analysis. The match tolerance and maximum difference between the propensity scores of any matched pair were set at 0.051. One-to-one PSM was performed to minimize the selection bias using variables including age, sex, body mass index (BMI), weight, and preoperative haemoglobin (Hb), hematocrit (HCT), prothrombin time (PT), and activated partial thromboplastin time (APTT) values to identify comparable patients. The included variables were not significantly different between the two groups before PSM. Patients were successfully selected such that no significant differences would be observed after matching (Table 1). Finally, 44 patients from the combined group were matched to 44

patients from the IV only group (Fig. 1). This study was approved by the Institutional Review Board of our hospital.

All operations were performed by a single senior surgeon using cementless acetabular and femoral components, and all procedures were performed via 2-incision MIS under general anesthesia. In the combined group, 1 g IV-TXA was administered 10 min before skin incision, and 1 g TXA in 50 mL physiological saline was injected intra-articularly after capsule and fascia closure. In the IV only group, patients received a single IV dose of 1 g TXA, 10 min before skin incision. In all patients, drainage was not performed. Additionally, for preventing venous thromboembolism (VTE) events, an intermittent pneumatic compression device was used postoperatively as a routine practice. Patients were examined daily for DVT symptoms (postoperative swelling in the affected leg, red or discolored skin on the leg, feeling of warmth in the affected leg); if any DVT symptoms were observed, venous Doppler ultrasound was performed.

The postoperative outcomes included TBL, OBL, and HBL. TBL was calculated using the Gross and Nadler formula [5, 19], OBL was defined as intraoperative blood loss, and HBL was defined as TBL excluding OBL. As drainage was not performed in all patients, a small amount of blood remained in the joint cavity postoperatively. In this study, this residual amount of blood was considered under HBL. We assessed Hb levels preoperatively; immediately post-operation; on postoperative day (POD) 1, POD 3, and POD 5; and 1-week postoperatively. Moreover, we calculated the Hb drop from immediately post-operation to 1-week post-operation. Regarding hip function, we assessed the Harris hip score (HHS) [20] preoperatively and at 3 months post-operation. Blood transfusion was deemed essential in patients presenting with symptomatic anemia (defined as lightheadedness, presyncope, fatigue precluding participation in physiotherapy, and palpitations or shortness of breath not attributed to other causes), characterized by Hb levels between 7 and 10 g/dL or Hb levels below 7 g/dL postoperatively.

Independent t-tests were applied for analyzing continuous data, which are expressed as means ± standard deviations. The Pearson chi-square test and Fisher's exact test were used to compare binary data, expressed as percentages. For all analyses, a p value of < 0.05 was considered to indicate statistical significance. IBM SPSS, version 24.0 (IBM Corp., Armonk, NY) was used for all statistical analyses in this study.

Results

Postoperatively, the TBL was significantly lower in the combined group (280.4 ± 64.2 mL vs. 335.3 ± 75.3 mL; $p < 0.001$). Additionally, OBL (155.5 ± 44.5 mL vs. 187.3 ± 54.4 mL; $p = 0.004$) and HBL (124.9 ± 38.4 vs. 148.1 ± 50 mL; $p = 0.017$) were significantly lower in the combined group than in the IV only group (Fig. 2). A post hoc power analysis was performed for TBL, OBL, and HBL postoperatively and showed values of 95.7%, 85.1%, and 81.6%, respectively, at a 0.05 type I error level.

Hb levels were not significantly different between the two groups from the preoperative period to 1-week post-operation. The Hb drop was significantly different between two groups from immediately post-operation, POD 1 and POD 3 (Fig. 3): immediately post-operation, combined group 1.3 ± 0.7 g/dL vs. IV

only group 1.8 ± 0.6 g/dL, $p = 0.001$; POD 1, 1.7 ± 1 g/dL vs. 2.3 ± 0.8 g/dL, $p = 0.015$; and POD 3, 2.2 ± 0.8 g/dL vs. 2.8 ± 1 g/dL, $p = 0.027$. The post hoc power analysis for immediately post-operation, POD 1, and POD 3 showed values of 94.9%, 87.4%, and 87.4%, respectively, at a 0.05 type I error level.

No difference was observed in the HHS between the two groups preoperatively (combined group: 60 ± 9.2; IV only group: 58.7 ± 9.3; $p = 0.575$) or 3 months postoperatively (combined group: 92.2 ± 2; IV only group: 91.2 ± 2.2; $p = 0.327$). Furthermore, there was no difference in operation time between the two groups (combined group: 78.6 ± 11.6; IV only group: 77.5 ± 12.3; $p = 0.658$) (Table 2). In the IV only group, two patients needed transfusion postoperatively. No symptomatic DVT or PE events were observed in the two groups; no patients presented with hematomas postoperatively (Table 3).

Discussion

Patients undergoing THA demonstrate a relatively high risk of requiring allogeneic blood transfusion. In the context of primary THA, several investigations regarding IV and topical TXA administration have reported the efficacy and safety of TXA in reducing blood loss and transfusions [13–16]. The combination of IV-TXA with topical TXA has been introduced and is used by surgeons in patients undergoing total knee arthroplasty (TKA) and THA with satisfactory results [17, 18, 21, 22]. Following preoperative IV-TXA administration, TXA is widely distributed across extracellular and intracellular compartments, rapidly reaching the maximum plasma concentration in 5–15 min. Furthermore, IV-TXA inhibits local fibrinolysis as soon as surgery is initiated, with maintenance of the plasma TXA concentration above the minimum therapeutic level for approximately 3 hours [23, 24]. However, concerns regarding the risk of DVT and PE due to systemic administration of high-dose TXA persist, hindering the widespread application of IV-TXA [25].

Compared with IV-TXA, topical TXA application has advantages such as ease of administration, inhibition of clot breakdown with maximum concentration at the bleeding site, and reduction in joint swelling, which leads to improved wound healing, with minimal systemic absorption [26, 27]. During surgery, most of the bleeding occurs during soft tissue release and acetabular and femoral canal preparation. Topical TXA administration directly targets the bleeding site in a surgical wound, maintaining maximum local TXA levels to induce partial microvascular hemostasis by preventing breakdown of the fibrin clot [28]. Considering the biological half-life of TXA in the bloodstream or joint space [29], topical TXA administration during wound closure can extend the effective time of TXA at the surgical site.

In the present study, the administration of 1 g topical TXA in combination with IV-TXA was more effective in reducing TBL, OBL, and HBL than the administration of IV-TXA alone. The post hoc power analysis revealed that the current study had > 80% power for comparing TBL, OBL, and HBL between the two groups. From immediately post-operation to 1-week post-operation, there was no significant change in Hb levels in the combined group compared with that in the IV only group. We speculate that this may be due to the differences in preoperative Hb levels, because the average Hb level in the IV only group was lower than that in the combined group (0.5 g/dL) preoperatively (combined group 12.9 ± 1.3 g/dL vs. IV only

group 13.4 ± 1.4 g/dL; $p = 0.086$). However, the Hb drop was significant from immediately post-operation to POD 3, and the post hoc power analysis showed > 80% power, demonstrating no significant difference in Hb drop between POD 5 and 1-week post-operation. Therefore, TXA is effective in controlling the Hb drop from immediately post-operation to POD 3. In a randomized double-blind controlled trial, Yue et al. [16] compared the application of 3 g topical TXA with the application of a placebo, which revealed that the Hb drop was significantly lower in the topical group at POD 1 and POD 3. These findings are consistent with our results. Interestingly, in our study, although the Hb drop at POD 5 was not significantly different, it demonstrated a strong tendency toward significance ($p = 0.051$).

Notably, the TXA dose has not been standardized and remains controversial. TXA is frequently administered intravenously with a loading dose of 10 or 15 mg/kg, followed by continuous infusion or repeated bolus doses [30, 31]. Husted et al. randomized patients to receive TXA as a bolus IV injection of 10 mg/kg (maximum 1 g) for 10 min, approximately 15 min before incision. This resulted in reduced blood loss and a reduced need for blood transfusion. Furthermore, no patient reported prolonged drainage, infection, clinical DVT, or PE during hospitalization or at the last follow-up. For topical administration, the TXA dose ranged from 0.5 g TXA/100 mL normal saline to 3 g TXA/100 mL normal saline, as reported by Zhao et al. [32] in a meta-analysis of six randomized controlled trials. As mentioned earlier, Yue et al. [16], in a randomized double-blind controlled trial, administered 3 g TXA in 150 mL saline at three points during THA and reported that the topical application of 3 g of TXA significantly reduced bleeding and transfusions in patients undergoing primary THA without increasing the risk of DVT and PE. Several investigators have reported another strategy for the combined administration of TXA in the setting of THA; in most of these studies, the maximum dose of TXA was < 3 g [17, 18]. Xie et al. [17] performed a prospective randomized controlled trial and compared the results according to administration route: IV, topical, and a combination of the two. In all three groups, the TXA dose was < 3 g. They observed that patients undergoing primary unilateral THA in the combined group demonstrated an effective decrease in TBL, resulting in higher postoperative Hb levels without the risk of higher complication rates, compared to those in the other two groups. Yi et al. [18] performed a prospective randomized controlled trial and compared the results of placebo, IV-TXA, and the combination of IV-TXA and topical TXA. The TXA dose was < 3 g both in the IV-TXA and combined groups. TXA has been administered at different doses and using different routes in patients undergoing primary THA, with most investigators routinely administering TXA at a dose of no more than 3 g. They considered that a dose of < 3 g is safe and efficacious in these patients. In our study, in the combined group, 1 g of IV-TXA was combined with 1 g of topical TXA, and the total TXA dose in the two groups was < 3 g. In both groups, we observed no cases of DVT or PE during hospitalization and until the last follow-up.

The performance of drainage after THA remains controversial. The most important reasons for drainage include preventing the accumulation of hematomas and decreasing the risk of infection [33]. However, some studies have presented differing conclusions, stating that drainage increases blood loss, which may increase transfusion rates and provide an entry point for skin microorganisms, resulting in infections [34, 35]. Zhou et al. [36] performed a meta-analysis of 20 randomized controlled studies evaluating the use of closed-suction drains in patients undergoing THA. They reported a significant increase in the

homologous transfusion rate in patients undergoing drainage, with no significant differences in the incidence of infections, hematomas, or thrombosis. Furthermore, they suggested that in patients undergoing elective THA, the routine use of closed-suction drains may result in more damage than benefits. Walmsley et al. [37] reported that the postoperative transfusion rate was significantly higher in the drainage group than in the no drainage group (33% vs. 26.4%, $p = 0.042$), concluding that drainage provides no clear advantage in the context of THA. Furthermore, a study by Valle et al. [38] showed that drainage confers no benefit in patients undergoing primary uncomplicated THA.

Most studies regarding TXA administration involved the use of drainage. We considered that a small amount of TXA may be lost owing to drainage, reducing the TXA concentration in the joint. A few studies have investigated primary THA without drainage [15]. However, no investigations have compared IV-TXA alone and IV-TXA combined with topical TXA in this population. In our study, to completely retain TXA in the joint, we did not perform any drainage; this approach was considered better for evaluating the effect of topical TXA. In the present study, only two patients needed transfusions, and in both groups, no patient presented with symptomatic hematoma, deep infection, or wound complications postoperatively, until discharge.

This study has several limitations. First, the study population was relatively small. We believe that a larger sample size is needed to effectively detect the difference in DVT and PE incidence between the two groups. Second, this study did not include a placebo group. IV-TXA may be significantly superior to a placebo but not as effective as the combination of IV-TXA and topical TXA. We considered that using combined administration as a control rather than a pure placebo was clinically a more useful and appropriate methodology.

Conclusion

The most important finding of this study was in unilateral primary THA, administration of topical TXA with IV-TXA without drainage can effectively decrease the TBL and elicit higher postoperative Hb levels without increasing the risk of complications compared with IV-TXA alone.

Abbreviations

TXA: Tranexamic acid; THA: Total hip arthroplasty; TKA: Total knee arthroplasty; IV: Intravenous; TBL: Total blood loss; OBL: Overt blood loss; HBL: Hidden blood loss; DVT: Deep vein thrombosis; PE: Pulmonary embolism; POD: Postoperative day; HB: Hemoglobin; OA: Osteoarthritis; ONFH: Osteonecrosis of the femoral head; MIS: Minimally invasive surgery; VTE: Venous thromboembolism; HHS: Harris hip score; BMI: Body mass index; Post Hb drop: hematocrit; PT: Prothrombin time; APTT: Activated partial thromboplastin time

Declarations

Acknowledgements

The authors thank all clinical researchers involved in the research we included in this article. This study was not supported by any company or grant.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Authors' contributions

JYJ and QSL Data analysis and writing of the manuscript. KSP: Study conception and study design. TRY: Study conception and study design as well as review and correction of the manuscript draft. SYJ: Data collection and analysis. MGK: Data analysis and writing of the manuscript. All authors have read and approved the manuscript for submission and publication in this journal.

Ethics approval and consent to participate

– Institution: Chonnam National University Hwasun Hospital (No: CNUHH 2020–089)

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Author details

[1]Department of orthopedic Surgery, Center for Joint Disease at Chonnam National University Hwasun Hospital, 322, Seo Yang-Ro, Hwasun-Eup, Hwasun-Gun, Jeonnam 519-809, Republic of Korea.

[2]Orthopedic Trauma Service Center, Third Hospital of Hebei Medical University, Shijiazhuang, Hebei, P.R. China. [3]Department of Orthopedic Surgery, Center for Joint Disease, Affiliated Hospital of YanBian University, YanJi, China

References

1. Bierbaum BE, Callaghan JJ, Galante JO, Rubash HE, Tooms RE, Welch RB. An analysis of blood management in patients having a total hip or knee arthroplasty. The Journal of bone joint surgery American volume. 1999;81(1):2–10. doi:10.2106/00004623-199901000-00002.
2. Vamvakas EC, Blajchman MA. Transfusion-related mortality: the ongoing risks of allogeneic blood transfusion and the available strategies for their prevention. Blood. 2009;113(15):3406–17. doi:10.1182/blood-2008-10-167643.
3. Allain JP, Stramer SL, Carneiro-Proietti AB, Martins ML, Lopes da Silva SN, Ribeiro M, et al. Transfusion-transmitted infectious diseases. Biologicals: journal of the International Association of Biological Standardization. 2009;37(2):71–7. doi:10.1016/j.biologicals.2009.01.002.
4. Hill GE, Frawley WH, Griffith KE, Forestner JE, Minei JP. Allogeneic blood transfusion increases the risk of postoperative bacterial infection: a meta-analysis. The Journal of trauma. 2003;54(5):908–14. doi:10.1097/01.ta.0000022460.21283.53.
5. Liu X, Zhang X, Chen Y, Wang Q, Jiang Y, Zeng B. Hidden blood loss after total hip arthroplasty. J Arthroplast. 2011;26(7):1100-5.e1. doi:10.1016/j.arth.2010.11.013.
6. Woolson ST, Marsh JS, Tanner JB. Transfusion of previously deposited autologous blood for patients undergoing hip-replacement surgery. The Journal of bone joint surgery American volume. 1987;69(3):325–8.
7. Mawatari M, Higo T, Tsutsumi Y, Shigematsu M, Hotokebuchi T. Effectiveness of autologous fibrin tissue adhesive in reducing postoperative blood loss during total hip arthroplasty: a prospective randomised study of 100 cases. J Orthop Surg. 2006;14(2):117–21. doi:10.1177/230949900601400202.
8. Conteduca F, Massai F, Iorio R, Zanzotto E, Luzon D, Ferretti A. Blood loss in computer-assisted mobile bearing total knee arthroplasty. A comparison of computer-assisted surgery with a conventional technique. International orthopaedics. 2009;33(6):1609–13. doi:10.1007/s00264-008-0651-7.
9. Keyhani S, Esmailiejah AA, Abbasian MR, Safdari F. (2016) Which Route of Tranexamic Acid Administration is More Effective to Reduce Blood Loss Following Total Knee Arthroplasty? The archives of bone and joint surgery.4(1):65 – 9.
10. Sukeik M, Alshryda S, Haddad FS, Mason JM. Systematic review and meta-analysis of the use of tranexamic acid in total hip replacement. The Journal of bone joint surgery British volume. 2011;93(1):39–46. doi:10.1302/0301-620x.93b1.24984.

11. Ueno M, Sonohata M, Fukumori N, Kawano S, Kitajima M, Mawatari M. Comparison between topical and intravenous administration of tranexamic acid in primary total hip arthroplasty. Journal of orthopaedic science: official journal of the Japanese Orthopaedic Association. 2016;21(1):44–7. doi:10.1016/j.jos.2015.10.011.
12. Camarasa MA, Olle G, Serra-Prat M, Martin A, Sanchez M, Ricos P, et al. Efficacy of aminocaproic, tranexamic acids in the control of bleeding during total knee replacement: a randomized clinical trial. Br J Anaesth. 2006;96(5):576–82. doi:10.1093/bja/ael057.
13. Benoni G, Fredin H, Knebel R, Nilsson P. Blood conservation with tranexamic acid in total hip arthroplasty: a randomized, double-blind study in 40 primary operations. Acta Orthop Scand. 2001;72(5):442–8. doi:10.1080/000164701753532754.
14. Husted H, Blond L, Sonne-Holm S, Holm G, Jacobsen TW, Gebuhr P. Tranexamic acid reduces blood loss and blood transfusions in primary total hip arthroplasty: a prospective randomized double-blind study in 40 patients. Acta Orthop Scand. 2003;74(6):665–9. doi:10.1080/00016470310018171.
15. Martin JG, Cassatt KB, Kincaid-Cinnamon KA, Westendorf DS, Garton AS, Lemke JH. Topical administration of tranexamic acid in primary total hip and total knee arthroplasty. J Arthroplast. 2014;29(5):889–94. doi:10.1016/j.arth.2013.10.005.
16. Yue C, Kang P, Yang P, Xie J, Pei F. Topical application of tranexamic acid in primary total hip arthroplasty: a randomized double-blind controlled trial. J Arthroplast. 2014;29(12):2452–6. doi:10.1016/j.arth.2014.03.032.
17. Xie J, Ma J, Yue C, Kang P, Pei F. Combined use of intravenous and topical tranexamic acid following cementless total hip arthroplasty: a randomised clinical trial. Hip international: the journal of clinical experimental research on hip pathology therapy. 2016;26(1):36–42. doi:10.5301/hipint.5000291.
18. Yi Z, Bin S, Jing Y, Zongke Z, Pengde K, Fuxing P. Tranexamic Acid Administration in Primary Total Hip Arthroplasty: A Randomized Controlled Trial of Intravenous Combined with Topical Versus Single-Dose Intravenous Administration. The Journal of bone joint surgery American volume. 2016;98(12):983–91. doi:10.2106/jbjs.15.00638.
19. Gross JB. Estimating allowable blood loss: corrected for dilution. Anesthesiology. 1983;58(3):277–80. doi:10.1097/00000542-198303000-00016.
20. Harris WH. Traumatic arthritis of the hip after dislocation and acetabular fractures: treatment by mold arthroplasty. An end-result study using a new method of result evaluation. The Journal of bone joint surgery American volume. 1969;51(4):737–55.
21. Huang Z, Ma J, Shen B, Pei F. Combination of intravenous and topical application of tranexamic acid in primary total knee arthroplasty: a prospective randomized controlled trial. J Arthroplast. 2014;29(12):2342–6. doi:10.1016/j.arth.2014.05.026.
22. Lin SY, Chen CH, Fu YC, Huang PJ, Chang JK, Huang HT. The efficacy of combined use of intraarticular and intravenous tranexamic acid on reducing blood loss and transfusion rate in total knee arthroplasty. J Arthroplast. 2015;30(5):776–80. doi:10.1016/j.arth.2014.12.001.

23. Benoni G, Björkman S, Fredin H. Application of Pharmacokinetic Data from Healthy Volunteers for the Prediction of Plasma Concentrations of Tranexamic Acid in Surgical Patients. Clin Drug Investig. 1995;10(5):280–7. doi:10.2165/00044011-199510050-00005.
24. Benoni G, Carlsson A, Petersson C, Fredin H. Does tranexamic acid reduce blood loss in knee arthroplasty? Am J Knee Surg. 1995;8(3):88–92.
25. Morrison JJ, Dubose JJ, Rasmussen TE, Midwinter MJ. (2012) Military Application of Tranexamic Acid in Trauma Emergency Resuscitation (MATTERs) Study. Archives of surgery (Chicago, Ill: 1960).147(2):113-9. doi:10.1001/archsurg.2011.287.
26. Wong J, Abrishami A, El Beheiry H, Mahomed NN, Roderick Davey J, Gandhi R, et al. Topical application of tranexamic acid reduces postoperative blood loss in total knee arthroplasty: a randomized, controlled trial. The Journal of bone joint surgery American volume. 2010;92(15):2503–13. doi:10.2106/jbjs.i.01518.
27. Patel VP, Walsh M, Sehgal B, Preston C, DeWal H, Di Cesare PE. Factors associated with prolonged wound drainage after primary total hip and knee arthroplasty. The Journal of bone joint surgery American volume. 2007;89(1):33–8. doi:10.2106/jbjs.f.00163.
28. Krohn CD, Sorensen R, Lange JE, Riise R, Bjornsen S, Brosstad F. (2003) Tranexamic acid given into the wound reduces postoperative blood loss by half in major orthopaedic surgery. The European journal of surgery Supplement: = Acta chirurgica Supplement. (588):57–61.
29. Ahlberg A, Eriksson O, Kjellman H. Diffusion of tranexamic acid to the joint. Acta Orthop Scand. 1976;47(5):486–8. doi:10.3109/17453677608988725.
30. Eubanks JD. Antifibrinolytics in major orthopaedic surgery. J Am Acad Orthop Surg. 2010;18(3):132–8.
31. Hourlier H, Fennema P. Single tranexamic acid dose to reduce perioperative morbidity in primary total hip replacement: a randomised clinical trial. Hip international: the journal of clinical experimental research on hip pathology therapy. 2014;24(1):63–8. doi:10.5301/hipint.5000090.
32. Zhao-Yu C, Yan G, Wei C, Yuejv L, Ying-Ze Z. (2014) Reduced blood loss after intra-articular tranexamic acid injection during total knee arthroplasty: a meta-analysis of the literature. Knee surgery, sports traumatology, arthroscopy: official journal of the ESSKA.22(12):3181–90. doi:10.1007/s00167-013-2814-3.
33. Beer KJ, Lombardi AV Jr, Mallory TH, Vaughn BK. The efficacy of suction drains after routine total joint arthroplasty. The Journal of bone joint surgery American volume. 1991;73(4):584–7.
34. Murphy JP, Scott JE. The effectiveness of suction drainage in total hip arthroplasty. J R Soc Med. 1993;86(7):388–9.
35. Willett KM, Simmons CD, Bentley G. The effect of suction drains after total hip replacement. The Journal of bone joint surgery British volume. 1988;70(4):607–10.
36. Zhou XD, Li J, Xiong Y, Jiang LF, Li WJ, Wu LD. Do we really need closed-suction drainage in total hip arthroplasty? A meta-analysis. International orthopaedics. 2013;37(11):2109–18. doi:10.1007/s00264-013-2053-8.

37. Walmsley PJ, Kelly MB, Hill RM, Brenkel I. A prospective, randomised, controlled trial of the use of drains in total hip arthroplasty. The Journal of bone joint surgery British volume. 2005;87(10):1397–401. doi:10.1302/0301-620x.87b10.16221.
38. Gonzalez Della Valle A, Slullitel G, Vestri R, Comba F, Buttaro M, Piccaluga F. No need for routine closed suction drainage in elective arthroplasty of the hip: a prospective randomized trial in 104 operations. Acta Orthop Scand. 2004;75(1):30–3. doi:10.1080/00016470410001708050.

Tables

Table 1: Demographic data of patients before and after matching

		Before matching: total n = 244			After matching: total n = 88	
	Combined group (n = 44)	IV only group (n = 200)	p value	Combined group (n = 44)	IV only group (n = 44)	p value
Age (years)	58.5 ± 13.3	58.7 ± 16	0.947	58.5 ± 13.3	55.8 ± 16.4	1
Sex	17 (M)/27 (F)	34(M)/36 (F)	0.401	17 (M)/27 (F)	23(M)/21 (F)	0.199
BMI (kg/m^2)	24.1 ± 3.4	25.63 ± 4.1	0.133	24.1 ± 3.4	25 ± 3.6	1
OA/ONFH	20/24	30/72	0.086	20/24	16/28	0.386
Weight (kg) Preoperative laboratory values	62.9	65.7 ± 13.1	0.257	62.9	66.2	0.233
Hb (g/dL)	12.9 ± 1.3	13.1 ± 1.3	0.269	12.9 ± 1.3	13.4 ± 1.4	0.086
HCT (L/L)	39.3 ± 2.5	39.3 ± 2.6	0.997	39.3 ± 2.5	39.7 ± 2.8	0.412
PT (s)	12.5 ± 0.7	12.4 ± 0.9	0.536	12.5 ± 0.7	12.4 ± 1	0.613
APTT (s)	33.5 ± 2.6	33.5 ± 3.2	0.946	33.5 ± 2.6	33.7 ± 3.2	0.788

IV = intravenous; BMI = body mass index; OA = osteoarthritis; ONFH = osteonecrosis of the femoral head; M = male; F = female; Hb = haemoglobin; HCT = hematocrit; PT = prothrombin time; APTT = activated partial thromboplastin time; *p values < 0.05 were considered statically significant

Table 2: Intraoperative and postoperative outcomes of the patients

	Combined group (n = 44)	IV only group (n = 44)	p value
TBL (mL)	280.4 ± 64.2	335.3 ± 75.3	< 0.001
OBL (mL)	155.5 ± 44.5	187.3 ± 54.4	0.004
HBL (mL)	120.9 ± 38.4	148.1 ± 50	0.017
Postoperative Hb levels (g/dL)			
Preoperative	12.9 ± 1.3	13.4 ± 1.4	0.086
Immediately postoperative	11.6 ± 1.3	11.6 ± 1.5	0.866
POD 1	11 ± 1.3	11.1 ± 1.3	0.916
POD 3	10.5 ± 1.2	10.6 ± 1.5	0.851
POD 5	11.4 ± 1.1	11.4 ± 1.1	1
POD 7	11.5 ± 1.1	11.6 ± 1.8	0.744
Postoperative change in Hb (g/dL)			
Immediate postoperative	1.3 ± 0.7	1.8 ± 0.6	0.001
POD 1	1.7 ± 1	2.3 ± 0.8	0.015
POD 3	2.2 ± 0.8	2.8 ± 1	0.027
POD 5	1.6 ± 0.8	1.9 ± 0.9	0.051
POD 7	1.5 ± 0.8	1.7 ± 1.8	0.155
Transfusion rate	0	2	0.494
Preoperative HHS	60 ± 9.2	58.7 ± 9.3	0.575
HHS 3 months postoperatively	92.2 ± 2	91.2 ± 2.2	0.327
Operation time (min)	78.6 ± 11.6	77.5 ± 12.3	0.658

Table 3 not available with this version

Figures

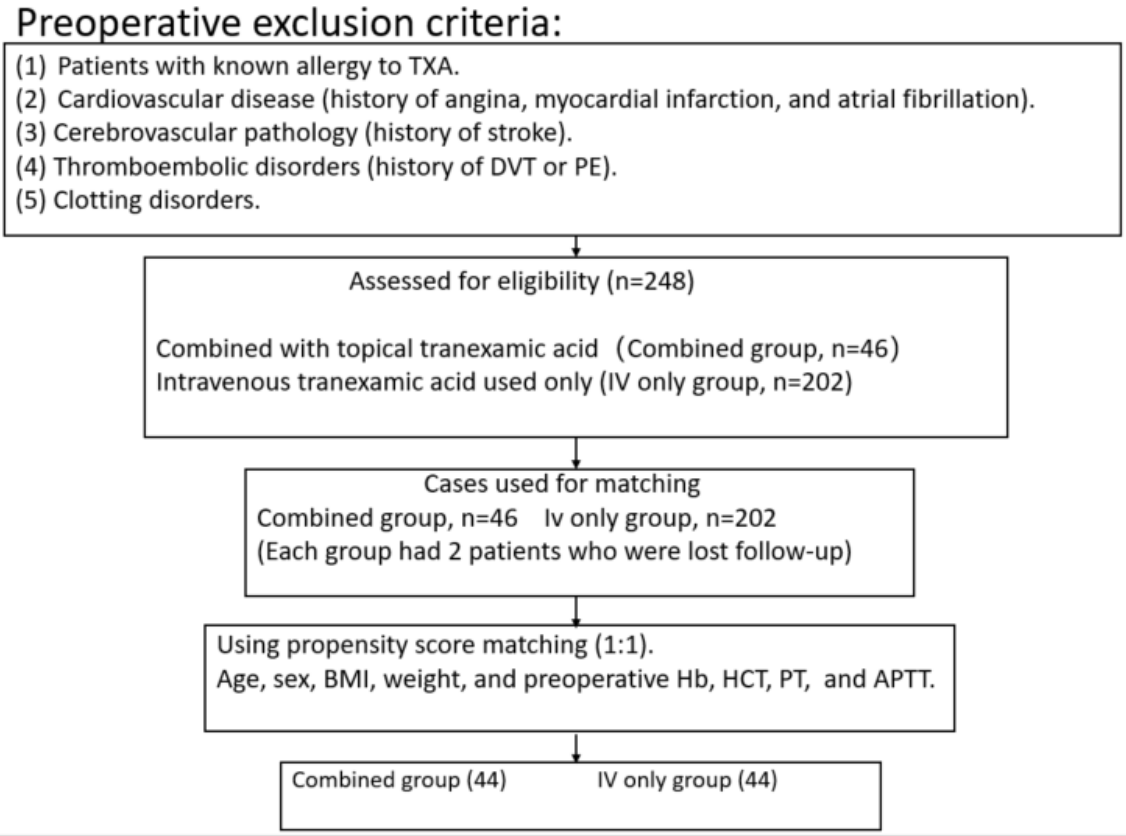

Figure 1

Flow chart of patient selection and propensity score matching analysis.

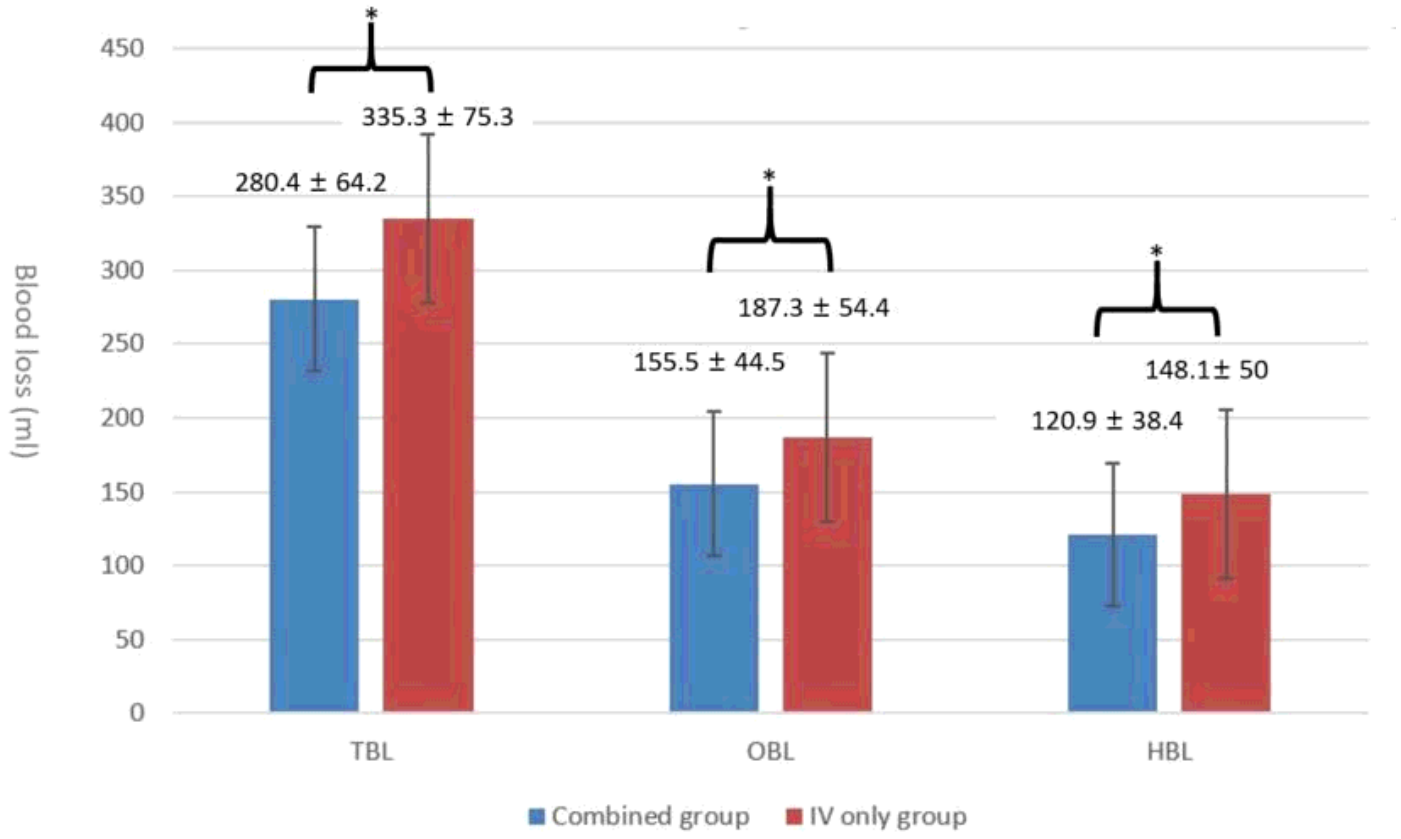

Figure 2

Histograms of total blood loss (TBL), overt blood loss (OBL), and hidden blood loss (HBL) From figure 2, we could see the TBL, OBL and HBL in the combined group were less than in the IV only group postoperatively (The asterisks indicate values that were significantly different between the groups). IV = intravenous.

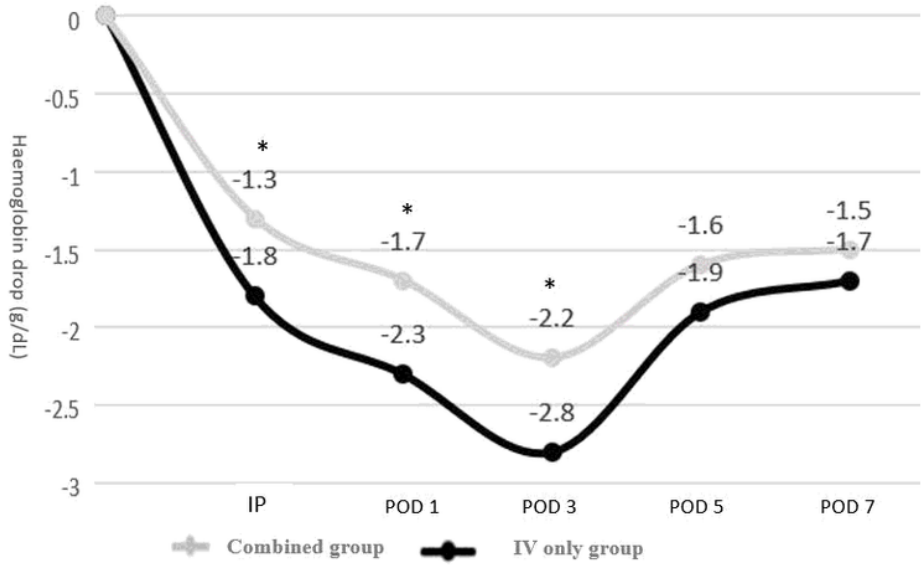

Figure 3

Line diagram of haemoglobin drop Haemoglobin levels dropped postoperatively. Since no change was observed in preoperative haemoglobin levels, we defined the preoperative value as zero. IP indicates the time at which patients exited the recovery room (as the first postoperative blood test was performed in the recovery room in our institution). The asterisks indicate values that were significantly different between the groups. IP = immediately postoperative; POD 1 = postoperative day 1.