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ORIGINAL ARTICLE

Intravenous tranexamic acid reduces total blood loss in reverse total shoulder arthroplasty: a prospective, double-blinded, randomized, controlled trial

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Background: Patients undergoing reverse total shoulder arthroplasty (RTSA) are at risk of significant perioperative blood loss. To date, few studies have examined the effectiveness of tranexamic acid (TXA) to reduce blood loss in the setting of RTSA.

Methods: In a prospective, double-blinded, single-surgeon trial, we analyzed 102 patients undergoing primary RTSA who were randomized to receive intravenous TXA (n = 53) or placebo (n = 49). Calculated total blood loss, drain output, and hemoglobin (Hb) drop were measured. Postoperative transfusions were recorded. Complications were assessed out to 6 weeks postoperatively.

Results: Total blood loss was less for the TXA group (1122.4 ± 411.6 mL) than the placebo group (1472.6 ± 475.4 mL, $P < .001$). Total drain output was less for the TXA group (221.4 ± 126.2 mL) than the placebo group (371.9 ± 166.3 mL , $P < .001$). Total Hb loss was less in the TXA group (154.57 ± 60.29 g) compared with the placebo group (200.1 ± 65.5 g, $P = .001$). Transfusion rates differed significantly at postoperative day 1; however, overall transfusion rates did not vary significantly. Seven patients (14.3%) and 12 units were transfused in the placebo group compared with 3 patients (5.7%) and 3 units in the TXA group.

Discussion: In this cohort of patients undergoing primary RTSA, TXA was effective in reducing total drain output, total Hb loss, and total blood loss compared with a placebo control.

Level of evidence: Level I; Randomized Controlled Trial; Treatment Study

Keywords: tranexamic acid; antifibrinolytic; reverse total shoulder arthroplasty; blood loss; blood transfusion; prospective randomized trial

Shoulder arthroplasty is associated with the risk of significant perioperative blood loss, with an overall rate of allogeneic blood transfusion reported to be 4.3% to 43%.[2,12,13,19,25] Patients undergoing reverse total shoulder arthroplasty (RTSA) are at even further risk of requiring a postoperative blood transfusion.[12] Although risks of infectious complications from blood transfusions have become rare,

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other complications occur more frequently, including allergic reactions, immunosuppression, transfusion-related acute lung injury, or transfusion-associated circulatory overload, with prevalence as high as 1 in 10,000 to 1 in 100.[3,21]

There have been various approaches to minimizing blood loss and transfusion rates after surgery,[24] and the use of pharmacologic agents, such as tranexamic acid (TXA), has been gaining popularity.[15] TXA is a synthetic antifibrinolytic agent that reversibly binds to plasminogen, preventing the normal cascade of fibrin clot dissolution.[7,17] It is increasingly being used in orthopedic joint reconstructive surgery, and multiple meta-analyses have proven that use of TXA in the setting of total knee arthroplasty and total hip arthroplasty leads to significantly less overall blood loss and lower rates of blood transfusion without increasing rates of venous thromboembolism or other complications.[1,30,32] However, only 2 studies to date have examined its use in shoulder arthroplasty.[8,9] In the present study, we conducted a single-surgeon, prospective, double-blinded, randomized controlled trial of administration of intravenous TXA compared with placebo in the setting of primary RTSA. The primary objective of this study was to determine whether TXA can significantly reduce total blood loss perioperatively as measured by calculated blood loss, drain output, and drop in hemoglobin (Hb) and reduce transfusion rates.

Materials and methods

Study design and patients

Patients undergoing primary RTSA by the senior author (J.M.W.) were screened for eligibility. The indication for primary RTSA was massive cuff deficiency, with or without glenohumeral arthrosis. The exclusion criteria were minors, acute proximal humeral fracture, concomitant procedures (eg, latissimus dorsi tendon transfer), known allergy to TXA, preoperative anemia (Hb <11 g/dL in women, Hb <12 g/dL in men), refusal of blood products, coagulopathy (thrombophilia, platelet count <150,000 mm^3, international normalized ratio >1.4, partial thromboplastin time >1.4 times normal), history of thromboembolic event, major comorbidities (severe pulmonary disease, coronary artery disease, previous myocardial infarction, renal failure), or refusal to give written consent. For all patients, use of anticoagulation therapy was stopped within 5 days before surgery. Eligible patients were approached by the senior author in the clinic. Informed written consent was obtained before surgery.

Randomization

Study subjects were randomized to receive an infusion of the standard dose of TXA (10 mg/kg) or placebo (an equivalent volume of normal saline). One 10 mg/kg dose was given within 60 minutes before surgery, and a second 10 mg/kg dose was given at wound closure. An independent pharmacist generated the random allocation sequence and prepared the intravenous (IV) bags, all of which looked identical. The surgeon, surgical staff members, all health care providers, and the patient were blinded to the assignment.

Surgical and postsurgical protocol

All procedures were performed by a single surgeon through a standard anterior deltopectoral approach. The implants used were Zimmer (Warsaw, IN, USA) in 79, DePuy (Warsaw, IN, USA) in 11, Biomet (Warsaw, IN, USA) in 4, and Encore (Austin, TX, USA) in 2. All implants were press fit; cement was not used. The same standard techniques and hemostasis were applied during all procedures.

A medium Hemovac (Zimmer) drain was used in all cases. One tube was placed in the deep space and another tube between the deltoid and the skin, both draining to a single drain evacuator. All drains were on suction, regardless of output, and were removed on postoperative day 2 unless they had greater than 50 mL of output during 8-hour period.

Analgesia and thromboembolism prophylaxis protocol

An interscalene regional block (ropivacaine 2%) with an indwelling catheter combined with general anesthesia was used in all cases. Postoperatively, all patients received deep venous thrombosis (DVT) prophylaxis consisting of 5000 units of subcutaneous unfractionated heparin every 8 hours until discharge and 325 mg of aspirin taken twice daily for 2 weeks after discharge unless contraindicated. Any long-term anticoagulation therapy that was stopped preoperatively was resumed on postoperative day 2. All patients wore compression stockings on both legs until discharge from the hospital.

Blood transfusion protocol

A standard of care transfusion protocol was used, which allowed for the standardization of blood transfusions across groups. Transfusion was not indicated in patients with an Hb concentration greater than 9 g/dL and was indicated in patients with an Hb concentration of less than 7 g/dL. For patients with a Hb concentration between 7 and 9 g/dL, transfusion was indicated only in patients who developed symptoms of anemia, other than low Hb, including fatigue, palpitation, pallor, tachycardia, or tachypnea.

Study end points

Blood loss was assessed by total blood loss, postoperative reduction in Hb and total loss of Hb, and total drain output. Hb and hematocrit were measured preoperatively (within 3 days of surgery) and the morning of postoperative days 1 and 2. Drain output was collected every 8 hours. Total Hb loss was estimated using the formula for total blood volume described by Nadler et al,[20] change of preoperative and final Hb recorded during hospital stay, and corrected for units of blood transfused (estimated to be 52 g of Hb per unit).[11] Hb loss was then used to calculate total blood loss, according to the method described by Good et al.[11] Calculations were performed as follows:

$$\mathrm{Hb_{loss}} = \text{blood volume (L)} \times [\mathrm{Hb_{initial}\ (g/L)} - \mathrm{Hb_{final}\ (g/L)}] + \mathrm{Hb_{transfused}}$$

$$\text{Total blood loss (mL)} = 1000 \times \mathrm{Hb_{loss}} / \mathrm{Hb_{initial}}$$

Complications were recorded and grouped as systemic (eg, thrombosis or myocardial infarction) or surgical site (eg, hematoma or