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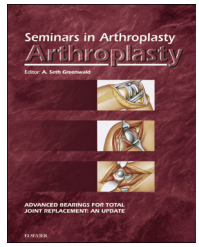

The role of tranexamic acid in a comprehensive blood management protocol for total hip and knee arthroplasty patients

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ABSTRACT

Allogeneic blood transfusions during total hip or knee arthroplasty have been associated with increased risks for perioperative complications as well as increased medical costs. A multi-modal approach toperioperative management of the patients to minimize the risk for an allogeneic blood transfusion can help both the patient and the health care system. This approach involves optimizing the patients' hemoglobin preoperatively, utilizing a variety of techniques intraoperatively including tranexamic acid to minimize blood loss, and using patient specific transfusion triggers post-operatively. In particular, the incorporation of tranexamic acid to the perioperative management of total hip and total knee replacement patients dramatically decreased the rate of allogeneic blood transfusions in our hospital.

1. Introduction

Total joint replacement patients have potential for significant blood loss during the course of their treatment [1–3]. It is not uncommon for patients to lose between 500 and 1500 mL intra-operatively from the exposure and injury to the muscles and bone [4]. Post-operatively, these patients may experience an additional drop in their hemoglobin between 1 and 3 g/dL due to bleeding into their muscle or forming a hematoma due to their venous thromboembolus (VTE) chemoprophylaxis [4]. Over the past decade, the utilization of autologous blood transfusions has continued to drop, replaced with allogeneic blood transfusions to maintain a stable overall blood transfusion rate following primary total hip and knee replacement surgery [5]. Allogeneic blood transfusions are not benign interventions. In addition to having substantial direct and indirect costs, ranging between $522 and $1183 per unit of blood transfused depending on the estimate [6]. In addition to cost, there are health risks associated with allogeneic blood transfusions including the risk for systemic transfusion reactions and immunomodulation with increased susceptibility for post-operative infection [7–11]. In addition, patients undergoing an allogeneic blood transfusion tend to have a higher association for complications such as reoperation, wound complications, extended lengths of stay in the acute care hospital, and higher in-hospital mortality [12–14].

Our study sought to re-evaluate the blood management process for patients undergoing primary total hip and knee arthroplasty. In particular, evaluate the three potential phases of peri-operative blood management: (1) pre-operative; (2) intra-operative; and (3) post-operative. We hypothesized that a carefully constructed peri-operative blood management protocol involving pre-operative screening, utilization of tranexamic acid (TXA) intra-operatively, and cautious utilization

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of blood products post-operatively could result in a decreased rate of allogeneic blood transfusions among primary total hip arthroplasty (THA) and total knee arthroplasty (TKA) patients.

2. Methods

The multi-modal approach to minimizing allogenic blood transfusions occurred in three phases: pre-operative, intra-operative, and post-operative management. The most sensitive predictor for receiving an allogeneic blood transfusion is the patient's pre-operative hemoglobin [14]. If a patient's hemoglobin is below 13 g/dL pre-operatively, it is recommended that it should be corrected prior to undergoing elective surgery. To appropriately treat the patient's anemia though, further laboratory studies are required to identify an underlying etiology to the anemia. If the patient had a hemoglobin level above 13.0 g/dL, then no further treatment was required, or if the patient's hemoglobin was below 10 g/dL, then the patient was referred to a hemotology specialist unless the reason for their anemia was already known and being actively treated. For patients with modest pre-operative anemia, a hemoglobin between 10 and 13 g/dL, further laboratory studies were required. The patient's ferritin and transferrin saturation (Tsat) levels were measured. If the patient's ferritin level was less than or equal to 100 mg/dL and Tsat level was less than or equal to 20%, then the patient received 1000 mg of intravenous iron. If the patient's blood work demonstrated either his ferritin was less than or equal to 100 mg/dL but Tsat was greater than 20%, or the ferritin level was between 101 and 500 mg/dL even with a low Tsat less than or equal to 20%, then the patient received 375–600 mg of IV iron (Fig.). If the patient's ferritin was $\geq$100 mg/dL and their Tsat was $\geq$20%, then patient received 40,000 units of Procrit subcutaneously weekly until the target hemoglobin (typically >13 g/dL) was attained. This algorithm was based upon others previously described in the literature as reducing the transfusion rate [15,16]. There are risks associated with using erythropoiesis-stimulating agents to obtain a target hemoglobin greater than 13 g/dL though. In particular, patients treated with erythropoiesis-stimulating agents may be at a higher risk of developing a deep venous thrombosis (DVT) [17].

2.1. *Intra-operative*

Within the operative theater, a multi-faceted approach to blood management was employed. The anesthesia team attempted to keep the patient in acute normovolemic hemodilution and use hypotensive regional anesthesia to minimize blood loss. If the surgery was believed to pose a risk for significant blood loss (>600 mL), then a blood salvage machine was used to be able to transfuse the patient with their own blood lost intra-operatively [18]. Awareness of blood conservation was improved with the surgical teams as well by emphasizing (1) their technique, specifically an expeditious exposure with good tissue handling and tissue hemostasis and (2) use of hemostatic agents both intravenously and topically, including combination gelatin and thrombin products, fibrin sealants, and tranexamic acid (TXA) [19,20]. In the presence of any medical comorbidities in which the patient may be more likely to develop a blood clot, including coronary artery disease with stents, a history of a myocardial infarction, pulmonary embolus, or stroke, or if the patient had renal failure and was on hemodialysis, then the TXA was administered topically [21]. The widespread incorporation of TXA into the routine treatment of THA and TKA patients in particular seemed to reduce the rate of blood transfusions without any noticeable increase in sequelae [22].

2.2. *Post-operative*

Since many of the peri-operative transfusions for joint replacement patients occur post-operatively, this was an equally important phase to evaluate. Transfusion trigger points were re-evaluated in order to allow for individualization based on symptoms and medical comorbidity. Post-operative fluids were also carefully monitored to keep the patient in a normovolemic state. A hard transfusion point

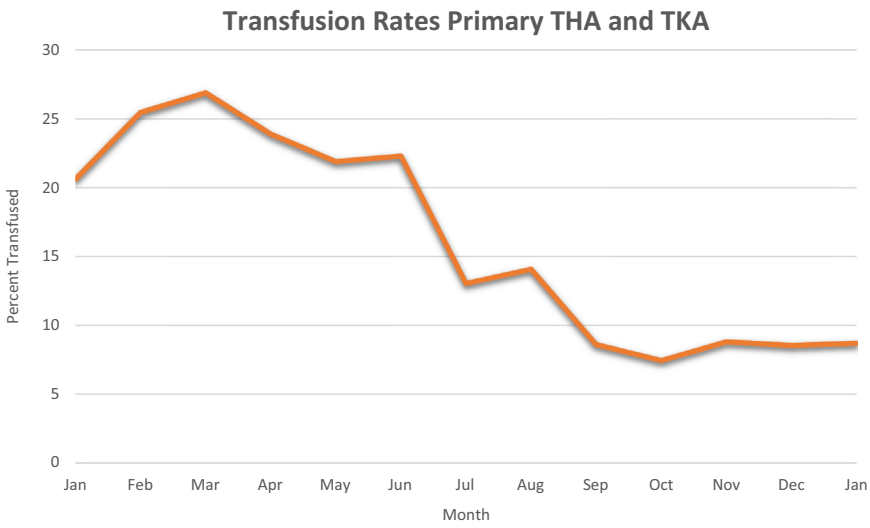

Figure – Transfusion rates for primary THA and TKA.