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Thromboelastography—does it impact blood component transfusion in pediatric heart surgery?

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ABSTRACT

Background: The administration of blood products during pediatric cardiac surgery is common. We sought to determine if thromboelastography (TEG) is a cost-effective tool to reduce blood product transfusion in open pediatric cardiac surgery.

Materials and methods: A retrospective case-control study was undertaken for 150 pediatric cardiac patients requiring cardiopulmonary bypass from January 2010–May 2012, in a University-affiliated pediatric hospital. Fifty sequential patients operated on when TEG was used were compared with 100 control patients before TEG availability. Groups were matched 2:1 for age and risk adjustment for congenital heart surgery score. Blood product utilization was compared between groups, as were outcomes metrics such as postoperative complications, length of stay, and hospital costs of transfusions.

Results: Demographic variables, risk adjustment for congenital heart surgery score classifications, and cardiopulmonary bypass times were similar between groups. Red cell and plasma transfusion were comparable between groups. TEG patients saw a substantial reduction in the administration of platelet (1 *versus* 2.2 U; $P < 0.0001$) and cryoprecipitate (0.7 *versus* 1.7 U; $P < 0.0001$) transfusions. A greater than 50% reductions in hospital costs of platelet ($595 *versus* $1309) and cryoprecipitate ($39 *versus* $94) transfusions were observed in the TEG group. Mortality, length of stay, ventilator requirements, postoperative bleeding, and thrombotic events were equivalent.

Conclusions: Intraoperative TEG use reduced platelet and cryoprecipitate transfusions without an increase in postoperative complications. TEG is a cost-effective method to direct blood product replacement.

1. Introduction

Children undergoing cardiopulmonary bypass (CPB) frequently require various blood product transfusions secondary to losses and acquired coagulopathy. The use of blood transfusions, although lifesaving, is not without significant risk. Blood product transfusions are associated with several complications, primarily immunologic or infectious [1]. Other complications include thrombosis, altered vasoregulation, multiple-organ failure, and respiratory distress syndrome. Transfusion

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reactions can vary from mild-to-moderate febrile reactions, hemolytic and allergic reactions to life-threatening anaphylaxis and acute lung injury [2]. Packed red cell transfusions are associated with an increased risk of bloodstream infection in critically ill adults (odds ratio, 2.23; 95% confidence interval, 1.43–3.52) [3]. Overall, the adverse events from transfusions in the United States account for about $17 billion in annual cost [1]. The cost burden of transfusion therapy is therefore significant, and multiple attempts to establish evidence-based transfusion management policy have been made. The serious consequences of transfusion reactions and transfusion-associated infections have led clinicians to investigate means of decreasing blood product transfusions [4].

Frequently, numerous blood transfusions are given in pediatric cardiac surgery patients [5]. This can be particularly problematic in the subpopulation of patients with an increased risk of pulmonary reactivity, predisposing them to a life-threatening intraoperative pulmonary hypertension crisis. Although the exact mechanism has not been clearly defined, interaction of activated circulating cells (i.e., platelets or leukocytes), and possibly previously damaged endothelial cells, could be the initiating mechanism for several forms of pulmonary hypertension [6].

Thromboelastography (TEG) is emerging as an important laboratory tool to evaluate the hemostatic system. Unlike the activated partial thromboplastin time, international normalized ratio, and prothrombin time, which only assess the activity of specific coagulation factors *in vitro*, TEG provides a nearly real-time snapshot of hemostasis, assessing coagulation factors, platelet activity, thrombolysis, and clot strength, by measuring the viscoelastic properties of the fibrin clot [7]. TEG serves as a powerful tool to better guide the decision to administer blood products in the prevention of bleeding during high-risk surgeries such as cardiac surgery requiring CPB, liver transplantation, and trauma [7].

In this study, we evaluate the use of intraoperative TEG in children undergoing cardiac surgery with CPB. We sought to determine the generalizability of TEG in guiding component therapy in the pediatric–cardiac surgical population. Specifically, our objective was to assess if the routine performance of intraoperative TEG lead to overall reduction in utilization of specific blood components leading to a proportionate cost savings and whether its use was associated with any changes in the overall prevalence of postoperative complications.

2. Materials and methods

The University of Texas Health Science Center San Antonio Institutional Review Board approved the study and waived the need for patient consent to publish study results. Data were obtained through review of electronic medical records, from a single-center congenital heart program that performs approximately 200 CPB-supported surgeries per year.

2.1. Study population

We performed a retrospective case-control study of 150 patients who met the inclusion criteria of having required CPB during cardiac surgery, age <18 y, which was performed from January 1, 2010–May 31, 2012. We identified 50 cases and 100 controls. Cases were defined as children who underwent CPB after the implementation of intraoperative TEG from November 28, 2011–May 30, 2012. Controls were defined as children who underwent CPB before the routine use of intraoperative TEG from January 1, 2010–September 18, 2011. The cohorts were matched 2:1 for age and risk adjustment for congenital heart surgery score.

The laboratory at the Children's Hospital of San Antonio purchased a Thromboelastographic Analyzer model 5000 (TEG; Haemonetics Corporation, Chicago, IL) in September 2011. The congenital heart team began to use TEG results intraoperatively to guide transfusion decisions in September 2011. We chose to evaluate cases starting November 2011 after 2 mo of intraoperative TEG use to minimize lack of experience as a confounding factor. Pre-TEG indications for blood products were clinical bleeding without a surgical source found. Post-TEG indications for blood product transfusion were nonsurgical bleeding and abnormal TEG. Although we did not have a formal protocol prospectively in place during the time of the retrospective study period, the following is representative of our general approach (Fig. 1). First, address all surgical bleeding completely and thoroughly. Decision making after addressing all surgical bleeding included the following: First scenario: normal or abnormal TEG without clinically significant bleeding. Action: received no transfusions. Second scenario: clinically significant bleeding with a normal TEG. Action: prompted first a reevaluation for possibly missed surgical source of bleeding and then reassessment with an additional TEG. Third scenario: clinically significant bleeding with an abnormal TEG. Action: treated with indicated blood components guided by the TEG findings.

2.2. Data collection

Data collection was done by a single trained reviewer, from the electronic medical records of the patients who underwent cardiac surgeries with and without the use of TEG. The primary and coinvestigators, to confirm accuracy of the data, performed a formal review of 20% of the cases each. During the study period, 92 surgeries were eligible to be included as cases. Thirty-three were excluded because surgery occurred within the first 2 mo of TEG use; two subsequent patients were excluded for a history of thrombosis and noncardiac CPB surgery (traumatic esophageal tear). The control population was chosen from 291 eligible pump cases. We collected the total volume of packed red blood cells, platelets, fresh frozen plasma (FFP), and cryoprecipitate and determined the absolute number of units, as well as the milliliters per kilogram, transfused. The TEG sample, 2.7 mL, was drawn as follows: The first TEG sent was prebypass, while in the operating room before incision. The second was run just before coming off bypass and the third after protamine administration. There was variation in the number of TEGs ran per surgery, but most commonly three TEGs per surgery. If less than three TEGs resulted, typically the TEG was not analyzable due interference during the test and not resent due to no clinical bleeding. Greater than three TEGs were sent when clinical bleeding persisted to retest the TEG after