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Plateletworks™ Platelet Function Test Compared to the Thromboelastograph™ for Prediction of Postoperative Outcomes

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Abstract: Approximately 3.5 million units of platelets are transfused in the United States each year to patients undergoing open-heart surgery with cardiopulmonary bypass (CPB). CPB is a known contributor to platelet loss and platelet dysfunction leading to disruption of hemostasis. Impaired hemostasis results in excess bleeding in 5–25% of all patients undergoing CPB. For this reason, it may be beneficial to measure platelet number and function in these patients. The purpose of this study was to compare the Plateletworks™ platelet function analyzer to the thromboelastograph (TEG) in predicting postoperatiave hemostatic outcomes as measured by blood product use and chest tube (CT) drainage. This study consisted of 35 adult patients undergoing cardiac surgery with cardiopulmonary bypass at Rush-Presbyterian-Saint Luke's Medical Center (RPSLMC). The Plateletworks™ and TEG tests were performed preoperatively, after protamine was given, and 24 hours postoperatively on all patients. Plateletworks™ demonstrated a statistically significant change in platelet function as shown by the adenosine diphosphate (ADP) reagent tube from the preoperative period to the removal of the aortic cross clamp (p = .011). The TEG did not demonstrate a significant change in the k-time and maximum amplitude (MA), but did show a significant change in the alpha-angle from the pre-operative to postoperatiave sample (p = .035). A correlation was found between Plateletworks™ collagen reagent tubes preoperatively and CT drainage (p = .048, r −0.324). No statistical correlation was established between TEG parameters and CT drainage at any time interval. TEG preoperative MA showed a correlation to receipt of blood products (p = .016). When comparing the Plateletworks™ to the TEG in this study, the Plateletworks™ system was a more useful predictor of blood product use and chest tube drainage. *JECT. 2004;36:149–152*

Approximately 3.5 million units of platelets are transfused to patients undergoing cardiopulmonary bypass (CPB) in the United States every year (1). CPB is a known contributor to platelet loss and dysfunction, attributable to activation and consumption (2–5). Platelets play an essential role in the coagulation process and maintenance of hemostasis. Platelets are critical for the patient undergoing open-heart surgery in avoiding postoperatiave bleeding (6). Second only to a break in vascular integrity, platelet loss is a major contributor to postoperatiave bleeding. CPB-induced platelet dysfunction often leads to excessive bleeding in 5–25% of CPB patients (1,7). A study performed by Wenger and associates (8) found platelet fragments and degranulated platelets in the extracorporeal circuit (ECC) after bypass, and a significant amount of the platelets left in the patient circulation had a loss of receptor sites, rendering them inactive (9). Cardiac surgical patients account for 25% of the demand put on United States blood banks each year (10). Analyzing platelet function may be an important tool used by the clinician to help guide care and improve outcomes for cardiac surgical patients.

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PLATELET FUNCTION

Hemostasis, the prevention of blood loss, is a complex multisystem process in which platelets play a vital role (11). The loss of vascular integrity from injury causes vessel constriction to reduce blood flow. Exposed endothelium releases chemicals that attract platelets to form a plug. The platelets change shape by extending pseudopods and covering the damaged area. Platelets release adenosine diphosphate (ADP) that recruits other platelets to the area, and a plug is formed. The platelet plug acts as a temporary inhibitor of blood loss. The surfaces encountered in the ECC are not physiologic, and therefore, activate and consume platelets (12). Other aspects of CPB, such as heparinization, have a negative effect on platelet function (13). Activated platelets proceed through stages of micro-aggregation and macro-aggregation. Heparin has been shown to decrease macro-aggregation of platelets and adversely affect the strength of platelet bonds (14).

Force development is the strength of platelet adhesion to one another and the injured vascular endothelium (15). Force development is essential in providing strength and reinforcement to the platelet plug to withstand the force of surrounding blood flow. Decreased force development between platelets could have significant effects on postoperatiave bleeding. Factors necessary for force development are platelet number, temperature, ionized calcium concentration, platelet receptor stimulation, and thrombin (13–15). Heparin inhibits force development through binding of antithrombin III (AT-III), this complex results in the inhibition of thrombin binding to platelets. A study conducted by Carr and associates (14) looked at force development before, during, and after coronary artery bypass graft (CABG) surgery. A Hemodyne™ clot retractometer (Hemodyne Inc., Richmond, VA) was used to measure force development, their findings demonstrated that force development during bypass is diminished and that platelets recover only 55% of force development after bypass.

PLATELETWORKS™

The Plateletworks point-of-care system (Helena Laboratories, Beaumont, TX) measures total platelet count in a whole blood sample and platelet aggregation in a second sample that has been exposed to a known agonist. Only functional platelets will be activated, the remaining inactive platelets are counted and percent aggregation can be calculated (Figure 1). Bacterial ADP and calf-derived collagen are used as platelet agonists, exogenous platelets respond to these reagents in a manner similar to endogenous mechanisms. Carville and associates (16) performed a study that compared Plateletwork, ADP, and collagen reagent tubes to traditional platelet-rich plasma aggregometry to assess platelet function. Both reagent tubes produced results that correlated significantly with the platelet-rich aggregometry with p-values = .001. Lakkis and associates (17) conducted a study that looked at benefits of the Plateletworks system. The central hospital laboratory provided results in 105 minutes. Similar results with the Plateletworks system are available in less than 10 minutes. Quick results enabled the surgical team to use preventive measures before leaving the operating room, thus avoiding postoperative bleeding and possible reoperation.

$$\frac{\text{Baseline Platelet Count} - \text{Agonist Platelet Count} \times 100}{\text{Baseline Platelet Count}} = \%\ \text{Aggregation}$$

Figure 1. Platelet function formula.

THROMBOELASTOGRAPHY

The thromboelastograph™ (TEG) is a qualitative test on whole blood of the viscoelastic properties of clot formation (18). A rotating cuvette is introduced to a 0.36 cubic centimeter (mL) sample; as clot formation occurs, the cuvette is displaced, and a "signature" marking is recorded. The TEG signature (Figure 2) consists of several elements. The K-time signifies the time it takes to reach a certain level of clot strength, the alpha-angle shows the speed of clot formation, and the maximum amplitude (MA) represents the strength of the clot. The TEG is a nonspecific gross evaluator of coagulation (19). Although the TEG is unable to detect specific hemostatic dysfunction or coagulation disturbances, an abnormal signature indicates the need for further examination (20,21). In addition, the TEG takes approximately 90 minutes for complete results. Despite these limitations, the TEG is effective in predicting postoperatiave blood loss after CPB.

The goal of this study is to determine which is a better predictor of postoperatiave outcomes as measured by postoperatiave bleeding and use of donor products. Utilizing an indicator of postoperatiave outcomes could have benefits in reducing postoperatiave bleeding, transfusion requirements, and reoperation for bleeding.

MATERIALS AND METHODS

The study received institutional review approval and included 35 adult patients undergoing open-heart surgery at Rush-Presbyterian-Saint Luke's Medical Center (RPSLMC). Excluded from the study were pediatric pa-

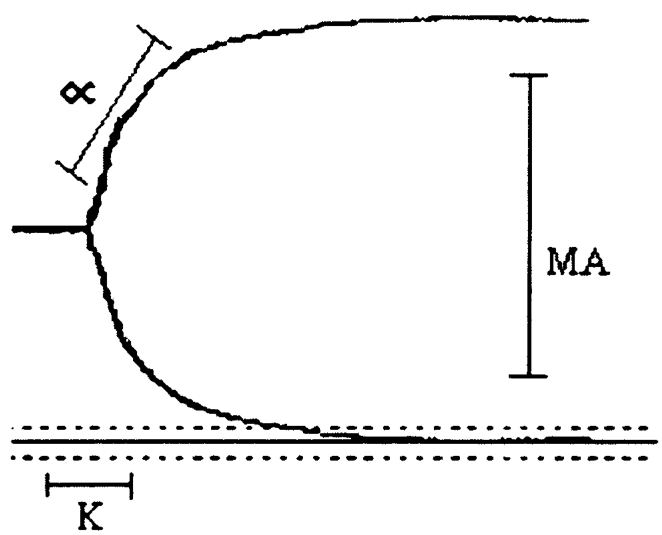

Figure 2. Normal thromboelastograph tracing.

tients, patients with known hemostatic disorders, and patients undergoing surgery with deep hypothermic circulatory arrest. Included in the study were patients undergoing valve repair or replacement, CABG, or combination. Demographics are shown in Table 1. The Plateletworks test was performed at four time intervals; pre-incision, after removal of the aortic cross clamp, 1 hour postoperatively, and 24 hours postoperatively. At each time interval 3 cc of the patient's blood was drawn from a previously inserted arterial line or the manifold of the heart–lung machine. The baseline, ADP, and collagen reagent tubes were used at each time interval, each requiring 1 cc of whole blood. The TEG was performed pre-incision, 1 hour postoperatively, and 24 hours postoperatively. Postoperatiave complications were measured by chest tube drainage and receipt of blood products. Statistical analysis was performed on SPSS 10.1. The one-way analysis of variance (ANOVA) test was used to determine the mean difference in time intervals for both the Plateletworks and TEG. The Spearman's rank correlation test was used to determine correlation between demographic parameters and CT drainage, Plateletworks platelet function, and CT drainage, and to determine correlation between TEG parameters and CT drainage. The Mann–Whitney test was used to determine significance of receipt of blood products to Plateletworks and TEG results, with a 95% confidence interval.

RESULTS

Plateletworks data demonstrated a statistically significant decrease in functional platelets from the preoperative sample to removal of the aortic cross clamp, measured by the ADP reagent tube with a p-value = .011 (Figure 3). The baseline and collagen reagent tubes indicated no significance at any time interval to platelet count or function, respectively. TEG data established a significant change in alpha-angle from preoperative to postoperative, with a p-value = .035 (Figure 4). There was no statistically significant change in k-time and MA at the time intervals. No correlation was found between demographic parameters and CT drainage. Preoperative platelet function measured by the collagen reagent tube exhibited a significant correlation to the CT drainage with $r = -0.324$ and p-value = .048 (Figure 5). No correlation was found at any time interval between TEG parameters and CT drainage. Plateletworks data showed no correlation at any time interval to receipt of blood products; however, there was a correlation between the TEG preoperative MA and receipt of blood products with a p-value = .016.

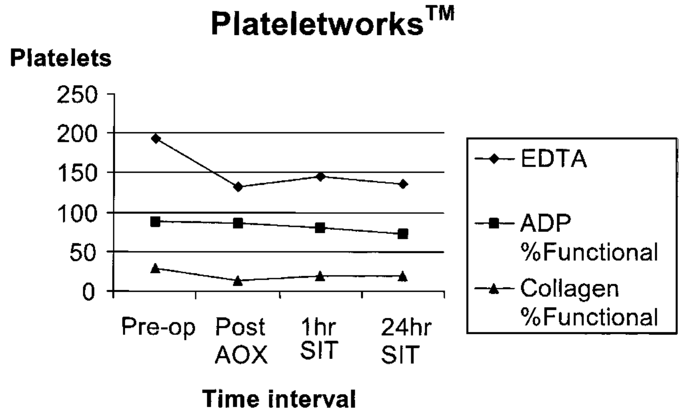

Figure 3. Plateletworks™ data compared at time intervals.

DISCUSSION

Half of the nearly 7 million units of platelets transfused every year in the United States are to patients undergoing cardiac surgical procedures. The ability to identify coagulopathies enables clinicians to use preventive measures to improve patient outcomes. The alpha-angle component of the TEG demonstrated reduced speed of clot formation from the pre-operative to postoperatiave period. The speed of clot formation correlates primarily to plasma concentration of fibrinogen and factor XIII. Administration of cryoprecipitate and fresh frozen plasma (FFP) should be considered in patients with an altered alpha-angle. TEG preoperative MA correlates to receipt of blood products. A diminished MA represents thrombocytopenia or platelet dysfunction. Postoperatiave platelet administration should be considered in patients with a small preoperative MA.

Significant decline in platelet function from the preoperative to postoperatiave period was identified in this study by the Plateletworks ADP reagent tube. Correlation was established between pre-operative platelet function and CT drainage by the Plateletworks collagen reagent tube. Postoperatiave transfusion of platelets should be anticipated for patients presenting with poor platelet function, regardless of platelet count. Specific results enable the clinician to differentiate between loss of vascular integrity, platelet dysfunction, or clotting factor deficiency, thus allowing component specific blood therapy.

Table 1. Demographics.

Patient $n = 35$	Age	CPB Time	AOX Time	Lowest Core Temp	Chest-Tube Drainage
Mean	63.5 years	157.1 min	114 min	30.7°C	540.1 mL
Range	43–83 years	89–383 min	40–251 min	25–35.3°C	50–1850 mL

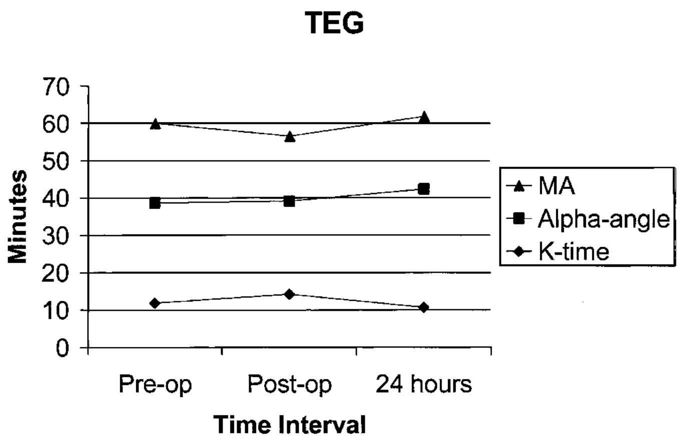

Figure 4. Thromboelastograph data compared at time intervals.

Platelet dysfunction occurs secondary to surgical intervention and cardiopulmonary bypass. Utilizing clotting tests directs the clinician to recognize and proactively treat coagulopathies and may eliminate unnecessary transfusions. Analyzing platelet function in addition to platelet count enables the clinician to anticipate the need for transfusion of specific blood components. The purpose of this study was to evaluate the Plateletworks system and to test correlations between this system, the TEG, and postoperatiave outcomes. Expected decline in platelet count and function was verified by the Plateletworks system. Considering the time it takes to run each test and the specific results, the Plateletworks system was a more useful predictor of postoperatiave blood product use and chest tube drainage. Both of the tests had statistically significant results within the limitations of the sample size, indicating the need for further studies with a larger sample size to establish more definitive correlations.

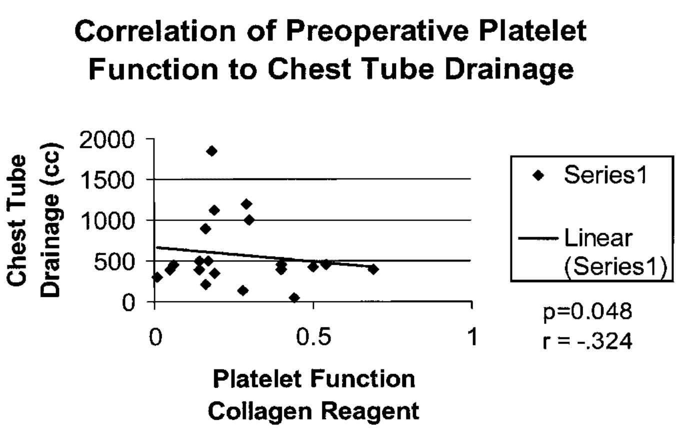

Figure 5. Plateletworks™ pre-operative collagen reagent tube correlation to chest tube drainage.

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