Follow this guide to lead a staff discussion on thromboelastography.

Thromboelastography

A means to transfusion reduction

This point-of-care test improves safety and outcomes by decreasing blood component transfusions.

Teaching guide

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   B. Budget implications
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Abstract: Consider using thromboelastography to improve care outcomes for cardiac surgery patients. [Nurs Manage 2005;36(5):27-34]

Any cardiac surgery program seeks to reduce the incidence of transfusion therapy without compromising patient health and safety. Enter thromboelastography (TEG), a new procedure that decreases blood component transfusions while maintaining patient safety and improving outcomes.

In the fast-paced world of cardiac surgery, coagulopathy is one of a nurse’s prime concerns during post-op treatment. Though similar in nature, coagulopathy needs to be differentiated from surgical bleeding. Platelet function and coagulation factors are altered as a result of cardiopulmonary bypass (CPB); they don’t normalize for up to 12 hours following surgery. When the patient receives antiplatelet agents within 7 days of surgery, the effects...
plasma) for coagulopathy is empirically guided in most institutions, yet not all cardiac surgery patients warrant transfusion therapy.

An alternative to transfusion
Transfusion therapy is a mainstay in the care of cardiac surgery patients, with cardiac surgery procedures consuming about 20% of the nation’s supply of allogenic blood. In addition, the administration of blood products is variable, ranging from 27% to 92% for packed red blood cells (PRBCs) and 0% to 36% for platelets and fresh frozen plasma (FFP). Most cardiac surgery programs empirically transfuse patients based on factors that include older CPB—anticoagulation, hemodilution, and hypothermia—are those that contribute to the incidence of bleeding. Diverting the patient’s blood through the artificial surface of the CPB machine activates the clotting cascade and decreases the number (as well as the function) of platelets. Since anticoagulation is required to reduce the effects of clotting caused by the machine, healthcare providers administer heparin. At the end of the surgery, providers reverse heparin with protamine, seeking a correct heparin-to-protamine ratio to avoid heparin rebound and further bleeding.

Hemodilution occurs when the patient’s blood mixes with the crystalloid solution used to prime the CPB machine. Since the patient’s blood is being diluted, the hematocrit drops, as does the concentration of coagulation factors, fibrinogen, and platelets. Practitioners employ hypothermia to decrease tissue oxygen requirements and protect the major organs. It slows down the process of clotting and decreases platelet function. Compounding the risks associated with CPB is its duration, which and stroke and death, has also been shown in patients who received one or more units of platelets to counteract the effects of CPB. Though platelet transfusion may have no causal role in these adverse patient outcomes, it may be a surrogate marker for sicker patients.

High-cost procedure
Since 1996, the use of antiplatelet agents as a preventive and treatment measure to reduce the incidence of thrombosis in acute coro-

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The authors disclose that they have no significant relationship with or financial interest in any commercial companies that pertain to this educational activity.

www.nursingmanagement.com May 2005 Nursing Management 29
nary, cerebrovascular, and peripheral arterial occlusive disease has risen dramatically. The effect of one antiplatelet agent, clopidogrel, on patients who have cardiac surgery following coronary angiography has demonstrated significantly higher percentage of patients transfused, and higher volumes of PRBCs.

In addition, researchers found significant reoperation rates for continued bleeding in the patients who received antiplatelet agents preoperatively, with one study reporting a 10-fold increase. The financial impact of preoperative administration of clopidogrel was statistically significant in regards to the increased cost for laboratory and blood services.

Clopidogrel is beneficial for individuals undergoing coronary angiography, as it reduces the incidence of thrombus formation by preventing the aggregation of platelets. For nonsurgical patients this is a prime benefit, but clopidogrel use in patients undergoing cardiac surgery proves problematic. Platelet function is integral to hemostasis in the early postoperative period of cardiac surgery, keeping patient bleeding to a minimum. Preoperative clopidogrel has the potential to deliver an additional insult to platelets already made dysfunctional by CPB. Its effect on platelets ranges from 3 to 7 days, and therefore, should be discontinued 5 to 7 days prior to surgery. This isn’t always feasible depending on the severity of the patient’s coronary artery disease. Further, clopidogrel also affects any postoperative platelet transfusions received within that 7-day period.

When it comes to transfusion therapy, hospital administrators aim to contain costs. Yet, hospitals vary in their transfusion practices for cardiac surgery. Even in low-risk groups of patients, one-quarter of the institutions surveyed transfused more than 20% of their patients with platelets. The combined administration of platelets and FFP suggests empirical administration of these hemostatic blood components instead of targeting the cause of the perioperative bleeding and sequentially providing the specific product. Recently, evidence-based medicine articles have supported transfusion-guided decisions in cardiac surgery patients, but the recommendations haven’t been widely instituted in cardiac surgery programs.

Thromboelastography’s history Developed in 1948, healthcare providers used TEG for liver transplant management. The principle of the procedure stems from clot formation. Clotting is a dynamic process, one that’s difficult to measure using static, end-point laboratory tests, which don’t supply information regarding clot quality or the dynamics of its formation.

TEG monitors the whole dynamic process of hemostasis, from clot formation to clot dissolution, as opposed to the conventional end-point tests, such as platelet count, protime, partial thromboplastin time, and fibrinogen. The procedure allows for a global assessment of hemostatic function, beginning with the interaction of platelets with the protein coagulation cascade, from the time of initial platelet-fibrin interaction, through platelet aggregation, clot strengthening and fibrin cross linkage, to eventual clot lysis. Time, rate, strength, and stability of the clot determines whether the developing clot will be able to do the work of hemostasis.

The volume of blood needed for this point-of-care test, 0.35 ml, is minimal in relation to the blood volume required to perform end-point laboratory tests. Healthcare workers use a pipette to place the blood in a small stationary cylindrical cup that sits in the well of the machine. The cup is raised and locked into place so that a pin attached to a torsion wire is suspended in the blood. The cup then rotates at a 4°45’ angle, with each rotation lasting 10 seconds. As the clot begins to form, the pin adheres to the clot. (See “Analysis of clot formation.”)

The resistance met by the pin generates a graph that’s displayed on the computer screen. The strength of the fibrin-platelet bonds in the clot affects the magnitude of the pin motion. When the clot begins to lyse, the fibrin-platelet bonds break and the motion of the cup diminishes. The concurrent graph tracing and numeric values that are generated allow the immediate evaluation of the coagulation status of the patient. Completed test results are available within 20 to 30 minutes.

The graph tracing and corresponding values allow for targeting the specific hemostatic blood component required in the treatment of coagulopathy. (See “Parameters measured by thromboelastography...
and corresponding normal values.

When the reactive time (R) parameter is prolonged, such as with anticoagulants, administration of FFP may be warranted. Since the clot formation time (K) measures the time it takes for the strength of the clot to reach a certain level, a prolongation would indicate a lack of fibrinogen. The angle (β), reflecting the rapidity of the formation of the clot, also reflects decreased fibrinogen levels when it’s narrow. These types of abnormalities may indicate the need for cryoprecipitate.

Maximum amplitude (MA), or width of the thromboelastograph, is affected by the platelet number and function and to a lesser extent by fibrinogen level. A decreased level may necessitate the administration of platelets. An antifibrinolytic agent may be warranted if there’s an increase in the clot lysis time (LY30) which represents hyperfibrinolysis, or a more rapid breakdown of the clot. All of these findings need to be coupled with the clinical presentation of the patient with regard to his bleeding state and history, so that the specific hemostatic blood component is administered.

Routine laboratory tests, such as protime and partial thromboplastin time, are generally performed on centrifuged plasma fractions. These tests examine only a portion of the coagulation cascade. TEG utilizes whole blood, which looks at the interdependent variables not seen in plasma end-point laboratory values such as partial thromboplastin time. This makes TEG more sensitive to detecting changes in hemostasis.

In addition, protime and partial thromboplastin time don’t have a high predictive value for perioperative bleeding, which is critical in postcardiac surgery patients. Since TEG is a point-of-care tool, the results from the R value, which corresponds to partial thromboplastin time, can be achieved in approximately 8 minutes, thereby affording a rapid evaluation as to whether the origin of bleeding is a coagulopathy or the result of surgical technique.

From theory to practice
Jersey Shore University Medical Center, Neptune, N.J., performs approximately 850 cardiac surgery cases per year, and its blood product use is about 27% of the medical center’s annual inventory. It’s comparable to other programs, as last year 16% of the patients were over 80 years of age and about 30% of the patients were female, both being at higher risk for bleeding. The hospital’s experience with clopidogrel is also similar to what’s reported in the literature. Because of all these factors, the cardiac surgeons, under the assumption that the normal coagulation pathway was disrupted, were empirically ordering platelets and FFP in these groups of patients. In most instances, PRBCs were being administered with the hemostatic blood components, though the patient may not have had abnormally low hemoglobin levels. The past experience of one of the cardiac anesthesiologists in the use of thromboelastography with liver transplantation raised the consideration for using this laboratory test. The goal was to reduce the transfusion rate of platelets and FFP in cardiac surgery patients by targeting the specific point in the process of clot formation where the problem was occurring and individually or sequentially ordering that hemostatic component.

The hospital acquired a TEG analyzer in the spring of 2004, and implemented the new plan in phases, to realize its impact on transfusion reduction at specific points during a cardiac surgery procedure. Phase I involved placing two machines in the cardiac surgery operating rooms, since about 60% of the transfusions of platelets and FFP occurred there. Perfusionists, anesthesiologists, cardiac surgeons, and laboratory medical staff received education on quality control and result interpretation. In addition, the hospital maintained New Jersey Department of Health and Human Services requirements and regulations for point-of-care testing.

Billing for the test was added to the charges generated during the surgical procedure. The anesthesiologist, in conjunction with the surgeon, reviewed the thromboelastograph and numeric results at three points...

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**Intraoperative reduction of platelets and FFP in cardiac surgery - 2004**

<table>
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<tr>
<th>Month</th>
<th>Pre-TEG transfusion volume</th>
<th>Post-TEG transfusion volume</th>
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<tr>
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<tr>
<td>Units of FFP</td>
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</tr>
<tr>
<td>Units of FFP</td>
<td>193</td>
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during the surgical procedure. By specifically targeting the point in the process of clot formation contributing to the coagulopathy, the quantity and type of product needed were determined, whether it was FFP, cryoprecipitate, platelets, or antifibrinolytic drugs.

We began monitoring the reduction of intraoperative platelet and FFP administration on May 1, 2004. We compared results from the following 8 months to the first 3 months of 2004, which reflected the general administration of blood products in the operating room for the previous 3 years (See “Intraoperative reduction of platelets and FFP in cardiac surgery.”) On average, a 50% reduction occurred in the administration of platelets and FFP, with a range of 35% to 66% for platelets and 35% to 80% for FFP. Though TEG doesn’t target low hemoglobin, there was a bonus value in the reduction of PRBC (transfusions given) because the physicians weren’t empirically giving PRBC with the hemostatic blood components. The hospital saved approximately $240,000 in platelets and FFP alone by implementing this performance-improvement activity, and an additional bonus savings of approximately $100,000 in PRBC reduction. These savings justified the initial expenditure for the first two machines, computers, monitors, and printers, which cost approximately $60,000. In addition, the number of blood products being ordered for cardiac surgery patients has been reduced, and those products that may have been targeted for this patient population and weren’t used have been diverted for use in other patients.

The apparent success of using a thromboelastograph-guided approach to transfusion therapy during cardiac surgery procedures resulted in the implementation of phase two of the plan. We’ve acquired a TEG machine for the cardiothoracic intensive care unit. Key nursing staff members are receiving education on the procedure, and they’ll take the lead in performing the quality controls and tests. The test will be performed in conjunction with the first postoperative laboratory studies, to allow for correlation with end-point laboratory studies. Nurse practitioners, cardiothoracic nurses, physician assistants, and cardiac surgery intensivists will learn how to interpret the results. The test will also be monitored through CLIA ’88 licensure. We’ve developed charge codes to bill for the test performed in the cardiothoracic intensive care unit. We’ll analyze the data over the next 6 months to determine the impact of TEG on identifying the cause and correct treatment of the coagulopathy during the postoperative period. Based on these results, the laboratory will implement phase three, which involves acquiring a machine for the hematology laboratory so all areas of the hospital can have a guided therapy for the administration of platelets and FFP.

TEG utilization enables clinicians to administer a specific hemostatic product or identify a surgical bleed. This is especially significant in lieu of the risk for transfusion-related complications. Researchers reported a higher incidence of post-operative infection, stroke, and death in patients who received platelet transfusions. There was also significant association between the administration of platelets and an increase in vasopressor, inotrope, antiarrhythmic, and respiratory medication use.

Transfusion-related complications will always be a concern for cardiac surgery patients. A multidisciplinary approach to the implementation of a point-of-care test, which would guide the administration of blood products to other patients at risk, is a reasonable expectation for any institution. As demonstrated at our hospital, it will not only improve patient safety and ultimate outcome, but also assist in the cost containment issues of our current healthcare environment.

### REFERENCES


### T H R O M B O E L A S T O G R A P H Y

#### Parameters measured by thromboelastography and corresponding normal values

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Normal Values</th>
</tr>
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<tbody>
<tr>
<td>R</td>
<td>Reactive time: Period of time from the blood placed in the thromboelastograph machine until the initial fibrin formation. Normal 4 to 8 minutes.</td>
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<tr>
<td>K</td>
<td>Clot formation time: Time from R or beginning of clot formation, until a fixed level of clot strength (amplitude of 20 mm) is reached. Normal 1 to 4 minutes.</td>
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<tr>
<td>Angle (θ)</td>
<td>Measures the rapidity (angle) of fibrin buildup and cross-linking, or the speed of clot strengthening. Normal 47 to 74 degrees.</td>
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<tr>
<td>MA</td>
<td>Maximum amplitude: Maximum strength or stiffness of the developed clot. Normal 55 to 73 mm.</td>
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<tr>
<td>LY30</td>
<td>Lysis of clot: Measures the rate of amplitude reduction, or breakdown of the clot, 30 minutes after MA and represents the ultimate stability of the clot. Normal 0% to 8%.</td>
<td></td>
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</tbody>
</table>


5. Ibid.


30. Ibid.

31. Ibid.


35. Spiess, B.: loc cit.


ABOUT THE AUTHORS

Ellen Ruth Sorensen is a cardiothoracic clinical nurse specialist, Tracy B. Lorme is the technical supervisor of transfusion services, and Dawn Heath is an assistant nurse manager in the cardiothoracic intensive care, Jersey Shore University Medical Center, Neptune, N.J.
Thromboelastography: A means to transfusion reduction

GENERAL PURPOSE: To familiarize the clinical laboratory professional with the benefits and use of thromboelastography in patients undergoing cardiac surgery.

LEARNING OBJECTIVES: After reading the preceding article and taking the following test, the reader will be able to: 1. Describe how use of cardiopulmonary bypass and antiplatelet drug therapy alter normal clot formation. 2. State the benefits of thromboelastography as it relates to patients undergoing cardiac surgery. 3. Describe proper procedure, result interpretation, and therapy related to thromboelastography.

1. Following surgery, cardiopulmonary bypass (CPB) inhibits the function of platelets and clotting factors for up to
   a. 12 hours.
   b. 24 hours.
   c. 36 hours.
   d. 48 hours.

2. What is the minimum amount of blood required for TEG?
   a. 0.1 ml
   b. 0.25 ml
   c. 0.35 ml
   d. 1.5 ml

3. What percentage of America’s allogenic blood supply is used for patients having cardiac surgery?
   a. 5%
   b. 10%
   c. 15%
   d. 20%

4. The R value corresponds to which of the following studies?
   a. PT- Prothrombin Time
   b. PTT- Partial Thromboplastin time
   c. Platelet count
   d. Bleeding time

5. Which of the following best describes what thromboelastography (TEG) monitors?
   a. the degree of clotting caused by use of CPB
   b. the conversion of fibrinogen to fibrin during clotting
   c. the role of platelets in clot formation
   d. the quality of a clot and the dynamics of its formation

6. Compared to end-point laboratory tests, the amount of blood needed for TEG is
   a. the same.
   b. minimal.
   c. slightly more.
   d. significantly more.

7. TEG results are accessible in
   a. half an hour.
   b. 2 hours.
   c. 12 hours.
   d. 24 hours.

8. Use of TEG at Jersey Shore University Medical Center has resulted in
   a. placement of an additional TEG machine for use in the cardiothoracic ICU.
   b. elimination of PRBC transfusions.
   c. reduction of bleeding risk for elderly females.
   d. cost reductions of over $1 million in blood component use.

9. At Jersey Shore University Medical Center, TEG has demonstrated an average reduction of platelet and FFP use by
   a. 35%.
   b. 50%.
   c. 60%.
   d. 80%.

10. How long does it take for the first fibrin to form once blood is placed in the TEG machine?
    a. 1 to 3 minutes
    b. 4 to 8 minutes
    c. 9 to 11 minutes
    d. 12 to 16 minutes