Impact of Rapid Thromboelastography (rTEG) on Intraoperative Blood Utilization in Cardiac Surgery

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Risk/Benefit of Blood Transfusion

Risks
- Infectious - viral, parasitic, bacterial, prion
- Immunologic – HTR, TRALI, GVHD, alloimmunization
- Non-immunologic (volume overload)

Benefits
- Difficult to find in the literature
- Practices learned and benefits assumed
- Practice changes over time, largely in response to appreciation of risks
Transfusion-related mortality: The ongoing risks of allogeneic blood transfusion and the available strategies for their prevention

Eleftherios C. Vamvakas and Morris A. Blajchman
Transfusion-Related Fatalities by Complication, FY2008- FY2012
Recent Transfusion Statistics

- New and established medical procedures require transfusion support; cardiothoracic surgery, hematopoietic and organ transplantation, trauma resuscitation, ECMO, VAD
- Widespread use of anti-platelet and anticoagulant drugs contribute to coagulopathies
  - 15 million red cell units
  - 2 million platelets
  - 2.4 million plasma units
  - 1 million cryoprecipitate
Cardiac Surgical procedures

- 50-60% of cardiac surgical patients receive blood
- 20% of nation’s blood supply used in their support
- 120,470 patients undergoing CABG at 798 sites in US;
- Rates of transfusion of all components varied from 0->90%, independent of case mix, # of procedures performed at site
- Transfusion rates varied within hospital, between hospitals and between geographic regions; no differences in mortality

JAMA-2010;304:1568
40% of platelet transfusions, 30% of plasma transfusion may be inappropriate
Effect of Transfusion in Cardiac Surgery

- Evidence associating adverse outcomes with transfusion
- Increased post operative infections
- Increased in hospital and long term mortality
“Transfusion Liberalism”

- Despite lack of certainty of benefits of transfusion in many instances (and evidence of harm), resistance to change is great—the two largest RCTs in non-bleeding patients recommend restrictive over liberal transfusion strategy
- Cling to a precautionary bias against undertransfusion?
- Practice influenced by physician fear-perception of risk of transfusion has shifted over the past 2 decades
- Most transfusion thresholds are surrogate measures at best; hemoglobin for tissue oxygenation, platelet count and PT/PTT for in vivo clotting capability
- Lack of real-time functional data, transfusions tend to be empiric
Cardiovascular Surgery

• Patients undergoing cardiopulmonary bypass procedures have a variety of hemostatic alterations:
  • Many are on platelet inhibitors (ASA, plavix)
  • Hemodilution during CPB due to use of non-blood prime; factor and platelet deficiencies
  • Hypothermia and circuit through CPB machine adversely affect platelet function
  • Consumption of coagulation factors and platelets
  • Anticoagulation with heparin while on bypass to prevent thrombosis
What can improve transfusion practice

• Transfusion algorithms based on best practice guidelines
• Point of care testing can reduce turn around time and provide more relevant data to support decision making
• Consider expanded POCT in cardiothoracic surgery to evaluate coagulation status
Thromboelastography-Guided Transfusion Algorithm Reduces Transfusions in Complex Cardiac Surgery

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Departments of *Anesthesiology and †Cardiothoracic Surgery, Mount Sinai Medical Center, New York, New York
Thromboelastography in cardiac surgery

100 complex cardiac surgery patients

- Randomized to TEG guided transfusion algorithm or routine coagulation monitoring
- No difference in intraoperative transfusion but significantly fewer post-op & total transfusions in TEG group
- Suggests improved hemostasis due to earlier identification of coagulation abnormality lead to appropriate and timely intervention
What is TEG?

• Thromboelastrograph (TEG) is a real-time analyzer of whole blood for coagulation

• Measures the viscoelastic properties of the hemostasis process functionally, the end-result being the hemostatic plug, or clot
What is TEG?

[Diagram showing TEG machine and its components: Torsion wire, Pin, Cup, .36 ml whole blood, Heating element, sensor & controller]
What is TEG?

Key:
- Green = Enzymatic System
- Blue = Platelet System
- Orange = Lytic System

Coagulation

Fibrinolysis

K

G = Clot Strength

$R = \text{Reaction time to end of thrombin burst}$

$K = \text{fibrin cross-linkage, fibrinogen function}$

$MA = \text{platelet function}$

$G = MA \text{ converted to kdynes/cm}^2$

$LY_{30} = \text{Lysis 30 minutes after MA reached}$
Normal TEG® Tracing
What is Rapid TEG™ (rTEG)?

• Maximally and simultaneously activates the two clotting cascades
  – Kaolin → Intrinsic Pathway
  – Tissue Factor → Extrinsic Pathway

• Reduces time to fibrin formation <1 min
  – Allows for rapid data availability
Standard TEG vs Rapid TEG™

Tracing Comparison
TEG in OR Suite
### TEG Test Results

<table>
<thead>
<tr>
<th>Channel</th>
<th>Patient</th>
<th>Sample date</th>
<th>Sample description</th>
<th>TEG ACT (sec)</th>
<th>SP (min)</th>
<th>R (min)</th>
<th>K (min)</th>
<th>Angle (deg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Patient 1 Baseline</td>
<td>7/24/2014 08:46:17</td>
<td>121.0</td>
<td>0.7</td>
<td>0.8</td>
<td>0.9</td>
<td>78.8</td>
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</tr>
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<td>Patient 1 Baseline</td>
<td>7/24/2014 08:30:42</td>
<td>121.0</td>
<td>0.6</td>
<td>0.8</td>
<td>1.3</td>
<td>72.7</td>
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<td>7/23/2014 19:14:13</td>
<td>113.0</td>
<td>0.6</td>
<td>0.7</td>
<td>0.8</td>
<td>79.0</td>
<td></td>
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<tr>
<td>2</td>
<td>Patient 1 post protamine</td>
<td>7/23/2014 19:14:13</td>
<td>152.0</td>
<td>1.0</td>
<td>1.1</td>
<td>0.9</td>
<td>78.6</td>
<td></td>
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<tr>
<td>1</td>
<td>Patient 1 post protamine</td>
<td>7/23/2014 19:13:51</td>
<td>121.0</td>
<td>0.8</td>
<td>0.8</td>
<td>0.8</td>
<td>80.6</td>
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<td>7/23/2014 19:13:51</td>
<td>183.0</td>
<td>0.9</td>
<td>1.4</td>
<td>7.0</td>
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<tr>
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<td>Patient 1 post protamine</td>
<td>7/23/2014 19:13:51</td>
<td>152.0</td>
<td>1.0</td>
<td>1.1</td>
<td>0.8</td>
<td>81.5</td>
<td></td>
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<tr>
<td>2</td>
<td>Patient 1 post protamine</td>
<td>7/23/2014 19:13:51</td>
<td>214.0</td>
<td>1.2</td>
<td>1.8</td>
<td>2.1</td>
<td>63.1</td>
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</tr>
</tbody>
</table>

**Interim Value**
**Citrated RapidTEG**

Sample: 7/24/2014 08:23-08:42

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEG ACT sec</td>
<td>113.0</td>
</tr>
<tr>
<td>SP min sec</td>
<td>94 — 126</td>
</tr>
<tr>
<td>R min</td>
<td>0.7</td>
</tr>
<tr>
<td>K min</td>
<td>0.8</td>
</tr>
<tr>
<td>Angle deg</td>
<td>79.0</td>
</tr>
<tr>
<td>MA mm</td>
<td>66.7</td>
</tr>
<tr>
<td>G d/sc</td>
<td>10.0K</td>
</tr>
<tr>
<td>EPL %</td>
<td>5.3K — 16.2K</td>
</tr>
<tr>
<td>LY30 %</td>
<td>*0%</td>
</tr>
<tr>
<td>CI</td>
<td>*0%</td>
</tr>
</tbody>
</table>

Click on a tracing to show details
<table>
<thead>
<tr>
<th>Channel</th>
<th>Patient name</th>
<th>Sample description</th>
<th>TEG ACT (sec)</th>
<th>SP (min)</th>
<th>R (min)</th>
<th>K (min)</th>
<th>Angle (deg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Patient 1</td>
<td>CRTH - 1 post protamine</td>
<td>121.0</td>
<td>0.6</td>
<td>0.8</td>
<td>1.8</td>
<td>67.8</td>
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<tr>
<td>1</td>
<td>Patient 1</td>
<td>CRT - C 1 post protamine</td>
<td>136.0</td>
<td>0.8</td>
<td>0.9</td>
<td>1.6</td>
<td>71.9</td>
</tr>
<tr>
<td>1</td>
<td>Patient 1</td>
<td>CRT - C 1 Baseline</td>
<td>136.0</td>
<td>0.8</td>
<td>0.9</td>
<td>1.3</td>
<td>72.7</td>
</tr>
</tbody>
</table>
PRELIMINARY

TEG® Analysis

Generated: 7/24/2014 8:00:24AM

Sample Date: 7/24/2014
Time on: 08:23
Off: 08:42
Duration: 10 min

Patient:
ID: SSN:
Birthday: Age: Gender:

Sample type: Clotted RapidTEG
Description: Baseline

Channel: 1
Sample status: Finished
Temp: 37

Site ID:
Operator ID: mcgradh

Ordered by:
Platelet drugs administered: No
Bleeding state:
Patient temperature:

Accession #:
Analyzer SN: S111103555

Result reported:
Reported date:
Reported by:

<table>
<thead>
<tr>
<th>Sample data:</th>
<th>Units:</th>
<th>Normal values:</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEG ACT: 113.0 sec</td>
<td>(64 — 120)</td>
<td></td>
</tr>
<tr>
<td>SP: 0.6 min</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R: 0.7 min</td>
<td>(2 — 1)</td>
<td></td>
</tr>
<tr>
<td>K: 0.8 min</td>
<td>(1 — 2)</td>
<td></td>
</tr>
<tr>
<td>Angle: 70.0 deg</td>
<td>(64 — 60)</td>
<td></td>
</tr>
<tr>
<td>MA: 56.7 mm</td>
<td>(62 — 71)</td>
<td></td>
</tr>
<tr>
<td>G: 10.9K dsc</td>
<td>(5.5K — 16.2K)</td>
<td></td>
</tr>
<tr>
<td>EPL: <em>0.0</em> %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LY30: <em>0.0</em> %</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Interim values are surrounded by asterisks* - Results final
<table>
<thead>
<tr>
<th></th>
<th>When and Where?</th>
<th>What tube?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Platelet Mapping</strong></td>
<td>-Pre OP&lt;br&gt;- Performed in Specialty Coag Lab</td>
<td>1 Blue top tube&lt;br&gt;1 Green top tube</td>
</tr>
<tr>
<td><strong>Baseline rTEG</strong></td>
<td>-After induction of Anesthesia&lt;br&gt;-Performed in OR Suite</td>
<td>1 Blue top tube&lt;br&gt;-Clear cup&lt;br&gt;-Heparinase cup if patient is on heparin pre-op</td>
</tr>
<tr>
<td><strong>Post protamine rTEG</strong></td>
<td>-Same time as ACT is drawn post protamine&lt;br&gt;-Performed in OR Suite</td>
<td>1 Blue top&lt;br&gt;- Clear cup and heparinase cup</td>
</tr>
</tbody>
</table>
Experience with rTEG in Cardiac Cases

- 154 cases in first 4 months that used rTEG
  - Isolated AVR: 26
  - Isolated CABG: 35
  - Isolated MVR: 23
  - TAH: 9
  - VAD: 9
  - Heart Transplant: 9
  - Aortic aneurysm resection and/or aortic root repair: 9
  - Combined (CABG, AVR, MVR, TVR) and Re-dos, etc: 43
Impact on Isolated CABG and AVR

<table>
<thead>
<tr>
<th></th>
<th>Baseline Data</th>
<th>First 4 months of rTEG-guided cases</th>
<th>% decrease in utilization</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AVR</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>* plasma</td>
<td>1.2</td>
<td>0.43</td>
<td>64%</td>
</tr>
<tr>
<td>* platelet</td>
<td>0.6</td>
<td>0.23</td>
<td>62%</td>
</tr>
<tr>
<td><strong>CABG</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>* plasma</td>
<td>1.4</td>
<td>0.53</td>
<td>62%</td>
</tr>
<tr>
<td>* platelet</td>
<td>0.8</td>
<td>0.38</td>
<td>53%</td>
</tr>
</tbody>
</table>

* per case
Impact on Isolated CABG and AVR

- 22 out of 35 isolated CABG cases did not use any plasma or platelets
- 18 out of 26 isolated AVR cases did not use any plasma or Platelets
Total Artificial Heart (TAH) and Ventricular Assist Devices (VAD)

<table>
<thead>
<tr>
<th></th>
<th>First 4 month of rTEG-guided cases</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TAH</strong></td>
<td></td>
</tr>
<tr>
<td>* plasma</td>
<td>n= 9</td>
</tr>
<tr>
<td>* platelet</td>
<td>1.8</td>
</tr>
<tr>
<td><strong>LVAD</strong></td>
<td></td>
</tr>
<tr>
<td>* plasma</td>
<td>n=9</td>
</tr>
<tr>
<td>* platelet</td>
<td>1.4</td>
</tr>
</tbody>
</table>

* per case
Technical Challenges
Summary

• Implementation of rTEG has helped decrease utilization of non-RBC components

• This approach requires multi-disciplinary collaboration between the laboratory, surgeons, anesthesiologist and specialized teams including perfusionists

• Technical challenges may preclude widespread use at the point of care