What is More Risky: Anemia or Transfusion?
Data from the PERForm Registry

Kenneth G. Shann, CCP
Massachusetts General Hospital
Boston, MA
Disclosures

No Relationships to Disclose
Acknowledgements

- David Fitzgerald, CCP
- John Fuller, CCP
- Theron Paugh, CCP
- Tim Dickinson, MS
- Josh Goldberg, MD
- Gaetano Paone, MD
- Rich Prager, MD
- Donny Likosky, PhD
Prior work has demonstrated:

- An association between nadir HCT during CPB and adverse outcome
- An association between transfusion and adverse outcome

It is unclear if the risk is related to anemia or transfusion

We utilized the PERForm Registry to study the unique contribution of anemia and transfusion to morbidity and mortality
The least of 3 evils: Exposure to red blood cell transfusion, anemia, or both?

1. No negative exposures: nadir HCT $\geq 25\%$ without RBC transfusion ($n = 6937; 76\%$).
2. Single negative exposure: nadir HCT $\geq 25\%$ with RBC transfusion ($n = 246; 2.7\%$).
4. Double negative exposure: nadir HCT $< 25\%$ with RBC transfusion ($n = 956; 10\%$).

Submitting cases | Interested | Negotiating

Perfusion Measures and Outcomes (PERForm) Registry

AMERICAN SOCIETY OF EXTRACORPOREAL TECHNOLOGY
Focus on technology, circuit priming volume and constituents, medication utilization during CPB, blood management, cardioplegia strategies, temperature and volume management.
Perfusion Measures and Outcomes (PERForm) Registry

Surgical Data

Perfusion Data

Records Merged
Methods

• 14,126 consecutive patients at 26 institutions between 2010 – 2014

• Excluded patients with missing:
  – Predicted risk of mortality or prolonged ventilation
  – Hematocrit values
  – Intraoperative RBC transfusions
Methods

• Patients were divided into four groups
  – Nadir HCT ≥ 21 without transfusion
  – Nadir HCT ≥ 21 with transfusion
  – Nadir HCT < 21 without transfusion
  – Nadir HCT < 21 with transfusion

• Using logistic regression or Poisson models we studied the relationship between HCT, transfusion, 30-day mortality, prolonged ventilation and AKI

• We adjusted for predicted risk of mortality, prolonged ventilation, preoperative HCT and hospital
# Demographics

<table>
<thead>
<tr>
<th>Measure</th>
<th>Nadir Hct&gt;=21 / No RBC</th>
<th>Nadir Hct&gt;=21 / RBC</th>
<th>Nadir Hct&lt;21 / No RBC</th>
<th>Nadir Hct&lt;21 / RBC</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-operative</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Predicted Risk of Mortality (mean, sd)</td>
<td>1.9 (2.7)</td>
<td>5.3 (6.3)</td>
<td>3.1 (3.7)</td>
<td>5.1 (6.1)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Age (mean, sd)</td>
<td>64.7 (11.0)</td>
<td>69.6 (11.9)</td>
<td>67.5 (11.3)</td>
<td>69.5 (11.6)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Female (%)</td>
<td>21.3</td>
<td>48.7</td>
<td>54.3</td>
<td>64.6</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Body Mass Index (mean, sd)</td>
<td>30.5 (8.8)</td>
<td>28.5 (6.2)</td>
<td>29.5 (13.0)</td>
<td>29.1 (13.1)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Body Surface Area (mean, sd)</td>
<td>2.1 (0.25)</td>
<td>1.9 (0.26)</td>
<td>1.9 (0.24)</td>
<td>1.9 (0.24)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Weight (mean, sd)</td>
<td>91.0 (19.6)</td>
<td>80.1 (19.1)</td>
<td>79.9 (18.1)</td>
<td>77.3 (18.5)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Hematocrit, Last Pre-operative (mean, sd)</td>
<td>39.9 (4.8)</td>
<td>34.2 (5.6)</td>
<td>34.9 (4.9)</td>
<td>33.0 (5.1)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>
# Intraop Process

<table>
<thead>
<tr>
<th>Measure</th>
<th>Nadir Hct&gt;=21 / No RBC</th>
<th>Nadir Hct&gt;=21 / RBC</th>
<th>Nadir Hct&lt;21 / No RBC</th>
<th>Nadir Hct&lt;21/ RBC</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intra-operative</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Procedure (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Isolated CABG</td>
<td>65.7</td>
<td>43.4</td>
<td>58.7</td>
<td>54.1</td>
<td></td>
</tr>
<tr>
<td>Isolated Valve</td>
<td>22.5</td>
<td>29.1</td>
<td>23.8</td>
<td>21.6</td>
<td></td>
</tr>
<tr>
<td>CABG+Valve</td>
<td>9.9</td>
<td>21.4</td>
<td>15.6</td>
<td>20.7</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>1.9</td>
<td>6.2</td>
<td>1.9</td>
<td>3.7</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Pump time (mean, sd)</td>
<td>105.1 (44.7)</td>
<td>127.3 (68.2)</td>
<td>110.3 (53.8)</td>
<td>130.0 (69.4)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Clamp time (mean, sd)</td>
<td>80.7 (36.4)</td>
<td>92.7 (50.0)</td>
<td>83.5 (39.5)</td>
<td>95.7 (50.4)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Hematocrit (mean sd)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Last Pre-CPB</td>
<td>35.4 (4.7)</td>
<td>28.8 (4.9)</td>
<td>29.2 (3.2)</td>
<td>27.1 (4.2)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>First CPB</td>
<td>28.5 (4.6)</td>
<td>24.3 (3.0)</td>
<td>20.9 (2.7)</td>
<td>19.9 (2.9)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Nadir CPB</td>
<td>27.2 (4.2)</td>
<td>23.1 (2.3)</td>
<td>19.2 (1.2)</td>
<td>18.4 (1.7)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Last CPB</td>
<td>28.2 (4.3)</td>
<td>24.7 (2.7)</td>
<td>20.8 (2.3)</td>
<td>22.0 (2.9)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>
Results

Effect of Low Nadir HCT on CPB and Intra-operative Transfusion on Morbidity and Mortality

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>HCT ≥ 21-RBC</td>
<td>10,630</td>
<td>75</td>
</tr>
<tr>
<td>HCT ≥ 21+RBC</td>
<td>1,174</td>
<td>8</td>
</tr>
<tr>
<td>HCT &lt; 21-RBC</td>
<td>944</td>
<td>7</td>
</tr>
<tr>
<td>HCT &lt; 21+RBC</td>
<td>1,378</td>
<td>10</td>
</tr>
</tbody>
</table>

*Adjusted for predicted risk of mortality, preop HCT, institution

Relative to patients who had nadir HCT > 21 and no transfusion, patients exposed to transfusion had:

- 3-fold odds of mortality
- 2-fold odds of prolonged ventilation
- 20 – 30% increased odds of AKI
Possible Mechanism of Transfusion Injury

- RBCs undergo changes during storage
  - Decreased 2,3 DPG, ATP, and S-nitrosohemoglobin
  - Increased lactate, potassium, cytokines, iron, and free hemoglobin
  - Red cells become progressively less deformable and more fragile
  - Up to 25% of RBCs are predisposed to early hemolysis
- These changes can lead to impairment of O₂ delivery, increased inflammatory response, and increased oxidative stress
Standard 9: Blood Management

Standard 9.1: The Perfusionist shall participate in efforts to minimize hemodilution and avoid unnecessary blood transfusions\textsuperscript{13}

Standard 9.2: The Perfusionist shall minimize the cardiopulmonary bypass (CPB) circuit size to reduce prime volume\textsuperscript{13}

Standard 9.3: The perfusionist shall calculate and communicate to the surgical team prior to initiating CPB, a patient's predicted post-dilutional haemoglobin or hematocrit
Oxygen Delivery vs. HCT At Different Flow Rates

\[ DO_2 = Q(\text{indexed}) \times 10 \times (\text{HGB} \times 1.36 \times \text{SaO}_2 + \text{pO}_2 \times 0.003) \]

Cardiac Index

- 2.0
- 2.4
- 2.8

Summary

- Anemia is associated with poor outcome
- Transfusion is associated with poor outcome
- The combination of anemia and transfusion is associated with higher risk than the single exposure
- These data further support efforts to identify practices that minimize hemodilution, minimize anemia and ultimately minimize transfusion