Transfusion and Blood Conservation

Kenneth G. Shann, CCP
Assistant Director, Perfusion Services
Senior Advisor, Performance Improvement
Department of Cardiovascular and Thoracic Surgery
Montefiore Medical Center
New York
Disclosures

No Relationships to Disclose
Overview

- Risks of anemia and transfusion
- Concept of balancing hemodilution and oxygen delivery:
  - Preserve red cell mass
  - Avoid low nadir hematocrits
  - Modify CPB flow according to hematocrit
- Salvage the patient’s blood at the end of the procedure
- Participate in the creation and management of a multidisciplinary blood management team at your center
Adverse effects of low hematocrit during cardiopulmonary bypass in the adult: Should current practice be changed?

Robert H. Habib, PhD\textsuperscript{a,b,c}
Anoar Zacharias, MD\textsuperscript{a,b,c}
Thomas A. Schwann, MD\textsuperscript{a,b,c}
Christopher J. Riordan, MD\textsuperscript{a,b,c}
Samuel J. Durham, MD\textsuperscript{a,b,c}
Aamir Shah, MD\textsuperscript{a,b,c}

*J Thorac Cardiovasc Surg* 2003;125: 1438-50
Anemia is Bad! 
Does Transfusion Mitigate that?

- Ranucci M et al. Lowest hematocrit on cardiopulmonary bypass impairs the outcome in coronary surgery: an Italian multicenter study from the National Cardiothoracic Database. Tex Heart Inst J 2006; 33: 300-5.
The Association of Perioperative Red Blood Cell Transfusions and Decreased Long-Term Survival After Cardiac Surgery

BACKGROUND: Exposure to red blood cell (RBC) transfusions has been associated with increased mortality after cardiac surgery. We examined long-term survival for cardiac surgical patients who received one or two RBC units during index hospitalization.

METHODS: Nine thousand seventy-nine consecutive patients undergoing coronary artery bypass graft, valve, or coronary artery bypass graft/valve surgery at eight centers in northern New England during 2001–2004 were examined after exclusions. A probabilistic match between the regional registry and the Social Security Administration’s Death Master File determined mortality through June 30, 2006. Cox Proportional Hazard and propensity methods were used to calculate adjusted hazard ratios.

RESULTS: This analysis included 2254 patients receiving RBC transfusions. Exposure to 1 or 2 units of RBCs was associated with a 16% increased hazard of decreased survival after cardiac surgery. Hospitalization for cardiac surgery compared with those who received none ($P < 0.001$). After adjustment for patient and disease characteristics, patients exposed to 1 or 2 units of RBCs had a 16% higher long-term mortality risk (adjusted hazard ratios $= 1.16$, 95% CI: 1.01–1.34, $P = 0.035$).

Surgenor SD, Kramer RS, Olmstead EM, et al
- Septicemia/bacteremia
- Pneumonia

- Afib
- Prolonged ventilation
- Bleeding
- Renal Failure
- Quality of Life
- Mortality (short and long term)

**Relative Odds of Receiving Packed Red Blood Cells Transfusion**

<table>
<thead>
<tr>
<th>Factor</th>
<th>Odds Ratio Adjusted*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low HCT</td>
<td>15.5</td>
</tr>
<tr>
<td>Use of pump</td>
<td>7.91</td>
</tr>
<tr>
<td>Female Gender</td>
<td>2.37</td>
</tr>
<tr>
<td>Lower Body Weight</td>
<td>2.18</td>
</tr>
<tr>
<td>Older Age</td>
<td>1.99</td>
</tr>
</tbody>
</table>

\[ p \text{ value} < 0.001 \]

Which of these is modifiable by the operative team?
Body size is related to low nadir hematocrit during CPB


We can’t change the size of our patients, but we can customize our strategy to accommodate their size
Strategies to Minimize Hemodilution

- Minicircuits  
  (Class I Level of evidence A)

- Vacuum-assisted venous drainage  
  (Class IIb Level of evidence C)

- Retrograde autologous priming  
  (Class IIb Level B)

- Biocompatible CPB circuits  
  (Class IIb Level of evidence A)
Matching the Circuit to the Size of the Patient

Mrs. Nussbaum

- Oxygenator with integrated arterial filter
  - 140mL prime
  - 3/8 inch venous line
  - All circuit tubing length minimized
  - Biocompatible surface coating
  - Retrograde and antegrade autologous priming
  - Net prime 400mL
Retrograde and Antegrade Autologous Priming

- The passive displacement of crystalloid solution from the CPB circuit using the patient’s blood volume via the arterial and venous lines of the CPB circuit.
- Perceived benefits:
  - Less hemodilution during the initiation of CPB
    - ↑ Hemoglobin, COP, plasma and platelets
  - ↓ dilution of circulating pharmacologic agent
  - Reduced blood transfusions on CPB
  - Inexpensive

Post Dilutional HCT vs Body Weight With Different Hemodilution Strategies

First HCT in OR 35%
Oxygen Delivery During Cardiopulmonary Bypass and Acute Renal Failure After Coronary Operations

Marco Ranucci, MD, Federica Romitti, MD, Giuseppe Isgrò, MD, Mauro Cotza, CCP, Simonetta Brozzi, CCP, Alessandra Boncilli, CCP, and Antonio Ditta, CCP


\[ \text{DO}_2 = \text{pump flow} \times (\text{hemoglobin} \times 1.36 \times \text{hemoglobin saturation} + 0.003 \times \text{arterial oxygen tension}) \]
Oxygen Delivery vs. HCT At Different Flow Rates

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

Oxygen Delivery (ml/min/m²)

HCT (%)
Blood Salvage and Collaboration

- **Pump salvage** (Class IIa Level of evidence C)
- **Centrifugation** instead of direct infusion (Class IIa Level of evidence A)
- **Modified ultrafiltration (MUF)** (Class I Level of evidence A)
- **Multidisciplinary blood management teams** (Class IIa Level of evidence B)
Modified Ultrafiltration

- Using the cardioplegia pump, blood is pumped retrograde out of aorta, hemoconcentrated, and returned to right atrium
- Performed for 10 to 20 minutes
- 10-15mL/kg/min up to 500mL/min
- Volume removed through ultrafiltration is replaced with volume from CPB circuit
- Substances less than 65,000 daltons are removed

*Ann Thorac Surg 1994;58:573-4*
Blood Conservation Saves Lives?
Risk score matched patients!

The Impact of Blood Conservation on Outcomes in Cardiac Surgery: Is It Safe and Effective?

David M. Moskowitz, MD, Jock N. McCullough, MD, Aryeh Shander, MD,
James J. Klein, MD, Carol A. Bodian, DrPH, Richard S. Goldwein, MD, and
M. Arisan Ergin, MD

Department of Anesthesiology, Critical Care Medicine, Hyperbaric Medicine and Pain Management, Department of
Cardiothoracic Surgery, and Division of Cardiology, Department of Internal Medicine, Englewood Hospital and Medical Center,
Englewood, New Jersey; and Department of Anesthesiology, Division of Biostatistics, The Mount Sinai Hospital and Medical Center,
New York, New York

Background. Increasing evidence shows that perioperative
blood transfusion in cardiac surgery is associated with
increased postoperative morbidity and mortality and de-
creased long-term survival. Tolerance of "permissive ane-
mia" is an important element of perioperative blood con-
servation strategy. The safety of tolerating perioperative
anemia has been a significant deterrent for widespread
application of blood conservation. This study examines
whether blood conservation is equally safe or superior to the
common practice of transfusion in cardiac surgery.

Methods. The total study population consisted of
32,449 patients who underwent isolated coronary artery
bypass surgery from June 2000 until December 2004 with
complete data from 17 institutions in the State of New
Jersey. Englewood Hospital and Medical Center (EH) has a
well-established blood conservation program. Five
hundred eighty-six EH patients (blood conservation co-
hort) were compared with a propensity score-matched
cohort of 586 patients from the other New Jersey insti-
tutions (OH-M) representing the common practice of trans-
fusion. Outcomes were classified as very serious complic-
ations, serious complications, or neither (no very serious
complication or serious complication). Analysis con-
sisted of McNemar tests and multiple logistic regression.

Results. Fewer patients were transfused at EH com-
pared with OH-M (10.6% versus 12.5%; p < 0.0001). Englewood Hospital had 5 (0.8%) deaths versus 15 (2.5%)
in the OH-M group (p = 0.02). Of the EH patients, 11.1%
experienced a very serious complication or serious com-
lication versus 18.7% in the OH-M cohort (p = 0.002).
Transfusion was associated with an increased risk of an
adverse outcome in both cohorts (EH: odds ratio, 7.9; 95%
confidence interval, 3.7 to 14.4 versus OH-M: odds ratio,
4.6; 95% confidence interval, 2.8 to 7.9).

Conclusions. Blood conservation is safe and effective in
reducing transfusions. Tolerance of perioperative ane-
mia, which is one of the main components of blood
conservation, does not increase the risk of complications
or death in cardiac surgery. Avoidance of transfusion
reduces the risk of complications. This study further
validates the relationship between transfusion and adverse
outcome in cardiac surgery.

(Am Thorac Surg 2010;90:451-4)
© 2010 by The Society of Thoracic Surgeons

Table 1. Classification of Patients and Incidence of Complications

<table>
<thead>
<tr>
<th>Complicationa</th>
<th>EH (n = 586)</th>
<th>OH-M (n = 586)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very serious complications (VSC)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Death</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>Permanent stroke</td>
<td>8</td>
<td>15</td>
</tr>
<tr>
<td>Myocardial infarction</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Prolonged ventilation</td>
<td>15</td>
<td>55</td>
</tr>
<tr>
<td>Multisystem organ failure</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Cardiac arrest</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>Coma &gt;24 h</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Renalb</td>
<td>42</td>
<td>23</td>
</tr>
<tr>
<td>Serious complications (SC)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tamponade</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Postoperative bleeding</td>
<td>3</td>
<td>17</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>3</td>
<td>14</td>
</tr>
<tr>
<td>Sternal wound infection</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>Septicemia</td>
<td>0</td>
<td>12</td>
</tr>
<tr>
<td>Urinary tract infection</td>
<td>5</td>
<td>14</td>
</tr>
</tbody>
</table>

a This listing includes patients with multiple complications among the 82 Englewood Hospital (EH) and 80 propensity-matched patients at other hospitals (OH-M) who experienced at least one VSC, and among 44 EH and 29 OH-M patients who experienced at least one SC but no VSC.

b Includes patients whose creatinine is greater than 2.0 mg/dL or doubled from most recent preoperative creatinine level or who experienced renal failure requiring dialysis postoperatively.
Summary

• Anemia is bad
• Transfusion is not the answer
• Balance hemodilution and oxygen delivery
  – Match CPB circuit to size of patient
  – Retrograde and antegrade autologous prime
  – Modifying CPB flow rate will modify oxygen delivery and should be considered prior to transfusion
• Centrifugation and modified ultrafiltration should be considered for salvaging residual blood
• Perfusionists should actively participate in blood management
  • Collect and report transfusion data
  • Report variation in blood loss