Keeping the Focus of Transfusion Medicine on Patient Care

April 30, 2013
Heart of America Association of Blood Banks
No relevant financial relationships with any commercial interests
Blood Utilization – United States

- Surgenor HEJM 1990; 322:1646
- Wallace Transfusion 1995; 35: 802
- Wallace Transfusion 1998; 38: 625
Units Transfused per 1,000 Population

<table>
<thead>
<tr>
<th></th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012 est</th>
</tr>
</thead>
<tbody>
<tr>
<td>KC</td>
<td>43.6</td>
<td>43.9</td>
<td>45.3</td>
<td>43.5</td>
<td>39.8</td>
<td>38.2</td>
<td>35.6</td>
</tr>
<tr>
<td>US</td>
<td>48.9</td>
<td></td>
<td>49.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Units Transfused per 1,000 Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
</tr>
<tr>
<td>85,403</td>
</tr>
</tbody>
</table>

Slide 4
Hence, in my career, two significant downturns in transfusion utilization.

- Different scenarios / causes

Lessons to be learned?

- Past is prologue?

Four perspectives:

- Patients
- Clinicians
- Hospitals / Health Care Institutions
- Transfusion Medicine Specialists
Patients:

- Transfusion associated - HIV
- Autologous transfusions
- “Dread fear” of transfusions
Autologous Blood Collection/Transfusion

1980: Collected 28,000, Transfused 0
1982: Collected 28,000, Transfused 0
1984: Collected 58,000, Transfused 0
1986: Collected 200,000, Transfused 0
1987: Collected 397,000, Transfused 0
1989: Collected 770,000, Transfused 1,117,000
1992: Collected 1,117,000, Transfused 0
1994: Collected 750,000, Transfused 643,000
1997: Collected 651,000, Transfused 619,000
1999: Collected 619,000, Transfused 458,000
2001: Collected 335,000, Transfused 359,000
2004: Collected 270,000, Transfused 270,000
2006: Collected 189,000, Transfused 189,000
2008: Collected 159,000, Transfused 159,000
Cognitive Map

- Not observable
- Unknown
- Delayed

- Controllable
- Not dread
- Equitable
- Voluntary

- Observable
- Known
- Immediate

- Uncontrollable
- Dread
- Not equitable
- Involuntary

Factor 2
unknown risk

DNA Technology

nuclear reactor accidents

nuclear weapons fallout

Factor 1
dread risk

skyscraper fires

nuclear weapons (war)

auto accidents

dynamite

- caffeine

- ASA

- vaccines

- skateboards

- chainsaws

- bicycles

- fireworks
Clinicians:

- Consensus Conferences
- Transfusion Guidelines
- Assure transfusions given when benefit > risk
Hb values $\geq$ 10 g/dL - rarely require peri-op transfusion
Hb values $< 7$ g/dL - frequently require red cell transfusion

- Decision to Transfuse
  - Depends on clinical assessment aided by lab data
    - Arterial oxygenation
    - Mixed venous oxygen tension
    - Cardiac output
    - Oxygen extraction ratio
    - Blood volume

References:
- JAMA 1988; 260:2700-2703
- Transfusion Medicine Reviews 1988; 3:63-68
### Transfusion Requirements in Critical Care (TRICC)

**RCT critically ill Canadian ICU patients at 25 hospitals**

<table>
<thead>
<tr>
<th></th>
<th>Restrictive</th>
<th>Liberal</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>418 patients</td>
<td>420</td>
</tr>
<tr>
<td>Hb Trigger</td>
<td>7.0 g/dL</td>
<td>10.0</td>
</tr>
<tr>
<td>Maintenance Hb</td>
<td>7-9 g/dL</td>
<td>10-12</td>
</tr>
<tr>
<td>Leuko Reduction</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>RBC txf’d</td>
<td>2.6 units</td>
<td>5.6 p=0.01</td>
</tr>
<tr>
<td>No txf p randomization</td>
<td>33%</td>
<td>0% p&lt;0.01</td>
</tr>
<tr>
<td>Primary Outcome</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Death within 30 days</td>
<td>18.7%</td>
<td>23.3% p=0.11</td>
</tr>
<tr>
<td>Cardiac events (pulmonary edema, M.I.)</td>
<td>13.2%</td>
<td>21.0% p&lt;0.001</td>
</tr>
</tbody>
</table>

Transfusion Requirements in Critical Care (TRICC) - continued

RCT, critically ill Canadian ICU patients at 25 hospitals

Sub-group analysis – 30 day mortality

<table>
<thead>
<tr>
<th></th>
<th>Restrictive</th>
<th>Liberal</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>APACHE II scores &lt;20</td>
<td>8.7%</td>
<td>16.1%</td>
<td>&lt;0.03</td>
</tr>
<tr>
<td>Age &lt;55 years</td>
<td>5.77%</td>
<td>13.07%</td>
<td>=0.02</td>
</tr>
</tbody>
</table>

Conclusion: 7.0 g/dL threshold (7-9 g/dL maintenance) - effective
FOCUS (Functional Outcomes in Cardiovascular Patients Undergoing Surgical Hip Fracture Repair)

Liberal vs. Restrictive Transfusion Trigger Trial

- 10 g/dL vs. 8 g/dL or symptoms
- High risk patients (n = 2,016 patients; greater than 50 years old; H/O cardiovascular disease; Hb < 10 g/dL post surgery)
- 47 clinical sites
- Randomized, controlled clinical trial

Primary Outcome

- Death at 60 days
- Inability to walk across a room without assistance at 60 days

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Liberal</th>
<th>Restrictive</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>1007</td>
<td>1009</td>
</tr>
<tr>
<td>Age (years)</td>
<td>81.8</td>
<td>81.5</td>
</tr>
<tr>
<td>Cardiovascular Disease</td>
<td>63.3%</td>
<td>62.5%</td>
</tr>
<tr>
<td>Hypertension</td>
<td>82.2%</td>
<td>81.7%</td>
</tr>
<tr>
<td>DM</td>
<td>25.1%</td>
<td>25.5%</td>
</tr>
<tr>
<td>Hip Fracture:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Femoral Neck</td>
<td>43.0%</td>
<td>41.9%</td>
</tr>
<tr>
<td>- Intertrochanter</td>
<td>51.0%</td>
<td>51.8%</td>
</tr>
<tr>
<td>Hb (g/dL):</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Before Transfusion</td>
<td>9.2</td>
<td>7.9</td>
</tr>
<tr>
<td>- Symptoms leading to transfusion: tachycardia or hypotension</td>
<td>4.3%</td>
<td>12.2%</td>
</tr>
<tr>
<td>Leukocyte reduced RBC</td>
<td>90.2%</td>
<td>88.6%</td>
</tr>
<tr>
<td>Transfusion after randomization:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- 0</td>
<td>3.3%</td>
<td>59.0%</td>
</tr>
<tr>
<td>- 1</td>
<td>41.9%</td>
<td>24.4%</td>
</tr>
<tr>
<td>- 2</td>
<td>34.5%</td>
<td>12.6%</td>
</tr>
</tbody>
</table>

- p = significant

Carson JL, et al. NEJM 2011; 365:2453
### Outcomes

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Liberal</th>
<th>Restrictive</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Death or inability to walk 60 days</td>
<td>35.2%</td>
<td>34.7%</td>
<td>0.90</td>
</tr>
<tr>
<td>Death 30 days</td>
<td>5.2%</td>
<td>4.3%</td>
<td>NS</td>
</tr>
<tr>
<td>Death 60 days</td>
<td>7.6%</td>
<td>6.6%</td>
<td>NS</td>
</tr>
<tr>
<td>O.R. primary outcomes:</td>
<td>1.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Men</td>
<td>1.45</td>
<td></td>
<td>0.03</td>
</tr>
<tr>
<td>- Women</td>
<td>0.91</td>
<td></td>
<td>NS</td>
</tr>
<tr>
<td>Function &amp; Symptom Scale:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- In hospital myocardial infarction</td>
<td>2.3%</td>
<td>3.8%</td>
<td>NS</td>
</tr>
<tr>
<td>- CXR Infiltrate</td>
<td>6.0%</td>
<td>4.8%</td>
<td>NS</td>
</tr>
<tr>
<td>- Wound infection</td>
<td>1.4%</td>
<td>0.8%</td>
<td>NS</td>
</tr>
<tr>
<td>- Stroke or TIA</td>
<td>0.8%</td>
<td>0.3%</td>
<td>NS</td>
</tr>
<tr>
<td>- Death: M.I., pneumonia</td>
<td>8.9%</td>
<td>8.9%</td>
<td>NS</td>
</tr>
<tr>
<td>- Randomization to discharge (days)</td>
<td>3.67</td>
<td>3.97</td>
<td>NS</td>
</tr>
</tbody>
</table>

*No difference in mortality rates: transfusion vs. non-transfusion*

- **Conclusion:** Reasonable to withhold transfusion in absence of symptoms of anemia or decline < 8g/dL - even in elderly patients with underlying cardiovascular disease or risk factors

Hospitals / Health Care Institutions

• Risk Mitigation
• Informed consent
• Transfusion Committee Utilization Review
Transfusion Medicine Specialists

- Zero Risk
  - Product Safety
    - Infectious Disease Testing
    - Leukocyte reduction
  - Adherence to FDA regulations in:
    - Current Good Manufacturing Practices (cGMP)
    - Standardization
Risk Analysis -- early 1980's

- Transfusion-associated AIDS compared favorably with other more general risks
- Initially, these comparisons were helpful
- However, public eventually compared risk of transfusion-associated AIDS with less risky alternatives
- Stated comparisons involved voluntary activities
  - Blood transfusion is involuntary
Risk Analysis (cont'd)

- Number of deaths per year
  - e.g. 1 in 125,000 from leukemia
  - e.g. 1 in 588,000 from an earthquake in California
- Deaths per million hours pursuing an activity
  - e.g. 1 in 7,150 hours rock climbing
- A decision to undertake a "risk" is a personal decision based on quantifiable data
Benefits of Transfusion

- Perceived benefits ameliorate perceived risks
- "Milk - it does a body good"
milk it does a BODY GOOD
Trust

- Public relies on experts to provide stewardship and maintain quality
- Asymmetry between creating trust and destroying trust
  - Trust-destroying events are more noticeable than trust-building events
  - Bad news has more credibility than good news
Frame of Reference for Evaluating Improvements -- Prospect Theory

- Consider change from a reference position
- Restoration to a better, previous state versus improvement of current conditions
  - e.g. polluted river:
    - return to previous condition
    - improve the river
GET INVOLVED NOW.
POLLUTION HURTS ALL OF US.

You can help by becoming a community volunteer. Write:
Keep America Beautiful, Inc.
99 Park Avenue, New York, New York 10016
A Public Service of Transit Advertising & The Advertising Council.

People start pollution.
People can stop it.
Risk Reduction 1980’s – 90’s

- Good Laboratory Practice
- Product Safety > Recipient Safety
  - Infectious disease testing
  - Adherence to FDA regulations
    - Current Good Manufacturing Practices
    - Standardization
    - Zero Risk

Risk per unit

Modeled Risk: I – WP Model

Retrospective Measured Risk:
- Prescreening donor prevalence
- PCR / culture studies
- Recipient SC studies

Cohorts:
- TTVS
- NIH
- TSS

- Revised Donor Deferral Criteria
- HBSAg Screening
- HIV Antibody Screening
- Non-A, non-B Hepatitis Surrogate Testing
- HCV Antibody Screening
- p24 Antigen Testing
- HCV and HIV NAT

- Busch Transfusion 2006
Zero risk

- Multiple infectious disease tests
  - NAT in addition to EIA tests to reduce “window period”
    donations i.e. donations made between serologic and RNA/DNA detection
    - HIV: 11 days (22 → 11 days)
    - HCV: 63 days (70 → 10-25 days)
    - HBV: 29 days (69 → 40 days)
Missouri Hospitals Patient Discharges

MO Hospitals Patients Discharged

Year: 2006 to 2012

Discharge Count:
- 2006: 915,000
- 2007: 915,000
- 2008: 905,000
- 2009: 905,000
- 2010: 895,000
- 2011: 885,000
- 2012: 875,000
RBCs Billed - Units per Discharge

---

- X-axis: Years from 2006 to 2012
- Y-axis: Units per Discharge

Graph showing the trend of RBCs billed per discharge from 2006 to 2012.
Unemployment 8.2% in Kansas City
  • Widespread concern about job stability
  • Fewer donors at mobiles
  • Fewer patients with insurance

“Bad economy leads patients to put off surgery, or rush it” NY Times – March 13, 2009
  • Hip surgeries down 45%
  • Patients admitted to hospitals are sicker
  • Healthcare employment increasing
Patients:

- Great Recession
- Elective surgery procedure delayed
  - 10% of blood utilization
Clinicians:

- Adoptions of TRICC findings
- FOCUS results
- Pediatric/Low Birth Weight Studies
- Patient Blood Management Programs
  - Less is more
Hb < 7 g/dl (restrictive) versus Hb < 9.5 g/dl (liberal)
N = 320 and N = 317
Stable ICU Patients
Leukocyte-reduced RBC
Not blinded
Primary outcome: Multiple-organ-dysfunction syndrome (MODS)

<table>
<thead>
<tr>
<th></th>
<th>Restrictive</th>
<th>Liberal</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any transfusion</td>
<td>46%</td>
<td>98%</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Number of txf</td>
<td>301</td>
<td>542</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Hb before first txf</td>
<td>6.7</td>
<td>8.1</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>New/progressive MODS</td>
<td>12%</td>
<td>12%</td>
<td></td>
</tr>
</tbody>
</table>

Conclusion: Restrictive Strategy
- 96% reduction in transfusion exposure
- 44% fewer RBC’s transfused
- no increase in rate of new or progressive MODS in stable critically ill children (not applicable to premature infants or children with severe hypoxemia, hemodynamic instability, active blood loss, cyanotic heart disease)

Lacroix, et al. NEJM 2007; 356:1609
TRIPICU Sub-group Analysis

- Restrictive versus liberal strategy on MODS and adverse outcomes in critically ill stabilized children with sepsis or septic shock.
- N = 137 septic patients
- Randomization: N=69 restrictive versus N=68 liberal strategy

<table>
<thead>
<tr>
<th></th>
<th>Restrictive</th>
<th>Liberal</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Received Transfusion</td>
<td>56%</td>
<td>99%</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Median txf volume (mL/Kg)</td>
<td>7.6</td>
<td>15.7</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>New/progressive MODS</td>
<td>18.8%</td>
<td>19.1%</td>
<td>NS</td>
</tr>
</tbody>
</table>

**Conclusion:** Restrictive strategy may be safe for hemodynamically stabilized septic patients admitted to the PICU (most severely ill with sepsis were excluded).

2 RCT’s
Different study designs, study populations, Hb threshold

<table>
<thead>
<tr>
<th></th>
<th>Percent Transfused</th>
<th>Number Transfusions</th>
<th>Death/Severe Morbidity</th>
<th>Cognitive Delay</th>
<th>Adverse Brain Event</th>
<th>Apneic Episode</th>
</tr>
</thead>
<tbody>
<tr>
<td>PINT/PINT-OS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Low Threshold</td>
<td>89%</td>
<td>4.9</td>
<td>74.0%</td>
<td>24.4%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• High Threshold</td>
<td>95%</td>
<td>5.7</td>
<td>69.7%</td>
<td>17.6%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• P Value</td>
<td>0.037</td>
<td>0.070</td>
<td>0.25</td>
<td>0.06</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iowa</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Restrictive</td>
<td>90%</td>
<td>2.7</td>
<td></td>
<td></td>
<td>12%</td>
<td>0.84</td>
</tr>
<tr>
<td>• Liberal</td>
<td>88%</td>
<td>4.8</td>
<td></td>
<td></td>
<td>0%</td>
<td>0.43</td>
</tr>
<tr>
<td>• P Value</td>
<td>1.0</td>
<td>0.006</td>
<td></td>
<td></td>
<td>0.012</td>
<td>0.004</td>
</tr>
</tbody>
</table>

**Conclusion:** Concern about brain injury; higher Hb transfusion threshold → neuro-protection

Hospitals:

- Reimbursement rates restrained
- Lean / Six Sigma
- Cost containment
- Consolidation of hospitals into hospital systems
Transfusion Costs

Fig. 2. Total costs of blood transfusions showing all contributing cost elements at two US and two European hospitals in 2007. Costs at CHUV (SF) and AKH (CH) converted to $USD using 1-year currency conversion average (May 2006-May 2007). Percentages of each contributing element shown next to $USD amount.
• Cost of transfusion in surgical setting
• Activity-based costing study
• Four Hospitals – Three Countries
• Cost of transfusion for surgical procedures higher than previously reported

<table>
<thead>
<tr>
<th></th>
<th>NEW JERSEY</th>
<th>RHODE ISLAND</th>
<th>SWITZERLAND</th>
<th>AUSTRIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost per Unit</td>
<td>$1,183</td>
<td>$726</td>
<td>$611</td>
<td>$522</td>
</tr>
<tr>
<td>Consent Requirements</td>
<td>2.5%</td>
<td>2.5%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outsource In-Hospital Management</td>
<td></td>
<td></td>
<td>- 4%</td>
<td>- 4%</td>
</tr>
<tr>
<td>Indirect Costs</td>
<td>40%</td>
<td>40%</td>
<td>33%</td>
<td>33%</td>
</tr>
</tbody>
</table>

Blood Management
Bloodless Surgery

- Custer. *Transfusion* 2010; 50:742
Dollars per Quality Adjusted Life-Year (QALY)

1983 - Revised HIV Risk Behavior Donor Criteria
1985 - HIV Sero-Testing
1987 - Non A, Non B Sero-Testing (ALT, Anti-HBc)
1988 - HTLV Sero-Screening
1990 - HCV Sero-Screening
1996 - HIV p24 Antigen Testing
1999 - HIV and HCV NAT (p24 antigen testing discontinued)
2003 - West Nile Virus NAT
2007 - T. cruzi Sero-Testing (all donors)
2009 - T. cruzi Sero-Testing (first time donors only)
2010 - Minipool HIV / HCV / HBV NAT
Transfusion Medicine Specialists

- Transfusion related fatalities
- Patient based innovations
  - Match RBC & FFP
  - Antibody Registry
  - Gift of Smiles Program
  - Patient Blood Management – Outcomes
Figure 1. Pleating Risk Scale for Major Transfusion Hazards

Source: Sunny Dzik, MD. Data: 2001
Transfusion-Related Fatalities by Complication, FY2007 through FY2011

<table>
<thead>
<tr>
<th>Complication</th>
<th>FY07</th>
<th>FY08</th>
<th>FY09</th>
<th>FY10</th>
<th>FY11</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRALI</td>
<td>34</td>
<td>16</td>
<td>13</td>
<td>18</td>
<td>10</td>
</tr>
<tr>
<td>HTR (non-ABO)</td>
<td>2</td>
<td>7</td>
<td>8</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>HTR (ABO)</td>
<td>3</td>
<td>10</td>
<td>4</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Microbial Infection</td>
<td>6</td>
<td>7</td>
<td>5</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>TACO</td>
<td>5</td>
<td>3</td>
<td>12</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>Anaphylaxis</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Other</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Number of Fatalities
## Reports of TRALI by Implicated Blood Product
**FY2007 through FY2011**

<table>
<thead>
<tr>
<th>Blood Product</th>
<th>FY07</th>
<th>FY08</th>
<th>FY09</th>
<th>FY10</th>
<th>FY11</th>
</tr>
</thead>
<tbody>
<tr>
<td>FFP</td>
<td>12</td>
<td>4</td>
<td>2</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>RBC</td>
<td>12</td>
<td>5</td>
<td>6</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>FP24</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Platelets Pheresis</td>
<td>1</td>
<td>5</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Pooled Platelets</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Multiple Products</td>
<td>9</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>1</td>
</tr>
</tbody>
</table>

**Number**

---

*Slide 47*
- Fresh whole blood versus reconstituted whole blood → no advantage*
- Decrease donor exposure
  - Children’s Mercy Hospital, Kansas City**
  - Match RBC’s and FFP from same donor
    - Saved 132 exposures for 166 patients (3-month period)
    - 81 of 83 open-heart operations – primed with RBC and FFP from same donor (Jan-Jun, 2004)

* Mou. et al. NEJM 2004; 351:1635
** Hamilton, Menitove. NEJM 2005; 352:731
Fig. 1. Searching for a patient record.

Schwickerath, et al Transfusion; 50: 1465
**TABLE 3. Registry experience reported by hospitals and IRL**

<table>
<thead>
<tr>
<th>Antibody(-ies) recorded in registry</th>
<th>Registry checked before transfusion</th>
<th>Antibody(-ies) detected at the hospital</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anti-K, -C, and -V</td>
<td>Yes</td>
<td>None</td>
</tr>
<tr>
<td>Anti-K, -E, and -c</td>
<td>Yes</td>
<td>Anti-K only</td>
</tr>
<tr>
<td>Anti-E and -Fy^a</td>
<td>Yes</td>
<td>Anti-E only</td>
</tr>
<tr>
<td>Anti-K</td>
<td>Yes</td>
<td>None</td>
</tr>
<tr>
<td>Anti-Lw^b and -S</td>
<td>No</td>
<td>None</td>
</tr>
<tr>
<td>Anti-Tc^a</td>
<td>No</td>
<td>Antibody detected, not identified as anti-Tc^a</td>
</tr>
<tr>
<td>Anti-C, -E, and -Le^x</td>
<td>No</td>
<td>None</td>
</tr>
<tr>
<td>Anti-D, -E, -C^x, -Fy^a, and -S^x</td>
<td>No</td>
<td>Anti-D and -E only</td>
</tr>
</tbody>
</table>

* Reported in first 6 months of the second year.
Transfusion by the Numbers: August 2009 – July 2011

- 1442 RBC Tx
- 33 Patients Total

100% Antigen Matched

9 Days Average RBC Age

ZERO

Tx: Donor Ratio
- 1.2 Sept 11
- 1.18 July 11
- 1.14 Feb 11

20 Patients
- Sept 2011

941 Donors
- Gift of Smiles Program

New Antibodies
- Jehovah’s Witness’ patients
  - N = 2,083
  - Surgical procedures (13 hospitals, 1981-1994)
  - Average age = 57 years

<table>
<thead>
<tr>
<th>Hb Concentration</th>
<th>Morbidity</th>
<th>Mortality Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.1 – 8.0 g/dL</td>
<td>09.4%</td>
<td>0%</td>
</tr>
<tr>
<td>6.1 – 7.0</td>
<td>22.0%</td>
<td>08.9%</td>
</tr>
<tr>
<td>5.1 – 6.0</td>
<td>28.6%</td>
<td>09.3%</td>
</tr>
<tr>
<td>4.1 – 5.0</td>
<td>57.7%</td>
<td>34.4%</td>
</tr>
<tr>
<td>3.1 – 4.0</td>
<td>52.6%</td>
<td>25.0%</td>
</tr>
<tr>
<td>2.1 – 3.0</td>
<td>91.7%</td>
<td>54.2%</td>
</tr>
<tr>
<td>1.1 – 2.0</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Arrhythmia, CHF, M.I., bacteremia, pneumonia, wound infection, death
Re-analysis of *Transfusion* 2002; 42:812

<table>
<thead>
<tr>
<th>Hb Concentration</th>
<th>Median Days Prior to Death</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1 – 5.0 g/dL</td>
<td>11</td>
</tr>
<tr>
<td>3.1 – 4.0 g/dL</td>
<td>2</td>
</tr>
<tr>
<td>2.1 – 3.0 g/dL</td>
<td>2.5</td>
</tr>
<tr>
<td>&lt; 2.0 g/dL</td>
<td>1.0</td>
</tr>
</tbody>
</table>

- Temporal latitude exists for treating profound anemia
- Only 10% developed cardiac arrhythmias
- Absence of cardiac sx’s understates poor clinical outcome

Recommendation 1:
  • Restrictive strategy (7-8 g/dL Hb)
    - Hospitalized, stable patients

Recommendation 2:
  • Restrictive strategy
    - Hospitalized patients with pre-existing cardiovascular disease
    - Consolidation of txf for patients with sx’s or Hb ≤ 8 g/dL

Recommendation 3:
  • No recommendation for hospitalized, hemodynamically stable patients with acute coronary syndrome

Recommendation 4:
  • Txf decisions influenced by sx’s as well as Hb

March 26, 2012
Percent of Patients Receiving Transfusions
with Hemoglobin > 10g/dL at Discharge

<table>
<thead>
<tr>
<th></th>
<th>CV</th>
<th>ER</th>
<th>FP</th>
<th>GI</th>
<th>Gen Surg</th>
<th>Med</th>
<th>Neph</th>
<th>Onc</th>
<th>OB/GYN</th>
<th>Ortho</th>
<th>Pulm</th>
</tr>
</thead>
<tbody>
<tr>
<td>HOSPITAL A - 2Q09</td>
<td>48%</td>
<td>47%</td>
<td>59%</td>
<td>66%</td>
<td>60%</td>
<td>52%</td>
<td>52%</td>
<td>29%</td>
<td>20%</td>
<td>52%</td>
<td>67%</td>
</tr>
<tr>
<td>HOSPITAL B - 2009</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>50%</td>
<td>37%</td>
<td>0%</td>
<td>38%</td>
<td>16%</td>
<td>6%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>HOSPITAL C - 2Q09</td>
<td>52%</td>
<td>35%</td>
<td>57%</td>
<td>0%</td>
<td>59%</td>
<td>46%</td>
<td>38%</td>
<td>0%</td>
<td>9%</td>
<td>58%</td>
<td>0%</td>
</tr>
<tr>
<td>HOSPITAL F - 3Q10</td>
<td>36%</td>
<td>17%</td>
<td>61%</td>
<td>38%</td>
<td>0%</td>
<td>40%</td>
<td>42%</td>
<td>44%</td>
<td>24%</td>
<td>13%</td>
<td>44%</td>
</tr>
<tr>
<td>HOSPITAL G - 3Q10</td>
<td>0%</td>
<td>0%</td>
<td>36%</td>
<td>29%</td>
<td>0%</td>
<td>30%</td>
<td>0%</td>
<td>50%</td>
<td>0%</td>
<td>44%</td>
<td>0%</td>
</tr>
<tr>
<td>Hospital</td>
<td>2009-10</td>
<td>2012</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------</td>
<td>---------</td>
<td>------</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>48%</td>
<td>17%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>27%</td>
<td>25%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>40%</td>
<td>27%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G</td>
<td>38%</td>
<td>50%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Majority are decreasing (#) compared to increasing (*).
Adverse effects of RBC transfusion contrasted with other risks. Risk is depicted on a logarithmic scale.


©2012 by American College of Physicians
Transfusion Medicine

• Utilization peaks and valleys
  - Reflect safety and efficacy, the economy, and outcomes
• Product safety standards – highest achieved to date
• Next generation
  - Less is more – patient outcomes and cost
  - Continued focus on patient support
    - Cellular therapy including cancer vaccination protocols
    - Regenerative medicine
• Paradigm change
  - Zero risk → Risk based decision making
  - Pathogen reduction (chemical, photo/chemical treatments of red cells, platelets and plasma)
Questions and Answers