Principles of Perioperative Autologous Cell Processing

AmSECT International Conference
Reno, Nevada: April 27, 2010

Preparation / Review for IBBM PBMT Exam

No disclosures or conflicts to report
# Perioperative Blood Management Technologist [PBMT] Job Domain Analysis

*Theoretical Hierarchical Construct for K/S/A for Competency Exam*

<table>
<thead>
<tr>
<th>Environmental Factors</th>
<th>Equipment / Disposables</th>
<th>Patient Care Procedures</th>
<th>Critical Incidents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inter-team member communication and patient privacy [1.3]</td>
<td>Disposable supplies and interface with hardware [2.3]</td>
<td>Follow guideline indications for use and record keeping [3.3]</td>
<td>Respond correctly to critical incidents and emergencies [4.3]</td>
</tr>
</tbody>
</table>

Increasing complexity, proficiency and difficulty

Riley, April, 2008
## April 2010: Examination Plan

<table>
<thead>
<tr>
<th>Section</th>
<th>Label</th>
<th>Items</th>
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**Total** | 110 | 1.00 | 110 | 1.00
# Perioperative Blood Management Technologist (PBMT) Job Domain Analysis

## Theoretical Hierarchical Construct for K/S/A for Competency Exam

<table>
<thead>
<tr>
<th>Environmental Factors</th>
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<td>Hardware and device technical knowledge [2.1]</td>
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<tr>
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Increasing complexity, proficiency and difficulty

Riley, April, 2008
Intraoperative Autologous Transfusion
Principles of Cell Washing for the PBMT

Objectives / Review Areas

"I'M HOPING THAT, BY THE TIME EVERYONE SEES OUR SIGN, STICKER SHOCK WILL JUST BE A PART OF DAILY LIVING!!"
- RBCs
- WBCs
- Platelets
- Buffy Coat
- Plasma
- Hematocrit
- Hemoglobin
- Hemolysis
- Hemoglobinuria
- Blood typing / Rh

\[ Hb \text{ g/dL} \approx \frac{\% \text{ HCT}}{3} \]
Effects of Hemodilution

- Reduces blood viscosity
- Reduced hematocrit decreases total vascular resistance
- Marked dropped in perfusion pressure followed by compensatory increase in cardiac output
- Patients with arterial occlusive disease may be susceptible to ischemia
- Surgical bleeding results in less RBC loss
- Transfusion triggers are important
- What is ANH (acute normovolemic hemodilution)?
Whole blood

**Plasma**
- Proteins / Lipids
- Antibodies
- Electrolytes
- Water

'Buffy' coat
- Platelets
- White blood cells

Red blood cells
- Hemoglobin

Blood separation technology

- Plasma components, clotting factors
- platelets & WBCs
- Packed RBCs & platelets

PRP v. PPP

Hematocrit:
- 55% Plasma
- Water
- Proteins
- Salts
- Lipids

- 45% Formed Elements
  - Red cells: 4,200,000 - 6,200,000 / ul
  - White cells: 4,500 - 11,000 / ul
  - Platelets: 150,000 - 400,000 / ul
Whole blood

Plasma

Proteins / Lipids
Antibodies
Electrolytes
Water

'Buffy' coat

Platelets
White blood cells

Red blood cells

Hemoglobin

Platelet rich plasma (PRP) sequestration, platelet gel / glue, AGF\textsuperscript{tm}, Stem cell harvesting

collect whole blood

separate\* plasma, RBCs and 'buffy' coat

Keep the plasma?

NO

Decant concentrated 'buffy' coat rich with PLTs

Return RBCs

Return PP plasma

Keep the cells?

YES

PLT rich concentrate delivered to surgeon

NO

* Via centrifuge
Common BCST Terminology

- adsorption column
- aggregated growth factor
- antibodies
- apheresis
- autoimmune disease
- autotransfusion
- bovine
- ‘buffy’ coat
- cell processing
- centrifugation
- colony stimulating factors
- cryoglobulin
- erythrocyte (RBC)
- fibrinogen
- filtration
- granulocytes (WBC)
- hemoconcentration
- hemofiltration
- leukocyte (WBC)
- lymphocyte (WBC)
- leukodepletion
- photopheresis
- platelet derived growth factor
- platelet gel or glue
- platelet poor / rich plasma
- platelet-pheresis
- rheumatoid arthritis
- thrombin
- thrombocyte (platelet)
- transforming growth factor
Clotting Factors in plasma

### Normal Lab Values

<table>
<thead>
<tr>
<th>Factor</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Fibrinogen</td>
</tr>
<tr>
<td>II</td>
<td>Prothrombin</td>
</tr>
<tr>
<td>III</td>
<td>Platelet factor 3 (thromboplastin)</td>
</tr>
<tr>
<td>IV</td>
<td>Calcium</td>
</tr>
<tr>
<td>V</td>
<td>Labile factor (proaccelerin)</td>
</tr>
<tr>
<td>VI</td>
<td>Not assigned</td>
</tr>
<tr>
<td>VII</td>
<td>Stable factor (proconvertin)</td>
</tr>
<tr>
<td>VIII</td>
<td>Antihemophilic factor A (AHF)</td>
</tr>
<tr>
<td>IX</td>
<td>Antihemophilic factor B</td>
</tr>
<tr>
<td>(Christmas factor)</td>
<td></td>
</tr>
<tr>
<td>X</td>
<td>Stuart-Prower Factor</td>
</tr>
<tr>
<td>XI</td>
<td>Antihemophilic factor C (PTA)</td>
</tr>
<tr>
<td>XII</td>
<td>Hageman factor</td>
</tr>
<tr>
<td>XIII</td>
<td>Fibrin-stabilizing factor (FSF)</td>
</tr>
</tbody>
</table>

*Factors V and VIII are not true serine proteases, but are commonly referred to as such.*

Dailey pp 61; Brodie pp 41
Stem Cells

Dailey pp 4; Austin pp 11
Potential Uses for Stem Cells

<table>
<thead>
<tr>
<th>Potential Uses for Stem Cells</th>
</tr>
</thead>
<tbody>
<tr>
<td>Growing nerve cells to repair spinal injuries and restore function to paralyzed limbs.</td>
</tr>
<tr>
<td>Growing heart muscle cells to replace useless scar tissue after a heart attack.</td>
</tr>
<tr>
<td>Making brain cells that would secrete dopamine for the treatment and control of Parkinson's disease.</td>
</tr>
<tr>
<td>Growing cells that make insulin, creating a lifelong treatment for diabetes.</td>
</tr>
<tr>
<td>Growing bone marrow to replace blood-forming organs damaged by disease or radiation.</td>
</tr>
<tr>
<td>Making blood cells genetically altered to resist specific disease, such as HIV, to replace diseased blood cells.</td>
</tr>
</tbody>
</table>

Source: James Thomson, assistant professor of anatomy at the University of Wisconsin Medical School, and John Gearhart, a professor of GYN/OB and physiology at Johns Hopkins University School of Medicine

What happens to platelets during normal cell processing?
RBC antigens and antibodies

Figure 4.1 ABO BLOOD GROUPING COMPATIBILITY

Figure 5.6 RED BLOOD CELL HEMOLYSIS

One cause of red cell hemolysis is the oposinization of complement protein on the red cell membrane.

Dailey, pp 26, 38
**Blood Typing: RBCs**

- Group A has anti-B antibodies
- Group B has anti-A antibodies
- Group AB has both antigens and no antibodies
- Group O has no antigens and both antibodies

---

**Types of Components**

<table>
<thead>
<tr>
<th>Component</th>
<th>Volume/Unit</th>
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<td>Plasma (FFP)</td>
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</tr>
<tr>
<td>Plasma Cryoprecipitate</td>
<td>180-250 mL</td>
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<tr>
<td>Reduced</td>
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</tr>
<tr>
<td>Cryoprecipitate</td>
<td>10-20 mL</td>
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</table>

**Compatibility**

**ABO**
- Plasma components should be ABO compatible.

<table>
<thead>
<tr>
<th>Patient Group</th>
<th>Compatible Donor Groups for Plasma*</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>A, AB</td>
</tr>
<tr>
<td>B</td>
<td>B, AB</td>
</tr>
<tr>
<td>AB</td>
<td>AB</td>
</tr>
<tr>
<td>O</td>
<td>A, B, AB, O</td>
</tr>
</tbody>
</table>

* Cryoprecipitate may be given without regard to ABO type in adults.

**Rh**
- Plasma and cryoprecipitate may be transfused without regard to Rh type.

---

Dailey, pp 26
**Risks Allogeneic Transfusion**

### TABLE 1. Risks of transfusion

<table>
<thead>
<tr>
<th>Risk</th>
<th>Occurrence</th>
<th>Mortality</th>
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<tbody>
<tr>
<td>1. Hepatitis B</td>
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</tr>
<tr>
<td>2. Hepatitis C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. HIV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. HTLV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. TTV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. West Nile virus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Cytomegalovirus conversion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Epstein-Barr virus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. TRALI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. ABO-Rh mismatch</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Delayed hemolytic reaction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Alloimmunization (PLTs and WBCs)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. Alloimmunization (RBCs)</td>
<td></td>
<td></td>
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<tr>
<td>14. Allergic reactions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15. Febrile reaction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16. GVHD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17. Volume overload</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18. Depressed erythropoiesis</td>
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</table>

* Some of the reported risks of transfusion may be either as risk per number of units transfused or as an absolute risk.

**Fig. 1.** The Kaplan-Meier mortality curves for those patients transfused perioperatively and for those not transfused. Those patients not transfused had approximately 2.5-fold better survival than those that received one or more units of RBCs during their CABG hospital stay. These data were after propensity analysis weighting confounding events and risks. Reprinted with permission from Engoren et al.³⁸

Spiess BD. Risks of transfusion: Outcome focus. *Transfusion.* 2004;44:4S-14S
Simulation flow for basic PBMT defined competencies

Quick set-up reservoir and anti-coagulant drip → Review patient medical record and start ATS procedure record; [Checklist] → Monitor patient blood loss follow ATS P&Ps; [Indications / contraindications]

Set-up cell processing disposable equipment → Process shed blood according to protocol; Perform Q/C → Interact effectively with OR team; Communicate safely with surgeon and anesthesia

Document procedure accurately; Follow perioperative P&Ps → Conduct safe clean-up procedure

Where are the failure modes?
# Blood Management Techniques During Phases of Operative Period

## Perioperative Blood Management

<table>
<thead>
<tr>
<th>Pre-Op</th>
<th>Anesthetic</th>
<th>Operative</th>
<th>Post-Op</th>
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<tbody>
<tr>
<td>Hematologic analysis</td>
<td>Pharmacology</td>
<td>Meticulous hemostasis</td>
<td>ATS: Cell processing</td>
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<tr>
<td>Plan for hemorrhage</td>
<td>BCST, Cellular therapies</td>
<td>ATS: Cell processing</td>
<td>Cell washing</td>
</tr>
<tr>
<td>Pharmacology</td>
<td>Plasma sequestration</td>
<td>Tissue glue</td>
<td>Transfusion</td>
</tr>
<tr>
<td>Pre-donation</td>
<td>RBC sequestration</td>
<td>Platelet gel</td>
<td>Total leukocyte depletion</td>
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<tr>
<td>Pheresis</td>
<td>Hypotension</td>
<td>Ultrafiltration</td>
<td>Ultrafiltration</td>
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<td>Exchange transfusion</td>
<td>Transfusion</td>
<td>Surface treatments</td>
<td>Hematologic monitoring</td>
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<tr>
<td>Genetic therapy</td>
<td>Non-blood vol expansion</td>
<td>Transfusion</td>
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<tr>
<td>Transfusion</td>
<td>Artificial blood</td>
<td>Rapid infusion</td>
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<tr>
<td>Hematologic monitoring</td>
<td>Hematologic monitoring</td>
<td>Artificial blood</td>
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Safe IAT Circuit

Failure modes?
Hemoconcentration

• Hemoconcentrators
  – Dialysis
  – Ultrafiltration

• Centrifuge
  – Single bowl
  – Continuous processing

• Filtration
  – Micro-aggregate filtration
  – Leukocyte-depleting filters
Anticoagulation for ATS

• ACD, CPD
  – 15 ml/100 ml shed blood
  – 1:7 ratio
  – $[\text{Ca}^{+2}]$
  – Thrombocytes

• Heparin solution
  – (30,000 IU/L)
  – 1:7 ratio
  – Antithrombin
Organizations

- FDA
- OSHA
- CDC
- JC
- CAP
- CMS
- AABB
- ASA
- AmSECT

- Hand hygiene
- Body fluid precautions
- Blood labeling
- Storage time
- Body fluid exposure
- Sharps
- Contaminated waste
- PPE
- Guidelines for PABCT
- GLP
- POCT
Collection System / Vacuum

- Filtered vs. non-filtered
- Safe vacuum levels / Suction tips
- Blood-gas interface
  - SIRS
- Activated WBCs
Tonicity

• Osmolarity
  – Ions (osmotic force)
  – Proteins (oncotic force)

• Hypotonic
  – Cells placed in a hypotonic solution swell

• Isotonic

• Hypertonic
  – Cells placed in a hypertonic solution shrink

• Hemolysis
Wash solutions

- Saline
- PlasmaLyte-A
- NormoSol-R
- Lactated Ringers – contains calcium ions
- $D_5W$ – do not use as a wash solution
- Anticoagulant compatibility
- IV compatibility
- Type of shed blood (procedure-specific)
Blood and plasma volume

- Body weight: pounds to kg
- Estimated blood volume: % kg
- Estimated plasma volume: \((1.0 - f_{Hct})\)
- Red cell mass (L)
  - Patient
  - ATS reservoir
- ANH volumes
- PRP (plasma pheresis fraction)
Pharmacology

- Anticoagulation
  - Anti-platelet drugs
- Antibiotics
  - Plasma-bound
- IV wash solutions – FDA indications
- Electrolytes / supplement
- Procoagulants
  - Topical hemostatic agents
- Allogeneic blood products
Theory and practice of Latham Bowl ATS

Megakaryocytes are similar in density to the lower density RBCs, so some platelets are found in the top of the RBC pack.
Contaminants vary, always consider the source of the shed blood.

TABLE 2. Contaminants found in shed wound or pump blood

- Fibrinogen split products and D-dimers
- Activated fibrinolytic products—plasmin
- Activated complement—C3a and C5a
- Proteolytic enzymes
- Marker enzymes, including creatine phosphokinase-myocardial fraction (CPKMB) from mediastinal drainage
- Stroma, cell fragments, and internal cellular contents
- Activated WBCs
- Free Hb
- Bacteria and endotoxins
- Fats
- Anticoagulants

Fig. 2. Bowl g forces at 5600 rpm.

\[ F = m \left( \frac{v^2}{r} \right), \]

Newton
RPM Determine G Forces

![Graph showing the relationship between RPM and g forces](image)

**Fig. 1.** Relationship between rpm and developed g forces in centrifugal cell processing bowls.
Operational Settings

Higher rotation rates apply higher G forces, different cell processing algorithms employ different RPMs to optimize RBC / buffy coat separation

<table>
<thead>
<tr>
<th>Machine type</th>
<th>Fill (W)</th>
<th>Wash (W)</th>
<th>Empty (W)</th>
<th>Fill (S)</th>
<th>Wash (S)</th>
<th>Empty (S)</th>
<th>Fill (M)</th>
<th>Wash (M)</th>
<th>Empty (M)</th>
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<tr>
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<td>1000</td>
<td>1000</td>
<td>1000</td>
</tr>
<tr>
<td>Sequestra</td>
<td>300</td>
<td>300</td>
<td>300</td>
<td>500</td>
<td>500</td>
<td>500</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
</tr>
<tr>
<td>BRAT-2</td>
<td>400</td>
<td>800</td>
<td>600</td>
<td>500</td>
<td>500</td>
<td>500</td>
<td>1300</td>
<td>1300</td>
<td>1300</td>
</tr>
<tr>
<td>Compact A</td>
<td>400</td>
<td>450</td>
<td>500</td>
<td>500</td>
<td>500</td>
<td>500</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
</tr>
<tr>
<td>Cell Saver 4</td>
<td>500</td>
<td>600</td>
<td>500</td>
<td>500</td>
<td>500</td>
<td>500</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
</tr>
<tr>
<td>Cell Saver 5</td>
<td>200-600</td>
<td>200-600</td>
<td>500</td>
<td>500</td>
<td>500</td>
<td>500</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
</tr>
</tbody>
</table>
Before Wash

**TABLE 3. Coagulation factors in shed blood**

<table>
<thead>
<tr>
<th>Coagulation factor</th>
<th>Venous blood</th>
<th>Shed blood</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factor VIII (%)</td>
<td>156.7</td>
<td>17</td>
</tr>
<tr>
<td>Factor V (%)</td>
<td>113.5</td>
<td>0</td>
</tr>
<tr>
<td>Antithrombin III (%)</td>
<td>97.3</td>
<td>46</td>
</tr>
<tr>
<td>Fibrinogen (mg/dL)</td>
<td>246</td>
<td>0</td>
</tr>
<tr>
<td>Plasminogen (%)</td>
<td>84.3</td>
<td>54.0</td>
</tr>
<tr>
<td>Protein C (%)</td>
<td>89.7</td>
<td>68.7</td>
</tr>
<tr>
<td>Protein S (%)</td>
<td>88.7</td>
<td>73.7</td>
</tr>
</tbody>
</table>

**TABLE 4. Biochemical debris in shed blood**

<table>
<thead>
<tr>
<th>Biochemical agent</th>
<th>Venous blood</th>
<th>Shed blood</th>
</tr>
</thead>
<tbody>
<tr>
<td>D-dimer (µg/mL)</td>
<td>0.7</td>
<td>1024</td>
</tr>
<tr>
<td>Fibrin (ogen) degradation</td>
<td>4.0</td>
<td>5120</td>
</tr>
<tr>
<td>products (µg/mL)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tissue plasminogen activator</td>
<td>16</td>
<td>38.5</td>
</tr>
<tr>
<td>(ng/mL)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Complement C3a (ng/mL)</td>
<td>428</td>
<td>14784</td>
</tr>
</tbody>
</table>

Fat and debris removal are issues

http://www.gcarlson.com/cellular_platelets.htm
Quality Indicators of Cell Processing

Table 1. ATS Quality Indicators

<table>
<thead>
<tr>
<th>Quality Monitoring Parameter</th>
<th>Reference</th>
<th>Threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td>hematocrit</td>
<td>Serrick, et al. (2003)</td>
<td>&gt; 50 - 55%</td>
</tr>
<tr>
<td>plasma free hemoglobin</td>
<td>Serrick, et al. (2003); FMCEA (2003)</td>
<td>90 - 98% removal</td>
</tr>
<tr>
<td>irrigants / clot / fat / bone fragment</td>
<td>Serrick, et al. (2003)</td>
<td>90% removal</td>
</tr>
<tr>
<td>RBC recovery</td>
<td>Serrick, et al. (2003)</td>
<td>100% recovery</td>
</tr>
<tr>
<td>electrolytes</td>
<td>Serrick, et al. (2003)</td>
<td>90% removal</td>
</tr>
<tr>
<td>proteins</td>
<td>Serrick, et al. (2003); FMCEA (2003)</td>
<td>90% removal; 95% removal</td>
</tr>
<tr>
<td>IL-8 RBC recovery rate</td>
<td>Pifer and Saulitis. 2005. OSU AABB Guidelines, Sections 5.3, 5.4, 7.2 and 9.0 offer recommendations for analysis of intraoperative, autologous blood products</td>
<td></td>
</tr>
</tbody>
</table>

Intraoperative blood salvage in cancer surgery: safe and effective?

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Department of Anesthesiologie, University of Regensburg, D-93042 Regensburg, Germany

Abstract

To support blood supply in the growing field of cancer surgery and to avoid transfusion induced immunomodulation caused by the allogeneic barrier and by blood storage lesions we use intraoperative blood salvage with blood irradiation. This method is safe as it provides efficient elimination of contaminating cancer cells, and as it does not compromise the quality of RBC. According to our experience with more than 700 procedures the combination of blood salvage with blood irradiation also is very effective in saving blood resources. With this autologous, fresh, washed RBC a blood product of excellent quality is available for optimal hemotherapy in cancer patients. © 2002 Elsevier Science Ltd. All rights reserved.

Keywords: cell salvaging, contraindications, neoplasm, in vitro, blood salvage, intraoperative technique, autotransfusion
Fill

Fig. 4. Relationship between fill speed and achieved Hct.

Watch for spilling of RBCs
Examine the exudate

Fig. 5. Effect of flow rate and saline volume on plasma removal. (◆) 750-mL wash; (■) 100-mL wash; (▲) 1500-mL wash.
Notes on "Proposed Contraindications"

- Procedure-specific CPGs should contain indications and contraindications.
- MDs may veto contraindications in verbal order, confirm in writing.
- See Waters JH. Transfusion. 2004;44:40S-44S.

**TABLE 1. General indications for CS**

<table>
<thead>
<tr>
<th>Specialty</th>
<th>Surgical procedure</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiac</td>
<td>Valve replacement</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Redo bypass grafting</td>
<td></td>
</tr>
<tr>
<td>Orthopedics</td>
<td>Major spine</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bilateral knee</td>
<td></td>
</tr>
</tbody>
</table>

**TABLE 2. Proposed contraindications to CS**

- Pharmacologic agents
  - Clotting agents (Avitene, Surgicel, Gelfoam, etc.)
  - Irrigating solutions (Betadine, antibiotics meant for topical use)
  - Methylmethacrylate
- Contaminants
  - Urine
  - Bone chips
  - Fat
  - Bowel contents
  - Infection
  - Amniotic fluid
- Malignancy
- Hematologic disorders
  - Sickle cell disease
  - Thalassemia
- Miscellaneous
  - Carbon monoxide (electrocautery smoke)
  - Catecholamines (pheochromocytoma)
  - Oxymetazoline (Afrin)
“When appropriate, intraoperative or postoperative blood recovery and other means to decrease blood loss (e.g., deliberate hypotension) may be beneficial. Acute normovolemic hemodilution, although rarely used, may also be considered.”
Quality Monitoring

• Process steps QC
• Final Product Quality Monitoring
  – Hct, [Pr], wash exudate clarity
• Process Improvement
  – Capture opportunities for improvement
  – Capture failure modes
  – Impound non-functioning equipment
• Qualifying FDA-cleared devices for a specific use [AABB]
Safe IAT Circuit
Critical Incidents

1. Contamination of sterile field and circuit components
   1. Set-up contamination
   2. Contamination during cell processing
   3. Bacteremia

2. Record keeping errors
   1. Record entry error
   2. Record entry omission
   3. Mislabel autologous blood product
   4. Quality indicator failure

3. Hemolysis
   1. Wrong cell wash solution
   2. Wrong heparin drip solution

4. Inadequate de-airing of anesthesia red cell infusion bag
   1. Accidental venous air infusion

Reference
Critical Incidents

5. Medication errors
   1. Wrong anticoagulant drug
   2. Wrong anticoagulant drug dose
   3. Wrong anticoagulant drip solution

6. Allergic reactions
   1. Anaphylactic reaction (3)

7. Equipment failure
   1. Cell washing devices
   2. Platelet concentration devices
   3. Rapid infusion devices
   4. Blood warming devices

8. Circuit disposable component failure
   1. Shed blood reservoir
   2. Cell washing bowl or chamber

9. Circuit blood line separation
   1. Blood spray
   2. Blood loss

Reference

Critical Incidents

10. **Special patient management requirements**

1. Partial cell washing bowl volume (2, 4)
2. Massive red blood cell and platelet loss (5)
3. Massive plasma protein and clotting factor loss
4. Pediatric patients (6)
5. Jehovah Witness (7)
6. Cancer patient (8)
7. Cesarean patient (9, 10)
8. Liver transplant patient

Reference

Riley.Jeffrey@Mayo.edu

Questions?