Apheresis in Hematology
(Erythrocytapheresis in Sickle Cell Disease)

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Apheresis in Hematology

(Erythrocytapheresis in Sickle Cell Disease)

Objectives

- Application of Apheresis in Hematology
- Overview of Erythrocytapheresis
- Erythrocytapheresis for Management of Acute and Chronic Complications of Sickle Cell Disease
- Technical Challenges with Apheresis in Children
<table>
<thead>
<tr>
<th>Disease</th>
<th>TA Modality</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aplastic anemia; Pure red cell aplasia</td>
<td>TPE</td>
<td>III</td>
</tr>
<tr>
<td>Autoimmune hemolytic anemia: - Severe WAHA</td>
<td>TPE</td>
<td>III</td>
</tr>
<tr>
<td>- Severe cold agglutinin disease</td>
<td>TPE</td>
<td>II</td>
</tr>
<tr>
<td>Catastrophic antiphospholipid syndrome</td>
<td>TPE</td>
<td>II</td>
</tr>
<tr>
<td>Coagulation factor inhibitors: Alloantibody</td>
<td>TPE IA</td>
<td>IV III</td>
</tr>
<tr>
<td>Coagulation factor inhibitors: Autoantibody</td>
<td>TPE IA</td>
<td>III III</td>
</tr>
<tr>
<td>Cryoglobulinemia: Symptomatic/Severe</td>
<td>TPE IA</td>
<td>I II</td>
</tr>
<tr>
<td>Heparin-induced thrombocytopenia: - Pre-CPB</td>
<td>TPE</td>
<td>III</td>
</tr>
<tr>
<td>- Thrombosis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Henoch-Schonlein purpura: - Crescentric</td>
<td>TPE</td>
<td>III</td>
</tr>
<tr>
<td>- Severe extrarenal disease</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disease</td>
<td>TA Modality</td>
<td>Category</td>
</tr>
<tr>
<td>------------------------------------------------------------------------</td>
<td>-------------</td>
<td>----------</td>
</tr>
<tr>
<td><strong>Hyperviscosity in monoclonal gammopathies:</strong></td>
<td>TPE</td>
<td>I</td>
</tr>
<tr>
<td>- Symptomatic,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Prophylaxis for rituximab</td>
<td></td>
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<tr>
<td><strong>Immune thrombocytopenia (ITP):</strong></td>
<td>TPE</td>
<td>IV</td>
</tr>
<tr>
<td>Refractory</td>
<td>IA</td>
<td>III</td>
</tr>
<tr>
<td><strong>Post-transfusion purpura</strong></td>
<td>TPE</td>
<td>III</td>
</tr>
<tr>
<td><strong>Red cell alloimmunization in pregnancy</strong></td>
<td>TPE</td>
<td>III</td>
</tr>
<tr>
<td><strong>SLE:</strong></td>
<td>TPE</td>
<td>II</td>
</tr>
<tr>
<td>- Severe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Nephritis</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TMA, Drug associated:</strong></td>
<td>TPE</td>
<td>I</td>
</tr>
<tr>
<td>- Ticlopidine</td>
<td></td>
<td></td>
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<tr>
<td>- Clopidogrel, Cyclosporine, Tacrolimus</td>
<td>TPE</td>
<td>III</td>
</tr>
<tr>
<td><strong>TMA, HSCT associated, Refractory</strong></td>
<td>TPE</td>
<td>III</td>
</tr>
<tr>
<td><strong>TTP</strong></td>
<td>TPE</td>
<td>I</td>
</tr>
<tr>
<td><strong>ABO incompatible transplantation:</strong></td>
<td>TPE</td>
<td>I - III</td>
</tr>
<tr>
<td>- Organ</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Major HPC Marrow or Apheresis</td>
<td></td>
<td>II</td>
</tr>
<tr>
<td>Disease</td>
<td>TA Modality</td>
<td>Category</td>
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<tr>
<td>---------------------------------------</td>
<td>------------------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>Babesiosis:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Severe</td>
<td>Erythrocytapheresis</td>
<td>I</td>
</tr>
<tr>
<td>- High-risk population</td>
<td></td>
<td>II</td>
</tr>
<tr>
<td>Malaria: Severe</td>
<td>Erythrocytapheresis</td>
<td>II</td>
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<tr>
<td>Hereditary hemochromatosis</td>
<td>Erythrocytapheresis</td>
<td>I</td>
</tr>
<tr>
<td>Sickle cell disease</td>
<td>Erythrocytapheresis</td>
<td>I - III</td>
</tr>
<tr>
<td>Hyperleukocytosis:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Leukostasis</td>
<td>Leukocytapheresis</td>
<td>I</td>
</tr>
<tr>
<td>- Prophylaxis</td>
<td></td>
<td>III</td>
</tr>
</tbody>
</table>
Therapeutic Erythrocytapheresis (RBC Exchange)
Removal of patient’s RBCs (RBC Depletion ± non-RBC replacement)
- Reduction of blood viscosity in polycythemia
- Reduction of excessive iron in non-anemic hemochromatosis

Exchange patient’s abnormal RBCs with normal RBCs (RBC Exchange w/ RBC replacement)
- Hereditary or acquired RBC disorders
Sickle Cell Disease (SCD)
HbA: $\alpha_2\beta_2$

HbS: $\alpha_2\beta_2^{6\text{Glu} \rightarrow \text{Val}}$

Pathophysiology

HbS Mutation

<table>
<thead>
<tr>
<th>Nucleotide</th>
<th>CTG</th>
<th>ACT</th>
<th>CCT</th>
<th>GTG</th>
<th>GAG</th>
<th>AAG</th>
<th>TCT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amino Acid</td>
<td>Leu</td>
<td>Thr</td>
<td>Pro</td>
<td>Val</td>
<td>Glu</td>
<td>Lys</td>
<td>Ser</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td>9</td>
</tr>
</tbody>
</table>

- O$_2$

+ O$_2$

Single Hb S molecules in solution

Polymerized Hb S molecules in fibers

Abnormal, sickled, red blood cells (sickle cells)

Sickle cells blocking blood flow

Sticky sickle cells

Abnormal hemoglobin form strands that cause sickle shape

Cross-section of sickle cell
Sickle Cell Disease (SCD)

Clinical Manifestations

◆ Sickle Cell Crisis
  ➢ Vaso-occlusive events
    - painful crisis
    - acute chest syndrome
    - acute abdominal pain
    - acute CNS event
    - priapism
  ➢ Splenic sequestration
  ➢ Transient red cell aplasia

◆ Infections

◆ Chronic Organ Damage
Current Management of Patients with Sickle Cell Disease

- Newborn screening
- Comprehensive care
- Medical/surgical treatment
- Stimulation of HbF production: HU
- Transfusion Therapy
- Hematopoietic stem cell transplantation
- Gene therapy

Possibility of cure
Goals of Transfusion (Tx) in SCD

**02 Delivery to Tissues**
- Acute Exacerbation of Anemia
  - Transient red cell aplasia
  - Acute splenic sequestration

**HbS concentration**
- Vasoocclusive Events
  - ACS, CVA, Eye Cx, pain
- Preparation for Surgery
  - when Hb > 10 g/dL

Both (↑02 Delivery & ↓HbS)

Acute S-Tx

Acute or Chronic S-Tx or Ex-Tx

Ex-Tx
<table>
<thead>
<tr>
<th>SCD, Acute</th>
<th>Grade</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acute stroke</td>
<td>1C</td>
<td>I</td>
</tr>
<tr>
<td>Acute chest synd, severe</td>
<td>1C</td>
<td>II</td>
</tr>
<tr>
<td>Priapism</td>
<td>2C</td>
<td>III</td>
</tr>
<tr>
<td>Multiorgan failure</td>
<td>2C</td>
<td>III</td>
</tr>
<tr>
<td>Splenic/Hepatic sequestration, Intrahepatic cholestasis</td>
<td>2C</td>
<td>III</td>
</tr>
</tbody>
</table>
# Stroke in Sickle Cell Disease

## Clinical Presentation

<table>
<thead>
<tr>
<th>Condition</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hemiparesis</td>
<td>31</td>
<td>(53%)</td>
</tr>
<tr>
<td>Speech disturbance</td>
<td>11</td>
<td>(19%)</td>
</tr>
<tr>
<td>Seizures</td>
<td>10</td>
<td>(17%)</td>
</tr>
<tr>
<td>Monoparesis</td>
<td>9</td>
<td>(15%)</td>
</tr>
<tr>
<td>Headache</td>
<td>8</td>
<td>(14%)</td>
</tr>
<tr>
<td>TIA</td>
<td>7</td>
<td>(12%)</td>
</tr>
<tr>
<td>Coma/semicoma</td>
<td>6</td>
<td>(10%)</td>
</tr>
</tbody>
</table>

Ohene-Frempong. Sem Hematol. 1991
Stroke in SCD

If Untreated or Untransfused

- Mortality rate: 20% (Generally hemorrhagic)
- Recurrence rate: 67% within 3 yrs
  (Powars, 1978)
- Short-term Neurologic Outcome:
  (Ohene-Frempong, 1991)
  - Residual neurological sequelae: 37%
  - Gross neurological recovery: 63%
Types of Stroke in SCD

- **Infarctive (ischemic) Stroke**
  - More common in children
  - Occlusion or embolism from thrombi formed at point of vascular damage or areas of turbulent blood flow

- **Hemorrhagic Stroke**
  - More common in adults
  - Rupture of aneurysms formed in the arteries of the Circle of Willis
  - Commonly subarachnoid but may be intraventricular or parenchymal
  - Moya Moya
R.L.: 7 yo boy with SCD and Acute Stroke (left hemiparesis, slurred speech)
7 yo boy with SCD and Acute Stroke

MRA (6 mo. prior to stroke)
Acute Management of Stroke

- Evaluation to r/o hemorrhage: CT or MRI
- Supportive care as needed:
  - Oxygen
  - Control of BP, temperature, and glucose
- Transfusion:
  - Simple transfusion:
    - To improve oxygen delivery to brain
    - ↑ Hb level to ≤10 g/dL
  - Exchange transfusion (Erythrocytapheresis)
    - ↓ HbS <30%
    - ↑ Hb level: 10 – 12 g/dL
Erythrocytapheresis in SCD
Category I (ASFA 2010)

**Acute Stroke**

<table>
<thead>
<tr>
<th>Type</th>
<th>RCT</th>
<th>CT</th>
<th>CS</th>
<th>CR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>0</td>
<td>7(160)</td>
<td>7(9)</td>
</tr>
</tbody>
</table>

Type of Evidence: II-3
Recommendation: Grade 1C
SCD and 1st Overt Stroke
S-Tx vs. Ex-Tx

Retrospective Cohort Study

- 14 medical centers
- 137 children w/ SCA and stroke
  - on chronic Tx (S-Tx vs. Ex-Tx)
  - mean follow-up: 10.1 yr (5-24)
  - mean age at initial stroke: 6.3 yr (1.4-14)

### SCD and 1st Overt Stroke

<table>
<thead>
<tr>
<th>Initial Treatment</th>
<th>No. Patients (n=90)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Tx</td>
<td>1</td>
</tr>
<tr>
<td>Simple Tx</td>
<td>23 (25.6%)</td>
</tr>
<tr>
<td>Exchange</td>
<td>66 (73.3%)</td>
</tr>
</tbody>
</table>
## Transfusion (Tx) Method and Risk of Recurrent Stroke

<table>
<thead>
<tr>
<th>Transfusion Method</th>
<th>Patients No</th>
<th>Recurrent Stroke</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Acute S-Tx</strong></td>
<td>14</td>
<td>8 (57%)</td>
</tr>
<tr>
<td><strong>Acute Ex-Tx</strong></td>
<td>38</td>
<td>8 (21%)</td>
</tr>
<tr>
<td><strong>Chronic S-Tx</strong></td>
<td>18</td>
<td>7 (39%)</td>
</tr>
<tr>
<td><strong>Chronic Ex-Tx</strong></td>
<td>11</td>
<td>0</td>
</tr>
<tr>
<td>Author</td>
<td>N</td>
<td>Duration of Tx (yr)</td>
</tr>
<tr>
<td>--------------</td>
<td>-----</td>
<td>---------------------</td>
</tr>
<tr>
<td>Powars (1978)</td>
<td>35</td>
<td>0</td>
</tr>
<tr>
<td>Russell (1984)</td>
<td>23</td>
<td>0.7-9.2</td>
</tr>
<tr>
<td>Wilimas (1980)</td>
<td>10</td>
<td>1-2</td>
</tr>
<tr>
<td>Wang (1991)</td>
<td>10</td>
<td>5-12</td>
</tr>
<tr>
<td>Miller (1992)</td>
<td>14</td>
<td>4.5-13.7</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>12-27 mo</td>
</tr>
<tr>
<td>Pegelow (1995)</td>
<td>60*</td>
<td>191.7 pt-yr</td>
</tr>
<tr>
<td>Rana (1997)</td>
<td>9</td>
<td>1.5-16</td>
</tr>
</tbody>
</table>

*: 8 centers
1934 Children Screened (14 Sites)
3929 TCDs in 21 mo.

206 Patients with 2 TCDs ≥200 cm/sec
[36 with 1 TCD >200 cm/sec]
130 Patients Randomized

Transfusion (n=63)
1 Stroke (1.6%)

Standard Care (n=67)
11 Strokes (16%)

92% 1st stroke


DSMB terminated study early
STOP 2 Trial in SCD

Children with TCD $\geq$ 200 cm/sec

30 mo. on Transfusion
- With Low-risk TCD
- No Severe Lesions on MRA

Continue Transfusion
N=38

TCD Every 3 mo or Less

2 Strokes

Stop Transfusion
N=41

2 strokes
14 Abnormal TCDs

Transfusion Therapy in SCD and Stroke

**Conclusions**

- TCD screen reduces incidence of first stroke
- No known “safe” time to discontinue transfusions in first time *(primary)* and recurrent *(secondary)* stroke

Continue Transfusion Indefinitely
Chronic Management of Stroke
(reduce the risk of primary & secondary stroke)

Chronic Transfusion Therapy

- **HbS:** <30% (may increase to <50%)
- **Hb Level:** 10-12 g/dl (Hct ≤36%)
- **Simple Tx:** 10-15 ml RBC/kg every 3-4 wks
- **Erythrophagytapheresis:** every 3-4 wks
- **Antigen-matched RBC:** C, E, Kell Neg
Category II Indications for Erythrocytapheresis in SCD (ASFA 2013)

- Acute chest syndrome, severe
- Stroke Prophylaxis with Prevention of Transfusional Iron Overload
Category II Indications for Erythrocytapheresis in SCD (ASFA 2010)

**Acute Chest Syndrome**

<table>
<thead>
<tr>
<th>RCS</th>
<th>CT</th>
<th>CS</th>
<th>CR</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>12 (142)</td>
<td>8 (8)</td>
</tr>
</tbody>
</table>

Type of Evidence: II-3
Recommendation: Grade 1C
Acute Chest Syndrome (ACS) in SCD

Diagnostic criteria

New segmental pulmonary infiltrate with one or more of the following

• Chest pain
• Fever
• Respiratory Sx (tachypnea, cough, new onset hypoxia, increased work of breathing, etc)

Etiology

• Fat/bone marrow emboli
• Infections (bacterial, viral or mixed)
Erythrocytapheresis in SCD and ACS

32/35 patients with severe ACS had dramatic improvement to Ex-Tx

Nathan et al. Blood 1993
Erythrocytapheresis In Children with SCD and ACS

Retrospective Chart Review

- A single center experience
- 44 children w/ SCD and 53 episodes of ACS
  - median age: 10 yr (18 mo-19 yo)
  - received Ex-Tx on median D2 of adm
  - clinical respiratory score (CRS):
    0=no distress, ≥6 severe

Erythrocytapheresis
In Children with SCD and ACS

Indications for Erythrocytapheresis

- Worsening respiratory distress
- Worsening chest x-ray
- Worsening hypoxemia
- Other: concurrent neurologic deficit
  - pulmonary embolism
  - unrelenting pain
# Erythrocytapheresis in Children with SCD and ACS

## Effect of Erythrocytapheresis on CRS

<table>
<thead>
<tr>
<th>CRS*</th>
<th>ACS (n=35)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>On admission</td>
<td>3 (1-4)</td>
<td></td>
</tr>
<tr>
<td>Pre Ex-Tx</td>
<td>5 (4-6)</td>
<td></td>
</tr>
<tr>
<td>Post Ex-Tx</td>
<td>2 (0-3)</td>
<td></td>
</tr>
</tbody>
</table>

* clinical respiratory score (0 - ≥6)
### S-Tx vs. Erythrocytapheresis in Adults with SCD and ACS

<table>
<thead>
<tr>
<th></th>
<th>Apheresis n=20</th>
<th>S-Tx n=20</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Post-Ex length of stay</td>
<td>5.6 ± 4.1</td>
<td>5.9 ± 4.3</td>
</tr>
<tr>
<td>• Total length of stay</td>
<td>8.4 ± 4.1</td>
<td>8.0 ± 4.1</td>
</tr>
<tr>
<td>• Total No RBC units</td>
<td>10.3 ± 3.0</td>
<td>2.4 ± 1.2</td>
</tr>
</tbody>
</table>

Transfusion Therapy in SCD and ACS

Conclusions

Children

Chronic S-Tx: 10-fold reduction in the recurrent rate in 27 children with recurrent & severe ACS (J Hankins, et al. 2005)

Acute erythrocytapheresis: appears to be effective in improving respiratory distress

Adults

No difference between S-Tx and Ex-Tx

Vichinsky et.al. NEJM 2000

Turner et al. Transfusion 2009
Acute Erythrocytapheresis

Goal

- **Post-Aph Hct**: 30% ± 3% (≤36%)
- **Post-Aph HbS**: <15 - 30%

Spectra Proc. Guidelines

- **End Hct**: 30% ± 3%
- **FCR**: 20 – 30%
- **Start Donor RBCs**

**Isovolemia**

- No Divert Prime NSS
- Fluid Balance: 100%
- Skip Rinseback
# Erythrocytapheresis in SCD (ASFA 2013)

<table>
<thead>
<tr>
<th>SCD, Non-acute</th>
<th>Grade</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stroke prophylaxis w/ Iron overload prevention</td>
<td>1C</td>
<td>II</td>
</tr>
<tr>
<td>VOE pain crisis</td>
<td>2C</td>
<td>III</td>
</tr>
<tr>
<td>Pre-Op management</td>
<td>2A</td>
<td>III</td>
</tr>
</tbody>
</table>
Category II Indications for Erythrocytapheresis in SCD (ASFA 2013)

Acute chest syndrome

Stroke Prophylaxis with Prevention of Iron Overload

RCT (0), CT (0), CS (18/310), CR (3/3)

Type of Evidence: II-3
Recommendation: Grade 1C
1 mg of iron/mL of RBC

Transfusion of 1 unit of whole blood (or 200 mL of RBC) → add 200 mg of total iron to the body

Cause of Death: Cardiac complications of Iron overload (recurrent pericarditis, ventricular tachycardia & fibrillation, severe refractory CHF)
MS: a 16 yo male with SCD & S/P Stroke
Simple Tx

Wt: 50 kg
TBV: 3858 ml, Hct=30%
Total RBC Vol (TRV) = 3858 \times 0.3 = 1157 ml

AS 1-RBC (Hct=59%)
10 ml/kg \times 50 kg = 500 ml
TRV = 500 \times 0.59 = 295 ml

Pre-Tx
295 ml (HbA)
RV: 1157 ml
HbS=100%

Post-Tx
HbA: 21%
TRV: 295 + 1157 = 1452 ml
HbS=79%

Iron load
Erythrocytapheresis (FCR = 30%)

Pre-

HbS 100%

Waste bag

Intra-

HbA

HbS

Post-

HbA 70%

HbS 30%

HbA + HbS

No iron load
Modification of Erythrocytapheresis
Modification of Erythrocytapheresis

Goal
To reduce blood requirements and donor exposure

Isovolemic Hemodilution
### Erythrocytapheresis

#### Isovolemic Hemodilution

<table>
<thead>
<tr>
<th>Phase</th>
<th>Replacement</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>I (RBC Depletion)</strong></td>
<td><strong>0.9% NaCl</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Intra-Hct</strong></td>
</tr>
<tr>
<td></td>
<td><strong>HbS &lt; 30%</strong></td>
</tr>
<tr>
<td></td>
<td><strong>HbS &lt; 50%</strong></td>
</tr>
<tr>
<td><strong>II (RBC Exchange)</strong></td>
<td><strong>packed-RBC</strong></td>
</tr>
<tr>
<td><strong>Post-Hct:</strong></td>
<td><strong>30% + 3</strong></td>
</tr>
<tr>
<td>( \text{max Post-Hct} \leq 36% )</td>
<td></td>
</tr>
</tbody>
</table>
# Isovolemic Hemodilution

A 16 yo boy w/ SCD & S/P Stroke (Wt: 50 kg) (HbS<30%, Q 3 wk) RBC: 330 mL/U (Hct: 59%)

<table>
<thead>
<tr>
<th>Patient’s Hct (%)</th>
<th>RBC Required</th>
<th>% RBC Reduction Vol (mL)/Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre- Intra- Post- Vol (mL)/Unit</td>
<td>per proc. per yr per 10 yr</td>
</tr>
<tr>
<td>30</td>
<td>30</td>
<td>2305/ (7 U) No RBC Depletion</td>
</tr>
<tr>
<td>30</td>
<td>24</td>
<td>2060/ (6 U) 245/0.7 U (10.6%)</td>
</tr>
<tr>
<td>30</td>
<td>22</td>
<td>1977/ (6 U) 328/1 U (14.2%)</td>
</tr>
</tbody>
</table>

*Patient's Hct (%)*

*RBC Required*

*RBC Reduction Vol (mL)/Unit*
## Erythrocytapheresis Program at CHOP

<table>
<thead>
<tr>
<th>Year Established</th>
<th>1985</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total # of patients treated with Erythrocytapheresis</td>
<td>&gt;300</td>
</tr>
<tr>
<td>Total # of Erythrocytapheresis performed</td>
<td>&gt;13,664</td>
</tr>
<tr>
<td>Total # of patients-years of Erythrocytapheresis therapy</td>
<td>&gt;1,051.1</td>
</tr>
</tbody>
</table>
MS: 7 yo boy with SCD-SS stroke at 2 yr 9 mo

- **at 2.7 yo**: Hct: 22%
  Serum ferritin: **302 µg/L**

- **S-Tx**: Target Hb S <30%
  10-15 mL RBC/kg, every 3-4 wks

- **at 7 yo**: Hct: 25%
  Serum ferritin: **5,846 µg/L**
  Referred for erythrocytapheresis
Effect of Long-term Transfusions on Serum Ferritin Levels

- **Erythrocytapheresis**
- **Simple Tx**

Hb S: <30%
Hct: 25-30%

![Graph showing the effect of long-term transfusions on serum ferritin levels.](image)
Effect of Erythrocytapheresis on Serum Ferritin Levels in the Absence of Iron Chelation

Serum Ferritin (ng/mL)

Duration (months)

1st apheresis

Hb S <30%

Hb S <50%

<table>
<thead>
<tr>
<th>Date</th>
<th>MCV (fl)</th>
<th>Ferritin (ng/mL)</th>
<th>Fe/% sat</th>
</tr>
</thead>
<tbody>
<tr>
<td>7/99</td>
<td>83</td>
<td>18</td>
<td>18/11%</td>
</tr>
<tr>
<td>10/99</td>
<td>68</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>1/00</td>
<td>73</td>
<td>9</td>
<td>12/3%</td>
</tr>
</tbody>
</table>
Effect of Long-term Erythrocytapheresis on Serum Ferritin Levels

Serum Ferritin (μg/L) vs. Duration (yr) of Erythrocytapheresis

- HbS <30%
- n=5
Effect of Long-term Erythrocytapheresis on Serum Ferritin Levels

Serum Ferritin (µg/L)

Duration (yr) of Erythrocytapheresis

HbS <50%
No Patients: 45
Impact of a Regular Erythrocytapheresis on the Acute and Chronic Complications of SCD in Adults

Single Center (1998-2008)

- **13 Adults**: median age 30 yo (22-63)
- **Indications for Apheresis**: Recurrent painful crisis, ACS, silent infarct, Pulmonary hypertension, Multiple crisis and pregnancy
- **Apheresis**: Cobe Spectra, every 4 wks (4-6)
- **Goals**: Measure pre- and post-apheresis acute and chronic events

# Comparison of Annual Rate of Events (Pre- and post-initiation of Aph)

<table>
<thead>
<tr>
<th>Patient No.</th>
<th>Event in 5 yrs (Pre-/Post-)</th>
<th>Duration (mo)</th>
<th>Event rate /yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>16 / 4</td>
<td>101</td>
<td>3.2</td>
</tr>
<tr>
<td>5</td>
<td>16 / 6</td>
<td>112</td>
<td>3.2</td>
</tr>
<tr>
<td>7</td>
<td>2 / 0</td>
<td>65</td>
<td>0.4</td>
</tr>
<tr>
<td>9</td>
<td>5 / 1</td>
<td>84</td>
<td>1</td>
</tr>
<tr>
<td>11</td>
<td>10 / 0</td>
<td>26</td>
<td>2</td>
</tr>
<tr>
<td>12</td>
<td>8 / 0</td>
<td>27</td>
<td>1.6</td>
</tr>
</tbody>
</table>
Pediatric Apheresis
Pediatric Apheresis

Can procedure be performed safely?

Procedural Considerations (Technical/Physiological)

- Equipment (for adults)
- Patient/Donor (children)
# Equipment Factor

## CF Centrifugal Cell Separators

<table>
<thead>
<tr>
<th>Cell Separator</th>
<th>Type of Aph</th>
<th>ECV</th>
<th>ECRV</th>
</tr>
</thead>
<tbody>
<tr>
<td>COBE Spectra</td>
<td>Plasma/RBC</td>
<td>170</td>
<td>68</td>
</tr>
<tr>
<td>Baxter/CS-3000+</td>
<td>Plasma/RBC</td>
<td>393</td>
<td>68</td>
</tr>
<tr>
<td>Fresenius AS104</td>
<td>Plasma/RBC</td>
<td>150</td>
<td>90</td>
</tr>
</tbody>
</table>
Erythrocytapheresis
Intravascular volume shift

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>RBC-Ex</td>
<td>-100</td>
<td>+345</td>
<td>-100*</td>
<td>+245**</td>
</tr>
</tbody>
</table>

1 yo infant, 10 kg, Hct:30%
TBV: 70 ml/kg x 10 = 700
PV: 700 x 0.7 = 490
RV: 700 - 490 = 210

Standard RBC-Ex

Divert NSS: Yes
RBC Prime: No
Rinseback: Yes

+20%
-20%

-14%*
+35%**

Intra-aph
# Erythrocytapheresis

## Circulating red cell volume (RV) Shift

<table>
<thead>
<tr>
<th>Spectra</th>
<th>During Run</th>
<th>Intra-proc</th>
<th>Rinseback vol</th>
<th>Residual vol</th>
<th>Post-proc vol</th>
</tr>
</thead>
</table>

### Standard RBC-Ex

**1 yo infant, 10 kg, Hct:30%**

- TBV: 70 ml/kg x 10 = 700
- PV: 700 x 0.7 = 490
- RV: 700 - 490 = 210
- 68/210 x 100 = 32%

**Divert NSS** Yes

**RBC Prime** No 30%

**Rinseback** Yes

-32% (Hct=20%)*
10 kg infant,  Hct = 30%
TBV = 700 ml   RCV = 210 ml

#2 Modified RBC-Ex
No Divert & No Rinseback
Volume shift: 0%
Intra-Aph Hct : 20%

#3 Modified RBC-Ex
Blood prime: YES
How much RBC to order?
115 mL of AS-RBC (Hct 59%)

Fluid volume
Divert NSS  No
RBC Prime  YES
Rinseback  No
RV

divert intra post
Erythrocytapheresis

Advantages

- Rapid in Hct level without vol overload
- Rapid Hb S level without substantially the Hct level
- Maintain isovoleemia
- Rate of transfusional iron loading
- Duration of procedure compared to simple transfusion
Disadvantages

- Problems with venous access
- **Increased blood usage**
- Increased donor exposure
  - Transfusion-transmitted infections
  - RBC alloimmunization
- Increased cost for the proc. (?)
- Not universally available
Acknowledgements

Physicians
Deborah Sesok-Pizzini, MD
David Friedman, MD
Stella Chou, MD

Nursing Staff
Linda McNellis
Deanna Altschuler
Sandie Calabrese
Monique Crenshaw
Dana DiBlasi
Laura Durian
Jen Hill
Cathy Hulitt
Kathy Mullin
Michele Smith
Becky Weldon
Diana Whitehead