Red Blood Cell Exchange Procedure

Standard and Isovolemic Hemodilution

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Nothing to disclose
Learning Objectives

1. Describe Indications for RBCx
2. Define Goals of Acute and Chronic RBCx
3. Identify and Address the Challenges in Performing RBCx in Small Children
4. Discuss Advantages and Disadvantages of Standard-RBCx vs. Isovolemic Hemodilution (IHD)-RBCx
5. Discuss Contraindications for IHD-RBCx
Discussion Points

**Standard RBCx**

#1: What are the optimal target levels for Hb/Hct and HbS after RBCx?

#2: Should these targets be adjusted based on the patient’s pre-procedure Hct and serum ferritin level?

#3: What are the challenges of performing RBCx in small children?

**IHD-RBCx**

#4: What are the advantages and disadvantages of each procedure?

#5: What are the long-term benefits of each procedure?

#6: Should IHD-RBCx become the standard of care for patients requiring long-term transfusion therapy?

#7: What are the contraindications for IHD-RBCx?
RBC Exchange (RBCx)

**Methods of RBCx**

**Manual RBCx**
Removal of patient’s **whole blood** followed by infusion of donor RBCs + albumin/FFP

**Automated RBCx**
Erythrocytapheresis
Removal of patient’s **RBCs** while infusion of donor RBCs using blood cell separator

**Types of RBCx: Acute/Emergent vs. Chronic**
Management of Patients with SCD

- Newborn screening
- Comprehensive care
- Medical/surgical treatments
- Increase HbF level: hydroxyurea
- Transfusion therapy
- Hematopoietic stem cell transplant
- Gene therapy

Hope for a Cure
# Goals of Transfusion (Tx) in SCD

## O2 Delivery to Tissues
- Acute Exacerbation of Anemia
  - Transient red cell aplasia
  - Acute splenic sequestration

## HbS concentration
- Vasoocclusive Events
  - ACS, CVA
- Preparation for Surgery when Hb >10 g/dL

### Acute Simple Tx (S-Tx)
- Both (↑O2 Delivery & ↓HbS)

### Acute or Chronic S-Tx or RBCx
- RBCx
Guidelines for Transfusion Therapy in SCD

- American Society for Apheresis (ASFA) *(Evidence-based)*

  **2013: Indication Categories for Therapeutic Apheresis (RBCx)**

- National Heart, Lung and Blood Institute *(Evidence-Based & Consensus-based)*

<table>
<thead>
<tr>
<th>Acute/Emergent RBCx</th>
<th>ASFA Category/Grade</th>
<th>NHLBI Recom/Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acute stroke</td>
<td>I/1C</td>
<td>Moderate (S-Tx or RBCx*)</td>
</tr>
<tr>
<td>Acute chest syndrome severe &amp; symptomatic</td>
<td>II/1C</td>
<td>Strong (RBCx/Low)</td>
</tr>
<tr>
<td>Multisystem organ failure</td>
<td>III/2C</td>
<td>S-Tx or RBCx*</td>
</tr>
<tr>
<td>Sickle cell hepatopathy</td>
<td>III/2C</td>
<td>S-Tx or RBCx*</td>
</tr>
<tr>
<td>Priapism</td>
<td>III/2C</td>
<td>Moderate Against (Low)</td>
</tr>
</tbody>
</table>

*Consensus–Panel Expertise*

<table>
<thead>
<tr>
<th>Episodic RBCx</th>
<th>ASFA Category/Grade</th>
<th>NHLBI Recom</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-op management</td>
<td>III/2A</td>
<td>Consult</td>
</tr>
</tbody>
</table>
## Indications for Chronic RBCx in SCD

<table>
<thead>
<tr>
<th>Non-acute/Chronic Complications</th>
<th>ASFA 2013 (RBCx)</th>
<th>NHLBI 2014 (Tx)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Indication Category</td>
<td>Recom (Grade)</td>
</tr>
<tr>
<td>Primary stroke prevention for Abnormal TCD (&gt;200 cm/s)</td>
<td>II (RBCx)</td>
<td>1C</td>
</tr>
<tr>
<td>Secondary stroke Prevention</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prevention of Stroke &amp; Iron overload</td>
<td>III (RBCx)</td>
<td>IIC</td>
</tr>
<tr>
<td>Vaso-occlusive pain crisis</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
SCD and 1st Overt Stroke
Tx Method and Risk of Recurrent Stroke

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)

### Transfusion (Tx) Method and Risk of Recurrent Stroke

<table>
<thead>
<tr>
<th>Transfusion Method</th>
<th>No. Patients</th>
<th>Recurrent Stroke</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Acute Stroke</strong></td>
<td>52</td>
<td></td>
</tr>
<tr>
<td>• Acute Simple Tx</td>
<td>14</td>
<td>8 (57%)</td>
</tr>
<tr>
<td>• Acute RBCx</td>
<td>38</td>
<td>8 (21%)</td>
</tr>
<tr>
<td><strong>Stroke Prevention</strong></td>
<td>29</td>
<td></td>
</tr>
<tr>
<td>• Chronic Simple Tx</td>
<td>18</td>
<td>7 (39%)</td>
</tr>
<tr>
<td>• Chronic RBCx</td>
<td>11</td>
<td>0</td>
</tr>
</tbody>
</table>

Conclusions

Both acute and chronic RBCx may be more effective in preventing subsequent stroke than simple transfusion.
RBCx/Erythrocytapheresis
Procedure Guidelines
Q1: What are the optimal target levels for Hb/Hct and HbS after RBCx?

<table>
<thead>
<tr>
<th>Target</th>
<th>Acute</th>
<th>Chronic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post-Hct/Hb</td>
<td>27% - 30%</td>
<td>30% ± 5 (&lt;36%)</td>
</tr>
<tr>
<td></td>
<td>(9 - 10 g/dL)</td>
<td></td>
</tr>
<tr>
<td>Post-HbS</td>
<td>&lt;30%</td>
<td>HbS&lt;30%: 10-15%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>HbS&lt;50%: 20-25%</td>
</tr>
<tr>
<td>FCR*</td>
<td>25%-30%</td>
<td>40%-60%</td>
</tr>
<tr>
<td>Fluid balance</td>
<td>100%</td>
<td>100% - 110%</td>
</tr>
</tbody>
</table>

*FCR (%) = target HbS (%) / pre-HbS (%) x 100
  e.g., FCR = 20/50 x 100 = 40%
Case 3: a 16 yo male with SCA & s/p Stroke
Simple Transfusion

Wt.: 50 kg, Ht: 165 cm
TBV: 3858 ml, Hct=30%
RV = 3858x0.3 = 1157 ml

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

AS 1-RBC (Hct=59%)
10 ml/kg x 50 kg = 500 ml
RV = 500 x 0.59 = 295 ml

Post-Tx
1157 + 295 = 1452
HbS = 80%

Iron load
+ 295 mg of iron
Erythrocytapheresis
(FCR=30%; pre-& post-RBCx Hct=30%)

Pre-

Patient

HbS 100%

HbA

HbS

Intra-

Post-

No iron load

Waste bag

HbA 70%

HbS 30%

HbA + HbS
Q2: Should these targets be adjusted based on the patient’s pre-procedure Hct and serum ferritin level?

1. Prevent Primary and Secondary Stroke
   Target HbS <30% (or <50%?)

2. Prevent Trausional Iron Overload
   - **Post-Hct level = Pre-Hct level**
     Net RBC load = 0 ➔ No iron load
   - **Post-Hct level >>> Pre-Hct level**
     Net RBC load > 0 ➔ Greater iron load
Case 1: 3 yo boy with SCA
p/w left hemiparesis and slurred speech

Serum Ferritin Levels without Iron Chelation

- Erythrocytapheresis
- Simple Tx

HbS: 25-30%
Hct: 25-30%
Case 2

13 yo boy with SCD-HbSS and Stroke

<table>
<thead>
<tr>
<th>Date</th>
<th>MCV</th>
<th>Ferritin</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>12/3%</td>
</tr>
<tr>
<td>1/00</td>
<td>73</td>
<td>9</td>
<td></td>
</tr>
</tbody>
</table>
Q3: What are the challenges of performing erythrocytapheresis in small children?
Pediatric Apheresis
Can it be performed safely?

Procedural Considerations
(Technical/Physiological Factors)

◆ **Equipment**
  - Extracorporeal Blood Volume (EC-BV)
  - Extracorporeal RBC Volume (EC-RV)

◆ **Patient/Donor**
  - Size - Blood Volume (BV)
    RBC Volume (RV)
  - Clinical Condition
# Erythrocytapheresis

## Blood volume (BV) shift

<table>
<thead>
<tr>
<th>Spectra</th>
<th>Diverted NSS</th>
<th>Intra-Proc</th>
<th>Rinseback</th>
<th>Post-Proc</th>
</tr>
</thead>
<tbody>
<tr>
<td>RBCx</td>
<td>-100</td>
<td>-100</td>
<td>+345</td>
<td>+245</td>
</tr>
</tbody>
</table>

1 yo boy  
10 kg, Hct:30%  
TBV: 70 ml/kg x 10 = 700

#1 Standard RBCx  
Intra-: \(-100/700 \times 100 = -14\%\)  
Post-: \(245/700 \times 100 = +35\%\)

![Diagram showing volume shifts with labels for Divert NSS, RBC Prime, Rinseback, and volume changes]
# Erythrocytapheresis

## Circulating red cell volume (RV) Shift

<table>
<thead>
<tr>
<th>Spectra</th>
<th>During Run</th>
<th>Intra-Proc</th>
<th>Rinseback</th>
<th>Residual vol</th>
<th>Post-Proc</th>
</tr>
</thead>
<tbody>
<tr>
<td>RBCx</td>
<td>-68</td>
<td>-68*</td>
<td>+53</td>
<td>-15</td>
<td>-15</td>
</tr>
</tbody>
</table>

### #1 Standard RBCx

- **1 yo infant, 10 kg, Hct:30%**
- **TBV: 700 mL**

### RV: 700 x 0.3 = 210 mL

- Intra-RV shift
  - \(-68/210 \times 100 = -32\%\)

### Divert NSS
- Yes

### RBC Prime
- No 30%

### Rinseback
- No

-32\% (Hct=20%)
Erythrocytapheresis
Blood prime

10 kg infant, Hct = 30%
TBV = 700 ml  RV = 210 ml  pRBC Hct 57%

#2 Modified RBCx
No Divert
No Rinseback
BV shift: 0%

#3 Modified RBCx
Blood prime: YES
(119 mL pRBC for prime)
RV shift: 0%

BV
Divert NSS  No
RBC Prime  YES
Rinseback  No
RV

No blood prime: Intra-Hct 20%
Pediatric Apheresis

Factors to Consider for Blood Prime

\[ \downarrow \text{Circulating RBC vol} \rightarrow \uparrow \text{RV Shift (\%)} \]

\[ \uparrow \text{Circulating RBC vol} \rightarrow \downarrow \text{RV Shift (\%)} \]

- Low RBC volume:
  - Small size (<20 kg)
  - Anemia
- Underlying medical condition

\[ \text{BV Shift (\%)} = \frac{\text{EC-BV}}{\text{Total BV}} \times 100 \]

\[ \text{RV Shift (\%)} = \frac{\text{EC-RV}}{\text{Total RV}} \times 100 \]
Advantages of Erythrophagytapheresis

**Acute/Emergent RBCx**
- Rapidly achieves the target Hct level without volume overload
- Rapidly reduces HbS level to the target level without substantially the Hct level
- Maintains isovolemia

**Chronic RBCx**
- Markedly reduces the rate of transfusional iron accumulation/prevents iron overload
- Shorter duration of procedure compared to simple transfusion
Disadvantages of Erythrocytapheresis

- Requires large venous access
- **Increased blood requirements**
  - ↑ donor exposure
  - ↑ transfusion-transmitted infections
  - ↑ RBC alloimmunization
- Increased cost for the procedure (?)
- Not universally available
- Thrombocytopenia
Modification of Erythrocytapheresis

Goals

Reduce donor blood requirements and donor exposures

RBC Depletion with Isovolemic Hemodilution followed by Erythrocytapheresis (IHD-RBCx)
IHD–RBCx: Method

<table>
<thead>
<tr>
<th>Phase</th>
<th>Replacement</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>I. RBC Depletion</strong></td>
<td>0.9% NaCl</td>
</tr>
<tr>
<td></td>
<td>Removal of RBC and replacement by an equal vol of 0.9% NaCl until desired Hct is reached.</td>
</tr>
<tr>
<td><strong>II. RBC Exchange</strong></td>
<td>packed-RBC</td>
</tr>
<tr>
<td></td>
<td>Without terminating phase I, phase II (standard RBCx) is carried out.</td>
</tr>
</tbody>
</table>
What is the Optimal/Safe Hematocrit Level during RBC Depletion?

The greater the difference between Intra-proc Hct at the end of depletion and Pre-RBCx Hct levels, the less blood required.

How low can hematocrit levels be safely reduced when performing IHD-RBCx?
What is the Evidence for Safe RBC Depletion with Isovolemic Hemodilution?

- **Non-SCD**
  
  **Acute severe isovolemic anemia (ASIA)**
  
  *RB Weiskopf, et al. 2000-2005 (Depts of Anesthesia and Physiology, CV Research Institute, Univ California, SF)*

- **SCD**
  
  Severe anemia: Risk factor for silent/overt stroke
  
  - **Chronic severe anemia:** Low baseline Hb < 7.0 g/dL
    
  
Acute Severe Isovolemic Anemia (ASIA) in Non-SCD (RB Weiskopf, et al.)

Acute isovolemic anemia to a Hb conc of approx 5-6 g/dL

Effects of ASIA

- Heart rate increased linearly in response to anemia:
  - Females had a significant increase in heart rate with decreasing Hb level, compared to males.

How about children? Patients w/ SCD? Children w/ SCD?

- No decrease in supine blood pressure

- Cognitive function and memory:
  - at Hb 7: no changes; at Hb 5-6: subtle deficits

- No systemic evidence of inadequate O2 delivery at Hb of 5 g/dl, but this does not necessarily fully assess oxygenation of specific organs or tissues
Changes in heart rate are rapidly reversible with increasing O2 delivery by

- **Transfusion of autologous RBCs to Hb 7:** (also reverses energy level) (*P Toy, Transfusion, 2000*)

- **Increasing PaO2 by breathing O2 to**
  - 350 mmHg: equivalent to augmenting Hb >2 g/dl.
  - 406 mmHg: equivalent to augmenting Hb >2.78 g/dl. (*RB Weiskopf, Anesthesiology, 2002*)

**Conclusion:** Lowest safe Hb level appears to be 7 g/dL in healthy non-SCD subjects with ASIA.
Acute Severe Anemia in SCD

- Cerebrovascular Complications and Parvovirus B19 Infection in Homozygous SCD
  
  \begin{itemize}
  \item 58x greater risk for CVAs than expected
  \item Hb at aplastic crisis: 2.2 - 6.5 g/dL
  \end{itemize}

- Acute Silent Cerebral Ischemia (ASCI) and Infarction During Acute Anemia in Children with and without SCD
  
  \begin{itemize}
  \item In children w/ SCD, Hb \leq 5.5 g/dL (2.9-4.1) with at least a 30% decrease from the patient’s baseline may be responsible for ASCI
  \end{itemize}

\begin{flushright}
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\end{flushright}
## Effects of Chronic RBCx on Transfusional Iron Overload

<table>
<thead>
<tr>
<th>Author</th>
<th>Location</th>
<th>yr Pub</th>
<th>No Cases</th>
<th>Age (yr) at RBCx (Mean)</th>
<th>IHD No Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kim, HC</td>
<td>Philadelphia</td>
<td>1994</td>
<td>14</td>
<td>12-24 (18)</td>
<td>X</td>
</tr>
<tr>
<td>Adams, DM</td>
<td>Durham</td>
<td>1996</td>
<td>10</td>
<td>5-20 (12)</td>
<td>X</td>
</tr>
<tr>
<td>Singer, ST</td>
<td>Oakland</td>
<td>1999</td>
<td>8</td>
<td>7-17 (12.1)</td>
<td>X</td>
</tr>
<tr>
<td>Sarode, R</td>
<td>Dallas</td>
<td>2011</td>
<td>20</td>
<td>14-34 (22.5)</td>
<td>X</td>
</tr>
</tbody>
</table>
## Chronic IHD-RBCx (Dallas)

<table>
<thead>
<tr>
<th>Pre-procedure Hct</th>
<th>Target Hct Levels</th>
<th>Post-procedure Hct</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;23%</td>
<td>No IHD</td>
<td>27-30%</td>
</tr>
<tr>
<td>23-25%</td>
<td>20%</td>
<td>27-30%</td>
</tr>
<tr>
<td>26-30%</td>
<td>6% below Pre-Hct</td>
<td>Pre-Hct + 2%*</td>
</tr>
<tr>
<td>≥31%</td>
<td>8% below Pre-Hct</td>
<td>Pre-Hct (Max. 36%)</td>
</tr>
</tbody>
</table>

* Max 32%, if pre-procedure Hct ≤30%

# Chronic IHD-RBCx Target HbS <30% (at CHOP)

<table>
<thead>
<tr>
<th>Pre-Hct (%)</th>
<th>Intra-Hct (%)</th>
<th>Post-Hct (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;26 (Hb &lt;9)</td>
<td>No IHD</td>
<td>27-30%</td>
</tr>
</tbody>
</table>

- Non iron-overloaded patient: same as pre-Hct
- Iron-overloaded patient: <pre-Hct but ≥27% (≤36%)

* Depletion 6% - ≤10%, ↓ inlet flow rate by 30%
* Depletion >10%, ↓ inlet flow rate by 50%
## Chronic IHD-RBCx
Target HbS <50% (at CHOP)

<table>
<thead>
<tr>
<th>Pre-Hct</th>
<th>Intra-Hct</th>
<th>Post-Hct</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤23% (Hb &lt;8)</td>
<td>No IHD</td>
<td>27%</td>
</tr>
<tr>
<td>24-26% (Hb ≥7)</td>
<td>≥21%*</td>
<td>27-30%</td>
</tr>
</tbody>
</table>
| ≥27% (Hb ≥9) | ≥21%* (Hb ≥7) | - Non iron-overloaded patient: same as pre-Hct
- Iron-overloaded patient: <pre-Hct but ≥27% (≤36%)

*Depletion 6% - ≤10%, ↓ inlet flow rate by 30%
*Depletion >10%, ↓ inlet flow rate by 50%
Effects of IHD-RBCx on Blood Requirements

19 yo boy w/Hb SS and s/p CVA

Wt: 63kg, Ht: 179 cm, TBV: 4736 mL, pRBC Hct: 57%

<table>
<thead>
<tr>
<th>Pre-Hct 35%</th>
<th>Standard RBCx</th>
<th>IHD-RBCx</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post-Hct</td>
<td>35%</td>
<td>35%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Depletion (Hct)</th>
<th>No</th>
<th>28%</th>
<th>25%</th>
</tr>
</thead>
<tbody>
<tr>
<td>FCR: 30%</td>
<td>3483</td>
<td>3138* (↓10%)</td>
<td>2973* (↓15%)</td>
</tr>
<tr>
<td>pRBC vol (mL)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FCR: 50%</td>
<td>2005 ** (↓42%)</td>
<td>1807* (↓10%)</td>
<td>1633* (↓19%)+</td>
</tr>
<tr>
<td>pRBC vol (mL)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* compared to donor blood required w/o depletion
** compared to FCR 30%
## Effects of IHD-RBCx on Blood Requirements

**19 yo boy w/SCD & s/p Stroke**

Pre- & post-Hct: 35%, Pre-HbS 30%

<table>
<thead>
<tr>
<th>Depletion-Hct (%)</th>
<th>FCR Reduction w/ IHD</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>35 → 28</td>
</tr>
<tr>
<td>35</td>
<td>35 → 25</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>pRBC required (mL) for FCR 30%</th>
<th>3483</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>FCR (%)</th>
<th>30</th>
<th>26</th>
<th>24</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>pRBC required (mL) for FCR 50%</th>
<th>2005</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>FCR (%)</th>
<th>50</th>
<th>46</th>
<th>Unable to deplete</th>
</tr>
</thead>
</table>

pRBC Hct: 57%
**19 yo boy w/SCD & s/p Stroke**  
Pre- & post-Hct: 35%  
Pre-HbS <30%  
FCR 30%

<table>
<thead>
<tr>
<th>Depletion Hct (%)</th>
<th>Donor Blood (AS-3 RBC) Vol (ml)/proc</th>
<th>Unit/proc.</th>
<th>Unit/year*</th>
</tr>
</thead>
<tbody>
<tr>
<td>no</td>
<td>3483</td>
<td>11.2</td>
<td>~187</td>
</tr>
<tr>
<td>28</td>
<td>3138</td>
<td>10.1</td>
<td>~170 (↓9%)</td>
</tr>
<tr>
<td>25</td>
<td>2973</td>
<td>9.6</td>
<td>~162 (↓13%)</td>
</tr>
</tbody>
</table>

AS-3 RBC: 310 mL/unit (Hct: 57%)  
* every 3 wk (17 wks/yr)
Q4 & Q5: What are the advantages vs. disadvantages, and the long-term benefits of RBCx and IHD-RBCx procedures?

- Reduction in donor-RBC requirements
  - Efficiency of exchange
  - May prolong the RBCx intervals
  - Cost reduction due to less blood usage, fewer number of procedures and less frequent visits

- IHD-RBCx: safe, efficient, & cost effective

- When RBCx is chosen as long-term Tx therapy over simple Tx, IHD-RBCx should be considered as the standard of care rather than standard RBCx unless there is contraindications.

Q6:
### Q7: What are the contraindications for IHD-RBCx Procedure? (at CHOP)

#### Pre-requisite/Limiting Factors for IHD-RBCx

<table>
<thead>
<tr>
<th>Type of RBCx</th>
<th>Long-term</th>
<th>Episodic (Pre-op)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinical condition</td>
<td>stable</td>
<td>stable</td>
</tr>
<tr>
<td>Neurologic Exam</td>
<td>stable</td>
<td>stable</td>
</tr>
<tr>
<td>TCD, MRI &amp; MRA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Min. Weight (kg)</td>
<td>&gt;20</td>
<td>&gt;30</td>
</tr>
<tr>
<td>Min. Pre-Hct (HbS&lt;30%)</td>
<td>&gt;27%</td>
<td>&gt;30%</td>
</tr>
<tr>
<td>Min. Pre-Hct (HbS&lt;50%)</td>
<td>&gt;24%</td>
<td>NA</td>
</tr>
<tr>
<td>Intra-Hct (HbS&lt;30%)</td>
<td>&gt;24%</td>
<td>&gt;27%</td>
</tr>
<tr>
<td>Intra-Hct (HbS&lt;50%)</td>
<td>≥21%</td>
<td>NA</td>
</tr>
</tbody>
</table>

For Acute/Emergent RBCx: IHD-RBCx not indicated
IHD-RBCx (Think Twice Before Start)

- It must be stressed that the decision to modify standard RBCx by applying IHD must be made by the attending physician after careful evaluation of the patient’s clinical, neurologic, and cardiovascular status, and radiological studies of brain.

- To implement IHD-RBCx as the standard of care for patients requiring long-term transfusion therapy, the patient must be hemodynamically and neurologically stable and have no worsening of brain imaging studies.
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