A NOVEL APPROACH TO REDUCE RED BLOOD CELL UNIT EXPOSURES TO PEDIATRIC PATIENTS UNDERGOING HEART SURGERY

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Exposure to blood products

- The administration of blood products is associated with risks of transfusion associated circulatory overload (TACO), transfusion related acute lung injury, hemolytic transfusion reaction, infectious complications and immunomodulation.1
- As the amount of blood transfused increases there is a direct correlation with a prolonged ICU stay.
- Transfusion can also lead to allosensitization in which patients develop panel-reactive antibodies (PRAs). High levels of PRAs can lead to a longer time on the transplant list, and they are associated with an increased risk of death in the first year after orthotopic heart transplant.2
- Post transplant patients with PRAs >50% have a 17% higher mortality at 1 year after transplantation.

Prime

- <8 kg pts.
  - Fresh PRBC and FFP

- 8 to 15 kg pts.
  - Fresh PRBC, FFP or 25% Albumin
  - Changes with each patient

- >15 kg pts.
  - Bloodless? Crystalloid and 25% Albumin
  - If CPB hemodilution >25%

Check prime parameters pre-bypass

Cardiopulmonary Bypass Circuits

- Weight
  - 0-7 kg
  - 7-24 kg
  - 24-35 kg
  - 35-45 kg
  - >45 kg

- Art: Venous
  - 3/16" : 16"
  - 1/8" : 3/8"
  - 3/8" : 3/8"
  - 3/8" : 3/8"

- Oxygenator
  - Capiox RX05
  - Capiox RX15
  - Capiox RX25

- Prime Volume
  - 300 mL
  - 600 mL
  - 800 mL
  - 900 mL
  - 1200 mL
We believe that the transition on and off bypass should be as smooth as possible.

A post-dilutional hematocrit in the low to mid 30s is our clinically acceptable range on bypass however it is not uncommon to push it into the 40’s if necessary.

The hematocrit will be increased if extreme bleeding or post-operative cyanosis is expected.

Plasma is generously given to aid in hemostasis.

Considerations

- It is difficult to avoid transfusion in pediatric cardiac surgery patients due to the patient’s small blood volume in comparison to the volume of the CPB circuit, and multiple strategies for blood conservation in pediatric cardiac surgery have been implemented.

- These strategies include miniaturization of the CPB circuit, vacuum-assisted drainage, cell salvage, ultrafiltration, point of care testing (thromboelastometry or thromboelastography), transfusion algorithms, factor concentrate usage, and restrictive transfusion practices.

What options do you have when these considerations are relatively fixed?
New Protocol

- The idea of purposefully sending larger units of blood was proposed to the blood bank.
- They evaluated the request and determined its feasibility.
- Blood ordering guidelines were amended by the nurse practitioners.
- The new blood ordering guidelines were reinforced by the circulating nurse prior to surgery when applicable.
- The large units were marked with a sticker for identification.

### One unit

<table>
<thead>
<tr>
<th>2016</th>
<th>Post Intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient Weight</td>
<td>14.05 kg</td>
</tr>
<tr>
<td>Patient HCT Pre Bypass</td>
<td>36.89 %</td>
</tr>
<tr>
<td>Average PRBC unit</td>
<td>331.90 mL</td>
</tr>
<tr>
<td>PRBC added to Prime</td>
<td>281.72 mL</td>
</tr>
<tr>
<td>Prime HCT</td>
<td>25.83 %</td>
</tr>
<tr>
<td>Total PRBC Vol Used</td>
<td>333.96 mL</td>
</tr>
<tr>
<td>First HCT on Bypass</td>
<td>28.69 %</td>
</tr>
<tr>
<td>Last HCT on Bypass</td>
<td>31.59 %</td>
</tr>
</tbody>
</table>

### Two units

<table>
<thead>
<tr>
<th>2016</th>
<th>Post Intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient Weight</td>
<td>11.86 kg</td>
</tr>
<tr>
<td>Patient HCT Pre Bypass</td>
<td>36.33 %</td>
</tr>
<tr>
<td>Average PRBC unit</td>
<td>313.62 mL</td>
</tr>
<tr>
<td>PRBC added to Prime</td>
<td>317.66 mL</td>
</tr>
<tr>
<td>Prime HCT</td>
<td>22.65 %</td>
</tr>
<tr>
<td>Total PRBC Vol Used</td>
<td>571.65 mL</td>
</tr>
<tr>
<td>First HCT on Bypass</td>
<td>29.00 %</td>
</tr>
<tr>
<td>Last HCT on Bypass</td>
<td>37.22 %</td>
</tr>
</tbody>
</table>

### 3 or more units

<table>
<thead>
<tr>
<th>2016</th>
<th>Post Intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient Weight</td>
<td>12.13 kg</td>
</tr>
<tr>
<td>Patient HCT Pre Bypass</td>
<td>35.95 %</td>
</tr>
<tr>
<td>Average PRBC unit</td>
<td>313.46 mL</td>
</tr>
<tr>
<td>PRBC added to Prime</td>
<td>339.92 mL</td>
</tr>
<tr>
<td>Prime HCT</td>
<td>23.51 %</td>
</tr>
<tr>
<td>Total PRBC Vol Used</td>
<td>836.05 mL</td>
</tr>
<tr>
<td>First HCT on Bypass</td>
<td>29.03 %</td>
</tr>
<tr>
<td>Last HCT on Bypass</td>
<td>40.69 %</td>
</tr>
</tbody>
</table>
## Overall Comparison

### 2016
- **228 Patients**
- **Average Patient Weight**: 12.81 kg
- **Average Unit**: 321 mL
- **Hematocrit Prime**: 21%
- **Hematocrit Pump**: 28.88%
- **Hematocrit on Pump**: 28.88%
- **Hematocrit off Pump**: 35.49%
- **1 Unit RBC**: 41%
- **2 Unit RBC**: 42%
- **3+ Unit RBC**: 17%

### Post Intervention
- **90 Patients**
- **Average Patient Weight**: 12.12 kg
- **Average Unit**: 398 mL (24% Larger)
- **Hematocrit Prime**: 24.8%
- **Hematocrit Pump**: 30.06%
- **Hematocrit on Pump**: 30.06%
- **Hematocrit off Pump**: 36.87%
- **1 Unit RBC**: 54%
- **2 Unit RBC**: 36%
- **3+ Unit RBC**: 10%

## Precautions

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRBC unit Potassium</td>
<td>11.85 mmol/L</td>
</tr>
<tr>
<td>PRBC Unit HCT</td>
<td>55.91%</td>
</tr>
<tr>
<td>PRBC Unit Glucose</td>
<td>700.94 mg/dL</td>
</tr>
</tbody>
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## Prime

- The pump is primed with 45% NaCl (sodium 77 mmol/L and pH 5.0).
- PRBC and FFP are added as the crystalloid is chased out.
- By hemoconcentrating the circuit we can increase the hematocrit.
- Washing the prime with different crystalloid solutions can influence the electrolytes.
- We add Sodium Bicarbonate, Calcium and Heparin to the circuit.

## Conclusion

- **We were able to receive units of blood over 380 mL over 70% of the time when requested.**
- **The new blood ordering protocol has substantially decreased the amount of patients who received multiple units of RBC.**
- **The significantly larger units helped achieve a more clinically favorable hematocrit during cardiopulmonary bypass.**
- **The development and implementation of this protocol by a multidisciplinary team resulted in a decrease in the number of RBC exposures in pediatric patients undergoing cardiac surgery with the use of cardiopulmonary bypass. The use of this protocol and other blood conservation strategies can help to minimize transfusion-associated morbidity and allosensitization.**
References