The Benefits of Using a Remote Pump System for Children Undergoing Open Heart Surgery
Hemodilution Ratio
Patient Blood volume / Prime volume of the ECC

3 kg = 250ml / 400ml ≈ .5

85 kg = 5525ml / 1600 ml ≈ 3.5
Hemodilution Ratio

Patient Blood volume / Prime volume of the ECC


Investigation of the association between patient age and blood loss and transfusions

N = 414

Age groups

Group 1 (≤ month) Group 2 (1 month – 1 year) Group 3 (1-5 yrs) Group 4 (≥ 5 yrs)

**Findings**

Blood loss and transfusions were inversely correlated to age.

Median number of transfusions within 72 hours

Group 1 (8 units) Group 2 (6 units) Group 3 (2 units) Group (1 unit)
Hemodilution in Pediatric Patients

Allogeneic Transfusions

Inaccurate Heparin Management

Post-operative complications

Increased peri-operative times
Infection or suspected infection after hip replacement surgery with autologous or homologous blood transfusion   Murphy P et al. Transufusion 1999;31:212-7

N = 87 randomized to autologous or homologous blood

**Looked at:**  transfusions and the incidence of infection and LOS

**Results:**  26% increase in the incidence of infection for patients receiving homologous blood


Multivariate stepwise Logistic regression analysis of variability of predictors for LOS.

Transfusion as well as the number of units transfused accounts for 39% of the variability. The remaining 60% was accounted for by 20 other risk factors.


N = 1916 Mortality rates transfused (15%) nontransfused (7%)


Found serum citrate levels 5x normal in children undergoing CPB
Hemodilution in Pediatric Patients

- Allogeneic Transfusions
- Inaccurate Heparin Management
- Post-operative complications
- Increased peri-operative times
Anticoagulation on Children Undergoing Cardiopulmonary Bypass Is Overestimated by Current Monitoring Techniques.
John T. Owings, MD et al. University of Cal-Davis Arch Surg. 2000

Regression analysis of the markers of thrombosis at the end of CPB demonstrated strong inverse correlations with weight in the pediatric group ($P<.001$), but not in the adult group ($P>.05$).

**Whole blood heparin concentrations do not correlate with plasma antifactor Xa heparin concentrations in pediatric patients undergoing cardiopulmonary bypass**
C Gruencwald et al. Department of pediatrics Hospital for Sick Children, Toronto, Perfusion March 2000

Found that the lack of correlation ($r = 0.113$ $p = 0.429$) between the two assays may be related to the extreme hemodilution observed during CPB in small children, which leads to very low concentrations of coagulation proteins.
How to decrease hemodilution and perioperative blood use in the OR?

- Careful Surgical technique
- Retrograd Autologous Priming Circuits
- Anesthesia
  - Low volume administration
  - Diuretics
  - Aprotinin
Benefits in Prime Reduction


The effect of haemodilution on blood-biomaterial contact mediated CD 11b expression on neutrophils: ex vivo studies. Gourlay T. Perfusion 2003 Apr 18(2): 87-93
Traditional circuit configuration

Dilutional prime volume: $\approx 300$cc
Oxygenator/Reservoir
Arterial boot
AV loop w/Arterial filter
New circuit configuration

Dilutional prime volume: 165 cc
Oxygenator/Reservoir
Arterial boot
AV loop w/ Arterial filter (3/16 ,1/4)
New pump Configuration
Retrograde Autologous Priming

- How do we determine what the minimal size patient can be RAP’ed?
- Adults PBV / PV
  - ( 70 – 100 ) Kgs
    - $85 \times 65 = \text{PBV} \approx 5525 \text{ cc} \approx 3.5 – 4.0$
    - $\text{PV} \approx 1500 \text{ cc}$

Where does the PBV / Prime volume ratio reach 4.0 in children?
Retrograde Autologous Priming

Determining RAP by PBV/PV Ratio

- 165 PV
- 185 PV
- 245 PV
Demographics for Comparison of Patients on New Circuit and Historical Controls

- First comparison Patients (< 8 kg)
  - 20 patients matched for
    - Weight
    - Defect
    - CPB time
    - Pre-operative Hct and Platelet count

<table>
<thead>
<tr>
<th></th>
<th>New circuit</th>
<th>Historical Controls</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>4.87+/1.6</td>
<td>4.38+/-.8</td>
<td>P = 0.42</td>
</tr>
<tr>
<td>CPB time</td>
<td>148+/-40</td>
<td>150+/-31</td>
<td>P = 0.90</td>
</tr>
<tr>
<td>Pre-op Hct</td>
<td>35.6+/-1.2</td>
<td>37.1+/-1.6</td>
<td>P = 0.21</td>
</tr>
<tr>
<td>Pre-op Platelets</td>
<td>306+/-89</td>
<td>377+/-102</td>
<td>P = 0.09</td>
</tr>
</tbody>
</table>
Transfusion data comparing average units of blood products per case between Historical controls and patients on the New Circuit design 3.0 – 7.9 Kgs

<table>
<thead>
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<tbody>
<tr>
<td>PRBC</td>
<td>1.4</td>
<td>2.2</td>
<td>2.3</td>
<td>36%</td>
<td>(P &lt; 0.001)</td>
</tr>
<tr>
<td>FFP</td>
<td>1.0</td>
<td>1.8</td>
<td>0.9</td>
<td>45%</td>
<td>(P = 0.05)</td>
</tr>
<tr>
<td>Cryo</td>
<td>0.4</td>
<td>1.2</td>
<td>1.1</td>
<td>64%</td>
<td>(P &lt; 0.001)</td>
</tr>
<tr>
<td>Platelets</td>
<td>0.9</td>
<td>1.1</td>
<td>1.4</td>
<td>25%</td>
<td>(P = 0.27)</td>
</tr>
</tbody>
</table>
## Post operative values

<table>
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<tr>
<td>Post operative Hct</td>
<td>34.3+/- .9</td>
<td>35.9+/-2.6</td>
<td>P = 0.09</td>
</tr>
<tr>
<td>Post-operative Fibrinogen</td>
<td>158.5+/-66.6</td>
<td>132.7+/-18.8</td>
<td>P = 0.27</td>
</tr>
<tr>
<td>Post-operative Platelets</td>
<td>83.1+/-38.4</td>
<td>53.3+/-20.2</td>
<td>P = 0.049</td>
</tr>
</tbody>
</table>
Demographics for Comparison of Patients on New Circuit and Historical Controls

- First comparison Patients (8 – 17 kg)
  - 20 patients matched for
    - Weight
    - Defect
    - CPB time
    - Pre-operative Hct and Platelet count

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<tr>
<td>Weight kg</td>
<td>12 +/- 2.5</td>
<td>10.5 +/- 3.4</td>
<td>0.13</td>
</tr>
<tr>
<td>CPB time Min</td>
<td>117 +/- 40</td>
<td>107 +/- 59.1</td>
<td>0.25</td>
</tr>
<tr>
<td>Pre-operative Hct %</td>
<td>38.2 +/- 1.2</td>
<td>36.9 +/- 2.6</td>
<td>0.31</td>
</tr>
<tr>
<td>Pre-operative Platelets</td>
<td>401 +/- 101</td>
<td>427 +/- 75</td>
<td>0.065</td>
</tr>
</tbody>
</table>
Transfusion data comparing average units of blood products per case between Historical controls and patients on the New Circuit design 8.0 – 17.0 Kgs

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<tbody>
<tr>
<td>PRBC</td>
<td>0.25</td>
<td>1.6</td>
<td>84%</td>
<td>(P &lt; 0.001)</td>
</tr>
<tr>
<td>FFP</td>
<td>0.15</td>
<td>.95</td>
<td>84%</td>
<td>(P &lt; 0.001)</td>
</tr>
<tr>
<td>Cryo</td>
<td>0.1</td>
<td>0.5</td>
<td>80%</td>
<td>(P &lt; 0.001)</td>
</tr>
<tr>
<td>Platelets</td>
<td>0.05</td>
<td>0.75</td>
<td>93%</td>
<td>(P &lt; 0.001)</td>
</tr>
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</table>
## Post operative values

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<tbody>
<tr>
<td>Post operative Hct</td>
<td>27.9 +/- 4.32</td>
<td>31.2 +/- .49</td>
<td>P = 0.012</td>
</tr>
<tr>
<td>Post-operative Fibrinogen</td>
<td>176.5 +/- 76.6</td>
<td>109.7 +/- 30.8</td>
<td>P = 0.02</td>
</tr>
<tr>
<td>Post-operative Platelets</td>
<td>174.2 +/- 77</td>
<td>93.9 +/- 43.7</td>
<td>P &lt; 0.001</td>
</tr>
<tr>
<td>% No products</td>
<td>(8/20) 40%</td>
<td>(1/20) 5%</td>
<td>P &lt; 0.001</td>
</tr>
</tbody>
</table>
Thanks.........