Mild Hypothermic Arch Reconstruction Using Dual Cannulation in Neonates: The Children’s Hospital of Wisconsin Experience

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Disclosures
• none

Background
• Cerebral and visceral perfusion during aortic arch surgeries is extremely important — we are presented with hurdles while trying to achieve adequate oxygen delivery.
• Deep Hypothermic Circulatory Arrest (DHCA) has been widely accepted as a strategy to decrease oxygen demand and thereby allow for a safe drop in oxygen delivery.
  — Regional Cerebral Perfusion is a widely accepted strategy used to ensure continuous oxygen delivery to the brain during DHCA.
  — Somatic hypoperfusion during DHCA can lead to organ and tissue damage.
  — Additionally, cold-induced enzyme dysfunction can exacerbate bleeding issues following bypass.
• I am presenting Children’s Hospital of Wisconsin’s experience with a goal-directed, dual cannulation, mild-hypothermic perfusion strategy to overcome some of the deleterious effects of DHCA and hypoperfusion for Aortic Arch surgery in neonates.
  — The vast majority of our experience with this technique is for Stage 1 Palliation of Hypoplastic Left Heart Syndrome.

Stage one surgical palliation (S1P) of hypoplastic left heart syndrome (HLHS) requires complex reconstruction of the aortic arch with regional or complete interruption of blood flow.
• Varying strategies of DHCA and antegrade cerebral perfusion (ACP) have been employed to permit surgical repair and to minimize organ injury.
• Recent approaches to limit ischemic injury with ACP without deep hypothermia:
  — Dual aortic cannulation techniques of minimally hypothermic CPB have been used in adults to avoid regional ischemia during arch reconstruction.
  — Hammel (2013): ACP+DAC (descending aortic cannulation) via supradiaphragmatic access at 30-32°C: shorter support time, less AKI, same ECMO, ICU LOS, mortality.
  — Raess (2017): distal arch catheter; 60/40 flow ratio; less AKI, no change in clinical outcomes.
Methods

• Cannulation
  – Arterial
    • 8 fr via 3.5 mm graft on innominate
    • 3-4 fr Percutaneous introducer femoral artery sheath
  – Venous
    • Biceval cannulation: 12fr. Right Angle, 14fr. Straight venous

• Circuit Setup
  – Arterial Line y’d distal to oxygenator
  – Transonic flow probe on both lines
  – C-clamp on “head” line

Targets

• rSO2C >50% <85%
• rSO2S>60%
• Right radial pressure <50mmHg

Perfusion Conduct

• Full body perfusion and cooling to 32°C using innominate artery cannula
• Regional Femoral Perfusion (RFP) initiation
• Aortic arch occlusion (patent Left Carotid)
• Head flow stopped
• Cardioplegia via “head” arterial cannula
• Antegrade Cerebral Perfusion (ACP) initiation:
  – 50-80mL/kg/min (<50mmHg)
  – RFP 150-180mL/min
• Following arch repair: aortic arch occlusion (patient left carotid), ACP stopped, neo ascending aorta cannulated with 8fr. Arterial cannula.
• Whole body perfusion and rewarming.
<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean ± sd</th>
<th>Median ± sd</th>
<th>Min - Max</th>
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</thead>
<tbody>
<tr>
<td>Birth Weight (kg)</td>
<td>3.22 ± 0.47</td>
<td>3.15 (0.78)</td>
<td>2.53 – 4.32</td>
</tr>
<tr>
<td>Gest Age (wk)</td>
<td>38.9 ± 0.71</td>
<td>39.1 (0.2)</td>
<td>37.1 – 39.6</td>
</tr>
<tr>
<td>Age S1P (days)</td>
<td>5.89 ± 1.78</td>
<td>6 (1)</td>
<td>4 – 11</td>
</tr>
<tr>
<td>WT S1P (kg)</td>
<td>3.32 ± 0.52</td>
<td>3.17 (0.63)</td>
<td>2.55 – 4.46</td>
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<tr>
<td>BSA (m2)</td>
<td>0.22 ± 0.02</td>
<td>0.21 (0.02)</td>
<td>0.19 – 0.26</td>
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<tr>
<td>aao Diam (mm)</td>
<td>2.5 ± 0.7</td>
<td>2.0 (1.0)</td>
<td>2.0 – 4.0</td>
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<tr>
<td>Gender (female)</td>
<td>10/18 (56%)</td>
<td></td>
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<tr>
<td>Genetic Syndrome</td>
<td>4/18 (22%)</td>
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### Discussion

- Flow distribution measured and adjusted
- Concerns about leg ischemia are overcome by continuous NIRS monitoring of both legs.
Outcomes

• AKI – 0 (18)
• NEC – 0 (18)
• Leg ischemia – 0 (18)
• ECMO – 2 (18)
• Mortality – 1 (18) (POD 1 on ECMO)

Looking forward

• Regional perfusion and dual cannulation is not a new strategy for providing full body perfusion during arch repairs, however our method of cannulating the patient’s femoral artery to provide distal perfusion offers a significant advantage over other methods by removing a cannula and tubing from the direct surgical field.

Conclusion

• Modified dual arterial perfusion strategy with percutaneous femoral artery access pre-CPB permits flexible intraoperative perfusion strategy to avoid circulatory arrest with minimal periods of low flow and short total support time
• No limb ischemic events or early complications from percutaneous femoral access
• Mid and longer term outcomes need to be determined

Thanks!