Validation of a Mathematical Model of Bidirectional Glenn Circulation and the Implications for Qp/Qs Calculation
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Introduction

• In patients with superior cavopulmonary anastomosis:
  \[ \frac{Q_p}{Q_s} = \frac{S_aO_2 - SsvcO_2}{SpvO_2 - SpaO_2} \]
  For practical reasons, SsvcO2 is substituted for SivcO2 in clinical practice.
• Based on a previously published mathematical model of Glenn circulation with or without additional sources of pulmonary blood flow:
  \[ D_O_2 = Q_p \times CaO_2 \]
  \[ = \frac{1}{\frac{1}{1+kF/FS}} \times CO \times C_{py}O_2 - \frac{(1-k)\times CVO_2}{FS} \frac{F}{FS} \]
  Where k = proportion of pulmonary venous blood returning to the left ventricle.
• In this project we aimed to validate the previously published mathematical model with flow data from cardiac MRI (cMRI).
• Furthermore, we strive to compare Qp/Qs calculations based on:
  • Cardiac MRI flow data
  • Cardiac catheterization data using SsvcO2
  • and the above mathematical model

We identified patients who had both a cardiac MRI and cardiac catheterization in close temporal proximity.

• Data collected include:
  • Demographic information
  • From cardiac cath:
    • SVC, PA, PV, and arterial saturations
  • From cardiac MRI:
    • Flow data and cardiac outputs
• Qp/Qs was calculated:
  • based on flow data in cardiac MRI
  • based on cardiac cath data as:
  \[ \frac{Q_p}{Q_s} = \frac{S_aO_2 - SsvcO_2}{SpvO_2 - SpaO_2} \]

Results

Table 1: Demographic and Baseline Information

<table>
<thead>
<tr>
<th>Age (yrs)</th>
<th>Weight (kg)</th>
<th>Hemoglobin (g/dL)</th>
<th>CO (L/min)</th>
<th>SsvcO2 (%)</th>
<th>SpvO2 (%)</th>
<th>k</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.0 ± 4.2</td>
<td>15.2 ± 8.7</td>
<td>15.6 ± 2.0</td>
<td>6.9 ± 1.8</td>
<td>63.4 ± 6.8</td>
<td>96.5 ± 2.2</td>
<td>0.69 ± 0.22</td>
</tr>
</tbody>
</table>

Validation of Mathematical Model

Cardiac Cath vs Model Qp/Qs

Qp/Qs cMRI vs Cath

Discussion

• In this study we validated a mathematical model of bidirectional Glenn circulation using flow data from cardiac MRI and cardiac cath saturation data.
• Qp/Qs calculated utilizing data from cardiac MRI and cath data had reasonable agreement, except when cardiac MRI predicts a high Qp/Qs.
• SVC saturation had reasonable accuracy in predicting Qp/Qs in our patient population because the majority of patients fit into the inflection point of the curve in the model where the difference between IVC and SVC saturations were not significant to influence clinical decision making.

Future Directions:
• Continue data collection and increase sample size
• Limitations include:
  • Small number with diverse diagnosis
  • Patients frequently have collateralization
  • Multiple sources of pulmonary blood flow

Conclusion

• The previously published mathematical model of Glenn circulation has good predictive value and accuracy
• Qp/Qs estimated utilizing SsvcO2 from cath lab was reasonably accurate if SVC saturations were between 55 and 70%.

References