Surgical Management of Transposition of the Great Arteries (TGA)

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Disclosure: No Conflicts of Interest
Objectives

• Discuss surgical approach to the repair of D-TGA
• Discuss outcomes of surgery for D-TGA in the modern era
Scope of discussion

• D-TGA with intact ventricular septum
• Not discussed:
  • Associated lesions accompanying D-TGA
    • VSD
    • Arch obstruction
    • LVOTO
  • Corrected transposition (L-TGA)
Anatomy: Ventricular-Arterial Discordance

Normal

D-TGA
Physiology of TGA

Normal: Circulation in series

TGA: Circulation in parallel
Surgical solutions for D-TGA

D-TGA

Normal

Re-route outflow

Re-route inflow
Atrial Switch for D-TGA

• Senning operation (1957)
• Mustard operation (1963)
• Problems:
  • Pathway obstruction with growth
  • Atrial dysrythmias
  • Late RV (systemic) failure
Arterial Switch Operation for D-TGA

• Returns LV to the systemic circulation with minimal atrial impact
• Rate limiting factor was coronary transfer
• First successful arterial switch done by Jatene, reported in 1975 (staged following PA band + shunt)
• First neonatal switch was performed by Castaneda at Boston Children’s (1983)
• By the late 1980s neonatal arterial switch operation became the gold standard
Coronary artery classifications

• Yacoub classification:
  • Does not describe all variants
• Leiden classification:
  • Good for common nomenclature
  • Does not guide surgical principles
• Marie Lannelongue “French” classification:
  • Simple and guides coronary transfer techniques
Leiden classification of “usual / normal” coronary pattern in D-TGA (1AD,Cx; 2R)
Usual coronary artery course (1 AD, Cx; 2 R)
Leiden TGA coronary artery classification
Marie Lannelongue anatomic coronary artery classification in TGA

- “Normal” or usual course
- Looping course
- Intramural course
“Normal” (Usual) coronary course

- 60% cases
- L ostium: AD, Cx
- R ostium: RCA
- No coronaries cross in front or behind great vessels
Looping coronary artery course

- 35% involve looping courses
- 3 variations:
  - Posterior looping (20%)
  - Anterior looping (1%)
  - Double looping (14%)
Posterior looping course

- 2 variations (20%):
  - Posterior Cx branching from RCA (19%) 
  - Single coronary from R sinus with posterior looping LMCA (1%)
Anterior looping course

- 3 variations (1%)
- Great vessels oriented side-by-side
- 2 involve single coronary artery anatomy
Double looping course (14%)

- Usually Aorta and PA are more side-side
- Cx posterior loop, RCA anterior loop, (5%)
- LMCA posterior, RCA anterior (8%)
- Single coronary with Cx posterior and AD anterior (1%)
Intramural coronary artery course

- 5% of cases
- LMCA courses in the posterior aortic wall above or behind the posterior commissure
- Close proximity to commissure → intramural course
Uniform technique for the Arterial Switch Operation

• LeCompte maneuver
• Coronary origin and path determines transfer site
• Arterial switch is aortic surgery – not coronary surgery
• PA reconstruction with autologous pericardium
Great Vessel division and Lecompte maneuver
Relative position of Aorta and PA in TGA
Coronary button harvest
Coronary transfer
Pulmonary artery reconstruction
Early outcome of ASO for D-TGA,IVS

• Single institution reports with < 1%
• STS database 20011-2014: 1.8%
Early outcome of ASO for D-TGA

- Children’s Hospital Colorado (2003-2011)
- N=101 (52 simple DTGA, 49 complex DTGA)
- Operative mortality 0%
- Major morbidity 23%
- Survival: 99% at 49±27 months

Early survival for ASO in D-TGA/IVS: effect of center volume

Table 1. Patient Characteristics, Operative Characteristics, and Outcomes Stratified by Center Volume Tertiles

<table>
<thead>
<tr>
<th>Variable</th>
<th>0-5 Cases/y (n = 731)</th>
<th>5-10 Cases/y (n = 926)</th>
<th>&gt;10 Cases/y (n = 747)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (days)</td>
<td>7 (5–10)</td>
<td>6 (5–8)</td>
<td>6 (4–10)</td>
<td>0.097</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>3.4 (3.0–3.7)</td>
<td>3.4 (3.0–3.7)</td>
<td>3.4 (3.0–3.7)</td>
<td>0.455</td>
</tr>
<tr>
<td>Weight &lt; 2.5 kg</td>
<td>52 (7%)</td>
<td>45 (5%)</td>
<td>48 (6.4%)</td>
<td>0.137</td>
</tr>
<tr>
<td>Any preoperative risk factor</td>
<td>337 (46%)</td>
<td>473 (51%)</td>
<td>390 (52%)</td>
<td>0.05</td>
</tr>
<tr>
<td>Operative</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CPB time (min)</td>
<td>178 (152–216)</td>
<td>166 (142–193)</td>
<td>141 (118–167)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Cross-clamp time (min)</td>
<td>104 (82–127)</td>
<td>93 (79–117)</td>
<td>76 (61–95)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Length of stay (days)</td>
<td>20 (14–28)</td>
<td>17 (13–23)</td>
<td>516 (12–23)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Discharge mortality</td>
<td>242 (5.767%)</td>
<td>17 (1.8%)</td>
<td>21 (2.8%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Major complication</td>
<td>383 (52.4%)</td>
<td>461 (49.8%)</td>
<td>424 (56.8%)</td>
<td>0.017</td>
</tr>
</tbody>
</table>

Early outcome of ASO for D-TGA,IVS: effect of surgeon volume

Table 2. Patient Characteristics, Operative Characteristics, and Outcomes Stratified by Surgeon Volume Tertiles

<table>
<thead>
<tr>
<th>Variable</th>
<th>0–2 Cases/y (n = 390)</th>
<th>3–6 Cases/y (n = 1514)</th>
<th>&gt;6 Cases/y (n = 453)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (days)</td>
<td>7 (5–10)</td>
<td>7 (4–9)</td>
<td>6 (4–8)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>3.4 (3.0–3.7)</td>
<td>3.4 (3.0–3.7)</td>
<td>3.3 (2.9–3.6)</td>
<td>0.002</td>
</tr>
<tr>
<td>Weight &lt;2.5 kg</td>
<td>28 (7%)</td>
<td>72 (5%)</td>
<td>43 (10%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Any preoperative risk factor</td>
<td>176 (45%)</td>
<td>777 (51%)</td>
<td>234 (52%)</td>
<td>0.09</td>
</tr>
<tr>
<td>Operative</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CPB time (min)</td>
<td>182 (156–218)</td>
<td>162 (137–192)</td>
<td>146 (117–173)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Cross-clamp time (min)</td>
<td>99 (80–123)</td>
<td>93 (77–118)</td>
<td>75 (57–89)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Length of stay (days)</td>
<td>19 (13–28)</td>
<td>18 (13–25)</td>
<td>5 (12–23)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Discharge mortality</td>
<td>26 (6.7%)</td>
<td>45 (3.0%)</td>
<td>8 (1.8%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Major complication</td>
<td>72 (18.5%)</td>
<td>223 (14.7%)</td>
<td>52 (11.5%)</td>
<td>0.02</td>
</tr>
</tbody>
</table>

Karamalou Ann Thorac Surg 2014
Risk factors for early mortality of ASO for D-TGA

- Surgeon volume
- Center volume
- Complicated coronary anatomy:
  - Intra-mural coronary artery
  - Single coronary artery with inter-arterial course
  - Posterior looping course
High risk coronary artery patterns

- Intra-mural coronary artery course
- Single coronary with inter-arterial coronary artery course
- Posterior looping courses
Intra-mural coronary artery
Intra-mural coronary artery with interarterial course
Single coronary from right sinus with Inter-arterial course
Posterior looping risks positive feedback loop

Minor stretching or kink of posterior looping coronary

LV Ischemia

LV distension

↑PA pressure

RV Distension

↑stretch

Hypotension
Long-term issues following ASO

- Re-intervention ranges from 5-25%
- Pulmonary stenosis is most common factor requiring re-intervention
- Coronary artery stenosis:
  - Most common early (3 months)
  - Can be asymptomatic
- Neoaortic root dilation
- Neoaortic insufficiency (1-3% reoperation at 20 yrs)
Long-term outcome for D-TGA

Atrial Switch

Arterial Switch

Vejlstrup, et al *Circulation* 2015

Conclusions

• D-TGA is a technically demanding surgical challenge
• Standardization of techniques and experience have led to excellent early survival
• Long-term outcomes are very good but late re-operations are not uncommon