PDA: Closure Using Coils and Devices: Indications, Technique & Outcome

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Disclosure Information

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As a faculty member for this program, I disclose the following relationships with industry:

- (GRS): Grant/Research Support
- (C): Consultant
- (SB): Speaker’s Bureau
- (MSH): Major Stock Holder
- (AB): Advisory Board
- (E): Employment
- (O): Other Financial or Material Support

pfm Medical: C
Atrium Medical: C
Neurosigma Vascular: AB
NIH Challenge Grant, AHA Innovative Research Grant
How Common are PDA’s?

- Depends on age
  - < 2,000 gram premature infants (18%)
  - Other studies are as high as 70%

- US Birthrate in 2009 was 4,130,655
  - Calculates to on average 6-7,000 babies born with PDA every year in the US

- The 2 most common interventional procedure performed (35-50/year)
Why do we care?

- PDA’s in infants wreak havoc in the Neonatal Intensive Care Units (NICU’s)
  - Most common group to have PDA’s
  - Most likely to be symptomatic
  - Can cause severe lung damage/persistent need for ventilator

- Most common finding in children/adults over 1 year of age is heart murmur
  - Not infrequently misdiagnosed with asthma
  - Prolonged LA/LV enlargement can cause long-term ventricular dysfunction or CHF
Closing Patent Ductus Arteriosus

Gianturco Coil 1991

Amplatzer Duct Occluder I 2004

Amplatzer Duct Occluder II 2012
PDA: Indications for PDA closure

• Symptoms
  • Age dependent
  • Premie, timing
• Left-sided heart enlargement by ECHO
• “significant” sized PDA by ECHO
• PDA with murmur
• Any PDA on ECHO??
  • The Silent Ductus
  • sPDA “on the table”
What is the Optimal PDA Closure Device?

MRI Compatible
Retrievable/Repositionable
Easily Retrievable if Device Should Embolize
Minimal Residual Shunt @ Follow-up
Low Profile
Cheap
What is the Optimal PDA Closure Device?

Catheterization and Cardiovascular Interventions 75:687–695 (2010)

PEDIATRIC AND CONGENITAL HEART DISEASE

Original Studies

Trans-Catheter Closure of Patent Ductus Arteriosus—What Is the Best Device?

### TABLE I. Comparison of Four PDA Closure Devices

<table>
<thead>
<tr>
<th>Type of Device n (percent)</th>
<th>Gianturco 120 (22%)</th>
<th>Flipper 119 (22%)</th>
<th>Amplatzer 152 (28%)</th>
<th>Nit-Occlud 155 (28%)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yrs)</td>
<td>4.7 ± 5.1</td>
<td>4.3 ± 5.1</td>
<td>6.8 ± 10.1&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.5 ± 8.6&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.01</td>
</tr>
<tr>
<td>≤1 yr 140 (%)</td>
<td>27 (19.3)</td>
<td>38 (27.1)</td>
<td>36 (25.7)</td>
<td>39 (27.9)</td>
<td>NS</td>
</tr>
<tr>
<td>&gt;1–&lt;5 yrs 233 (%)</td>
<td>59 (25.3)</td>
<td>50 (21.5)</td>
<td>66 (28.3)</td>
<td>58 (24.9)</td>
<td>NS</td>
</tr>
<tr>
<td>&gt;5 yrs 169 (%)</td>
<td>34 (20.1)</td>
<td>31 (18.3)</td>
<td>47 (27.9)</td>
<td>57 (33.7)</td>
<td>NS</td>
</tr>
<tr>
<td>Male: Female</td>
<td>33: 87</td>
<td>44: 75</td>
<td>53: 99</td>
<td>49: 106</td>
<td>NS</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>20.4 ± 21.2</td>
<td>18.8 ± 6.4</td>
<td>20.5 ± 19.2</td>
<td>19.8 ± 16.6</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Narrowest PDA diameter (mm)</td>
<td>2.2 ± 0.8</td>
<td>2.2 ± 1.0</td>
<td>3.2 ± 1.5</td>
<td>2.3 ± 1.4</td>
<td></td>
</tr>
<tr>
<td>PDA type</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&gt;0.001</td>
</tr>
<tr>
<td>A 355 (%)</td>
<td>91 (25.6)</td>
<td>88 (24.8)</td>
<td>94 (26.5)</td>
<td>82 (23.1)</td>
<td></td>
</tr>
<tr>
<td>B 40 (%)</td>
<td>8 (20)</td>
<td>2 (5)</td>
<td>17 (42.5)</td>
<td>13 (32.5)</td>
<td></td>
</tr>
<tr>
<td>C 45 (%)</td>
<td>7 (15.6)</td>
<td>14 (31.1)</td>
<td>14 (31.1)</td>
<td>10 (22.2)</td>
<td></td>
</tr>
<tr>
<td>D 11 (%)</td>
<td>2 (18.2)</td>
<td>4 (36.4)</td>
<td>3 (27.2)</td>
<td>2 (18.2)</td>
<td></td>
</tr>
<tr>
<td>E 84 (%)</td>
<td>12 (14.3)</td>
<td>11 (13.1)</td>
<td>13 (15.5)</td>
<td>48 (57.1)</td>
<td></td>
</tr>
<tr>
<td>Unknown 11 (%)</td>
<td>–</td>
<td>–</td>
<td>11 (100)</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>No. of coils/device</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>1</td>
<td>87</td>
<td>89</td>
<td>152</td>
<td>143&lt;sup&gt;c&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>21</td>
<td>22</td>
<td>–</td>
<td>3&lt;sup&gt;d&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>≥3</td>
<td>12</td>
<td>8</td>
<td>–</td>
<td>–</td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup>Significant compared with Gianturco and Flipper group.

<sup>b</sup>Significant compared with Flipper group.

<sup>c</sup>Nine patients in whom a Nit-Occlud coil was initially tried eventually received an Amplatzer duct occluder for PDA closure—not included in the table.

<sup>d</sup>Amplatzer duct occluder was the second device used in three patients with residual shunts after PDA closure with Nit-Occlud coils.

All data expressed as sample number (n) and percentage (%) or mean and standard deviation (SD); Yrs, years, kg, kilograms; mm, millimeter; NS, not significant; No, number; PDA type - based on Krichenko’s classification.
What is the Optimal PDA Closure Device?

<table>
<thead>
<tr>
<th>Type of Device</th>
<th>Gianturco</th>
<th>Flipper</th>
<th>Amplatzer</th>
<th>Nit-Occlud</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>n (percent)</td>
<td>120 (22%)</td>
<td>119 (22%)</td>
<td>152 (28%)</td>
<td>155 (28%)</td>
<td></td>
</tr>
<tr>
<td>Immediate R.S.</td>
<td>42 (35)</td>
<td>38 (32)</td>
<td>66 (43.4)</td>
<td>80 (51.6)</td>
<td>0.004</td>
</tr>
<tr>
<td>R.S. at 6 months</td>
<td>15/96 (15.6)</td>
<td>12/95 (12.6)</td>
<td>5/150 (3.3)</td>
<td>3/143 (2.1)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Embolization</td>
<td>11 (9.2)</td>
<td>3 (2.5)</td>
<td>0</td>
<td>3 (2)</td>
<td>0.002</td>
</tr>
<tr>
<td>Coarctation</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1 (0.7) b</td>
<td>NS</td>
</tr>
<tr>
<td>LPA stenosis</td>
<td>2 (1.7)</td>
<td>0</td>
<td>1 (0.7)</td>
<td>0</td>
<td>NS</td>
</tr>
</tbody>
</table>

*Six-month follow-up echocardiographic data available only in these patients.*

*No interventions required to date.*

All data expressed as sample number (n) and percentage (%) in parenthesis; R.S, residual shunt; LPA, left pulmonary artery; NS, not significant.
PDA: Assessment

- Angiogram
  - RAO, LAT
  - High frame rate
  - Hold for levophase
- ECHO helps
  - Predicts size of shunt
  - "Guess-timates" size
- Angiogram is gold standard
- Detailed anatomy
- Ampulla size
- Distensible?
- Coarctation?
- PA anatomy
PDA: Angiography: LAT
PDA: Angiography: RAO
PDA: Angiography: LAT

- Length
- Narrowest width
- Aortic Ampulla
- Note distance to PAs
- Choose device

B: 5.4mm
C: 23.9mm
D: 15.1mm

A: 20.5mm

CF: 0.1311mm/p (x1.5)
PDA: Measurements

“Measure the frame on which it looks biggest not the frame on which you see it the best”

- Length (least critical)
- Narrowest width
- Aortic Ampulla
- Note distance to PAs
PDA: Device Delivery – Scout

Pfm
PDA-R
Not all PDA’s are Created Equal
PDA Devices: Current Choices

- ADO – Amplatz Duct Occluder****
- ADO II *
- AVP2/4 – Amplatz Vascular Plug***
- NitOcclud Coil ***
- Flipper Coil **
- Pushable Coils
- PDA-R – pfm Medical **
- mVSD Device **
- ASO – Amplatz Septal Occluder
PDA: Coil Choices

• Pushable Coils
  • MREye, 0.038’ coils
• Flipper Coil – Cook
  • MREye
  • 3mmX5cm, 5mmX6cm
• Nit-Occlud Coils –
  • pfm Medical
• Micro-Coils
  • Interlock, Axiom, Hydrogel
• RARELY Needed
PDA: Coil Size Choices

- Size coil to ampulla
- At least 1.5-2X the size of the PDA’s minimum diameter
- Do not want to get in the way of the aorta or pulmonary artery
PDA: Coil Delivery

- ≤ 1 loop in the PA
- Angiography prior to release (optional)
- Check coil orientation
- Prior to release
- No LPA obstruction
- No Dao obstruction
PDA: Angiogram After Release

- Do I need more coils?
- Risk of hemolysis?
- Is residual shunt acceptable?
Nit-Occlud Coils
- robust coil
- retrievable
- ideal shape
- FDA approved

<table>
<thead>
<tr>
<th>REF</th>
<th>Coil diameter</th>
<th>Implantation catheter</th>
<th>Implantation catheter length</th>
<th>Coil length</th>
<th>Type</th>
<th>PU</th>
</tr>
</thead>
<tbody>
<tr>
<td>143106</td>
<td>10 x 6 mm</td>
<td>5 F</td>
<td>105 cm</td>
<td>6.0 mm</td>
<td>Stiff</td>
<td>1</td>
</tr>
<tr>
<td>143126</td>
<td>12 x 6 mm</td>
<td>5 F</td>
<td>105 cm</td>
<td>6.0 mm</td>
<td>Stiff</td>
<td>1</td>
</tr>
<tr>
<td>143146</td>
<td>14 x 6 mm</td>
<td>5 F</td>
<td>105 cm</td>
<td>6.0 mm</td>
<td>Stiff</td>
<td>1</td>
</tr>
<tr>
<td>145044</td>
<td>4 x 4 mm</td>
<td>4 F</td>
<td>85 cm</td>
<td>3.5 mm</td>
<td>Flex</td>
<td>1</td>
</tr>
<tr>
<td>145054</td>
<td>5 x 4 mm</td>
<td>4 F</td>
<td>85 cm</td>
<td>3.5 mm</td>
<td>Flex</td>
<td>1</td>
</tr>
<tr>
<td>145065</td>
<td>6 x 5 mm</td>
<td>4 F</td>
<td>85 cm</td>
<td>3.5 mm</td>
<td>Flex</td>
<td>1</td>
</tr>
<tr>
<td>145076</td>
<td>7 x 6 mm</td>
<td>5 F</td>
<td>85 cm</td>
<td>4.5 mm</td>
<td>Medium</td>
<td>1</td>
</tr>
<tr>
<td>145096</td>
<td>9 x 6 mm</td>
<td>5 F</td>
<td>85 cm</td>
<td>5.0 mm</td>
<td>Medium</td>
<td>1</td>
</tr>
<tr>
<td>145116</td>
<td>11 x 6 mm</td>
<td>5 F</td>
<td>85 cm</td>
<td>6.0 mm</td>
<td>Medium</td>
<td>1</td>
</tr>
</tbody>
</table>
Case 1
13.9 ± 5.4 mm
Case 1

2.5±1.0 mm
Case 1
Case 1
Case 1
Case 1
Case 1
Case 1
Case 1
Case 2: PDA Occlusion
Case 2: PDA Occlusion
Case 2: PDA Occlusion
Case 2: PDA Occlusion
Case 2: PDA Occlusion
PDA Devices: When to use more than the average coil?

• Small PDA, needs adequate ampulla
• >2 mm at narrowest or distensible
• PDAs easily crossed from PA side
  • Retrograde delivery possible
  • Large PDAs that can’t be crossed from PA
    • especially in adults
    • requires snaring of wire in PA
• Most PDAs are now device closed
Case 3: PDA Occlusion
Case 3: PDA Occlusion
Case 3: PDA Occlusion
Case 3: PDA Occlusion
PDA Devices: Angiography

- Detailed anatomy
- Ampulla size
- Distensible?
- Coarctation?
- PA anatomy
PDA: To Close or Not To Close?

Surgery?
PDA Devices: Angiography

- Residual shunt
- PA obstruction
- DAo obstruction
- Risk to embolization
PDA Devices: Current Choices

- ADO – Amplatz Duct Occlud
- ADO II
- AVP2 – Amplatz Vascular Plug
- PDA-R – pfm Medical
- mVSD Device
- ASO – Amplatz Septal Occluder