Transcatheter interventions for Coarctation of aorta

BY

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Coarctation of the Aorta, 2-D & CW Doppler, Suprasternal Notch
Introduction; surgery

• Since 1st reported by Crafoord & Nylin, in 1945 surgical repair was the conventional option for most children with COA.

• Surgical mortality approaches 0% -- 2.9% for isolated COA in infants and older children.

• Surgical mortality rises to 5-15% or higher in infants with COA plus large VSD or more complex intracardiac lesions
Cont; surgery intro.

Surgical morbidity includes:
• 1-post-op paradoxical sys.hypertension.
• 2-paraplegia, weakness, cerebral event.
• 3-nerve injury.
• 4-bleeding & chylothorax.
• 5-infection.
• 6-mesenteric arteritis.
• 7-Reoperation or reintervention specially below 12 months
Outcome after extended arch repair for aortic coarctation

J D R Thomson, A Mulpur, R Guerrero, Z Nagy, J L Gibbs, K G Watterson
Departments of Congenital Cardiology and Cardiac Surgery, Yorkshire Heart Centre, Leeds General Infirmary, Leeds, UK

• Review of 191 consecutive children (154 (81%) under 1 year of age) 1990 and 2002
• Median time to follow up was 4.2 years (range 1–10.6 years).
• Single surgeon using extended arch reconstructive techniques.
• 1, coarctation alone, n = 104;
• 2, coarctation and ventricular septal defect, n = 38
• 3, coarctation in association with complex intracardiac anomalies, n = 49.

Heart 2006;92:90-94
• 9 patients died within 30 days of the original operation.

• 11 of the 182 survivors died late (> 30 days) at a median of 6.9 months (range 1.3–50.8 months) after surgery.

• Actuarial survival for the whole cohort at two, five, and 10 years was 92%, 88%, and 88%, respectively

*Heart* 2006;92:90-94
Neurological injury

• Paraplegia occurred in one patient after significant intraoperative bleeding from the anastomotic site.

• A second patient had transient lower limb weakness but recovered fully and walks normally. Both of these patients underwent extended end to end repair through a lateral thoracotomy.

• A third patient had a small segmental cerebral infarct on computed tomography after coarctation repair, arterial switch, and ventricular septal defect closure.

*Heart* 2006;92:90-94
Reintervention to the coarctation site

- Seven of 165 (4.2%) surviving patients required reintervention.

- All of these patients had diminished (grade 0 or 1) femoral pulsation and systemic hypertension.

- Three of seven were premature infants and three of seven had aortic arch hypoplasia.

- Six of seven patients with recurrent arch obstruction had discrete stenosis suitable for balloon angioplasty and one (premature) infant had a long segment stenosis. In this case a repeat operation was performed.

*Heart* 2006;92:90-94
Cont; surgery intro.

• Reoperation mortality of 5-15% can be explained in part by complex COA at 1st surgery (long segment COA, Arch hypo.)

• Aortic aneurysm formation may develop postoperatively & is highest (24%) post prosthetic patch repair. It tends to progress rapidly.

• Residual COA or recoarctation incidence varies 25-60% (or 15-30% when 40 mmHg resting gradient is adopted.) (4-5% in more recent studies) when repair in infancy.
Balloon angioplasty (BA) for COA.

- Widely accepted for post-op recurrent COA

- Can be considered an alternative to surgery beyond infancy.

BA complications include:

- 1-residual COA & recoarctation general incidence of 14-27% (up to 70% in 1st year of life, more so in 1st 3 months. M.O.Galal et al 2003.).

- 2-mortality is rare 0.7%

- 3-femoral artery thrombosis 20-25% specially in infants (responds well to heparin or streptokinase)

- 4-bleeding requiring transfusion, paradoxical hypertension, infection or CVA are rare.
Cont; Intro, BA

- Aneurysm formation is a concern initial reports 0-55%.
- Larger recent studies suggest 6-12% (even as low as 2%)
- (surgical end to end COA repair 0-4%).

McCrindle et al 1993
M.O. Galal et al 2003
BA results in 80 infant less than 12 kg

- 6% failure
- 20% FA injury (2.3% in adults).
- Aneurysm formation 1% (6-7% in older child. And adults).
- 1 procedure related death, 2 late death post VSD repair.
- Recoarctation 44%
- 71% free from coa at 15 y.

Curtesy prof M.O. Galal
Long-Term, Randomized Comparison of Balloon Angioplasty and Surgery for Native Coarctation of the Aorta in Childhood
Collin G. Cowley, MD; Garth S. Orsmond, MD; Peter Feola, MD; Lon McQuillan, MD; Robert E. Shaddy, MD

• August 1985 and November 1990, patients between the ages of 3 and 10 years with a hemodynamically significant native CoA.

• Participants were randomly assigned to BA or surgery with equal probability.

• For subjects randomized to BA, the balloon diameter was selected to match the diameter of the uninvolved aorta proximal to the coarctation.

(Circulation. 2005;111:3453-3456.)
36 original participants randomized to BA (n=20) or surgery (n=16)

21 subjects returned for evaluation (11 BA, 10 surgery) between April 2001 and November 2002.

(Circulation. 2005;111:3453-3456.)
20 subjects initially treated with BA

- 3 underwent repeat BA

- 3 underwent surgical repair (2 for aneurysm resection).

- 2 subjects initially treated surgically underwent BA. One of these subjects later returned for repeat surgery.

(Circulation. 2005;111:3453-3456.)
Aneurysm Formation

- Aneurysms were detected in 7 (35%) of the 20 BA subjects (4 diffuse, 3 discrete).

- No aneurysms were detected among the 16 surgical subjects ($P=0.011$).

- One of these subjects was referred for elective surgical repair 6.8 years after initial BA.

- No repeat interventions have been performed on the other subjects in whom aneurysms were detected early.

*(Circulation. 2005;111:3453-3456.)*
Stenting of native COA & recoarctation why?

- To reduce the incidence of residual COA & recoarctation by reducing elastic recoil.
- To treat complex COA
- To help reduce or abolish the risk of aneurysm formation.
- To provide a longer COA free periods and hence less hypertension and better overall prognosis.

- Could show in the animal model that stent can be reexpanded after growth.

- Stent implantation relieves aortic obstruction in experimental coarctation.

- Re-expansion of stents can be performed in an area of surgical aortotomy and coarctation without significant intimal or medial injury.

- Stent implantation may be used in preventing restenosis and aneurysm formation after angioplasty of coarctation.

• Successful stent implantation in 10 juvenile swine, 34 days after surgically produced coarctation.

• Repeat catheterization was performed 59 days after stent implantation. (in 5 re-expansion of stents, aortic specimens examined by light microscopy and electro-microscopy).

• All stents patent, no intra-luminal thrombosis. Stent occupied a sub-intimal, with no evidence of intimal or medial dissection.

• Showed that intravascular stents implanted in the normal thoracic aorta of swine can be reexpanded after growth with no significant injury to the neointima or media.
• 17 patients with coarctation of the aorta underwent stent implantation (median age 11 years, range 0.4-15 years)
• Six were treated for isolated coarctation
• Nine for recurrent coarctation (five after surgical repair
• Four after balloon dilatation
• Two for complex long segment coarctation.
RESULTS:

- Immediately after stent implantation the peak systolic gradient (mean (SD)) fell from 50.0 (24.5) to 2.1 (2.4) mm Hg (p < 0.05).
- The diameter of the stenotic lesion increased from 5.1 (1.5) mm to 13.9 (2.4) mm (p < 0.05).
- There were no deaths or procedure related complications.
- At a median follow up of 33 months, no cases of recoarctation were identified.
Use of balloon-expandable stents for coarctation of the aorta: initial results and intermediate-term follow-up
MR Ebeid, LR Prieto, and LA Latson Department of Pediatric Cardiology, Cleveland Clinic Foundation, Ohio, USA.

- Nine patients (>10 years old) with COA in whom balloon dilation alone was thought to be ineffective underwent stent implantation.

- Seven patients had a previous operation or balloon dilation, or both.

- RESULTS:
  - At the time of stent implantation, the systolic and mean gradients decreased from a mean (+/-SEM) of 37 +/- 7 and 14 +/- 3 mm Hg to 4 +/- 1 and 2 +/- 0.6 mm Hg, respectively (p < or = 0.002). The coarctation diameter increased from a mean of 9 +/- 1 to 15 +/- 1 mm (p < 0.002).

- The patients have been followed for up to 42 months (mean 18, median 13) with no complications; the stents remain in position with no fracture.

J Am Coll Cardiol, 1997; 30:1847-1852
RESULTS:

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• One patient underwent further successful dilation 3 years after stent implantation because of an exercise-induced gradient.
Stenting vs. balloon angioplasty for discrete unoperated coarctation of the aorta in adolescents and adults
Carlos A.C, et al

- September 1997, 21 consecutive adolescents and adults (24 ± 11 years) with discrete CoA underwent stenting (G1).

- The results were compared to those achieved by BA performed in historical group of 15 patients (18 ± 10 years; \( P = 0.103 \); G2).

- After the procedure, systolic gradient reduction was higher (99% ± 2% vs. 87% ± 17%; \( P = 0.015 \)).

- Residual gradients lower (0.4 ± 1.4 vs. 5.9 ± 7.9 mm Hg; \( P = 0.019 \)), gain at the CoA site higher (333% ± 172% vs. 190% ± 104%; \( P = 0.007 \)).
Aortic wall abnormalities were found in eight patients in G2 (53%) and in one in G1 (7%; \( P < 0.001 \)).

There was no major complication.

2 required late stenting due to aneurysm formation or stent fracture in G1.

Aortic wall abnormalities did not progress and one patient required redilation.
Transcatheter stent implantation to treat aortic coarctation in infancy.

A N Redington, A M Hayes, S Y Ho

• A ten week old girl who had previously undergone a palliative procedure for the hypoplastic left heart syndrome had unrelieved aortic coarctation that did not respond to standard balloon dilatation.

• Complete relief of coarctation with prompt clinical improvement was achieved with placement of an 8 mm self-expanding stent.

Conclusion;

• Transcatheter stent implantation may have a role in selected patients with aortic coarctation.
Results

Table 1: Demographic data of the studied cases

<table>
<thead>
<tr>
<th></th>
<th>Group 1 N = 26</th>
<th>Group 2 N = 31</th>
<th>Group 3 N = 17</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age (month)</strong></td>
<td>1.69±0.8</td>
<td>8.20±5.6</td>
<td>107.29±53.5</td>
<td>0.0001</td>
</tr>
<tr>
<td><strong>Body weight (kg)</strong></td>
<td>3.95±1.1</td>
<td>6.56±4.6</td>
<td>37.63±26.1</td>
<td>0.0001</td>
</tr>
<tr>
<td><strong>Right arm systolic BP (mmHg)</strong></td>
<td>118.62±18.8</td>
<td>115.87±26.8</td>
<td>150.35±21.2</td>
<td>0.0001</td>
</tr>
<tr>
<td><strong>Right arm/ leg systolic gradient (mmHg)</strong></td>
<td>48.58±16.7</td>
<td>44.32±17.4</td>
<td>50.94±13.1</td>
<td>0.363</td>
</tr>
</tbody>
</table>
### Results

Table 3: Angiographic and hemodynamic data before and after balloon angioplasty

<table>
<thead>
<tr>
<th></th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N = 26</td>
<td>N = 31</td>
<td>N = 17</td>
</tr>
<tr>
<td>Pre G (mmHg)</td>
<td>52.00±14.9</td>
<td>45.13±16.2</td>
<td>48.00±15.1</td>
</tr>
<tr>
<td>Post G (mmHg)</td>
<td>16.50±11.8</td>
<td>14.16±8.7</td>
<td>9.82±9.5</td>
</tr>
<tr>
<td>Pre D (mm)</td>
<td>2.00±0.5</td>
<td>2.53±1.0</td>
<td>3.99±1.1</td>
</tr>
<tr>
<td>Post D (mm)</td>
<td>4.83±0.7</td>
<td>5.93±1.7</td>
<td>9.35±2.9</td>
</tr>
<tr>
<td>Mean balloon size (mm)</td>
<td>5.56±0.8</td>
<td>6.74±2.2</td>
<td>12.53±3.4</td>
</tr>
<tr>
<td>Procedure time (minutes)</td>
<td>72.23±63.1</td>
<td>79.29±42.1</td>
<td>87.33±73.6</td>
</tr>
<tr>
<td>Fluoroscopy time (minutes)</td>
<td>15.26±19.1</td>
<td>15.13±11.9</td>
<td>24.65±46.6</td>
</tr>
<tr>
<td>Right arm SBP post (mmHg)</td>
<td>100.54±12.3</td>
<td>100.35±16.9</td>
<td>114.53±7.3</td>
</tr>
<tr>
<td>Right arm/leg systolic gradient post (mmHg)</td>
<td>18.77±8.8</td>
<td>17.06±8.8</td>
<td>18.35±9.2</td>
</tr>
<tr>
<td>Initial success</td>
<td>23 (88.4%)</td>
<td>27 (87%)</td>
<td>16 (94.1%)</td>
</tr>
<tr>
<td>Restenosis</td>
<td>18 (69.2%)</td>
<td>10 (32.3%)</td>
<td>4 (23.5%)</td>
</tr>
<tr>
<td>Stent</td>
<td>2 (7.7%)</td>
<td>3 (9.6%)</td>
<td>2 (11.7%)</td>
</tr>
<tr>
<td>Surgery for restenosis</td>
<td>10 (38.4%)</td>
<td>4 (12.9%)</td>
<td>1 (5.9%)</td>
</tr>
<tr>
<td>Repeat angioplasty</td>
<td>8 (30.8%)</td>
<td>6 (19.3%)</td>
<td>3 (17.6%)</td>
</tr>
<tr>
<td>Aneurysm</td>
<td>1(3.8%)</td>
<td>1(3.2%)</td>
<td>0 (0%)</td>
</tr>
</tbody>
</table>
CASE NO 1

• 19 m.o. male DX; hemangioma of face, neck & mediastinum, multiple segment COA, developmental delay.
• Wt. 9kg
• Echo gradient 100 mmHg.
• Sys BP 110mmHg
Now age 42months (11 months last cath)
Wt 11kg
Palpable
BP RUL 77 mmHg  LLL 74 mmHg.
No cardiac meds
CASE NO 2

- 3 m.o. female s/p DORV.
- CHF, FTT wt 4kg, shunted hydroceph, CVA.
- LV dysfunction, mod AI & MRC
- COA gradient 60mmHg
- BAP twice 3&8 months
- Age 14 months stented for gr.20 & LV dys
- Now 3y.o good LV FUNCTION no gr.by cath, palpable LL pulses.
CASE NO 3

• DX; Arnold chiari, meningocele, diaph hernia, COA, vsd, type 3 hypoplastic s/p BAP at ref hosp. (unsuccessful). Wt 5.2kg
• CHF, complicated by fungal sepsis and severe anasarca, prolonged NICU stay. Not fit for any type of cardiac surgery.
• Anterograde BAP followed by stenting
• Better LL pulses AND COA diameter
• Died several days after
CASE NO 4

- DX: ASD, SUPRACRYSYTAL VSD, tight COA (1.8mm)
- AGE 1 month 4.1 kg CHF biventricular dys, gr 45
- BAP, gr 15
- Age 2 month CHF, chest infection, mechanical vent, LV dys, not fit for OR, STARTED TO develop body oedema
- Cath & stent done
- VSD closed at 7 months surgically electively
- Now well wt 12.3kg cath gr 23 mmHG
CONCLUSION

• COA treatment remains a debate although there is significant evidence that the interventional arm is an acceptable treatment modality beyond the 1st year of life.

• COA stenting is of proven efficacy in the older child and adult.

• A very selected subset of younger children and infants may benefit from stenting were it becomes a more reliable palliation.
THANK YOU