Indications, Techniques and Outcomes for Angioplasty and Stenting of CoA in Adults

Dr Damien Kenny, MD, MRCPCH
Consultant Cardiologist
Our Lady’s Hospital for Sick Children
& The Mater Hospital
Dublin, Ireland
23 Yr old with previous switch for TGA and subclavian flap repair as a neonate. Aneurysm formation on CT.
Complications - Aortic Rupture
In Retrospect...
Treatment Options

• Surgery

• Balloon

• Stent
  – Bare
  – Covered
  – Stent Grafts
CoA and The Vasculature

• Injury is inevitable

• Nomenclature confusing

• Pre-coarctation vascular tree is abnormal

• Hypertension the single most important outcome variable
Long Term Survival

- Significant Late Morbidity and Mortality
  - Accelerated CVD
  - CVA
  - Heart Failure

**HYPERTENSION**

“The higher the postoperative systolic pressure, the higher the probability of death”

Balloon Angioplasty

• First Reported 1982\textsuperscript{1}

• Reasonable gradient relief....however
  – Restenosis
  – Aneurysm (up to 30%)\textsuperscript{2}

• Even “compliance testing” – aneurysm\textsuperscript{3}

• Limited place as therapy

Comparison of Surgical, Stent, and Balloon Angioplasty Treatment of Native Coarctation of the Aorta

An Observational Study by the CCISC (Congenital Cardiovascular Interventional Study Consortium)

Thomas J. Forbes, MD,* Dennis W. Kim, MD, PhD,† Wei Du, PhD,* Daniel R. Turner, MD,*† Ralf Holzer, MD,‡ Zahid Amin, MD,¶ Ziyad Hijazi, MD,¶ Abdolrahim Ghasemi, MD,§ Jonathan J. Rome, MD,|| David Nykanen, MD,# Evan Zahn, MD,# Collin Cowley, MD,** Mark Hoyer, MD,†† David Waight, MD,‡‡ Daniel Gruenstein, MD,§§ Alex Javois, MD,||| Susan Foerster, MD,¶¶ Jacqueline Kreutzer, MD,## Nancy Sullivan, MS, CCRC,* Asra Khan, MD,* Carl Owada, MD,*** Donald Hagler, MD,††† Scott Lim, MD, §§§ Joshua Canter, MD, |||| Thomas Zellers, MD, §§§ and the CCISC Investigators

Detroit, Michigan; Atlanta, Georgia; Columbus and Akron, Ohio; Tehran, Iran; Philadelphia and Pittsburgh, Pennsylvania; Chicago and Oak Lawn, Illinois; Orlando and Miami, Florida; Salt Lake City, Utah; Indianapolis, Indiana; Minneapolis and Rochester, Minnesota; St. Louis, Missouri; Fresno, California; Dallas, Texas; Charlottesville, Virginia; and Washington, DC
Comparative Outcome Data

<table>
<thead>
<tr>
<th>Table 3</th>
<th>Acute Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Surgery (n = 72)</td>
</tr>
<tr>
<td>---------</td>
<td>----------------</td>
</tr>
<tr>
<td>Post-intervention right-arm SBP, mm Hg</td>
<td>123 ± 13</td>
</tr>
<tr>
<td>Discharge ULG</td>
<td>7.7 ± 18.2</td>
</tr>
<tr>
<td>Discharge ULG ≤10 mm Hg</td>
<td>64%</td>
</tr>
<tr>
<td>Discharge ULG ≤15 mm Hg</td>
<td>73%</td>
</tr>
<tr>
<td>Post-intervention catheterization SBP gradient</td>
<td>NA</td>
</tr>
<tr>
<td>% Increase in coarctation measurement post-intervention</td>
<td>NA</td>
</tr>
<tr>
<td>Any complications</td>
<td>18.1%†</td>
</tr>
<tr>
<td>Aortic wall injury</td>
<td>UK‡</td>
</tr>
<tr>
<td>Dissection/intimal tear</td>
<td>UK‡</td>
</tr>
<tr>
<td>Aneurysm</td>
<td>UK‡</td>
</tr>
<tr>
<td>Balloon rupture</td>
<td>NA</td>
</tr>
<tr>
<td>Stent migration</td>
<td>NA</td>
</tr>
<tr>
<td>Femoral</td>
<td>UK‡</td>
</tr>
<tr>
<td>Atrial fibrillation</td>
<td>3%</td>
</tr>
<tr>
<td>Severe/prolonged hypertension</td>
<td>3%</td>
</tr>
<tr>
<td>Length of stay, days</td>
<td>6.4/5.0</td>
</tr>
</tbody>
</table>
Recommendations for Stent Placement in Native CoA and Re-CoA

Class I
• 1. Recurrent coarctation patients of sufficient size for safe stent placement, in whom the stent can be expanded to an adult size, and who have a transcatheater systolic coarctation gradient >20 mm Hg (Level of Evidence: B).

Class IIa
• Transcatheater systolic coarctation gradient of >20 mm Hg (Level of Evidence: B).
• Transcatheater systolic coarctation gradient of <20 mm Hg but with systemic hypertension associated with an anatomic narrowing that explains the hypertension (Level of Evidence: C).
• Long-segment coarctation with a transcatheater systolic coarctation gradient >20 mm Hg (Level of Evidence: B).
• When balloon angioplasty has failed, as long as a stent that can be expanded to an adult size can be implanted (Level of Evidence: B).

Class IIb
• 1. In infants and neonates when complex aortic arch obstruction exists despite surgical or catheter-mediated attempts to relieve this obstruction and when further surgery is regarded as high risk (Level of Evidence: C).
• 2. Transcoarctation gradient of <20 mm Hg but with an elevated left ventricular end-diastolic pressure and an anatomic narrowing (Level of Evidence: C).
• Transcoarctation gradient of <20 mm Hg but in whom significant aortic collaterals exist, which results in an underestimation of the coarctation (Level of Evidence: C).

Circulation 2011; 123: 2607-52
CoA in Adults

• Patient Age

• Genetics
  – Turners Syndrome

• Patient Preference

• Native vs Recurrent

• Position
  – Arch Involvement
  – Thoracic Involvement

• Coarctation Morphology
  – Discrete vs Long Segment
  – Severity

• Co-existing abnormalities
  – PDA
Procedure

- GA with biplane imaging
- RFA (Ultrasound) - Preclose
- 2nd Access for Angiography
- Hemodynamics
- Angiography with accurate measurements
- Wire position
- Long sheath
- Stent
- RV pacing
- Reassess
- IVUS
Pre-procedural Planning
CT
Bare Stenting vs Covered?
Stents

Valeo

Genesis XD

CP-Stent

CP-stent, 3 lg, 34 mm

11 mm

22 mm

CP

eV3
CP Stents
IntraStent® DoubleStrut™

IntraStent® Mega™

IntraStent® Max™

Flexibility

Strength
Andrastent
Covered Stents

- CP stent – COAST
- Atrium Stent – Advanta V12
- Self-expanding
- Self-fabricated
- Indications
Self-fabricated
Myth vs Truth

1. “The risk of aortic wall damage is high following stenting”

2. “Covered Stents ALWAYS protect against Aortic Wall Damage”

3. “There are no RCT’s comparing covered vs bare metal stents for CoA”
Aortic Wall Damage: 5 Studies

<table>
<thead>
<tr>
<th>Center/Reference</th>
<th>Patient N Procedure N</th>
<th>Age (mean/median)</th>
<th>Type of CoA</th>
<th>Aortic Wall Complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boston Cardiol Young. 2007;17:307-18.</td>
<td>153 patients 171 stents (Covered n=1)</td>
<td>15.8 yrs</td>
<td>Native 36%</td>
<td>2% F/Up – 6%</td>
</tr>
<tr>
<td>COAST CCI. 2013;82: 503-10.</td>
<td>105 patients BMS (Covered n=14)</td>
<td>16 yrs</td>
<td>Native 57%</td>
<td>Localized dissection – 1% Compliance Testing</td>
</tr>
<tr>
<td>Bristol Heart. 2010;96: 1212-16.</td>
<td>88 Pts 102 Procedures (Covered - 27%)</td>
<td>20.6 yrs</td>
<td>Native 51%</td>
<td>Acute - 2% (CCPS) Follow-up 1%**</td>
</tr>
<tr>
<td>Lahore CCI. 2013; 82: 511-18.</td>
<td>56 Pts (Selective) 59 CPCS</td>
<td>22.2 yrs</td>
<td>Native 100%</td>
<td>Dissection – 1.8%</td>
</tr>
</tbody>
</table>

The Risk of Acute AWI is 1-2%
“Covered Stents Always Protect”

• Bristol data (case already shown)

Covered Stents Don’t Always Protect

• Toronto:
  – 22 patients with CPCS – Pseudoaneurysm (n=1) ²
  – Case report – 51 yo Native Co - Aortic Rupture ³

• Brazil
  – 9 patients – Pseudoaneurysm (n=2) at follow-up ⁴

Comparison Between Covered and Bare Cheatham-Platinum Stents for Endovascular Treatment of Patients With Native Post-Ductal Aortic Coarctation

Immediate and Intermediate-Term Results

Bahram Sohrabi, MD,* Peiman Jamshidi, MD,* † Alireza Yaghoubi, MD,* Afshin Habibzadeh, MD,* Yashar Hashemi-aghdam, MD, † Araz Moin, MD, ‡ Babak Kazemi, MD,* Samad Ghaffari, MD,* Mohammad Reza Abdolahzadeh Baghayi, MD,* Khalil Mahmoody, MD.§

Tabriz and Zanjan, Iran; and Lucerne, Switzerland
No Difference Between BMS and CCPS

- Mean F-Up: 31.1±19.2
  - CT at 6/12

- Recurrent CoA:
  - BMS: N=4
  - CPCS: N=0

- Pseudoaneurysm
  - BMS: N=0
  - CPCS: N=2

- Death
  - BMS: N=1
  - CPCS: N=0

*JACC: Cardiovasc Interv. 2014;7: 416-23*
**Bare vs Covered - Data**

**TABLE I. Characteristics of Study Patients According to Group (n = 143)**

<table>
<thead>
<tr>
<th></th>
<th>Group</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>G1 (n = 71)</td>
<td>G2 (n = 72)</td>
<td>p</td>
</tr>
<tr>
<td>Male</td>
<td>45 (63.4%)</td>
<td>46 (63.9%)</td>
<td>1.000</td>
</tr>
<tr>
<td>Age (years)</td>
<td>17.0 (13.0–29.0)</td>
<td>17.5 (12.0–32.5)</td>
<td>0.543</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>55.25 ± 19.22</td>
<td>61.56 ± 20.17</td>
<td>0.058</td>
</tr>
<tr>
<td>Native</td>
<td>46 (64.8%)</td>
<td>56 (77.8%)</td>
<td>0.125</td>
</tr>
<tr>
<td>Complex lesions</td>
<td>31 (43.7%)</td>
<td>54 (75.0%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Aortic hypoplasia</td>
<td>14 (20.9%)</td>
<td>13 (18.6%)</td>
<td>0.899</td>
</tr>
<tr>
<td>Manual hemostasis</td>
<td>55 (77.5%)</td>
<td>7 (9.7%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Surgical hemostasis</td>
<td>7 (9.9%)</td>
<td>46 (63.9%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Long-sheath (French size)</td>
<td>10.48 ± 1.77</td>
<td>12.42 ± 1.72</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Balloon diameter (mm)</td>
<td>14.70 ± 3.28</td>
<td>13.85 ± 3.22</td>
<td>0.843</td>
</tr>
<tr>
<td>Gradient preprocedure (mm Hg)</td>
<td>39.28 ± 14.53</td>
<td>39.42 ± 13.58</td>
<td>0.952</td>
</tr>
<tr>
<td>Gradient postprocedure (mm Hg)</td>
<td>4.69 ± 6.03</td>
<td>5.26 ± 6.64</td>
<td>0.59</td>
</tr>
<tr>
<td>Success rate</td>
<td>67 (94.4%)</td>
<td>69 (95.8%)</td>
<td>1.000</td>
</tr>
<tr>
<td>Residual gradient &gt;10 mm Hg</td>
<td>17 (23.9%)</td>
<td>18 (25.0%)</td>
<td>1.000</td>
</tr>
<tr>
<td>Balloon/Coarctation ratio pre procedure</td>
<td>2.40 ± 1.33</td>
<td>4.77 ± 6.06</td>
<td>0.002</td>
</tr>
<tr>
<td>Proximal aorta/Coarctation ratio postprocedure</td>
<td>1.10 ± 0.19</td>
<td>1.11 ± 0.12</td>
<td>0.002</td>
</tr>
<tr>
<td>Minimal diameter pre procedure (mm)</td>
<td>7.29 ± 2.77</td>
<td>5.37 ± 3.08</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Minimal diameter post-procedure (mm)</td>
<td>14.86 ± 3.82</td>
<td>13.67 ± 3.58</td>
<td>0.071</td>
</tr>
<tr>
<td>Reintervention at follow-up</td>
<td>18 (26.9%)</td>
<td>16 (23.9%)</td>
<td>0.843</td>
</tr>
<tr>
<td>Mortality rate</td>
<td>1 (1.4%)</td>
<td>0 (0.0%)</td>
<td>0.994</td>
</tr>
</tbody>
</table>

Values are median (range), mean (standard deviation) or n (%).

Aortic Wall Complications (n=5 – 7%)
- 2 Pre-dilation
- 2 Over-dilation

Catheterization and Cardiovascular Interventions 83:953–963 (2014)
Approach to Coarctation Stenting

• Certain Groups at Risk
  – Age > 40 yrs
  – Abdominal location
  – ? 3.5 X original diameter
  – ? Long Segment

• Probably at Risk
  – Turners syndrome
  – Tortuosity

• Common Sense
  – Pre-existing aneurysm
  – Stent Fracture
  – Associated Ductus
  – Acute Injury

• AVOID Pre-Dilation!
  (11.4% vs. 3%; OR 4.18; P 0.001)
Aorto-bronchial Fistula

39 year old with two previous surgical interventions for CoA presented with hemoptysis
Aorto-bronchial Fistula
12 year old with iatrogenic CoA and false aneurysm formation following closure of arterial duct with a Rashkind device in childhood
CT Follow-up
Benefits of 3DRA

26 yo with previous CoA stent and subsequent AAO-DAO Bypass Graft
Initial 3DRA
Self-fashioned Covered Stents

Catheter Cardiovasc Interv. 2011:78:413-8
Following Implantation of Self-Fabricated Stent
Optimus Stent
Conclusions

• Pre-dilation consistently leads to AWD
• Data does not support universal use of CS
• Covered stents do not guarantee safety
• Reserve for “appropriate” situations
"I've missed more than 9,000 shots in my career. I’ve lost almost 300 games. 26 times I've been trusted to take the game winning shot and missed. I’ve failed over and over and over again in my life. And that is why I succeed."

~ Michael Jordan