Pulmonary Artery Angioplasty – Conventional and Cutting Balloons

Matthew J. Gillespie MD, FSCAI
The Children’s Hospital of Philadelphia
SCAI Fellows Course
December 9, 2014
Matthew J. Gillespie, MD
No Disclosures
• Pulmonary artery stenosis, distortion, hypoplasia
  • TOF, TOF/PA, Truncus Arteriosus, Fontan, etc, etc.
    – Major impact on patient outcome
• Historically difficult to treat surgically
Goals

- Spectrum of pulmonary artery pathology
- Indications for catheter treatment
- Treatment strategy decision-making
- Technique
- Outcomes
I. **Isolated Focal Stenosis**

- Well-developed distal pulmonary arteries
- Usually occurs post-operatively
- Excellent outcomes –
  - usually end up with stent
Pulmonary Artery Pathology: 4 General categories

I. Isolated Focal Stenosis, well-developed distal pulmonary arteries

II. Focal Stenosis with associated distal pulmonary artery hypoplasia

• Often in setting of low flow early in life
  – examples: tetralogy of Fallot; post surgical shunt with asymmetric flow
I. Isolated Focal Stenosis, well-developed distal Pas

II. Focal Stenosis with associated PA hypoplasia

III. Multiple Branch Stenoses

- Usually abnormal vessel wall at stenoses
- Common in TOF/PA with collaterals
- also seen in arteriopathies like Williams and Alagille
IV. Diffuse Hypoplasia

- Usually from intrinsic vascular abnormality: most common in arteriopathies
IV. Diffuse Hypoplasia

- Usually from intrinsic vascular abnormality: most common in arteriopathies
Diffuse PA Hypoplasia: IVUS
Decision-making:
1. Indications for Rx

**Single Ventricle**
- Anatomic obstruction with any gradient

**Biventricular Circulation**
- No intracardiac shunts
  - Right ventricular hypertension
  - Segmental PAH
  - Significantly decreased lung flow (MRI, nuc med)
  - PI in TOF
- With intracardiac shunt (ie TOF/PA with VSD)
  - More complex equation taking into account Qp and gradients
Factors to consider

• Site of obstruction - central vs distal pa branch
• Patient age - future growth of vessels
• Vessel/stent size - risk of ISR, outgrowing stent
• Mechanism of obstruction (intrinsic stenosis v external compression or kinking)
Technique: Preparation

• Equipment needs
  – Stock appropriate selection of balloons, wires, long sheaths, covered stents and embolization materials for bail-out)

• Diagnostics
  – Flow distribution assessment in biventricular circulation (MRI or Nuc Med)

• Risk-Stratification
  – General anesthesia for all but simpler cases
  – High risk patients (suprasystemic RVp, right heart failure) ECMO back-up
  – Multiple PA branch obstruction – LONG CASES...be prepared to suffer.....
Procedure

• Catheter diagnostics
  – Risk stratify more precisely:
    • Mixed venous saturation
    • RA pressure
    • RV pressure
    • Impact of catheter in RVOT/PA
  – If High Risk based on above
    • what is your plan?
      – ECMO candidate?
      – Prophylactic transseptal and ASD creation
      – Prophylactic CPS (infrequent but not unheard of in our experience)
• Supportive measures
  – 100% O2, optimize O2 carrying capacity, etc.
• Targeted angiography
  – Don’t flood both lungs with contrast
Dilation: Approach

- Selective angiography: lateral / LAO caudal for distal
Dilation: Approach

• Be efficient - pre-shaped Mullins to proximal pa branch
  – allows for rapid angiographic assessment and repositioning
Dilation: Approach

- Wire position, wire position, wire position

- Balloon size - start at $<150\%$ normal vessel
  - balloon:stenosis diameter ratio $< 4$
  - In arteriopathy patients be more conservative

- High pressure versus cutting balloon angioplasty?
  - Standard balloon angioplasty is faster, simpler, and probably lower procedural risk
  - It also doesn’t work as well
  - Cutting balloon angioplasty on average more effective
    - Also increased risk of dissection and other complications.
Approach: Standard Balloon

- **Vessel size ~4 mm or less**
  - Wires – 0.014 – 0.018” high torque exchange length
  - Balloons
    - Sterling (Boston Scientific) or equivalent (available 4-10mm) reasonably high pressure (14 atm)

- **Larger Vessels**
  - 0.035” wires (Rosen is our preferred)
  - Noncompliant balloon: Ultrathin Diamond (Boston Scientific) or equivalent
Cutting Balloons
Equipment

- Balloon ≤ 4 mm
  - Sheath at least 5 F; 0.014” wire (Extra support Boston Scientific)

- > 4 mm
  - 7 F sheath, 0.018” wire (High torque floppy)
Choosing correct cutting balloon size

- Safest (more laborious) is low pressure balloon-sizing.
  - Std angioplasty balloon (size based on prev criteria) at 6 atm
  - Cutting balloon diameter 1 mm greater than waist up to 1 mm > normal distal vessel size.
Special Considerations: Multiple Distal Stenoses with Severe Obstruction

- Careful monitoring, anesthesia
- Hemodynamic instability with balloon inflation
  - approach most severe lesions first
- Risk of reperfusion edema
  - dilate as many lesions as possible at each procedure to distribute flow
  - don’t be too aggressive with individual vessels
- Efficiency essential
Complication Management

• Dissection/ Aneurysm
  – Relieve residual obstruction

• Perforations/Rupture
  – embolization
Balloon Angioplasty: Results from Literature

**“Success”**: Variable results – early series 50%, recently 75-up to 90%.

**Criteria for success**:
- angiographic diameter ↑ of > 50%,
- > 20% ↓ in RV/AO pressure,
- > 20% ↑ in relative flow by lung scan.

**THESE CRITERIA DO NOT EQUAL CLINICAL SUCCESS**

- Complications: 6-10%, mortality 1%
- Restenosis: ???
Restenosis After Angioplasty

Incidence of restenosis = 35%

Unable to define specific predictors
Cutting Balloon Outcomes


- **85%** increase in minimum lumen diameter CB vs **52%** for HBP

### Table 5. Primary and Secondary Safety Outcomes

<table>
<thead>
<tr>
<th>Primary and Secondary Safety Outcomes</th>
<th>Cutting Balloon (n=107), n (%)</th>
<th>High-Pressure Balloon (n=66), n (%)</th>
<th>( p )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary safety outcome</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Any serious event in a study vessel</td>
<td>0 (3)</td>
<td>0 (0)</td>
<td></td>
</tr>
<tr>
<td>Secondary safety outcomes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Any serious event definitely attributable to balloon angioplasty in a study vessel</td>
<td>0 (3)</td>
<td>0 (0)</td>
<td></td>
</tr>
<tr>
<td>Any somewhat serious or serious adverse event resulting from balloon angioplasty in a study vessel</td>
<td>3 (3)</td>
<td>1 (2)</td>
<td>0.85</td>
</tr>
<tr>
<td>Any adverse event resulting from balloon angioplasty in a study vessel*</td>
<td>12 (11)</td>
<td>4 (6)</td>
<td>0.38</td>
</tr>
</tbody>
</table>

*Thirteen events in 12 vessels, including 1 patient with 2 events in 1 vessel (both device malfunction). One adverse event in a vessel randomized to high-pressure balloon therapy occurred after crossover (balloon rupture); here, it is attributed to the high-pressure balloon.
Conclusions: Pulmonary Angioplasty

• PA dilation remains a challenging intervention for several reasons
  – Has potential for substantial risk
  – Procedures are lengthy, and often frustrating in patients with multiple distal obstructions
  – Results remain suboptimal particularly in arteriopathies

• But for many lesions, it is the best we have, in current practice even with its limitations, remains an essential tool.
Conclusions (continued)
Acknowledgement

Jack Rome, MD
For sharing his slides
Thank You