Renal Intervention

Herbert D. Aronow, MD, MPH, FACC, FSCAI, FSVM
Director, Interventional Cardiology, Cardiovascular Institute
Director, Cardiac Cath Labs, Rhode Island & The Miriam Hospitals
Disclosures

• None
Appropriate Patient Identification For Renal Artery Intervention Remains Challenging

- Renal-artery stenosis
- Renal-artery stenosis and HTN
- Renal-artery stenosis, hypertension, and CKD
- HTN
- CKD
Observational Studies of Renal Artery Stenting

Blood Pressure Lowering

Stabilization Of Renal Function

Regression line slopes of reciprocal $S_{Cr}$ over time

Renal Artery Intervention
Meta-Analysis of 7 RCTs (n=2,139)

Renal Artery Intervention
Meta-Analysis of 7 RCTs (n=2,139)

Renal Artery Stenting
Meta-Analysis of 7 RCTs (n=2,139)

A = revascularization; B = medical therapy

### Renal Artery Stenting
Meta-Analysis of 7 RCTs (n=2,139)

#### Congestive heart failure (stenting)

<table>
<thead>
<tr>
<th>Study name</th>
<th>Odds ratio</th>
<th>Lower limit</th>
<th>Upper limit</th>
<th>Z value</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTRAL Trial</td>
<td>1.290</td>
<td>0.845</td>
<td>1.968</td>
<td>1.178</td>
<td>0.239</td>
</tr>
<tr>
<td>Bax et al</td>
<td>2.589</td>
<td>0.263</td>
<td>25.519</td>
<td>0.815</td>
<td>0.415</td>
</tr>
<tr>
<td>Cooper et al</td>
<td>0.970</td>
<td>0.610</td>
<td>1.542</td>
<td>-0.129</td>
<td>0.897</td>
</tr>
<tr>
<td></td>
<td>1.150</td>
<td>0.844</td>
<td>1.568</td>
<td>0.887</td>
<td>0.375</td>
</tr>
</tbody>
</table>

A = revascularization; B = medical therapy

Renal Artery Stenting
Meta-Analysis of 7 RCTs (n=2,139)

A = revascularization; B = medical therapy

## Renal Artery Stenting
### Meta-Analysis of 7 RCTs (n=2,139)

#### Number of antihypertensive medications

<table>
<thead>
<tr>
<th>Study name</th>
<th>Std diff in means</th>
<th>Standard error</th>
<th>Variance</th>
<th>Lower limit</th>
<th>Upper limit</th>
<th>Z value</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTRAL</td>
<td>-0.174</td>
<td>0.071</td>
<td>0.005</td>
<td>-0.312</td>
<td>-0.035</td>
<td>-2.462</td>
<td>0.014</td>
</tr>
<tr>
<td>Bax et al</td>
<td>-0.161</td>
<td>0.170</td>
<td>0.029</td>
<td>-0.494</td>
<td>0.173</td>
<td>-0.945</td>
<td>0.345</td>
</tr>
<tr>
<td>Cooper et al</td>
<td>-0.138</td>
<td>0.066</td>
<td>0.004</td>
<td>-0.267</td>
<td>-0.009</td>
<td>-2.101</td>
<td>0.036</td>
</tr>
<tr>
<td>VanJaarsveld et al</td>
<td>-0.556</td>
<td>0.198</td>
<td>0.039</td>
<td>-0.944</td>
<td>-0.167</td>
<td>-2.802</td>
<td>0.005</td>
</tr>
<tr>
<td>Scarpioni et al</td>
<td>-0.273</td>
<td>0.279</td>
<td>0.078</td>
<td>-0.820</td>
<td>0.275</td>
<td>-0.976</td>
<td>0.329</td>
</tr>
<tr>
<td></td>
<td>-0.178</td>
<td>0.044</td>
<td>0.002</td>
<td>-0.265</td>
<td>-0.091</td>
<td>-4.005</td>
<td>0.000</td>
</tr>
</tbody>
</table>

#### Std diff in means and 95% CI

-2.00 | -1.00 | 0.00 | 1.00 | 2.00

Favors revascularization
Favors medical therapy

## Pre-CORAL RCTs: Study Limitations: Small Sample Size

<table>
<thead>
<tr>
<th></th>
<th>EMMA</th>
<th>SNRASCG</th>
<th>DRASTIC</th>
<th>ASTRAL</th>
<th>STAR</th>
<th>NITER</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Location</strong></td>
<td>France</td>
<td>UK</td>
<td>Netherlands</td>
<td>UK, AU, NZ</td>
<td>Netherlands</td>
<td>Italy</td>
</tr>
<tr>
<td><strong>Indication</strong></td>
<td>HTN Unilat RAS</td>
<td>Resistant HTN (likely CRI)</td>
<td>Resistant HTN &lt; mild CRI</td>
<td>Resistant HTN or unexplained CRI</td>
<td>CRI</td>
<td>Resistant HTN CRI</td>
</tr>
<tr>
<td><strong>Percutaneous/medical</strong></td>
<td>23/26</td>
<td>25/30</td>
<td>56/50</td>
<td>403/403</td>
<td>64/74</td>
<td>28/24</td>
</tr>
<tr>
<td><strong>Mean follow up (mo)</strong></td>
<td>6</td>
<td>12</td>
<td>12</td>
<td>34</td>
<td>24</td>
<td>43</td>
</tr>
<tr>
<td><strong>HTN</strong></td>
<td>100</td>
<td>100</td>
<td>82</td>
<td>98</td>
<td>97</td>
<td>96</td>
</tr>
<tr>
<td><strong>Baseline S&lt;sub&gt;Cr&lt;/sub&gt;</strong></td>
<td>1.2</td>
<td>1.8</td>
<td>1.3</td>
<td>2.0</td>
<td>1.7</td>
<td>1.7</td>
</tr>
<tr>
<td><strong>Bilateral stenosis</strong></td>
<td>0</td>
<td>51</td>
<td>23</td>
<td>54</td>
<td>48</td>
<td>52</td>
</tr>
<tr>
<td><strong>Mean % stenosis</strong></td>
<td>NA</td>
<td>NA</td>
<td>74</td>
<td>76</td>
<td>NA</td>
<td>80</td>
</tr>
<tr>
<td><strong>Crossover to intervention</strong></td>
<td>27%</td>
<td>6%</td>
<td>44%</td>
<td>6%</td>
<td>1%</td>
<td>2%</td>
</tr>
<tr>
<td><strong>PTA Only</strong></td>
<td>91</td>
<td>80</td>
<td>96</td>
<td>7</td>
<td>2</td>
<td>0</td>
</tr>
</tbody>
</table>

Pre-CORAL RCTs: Study Limitations: Stents Underutilized

<table>
<thead>
<tr>
<th></th>
<th>EMMA</th>
<th>SNRASCG</th>
<th>DRASTIC</th>
<th>ASTRAL</th>
<th>STAR</th>
<th>NITER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>France</td>
<td>UK</td>
<td>Netherlands</td>
<td>UK, AU, NZ</td>
<td>Netherlands</td>
<td>France, Italy</td>
</tr>
<tr>
<td>Indication</td>
<td>HTN Unilat RAS</td>
<td>Resistant HTN (likely CRI)</td>
<td>Resistant HTN &lt; mild CRI</td>
<td>Resistant HTN or unexplained CRI</td>
<td>CRI</td>
<td>Resistant HTN CRI</td>
</tr>
<tr>
<td>Percutaneous/medical</td>
<td>23/26</td>
<td>25/30</td>
<td>56/50</td>
<td>403/403</td>
<td>64/74</td>
<td>28/24</td>
</tr>
<tr>
<td>Mean follow up (mo)</td>
<td>6</td>
<td>12</td>
<td>12</td>
<td>34</td>
<td>24</td>
<td>43</td>
</tr>
<tr>
<td>HTN</td>
<td>100</td>
<td>100</td>
<td>82</td>
<td>98</td>
<td>97</td>
<td>96</td>
</tr>
<tr>
<td>Baseline $S_{Cr}$</td>
<td>1.2</td>
<td>1.8</td>
<td>1.3</td>
<td>2.0</td>
<td>1.7</td>
<td>1.7</td>
</tr>
<tr>
<td>Bilateral stenosis</td>
<td>0</td>
<td>51</td>
<td>23</td>
<td>54</td>
<td>48</td>
<td>52</td>
</tr>
<tr>
<td>Mean % stenosis</td>
<td>NA</td>
<td>NA</td>
<td>74</td>
<td>76</td>
<td>NA</td>
<td>80</td>
</tr>
<tr>
<td>Crossover to intervention</td>
<td>27%</td>
<td>6%</td>
<td>44%</td>
<td>6%</td>
<td>1%</td>
<td>2%</td>
</tr>
<tr>
<td>PTA Only</td>
<td>91</td>
<td>80</td>
<td>96</td>
<td>21% no stent</td>
<td>28% no stent</td>
<td>0</td>
</tr>
<tr>
<td>Publication Year</td>
<td>EMMA</td>
<td>SNRASC CG</td>
<td>DRASTIC</td>
<td>ASTRAL</td>
<td>STAR</td>
<td>NITER</td>
</tr>
<tr>
<td>------------------</td>
<td>-------</td>
<td>-----------</td>
<td>---------</td>
<td>--------</td>
<td>------</td>
<td>-------</td>
</tr>
<tr>
<td>Location</td>
<td>France</td>
<td>UK</td>
<td>Netherlands</td>
<td>UK, AU, NZ</td>
<td>Netherlands, France</td>
<td>Italy</td>
</tr>
<tr>
<td>Indication</td>
<td>HTN Unilat RAS</td>
<td>Resistant HTN (likely CRI)</td>
<td>Resistant HTN &lt; mild CRI</td>
<td>Resistant HTN or unexplained CRI</td>
<td>CRI</td>
<td>Resistant HTN CRI</td>
</tr>
<tr>
<td>Percutaneous/medical</td>
<td>23/26</td>
<td>25/30</td>
<td>56/50</td>
<td>403/403</td>
<td>64/74</td>
<td>28/24</td>
</tr>
<tr>
<td>Mean follow up (mo)</td>
<td>6</td>
<td>12</td>
<td>12</td>
<td>34</td>
<td>24</td>
<td>43</td>
</tr>
<tr>
<td>HTN</td>
<td>100</td>
<td>100</td>
<td>82</td>
<td>98</td>
<td>97</td>
<td>96</td>
</tr>
<tr>
<td>Baseline $S_{Cr}$</td>
<td>1.2</td>
<td>1.8</td>
<td>1.3</td>
<td>2.0</td>
<td>1.7</td>
<td>1.7</td>
</tr>
<tr>
<td>Bilateral stenosis</td>
<td>0</td>
<td>51</td>
<td>23</td>
<td>54</td>
<td>48</td>
<td>52</td>
</tr>
<tr>
<td>Mean % stenosis</td>
<td>57% pts &lt; 75% stenosis</td>
<td>NA</td>
<td>74</td>
<td>41% pts &lt; 70% stenosis</td>
<td>50% pts &lt; 70% stenosis</td>
<td>80</td>
</tr>
<tr>
<td>Crossover to intervention</td>
<td>27%</td>
<td>6%</td>
<td>44%</td>
<td>6%</td>
<td>1%</td>
<td>2%</td>
</tr>
<tr>
<td>PTA Only</td>
<td>91</td>
<td>80</td>
<td>96</td>
<td>7</td>
<td>2</td>
<td>0</td>
</tr>
</tbody>
</table>

Pre-CORAL RCTs: Study Limitations: Short Follow Up

<table>
<thead>
<tr>
<th></th>
<th>EMMA</th>
<th>SNRASCG</th>
<th>DRASTIC</th>
<th>ASTRAL</th>
<th>STAR</th>
<th>NITER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>France</td>
<td>UK</td>
<td>Netherlands</td>
<td>UK, AU, NZ</td>
<td>Netherlands</td>
<td>Italy</td>
</tr>
<tr>
<td>Indication</td>
<td>HTN Unilat RAS</td>
<td>Resistant HTN (likely CRI)</td>
<td>Resistant HTN &lt; mild CRI</td>
<td>Resistant HTN or unexplained CRI</td>
<td>CRI</td>
<td>Resistant HTN CRI</td>
</tr>
<tr>
<td>Percutaneous/medical</td>
<td>23/26</td>
<td>25/30</td>
<td>56/50</td>
<td>403/403</td>
<td>64/74</td>
<td>28/24</td>
</tr>
<tr>
<td>Mean follow up (mo)</td>
<td>6</td>
<td>12</td>
<td>12</td>
<td>34</td>
<td>24</td>
<td>43</td>
</tr>
<tr>
<td>HTN</td>
<td>100</td>
<td>100</td>
<td>82</td>
<td>98</td>
<td>97</td>
<td>96</td>
</tr>
<tr>
<td>Baseline $S_{Cr}$</td>
<td>1.2</td>
<td>1.8</td>
<td>1.3</td>
<td>2.0</td>
<td>1.7</td>
<td>1.7</td>
</tr>
<tr>
<td>Bilateral stenosis</td>
<td>0</td>
<td>51</td>
<td>23</td>
<td>54</td>
<td>48</td>
<td>52</td>
</tr>
<tr>
<td>Mean % stenosis</td>
<td>NA</td>
<td>NA</td>
<td>74</td>
<td>76</td>
<td>NA</td>
<td>80</td>
</tr>
<tr>
<td>Crossover to intervention</td>
<td>27%</td>
<td>6%</td>
<td>44%</td>
<td>6%</td>
<td>1%</td>
<td>2%</td>
</tr>
<tr>
<td>PTA Only</td>
<td>91</td>
<td>80</td>
<td>96</td>
<td>7</td>
<td>2</td>
<td>0</td>
</tr>
</tbody>
</table>

CORAL’s Limitations

Inclusion & Exclusion Criteria

• Excluded from CORAL
  - Hospitalization for heart failure within 30 days
  - UA or MI within 30 days of study entry

• Included in CORAL
  - HTN on 2 or more anti-hypertensives
Renal Artery Stenting
Potential Candidates Moving Forward?

The following patient populations have not been well represented in RCTs to date; RAS may be helpful in these settings:

- Cardiac disturbance syndromes (ACS or flash pulm edema)
- Resistant HTN or ischemic nephropathy in setting of hemodynamically significant stenoses (e.g. FFR, HSG)
- Resistant HTN despite OMT (3-drugs, incl a diuretic +/- spironolactone)
- When there is not ‘clinical equipoise’!
Appropriate Care

- Cardiac Disturbance Syndromes (Flash Pulmonary Edema or acute coronary syndrome (ACS)) with severe hypertension
- Resistant HTN (Uncontrolled hypertension with failure of maximally tolerated doses of at least three antihypertensive agents, one of which is a diuretic, or intolerance to medications)
- Ischemic nephropathy with chronic kidney disease (CKD) with eGFR < 45 cc/min and global renal ischemia (unilateral significant RAS with a solitary kidney or bilateral significant RAS) without other explanation

SCAI Renal Artery Stenting ECD

May Be Appropriate Care

- Unilateral RAS with CKD (eGFR < 45 cc/min)
- Unilateral RAS with prior episodes of congestive heart failure (Stage C)
- Anatomically challenging or high risk lesion (early bifurcation, small vessel, severe concentric calcification, and severe aortic atheroma or mural thrombus)

Rarely Appropriate Care

- Unilateral, Solitary, or Bilateral RAS with controlled BP and normal renal function.
- Unilateral, solitary, or bilateral RAS with kidney size <7 cm in pole-to-pole length
- Unilateral, Solitary, or Bilateral RAS with chronic end stage renal disease on hemodialysis >3 months.
- Unilateral, Solitary, or Bilateral renal artery chronic total occlusion

How To Perform Renal Artery Intervention When Appropriate

- Vascular access
- Invasive diagnostics
- Renal artery access
- Guidewires
- EPDs
- Pre-dilation
- Stenting
- Completion angiography
- Challenging lesion subsets
## Vascular Access

### Bleeding Risk

<table>
<thead>
<tr>
<th>Access</th>
<th>↓</th>
<th>↑ ↑++</th>
<th>+++</th>
<th>+</th>
<th>++</th>
<th>+++</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radial</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brachial</td>
<td></td>
<td>↑↑↑</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Femoral</td>
<td></td>
<td>↑↑</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Aortoiliac Issues (AAA, severe athero, tortuosity)

<table>
<thead>
<tr>
<th>Access</th>
<th>Radial</th>
<th>Brachial</th>
<th>Femoral</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>+++</td>
<td>+++</td>
<td>+</td>
</tr>
</tbody>
</table>

### Equipment Options

<table>
<thead>
<tr>
<th>Access</th>
<th>Radial</th>
<th>Brachial</th>
<th>Femoral</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>+</td>
<td>++</td>
<td>+++</td>
</tr>
</tbody>
</table>

### Backup Support

<table>
<thead>
<tr>
<th>Access</th>
<th>Radial</th>
<th>Brachial</th>
<th>Femoral</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>++</td>
<td>+++</td>
<td>+</td>
</tr>
</tbody>
</table>

### Downgoing Artery

<table>
<thead>
<tr>
<th>Access</th>
<th>Radial</th>
<th>Brachial</th>
<th>Femoral</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>+++</td>
<td>+++</td>
<td>+</td>
</tr>
</tbody>
</table>

**Simple stenosis**
Invasive Diagnostics

• Non-selective abdominal aortography (origins L1-L2)
• Selective renal angiography prn; avoid scraping
  - CFA=>RDC, JR4, IM, Sos, Cobra
  - UE=>HS, MP
• FFR
  - No role for adenosine (vasoconstrictor)
  - NTG, papavarine, Ach incr renal blood flow
  - Independent predictor of BP response to stenting
• IVUS
  - Can be helpful as adjunct to intervention
  - Does not independently predict BP response
Renal Artery Access

- Exchange
- Bare-wire
- Direct guide
- No-touch
- Telescoping
Renal Artery Access: Exchange

- Engage 5 or 6F diagnostic cath/wire
- Exchange for long sheath or guide
- Advance PTA cath and stent to lesion

Renal Artery Access: Bare-Wire

- Engage 5 or 6 F diagnostic cath/wire as in Exchange Method but w/o long sheath or guide (E)

- Advance balloon/stent per routine (F)

- Can only perform angio if 2\textsuperscript{nd} angio catheter inserted

Renal Artery Access: Direct Guide

- Advance guide over 0.035” wire in abdominal aorta

- Remove wire

- Engage artery w/ bare guide (considerable contact/scraping)

- Once guide seated, wire, balloon and stent advanced to lesion as per routine

Renal Artery Access: No-Touch

- Advance 0.035” wire beyond guide tip. This straightens catheter variably depending upon length advanced (A)

- Advance 0.014”/0.018” guidewire into artery once adjacent/engaged (A)

- Remove 0.035” wire (B)

- Intervene as per routine (C)

Renal Artery Access: Telescopig

- Telescope

Start with small Dx catheter in guide or sheath

Cross lesion with .014” Wire and Rotate guide or sheath into position while holding wire and Dx catheter stationary

Bates M. TCT 2010, 2012
Guidewires

• Avoid hydrophilic wires and mind wire tip at all times to prevent **distal perforation**

• Use support wires with short transition to facilitate device delivery and prevent **proximal perforation**

Bates MC. TCT 2012
EPDs? Embolization is Ubiquitous

- N = 28 patients undergoing RAS
- Debris retrieved in all patients.
- Particles = 98.1 ± 60 (13 to 208)
- Size = 201 ± 76 µ (38 to 6,206 µ)

EPD 2x2 RCT (n=100)
Renal Artery Stent +/- EPD +/- Abciximab

Pre-dilation

- Outline lesion before stenting
- Verify vessel diameter
- Ease stent delivery
- Avoid situation where deployed stent cannot be expanded (e.g., heavy Ca++)

Photo: Cooper C.  TCT 2008
Stenting

- Lesions typically short/ostial
- Usually 6-7 mm diameter stent
- Few mm prox/distal to stenosis
- Stents reduce restenosis
- Size to normal vessel diameter (not post-stenotic dilated segment)
- Stop, if pain develops!
Renal Artery Stent Placement: Avoid Geographic Miss (‘Stick the Landing’)
Stenting: ‘The RAO Myth’
An MRA Study (n=137)

• Think 3-dimensionally at time of deployment

• Avg angle perpendicular to RRA ~ 20° and LRA ~ 10°

• 10°- 20° LAO allows visualization of both renal artery ostia in 75% (range 50° RAO-85° LAO)

Stenting

Techniques to ‘stick the landing’

• Szabo

• Ostial Pro™

• BullsEye™

Jokhi P, Curzen N. Eurointervention 2009;5:511-4
Completion Angiogram

- As stent delivery balloon deflates, gently advance guide/sheath over system
- Avoids stent trauma
- Facilitates re-crossing lesion if needed
- Allows optimal opacification for final angio
Challenging Lesion Subsets
For More Experienced Operators

- Tortuous renal artery
- Calcified lesion
- Restenotic lesion
- Abdominal aortic aneurysm
- Dual adjacent arteries
- Early bifurcation
Conclusions

• Renal artery stenting an option for certain patient subsets
• Vascular access tailored to patient bleeding risk and anatomy
• Minimize aortic scraping when seating the guide catheter
• Choose support wires
• Routinely pre-dilate
• Avoid geographic miss when stenting
• Be familiar with challenging lesion subsets
• Be prepared for potential complications
• CORAL-2 may be on the way…