How to assess the hemodynamic importance of a renal artery stenosis

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How to assess renal artery stenosis severity

1. Non-invasive assessments
   - Duplex ultrasound

2. Invasive assessments
   - Pressure gradient
   - Pd/Pa
   - Frame count
Duplex ultrasound

• Renal resistive indices
• Acceleration time
• Renal-aortic flow velocity ratio (RAR)
• Peak systolic flow velocity
Duplex ultrasound

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Renal Artery Duplex ultrasound - AT

AT: enddiastolic – peak systolic
Renal Artery Duplex ultrasound - AT

Three measurements at the edge between pelvis and parenchyma at three different locations

Radermacher J, Clin Nephrol 2000
Renal Artery Duplex ultrasound - AT

Normal Doppler-signal

AT <0.07 sec

Post-stenotic Doppler-signal

AT >0.07 sec

Three measurements at the edge between pelvis and parenchyma at three different locations

Radermacher J, Clin Nephrol 2000
Renal Artery Duplex ultrasound - RRI

To calculate RRI you need to measure:
• systolic peak velocity (A)
• enddiastolic velocity (B)

\[
RRI = \frac{(V \text{ max sys} - V \text{ max enddiast})}{V \text{ max sys}}
\]
Renal Artery Duplex ultrasound - RRI

Impacted by

• Age
• Medication
• Heart rate
• Stroke volume
• AV-Fistula
• ...


Renal Artery Duplex ultrasound - RRI

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The side-difference of the RI >0.05 is the crucial point in the diagnosis of a significant unilateral RAS not the absolute value!
Renal Artery Duplex ultrasound - RRI

- RRI and AT determine significant RAS (≥70%):
  - $\delta$RRI > 0.05
  - AT > 0.07 sec
USE OF DOPPLER ULTRASONOGRAPHY TO PREDICT THE OUTCOME OF THERAPY FOR RENAL-ARTERY STENOSIS

Jörg Radermacher, M.D., Ajay Chavan, M.D., Jörg Bleck, M.D., Annabel Vitzthum, Birte Stoess, Michael Jan Gebel, M.D., Michael Galanski, M.D., Karl Martin Koch, M.D., and Hermann Haller, M.D.
Revascularization of RAS with RRI >0.8 was not associated with improved renal function or blood pressure control.
Invasive Assessment

- Pressure gradient
- Pd/Pa
- Frame count
Balloon inflation (1 mm smaller than the stent) to produce a Controlled Gradient $P_d / P_a$ of ....

Controlled Unilateral RAS (2K1C)

Renin level

DeBruyne B, JACC 2006
What is a “significant” renal artery stenosis?

DeBryune B, JACC 2006
$\Delta P = 15 \text{ mm Hg}$

Right Upper Renal Artery
Resting and hyperemic pressure gradients, FFR and renin activation

Kapoor N, Cath Cardiovasc Interv 2010
Resting and hyperemic pressure gradients, FFR and renin activation

Kapoor N, Cath Cardiovasc Interv 2010
Renal frame count

- Still frame images obtained at 30 frames/s.
- First frame is counted with complete transverse opacification of the renal artery.
- Final frame being the identification of a cortical vessel in a relatively straight line.
- This subject had a renal frame count of 18 (normal).
RFC in the control group (n=17; 22 kidneys) without renal artery stenosis, and in the study group (n=24) before and after renal stenting for atherosclerotic renal artery stenosis.

Mahmud E, JACC Cardiovasc Interv 2008
Prediction of improved blood pressure control after stenting of unilateral RAS

- 6 month-FU
- SBP: 151 ± 16 mmHg → 129 ± 15 mmHg, P<0.001
- DBP: 77 ± 16 mmHg → 68 ± 10 mmHg, P=0.022
  - No change in antihypertensive drug regimen

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- Drop in RFC:
  - Blood pressure responder: 7.7 ± 4.6 vs.
  - Non-responders: 1.7 ± 5.1; P=0.009
  - 89% of pts. with drop in RFC >4 were responders (P=0.024)

Mahmud E, JACC Cardiovasc Interv 2008
How to determine hemodynamically relevant renal artery stenosis

Summary

• Duplex sonography including the measurement of RRI and AT is a valid method of choice for assessment of RAS severity
  – AT >70 ms and dRRI >0.05 are reliable indicators of significant unilateral RAS
  – If dRRI is <RRI 0.05 but bilateral ACT >100 ms, bilateral significant RAS are present
How to determine hemodynamically relevant renal artery stenosis

Summary

• Revascularization of RAS is meaningful if the pressure gradient ratio is
  – $P_d/P_a$ ratio $<0.90$ ($\approx \Delta 20$ mmHg)
• This ratio correlates with an angiographic diameter stenosis of $>70\%$
• The ratio correlates with duplex-derived RRI
Thank you!

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