Noncontrast MRA

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Disclosures

• none
Outline

• Background
• Techniques
  – Time of flight
  – Phase contrast
  – ECG-gated 3D FSE
  – ECG-gated 3D SSFP
• Conclusions
Critical need for noncontrast MRA in the era of nephrogenic systemic fibrosis

Patients with chronic renal dysfunction are frequently diabetics or hypertensives with concomitant aortic or peripheral vascular disease that may eventually require non-invasive imaging

Noncontrast MRA also critical in patients with renal failure of uncertain cause to evaluate for renal artery stenosis.
Background

- Traditional non-gadolinium MRA techniques, time-of-flight and phase-contrast, are well established and understood, but have some important limitations.

- Newer non-gadolinium MRA sequences, namely ECG-gated spin echo and bright blood based sequences, have recently become available and could eventually replace the old standards. However, these too have limitations.
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Time-of-Flight
Time-of-flight

- Well established technique, particularly in neuro imaging (3D TOF of cranial vessels)

- Relies on flow of non-saturated blood protons into the imaging plane.

- Image contrast is due to differences in signal of blood and suppressed background tissue.
Flow-related enhancement
Flow-related enhancement
Time-of-flight

Miyazaki M, Lee VS. Radiology 2008;248:20-33
Time-of-flight
Time-of-flight

In-plane flow saturation
Traveling saturation band

- Traveling saturation band allows selective venous or arterial imaging

Superior saturation band
Venous imaging

Inferior saturation band
Arterial imaging
TOF
Run-off
Time-of-flight

• Advantages:
  – Well-established, reliable technique
  – Selective arterial or venous imaging
  – Can improve sensitivity to flow using thin sections and by increasing TR
Time-of-flight

• Limitations:
  – Pseudostenoses or overestimation of stenosis:
    • saturation of in-plane flow (renal arteries, anterior tibial artery)
    • Post-stenotic signal voids due to dephasing of protons
  – Retrograde flow in collateral arteries will not be visualized if saturation band used
  – **Long** acquisition time
    • upper and lower legs ~ 10-12 minutes
    • abdomen ~5-10 minutes
Time-of-flight

• Limitations (continued):
  – Pulsation artifacts (can be avoided with ECG-gating, will increase imaging time)
  – Image quality generally not as good as contrast enhanced MRA
Phase-Contrast
Phase contrast imaging

• Technique:
  – Protons are encoded with signal proportional to their velocity in 3 directions
  – Signal from flowing blood is used to create an angiogram

• Disadvantages:
  – Slow
  – Turbulent flow overestimates stenoses due to dephasing
  – Not as widely used as TOF for MRA
Phase contrast imaging

Gad MRA  PC  Angio

ECG-gated Fast Spin Echo
ECG-gated FSE

• T2 weighted, fast spin echo, partial-fourier (single-shot) sequence

• Relies on arterial flow voids present on systolic phase imaging – ECG-gating required

• Subtraction method
  – Systole: flow voids in arteries, signal in veins
  – Diastole: signal in arteries and veins
  – (diastole – systole) = MRA

• Relatively fast and high resolution can be achieved (acquisition ~ 3 minutes for lower legs)
ECG-gated FSE

Morita et al. Radiographics
2011; 31(2): E13-E33
ECG-gated FSE

Systole

Diastole

MRA
ECG-gated FSE

Normal run-off

Digital occlusions in scleroderma
Acquisition timing

- Must time imaging to coincide with time of fastest and slowest arterial flow during the cardiac cycle

- ROI placed on arterial signal from scout images is used to select optimal imaging times from the R-wave
Acquisition timing

• Selection of proper delay time is critical to adequate imaging
ECG-gated FSE

• Advantages
  – Faster than TOF and PC
  – High resolution and can be made sensitive to slow flow
ECG-gated FSE

- Disadvantages:
  - Motion artifact can result in non-diagnostic images
  - Variable image quality patient to patient in our experience
  - Can be operator dependent, not push-button
    - Correct trigger time varies from patient to patient
  - No vessel walls
  - Arteries only, no veins
  - Arrhythmias are a problem (particularly if tachycardic)
ECG-gated Balanced Steady-state Free Precession
bSSFP

- Technique:
  - T2/T1 weighted balanced steady state free precession sequence
    - AKA: FIESTA, TrueFISP, bFFE, etc.
  - High SNR, fast (TR 3-4 msec)
  - Arteries and veins are bright (also fluid and fat) – saturation techniques and/or arterial spin labeling are necessary to suppress background signal

Coronal MIP
bSSFP

Axial MIP Technique for arteries and veins

Axial MIP Technique selected for arteries
bSSFP

• Advantages:
  – Fast and accurate
  – Provides vessel wall imaging
  – Used in coronary MRA, renal MRA

• Disadvantages:
  – Like any SSFP, susceptibility artifacts from metal, etc.
  – Background signal can be strong
  – Arterial images better quality than venous
  – Arrhythmias will limit quality
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Noncontrast MRA

• Several options now exist for noncontrast MRA that should be more than adequate to answer the majority of clinical questions

• TOF, although slow, is reliable and often sufficient. Imagers must be aware of in-plane saturation effects.

• ECG-gated FSE and SSFP are promising techniques for imaging of the extremities and the abdomen, however, are somewhat less reliable in our experience and best performed with an experienced technologist

• Time resolved imaging with non-gadolinium techniques is not yet available

• Ideally, further improvements in these newer sequences will hopefully lead to a robust, reliable noncontrast MRA sequence with quality that can compete with standard gadolinium-enhanced studies
Thank you