Michael Salerno MD, PhD

Cardiac MRI of Coronary Artery Disease

Overview of Coronary Artery Disease

1) Basic Cardiac and Coronary Anatomy
   a) Ventricular segmentation and nomenclature
   b) Coronary anatomy and territories
2) Coronary Artery Disease
   a) Narrowing of coronary arteries causing chest pain with exertion
   b) Plaque rupture causing an acute coronary syndrome and myocardial infarction
   c) Remodeling following myocardial infarction causing ventricular dilatation and heart failure
3) Treatment of CAD
   a) Medical therapy to reduce myocardial oxygen demand and reduce remodeling
   b) Percutaneous Interventions
      i) In ACS – to open up infarct related artery
      ii) In Chronic Angina – to relieve angina
   c) Coronary Artery Bypass Surgery – in left-main, 3V-disease, or cases where PCI cannot be performed

Clinical Questions in the Evaluation of a patient with known or suspected coronary artery disease.

1) *What is the left ventricular size and function?*
   a. Typical Technique:
      i. Breath-held retrospectively triggered cine imaging
   b. Clinical challenges – arrhythmias, inability to hold breath/cooperate
   c. Alternative Techniques:
      i. Prospective triggering – can overcome issues with arrhythmias, but cannot capture whole cardiac cycle.
      ii. Real-time – can overcome inability to hold breath, but limited spatial/temporal resolution and image quality. No clinical software to quantify LV function.
   d. Future Techniques:
      i. Real-time imaging with high spatial and temporal resolution
      ii. 3D whole heart techniques
      iii. Issue: need image quality approaching typical breath-hold techniques

2) *Is there evidence of a prior myocardial infarction?*
   a. Typical Techniques:
      i. Delayed enhancement using breath-held prospective IR FLASH
      ii. Phase-sensitive Inversion Recovery
   b. Clinical Challenges: inability to hold breath for long breath-hold duration
   c. Alternative Techniques:
      i. Single-shot (PS)IR delayed enhancement. Reduced spatial resolution, longer temporal footprint, reduced sensitivity for detecting scar.
      ii. Motion-corrected single-shot PSIR. Improved spatial and temporal resolution, issues if motion correction fails.
   d. Future Techniques:
      i. Dark-blood LGE techniques – potentially improve contrast for subendocardial scar

    ii. Whole heart 3D techniques – some issues with navigator gating, if it takes a long time and is not robust will not be clinically useful.

3) *Is there evidence of inducible ischemia?*
 a. Typical Technique:
   i. Adenosine stress perfusion imaging
   ii. Breath-held single-shot SR FLASH (typically 3-4 slices resolution 1.8-2.3 mm in-plane, Rate 2-3 parallel imaging). Adv Robust, disadvantages low SNR, DRA
 b. Clinical challenges: DRA, spatial coverage, spatial/temporal resolution
 c. Alternative Techniques:
   i. SSFP, interleaved EPI – higher SNR but off-resonance artifacts
   ii. K-t accelerated techniques – high SNR, spatial resolution, less robust with poor breath-holding.
 d. Future Techniques:
   i. Non-cartesian techniques – Spiral, radial
   ii. 3D whole heart techniques – 3D k-t PCA, stack-of-stars, stack-of-spirals

4) *Is there evidence of an acute coronary syndrome?*
 a. Typical Techniques:
   i. Dark-blood T2-w TSE – limited by motion-artifacts, coil sensitivity artifacts, incomplete attenuation of blood signal
   ii. Bright-blood T2w techniques – T2-Prep SSFP, ACUTE SSFP, some SSFP artifacts
 b. Clinical Challenges: Artifacts, sensitivity
 c. Alternative Techniques:
   i. T1 and T2 mapping techniques – more quantitative, lower spatial resolution than above techniques
 d. Future Techniques: Whole heart 3D, better T2 quantification?

Other Techniques with high-risk/potentially high rewards for evaluation of coronary artery disease
1) Coronary MRA
 a) Coronary CTA: Significant advances with whole heart coverage with 0.4mm isotropic resolution in a single breath-hold: (even single heart-beat!)
 b) Coronary MRA Challenges: Long acquisition time with navigator techniques, not robust clinically, does not always produce diagnostic images
 c) Potential Clinical Roles: Assessment of coronary plaque, assessment of coronary physiology, ruling out significant proximal coronary artery narrowing
2) ASL
 a) Challenge: Multiple other techniques for assessing myocardial perfusion with higher temporal and/or spatial resolution. Low SNR/CNR.
 b) Potential Clinical Roles: Assessing global coronary flow reserve in microvascular disease
3) BOLD
 a) Challenge: Low SNR, Low CNR, complex relationship to myocardial flow and oxygenation
 b) Potential Clinical Roles: Assessing interaction between myocardial perfusion and oxygenation