Cardiac Imaging at 3.0T

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Disclosure

- UW receives support from GE and Bracco
- Spouse is an employee of GE

*Off-label uses of Gadoliniumium contrast*
Function/Motion with SSFP

Short Axis

4 Chamber Long Axis
First Pass Perfusion Imaging:
Myocardial Ischemia RCA Territory

Case Courtesy of H. Sakuma MD
Myocardial Infarction
Hibernating Myocardium

4 Chamber  3 Chamber  2 Chamber
Hibernating Myocardium
Physics of 3.0T MRI:

*Increased SNR*

- Higher field strength
  - Doubles SNR …
  - Increase spatial resolution
  - Opportunity to reduce scan time using parallel imaging with same SNR

- Decreases T2 and increases T1
  - Reduces SNR slightly
  - SSFP: SNR depends on T2/T1

*Overall increase approximately 1.8x*
Physics of 3.0T MRI:

*Improved CNR*

- Longer $T_1$ at 3T
  - Improved Background Suppression
  - Results in improved CNR of enhancing tissue
- 1$^{st}$ pass perfusion imaging
  - Improved detection of small defects
- Viability Imaging
  - Improved delineation of infarct extent

*Most important benefit of 3T cardiac imaging*
Saturation Recovery: *Perfusion*

- Overall Contrast between Enhancing and Infarct Improved because background T₁ longer at 3.0T
Perfusion Imaging at 3T
Inversion Recovery: Viability

1.5T
- Zero-Crossing: TI = 180-250 ms
- Signal Enhancement

3.0T
- Zero-Crossing: TI = 250-350 ms
- Signal Enhancement

- $T_1$ of enhancing tissue relatively unchanged at higher field strength – Oshinski et al
- Overall contrast between normal and infarct improved
Viability Imaging at 3T
Improved CNR at 3.0T

• Improved SNR alone improves CNR by 2x
• But also have improved contrast from $T_1$ effect
• Overall, Contrast to Noise Ratio improves by much larger factor, perhaps as high at 3x
  – Precise improvement difficult to measure
  – (Look for papers in the literature)
LV Pseudoaneurysm
LV Pseudoaneurysm

6mm slices
Cardiac Sarcoidosis at 3T
Tagging: Comparison of 1.5T vs 3.0T

1.5 T

early systole

peak systole

end diastole

3T
Physics of 3.0T MRI:

Bo Field Homogeneity

• Increasing field strength worsens magnetic field inhomogeneity due to increased susceptibility

• Largest impact
  – Steady-State Free Precession
  – Leads to Banding and Flow Artifacts
    • Proportional to Bo inhomogeneity and TR
Cardiac SSFP

Increasing TR / Increasing Field Strength
The Importance of Shimming

No Localized Shimming

With Localized Shimming
SAR: Dependence on Amplitude vs Duration of RF Pulse

Flip Angle = $\Delta T \, B_1$

$SAR \propto \Delta T \, B_1^2$

RF Pulse Duration
RF Amplitude - doubles at 3T

4 Fold increase in SAR at 3T!!
Function/Motion - Comparison

1.5 T (60 deg)  
3.0 T (45 deg)
Summary

• Improved SNR with 3T
• Improved Contrast from longer T1
  – Improved Background Suppression
• Greatly improved quality of viability and perfusion imaging
• SSFP CINE imaging no longer a challenge
• 3T is our first line magnet for cardiac imaging