Clinical MRI: From Physical Principles to Practical Protocols

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Overview

→ Upper abdomen and pelvis protocol
→ Challenges and limitations

Evolving and existing novel techniques to overcome these challenges

Body MR Protocols

Upper Abdomen

Body MR Protocols

Pelvis

Body MR Protocols

Generic Protocol

• Localizer: localize, plan and anatomical overview
• T1-weighted Sequence: evaluate for presence of fat, hemorrhage, baseline before contrast; anatomy
• T2-weighted Sequence: Detect and characterize based on tissue contrast
• Gadolinium enhanced: dynamic sequence (charactere based on enhancement)
• Novel sequences: diffusion weighted, spectroscopy, quantitative

Body MR Protocols

Upper Abdomen

• Protocol Needs
  • Maximize CNR while having good overall signal
  • Overcome motion from breathing
  • Fulfill indication for MRI
    • Lesion detection or characterization
    • Complete scan in a reasonable time
  • Goal is to be done in 30 minutes
Body MR Protocols

Localizer

- SSFSE and TrueFISP are fast sequences that are suitable for localizers because of their sub second (typically ms) acquisition speed.

Vendor specific Sequence Acronyms

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<th>SEQUENCE</th>
<th>Siemens</th>
<th>General Electric</th>
<th>Philips</th>
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DIXON METHOD

Based on Chemical shift of fat and water (3.5 ppm)

S1 (TE1) = opposed-phase image = F - W
S2 (TE2) = in-phase image = F + W

Fat image = S2 + S1
Water image = S2 - S1

DIXON Technique

Applications:
- Robust fat / water imaging in abdominal applications.
- Fat quantification measurements.
- Low Field Fat Suppression technique
- Dual Echo 3D VIBE

Protocol

- Localizer
- T1-weighted Sequence
- T2-weighted Sequence

Provides good CNR
Aids in lesion detection and characterization
Complements the contrast enhanced sequences

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Provides good CNR
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TSE - Turbo Spin Echo

- Larger ETL means faster acquisition, however very large ETLs cause blurring
- In T2 weighted images fat and water are hyper-intense as the 180° pulses increase the T2 decay of fat

FRFSE - Fast Recovery FSE

- Also called DRIVE and RESTORE
- 90° Tip up pulse added at the end to a TSE
- Shortens TR hence shortens acquisition time

Protocol

- Localizer
- T1-weighted Sequence
- T2-weighted Sequence
- FRFSE
  - Beware of CNR issues

Protocol

- Localizer
- T1-weighted Sequence
- T2-weighted Sequence 3D
- 3D T2 with MIP for MRCP

Protocol

- Localizer
- T1-weighted Sequence
- T2-weighted Sequence 3D SPACE
- 3D SPACE

SPACE (Sampling Perfection with Application optimized Contrast using different angle Evolutions)

Isotropic 3D imaging
- Utilizes a variable flip angle pulse train for refocusing – reduces T2 decay to achieve a longer echo train
- High spatial resolution and minimal partial volume effect
- 3D imaging in all flavors
- Reduced scan times with parallel imaging

SPACE (Siemens)
VISTA (Philips)
CUBE, XE/IA (GE)
Motion

Biggest challenge in body imaging

Protocol
- Localizer
- T1-weighted Sequence
- T2-weighted Sequence
- Motion Correction

Body MR Protocols

- RT acquires echoes by adjusting the TR to motion sensed by bellows or a navigator pulse
- The acquisition of the image data is synchronized with the respiratory cycle of the patient influencing TA
- As a default, a block of image data is acquired when the diaphragm is in expiratory phase. However, it can be changed by the user.

T2-Weighted Imaging: TSE_BLADE

- BLADE continuously acquires low resolution images during motion
- BLADE measures and corrects for this motion

Parallel Imaging - Image or k-space Based

- GRAPPA, SMASH are Parallel imaging techniques based on k-space
- SENSE, PILS and ASSET are image-based Parallel imaging techniques

Protocol
- Localizer
- T1-weighted Sequence
- T2-weighted Sequence
- Motion Correction
**Protocol**
- Localizer
- T1-weighted Sequence
- T2-weighted Sequence
- Motion Correction

**Motion Correction**
- Swap Phase and Frequency

**End User Tricks**
- Non Dynamic
  - Can be 2D or 3D
  - Dynamic (3D preferred)
    - 3D Fast Gradient Echo BH
    - Fat Saturated
    - Acquired axially
    - Thin partitions
    - High resolution
    - Interpolated

**Localizer**
- T1-weighted Sequence
- T2-weighted Sequence
- Motion Correction
- Contrast (Gadolinium) Enhancement

**Protocol**
- Localizer
- T1-weighted Sequence
- T2-weighted Sequence
- Motion Correction
- Contrast (Gadolinium) Enhancement
- Novel Sequences (diffusion weighted)

**Body MR Protocols**
- How does diffusion work and what are some new developments

**Diffusion Weighted Imaging**
- Diffusion works on the principle of Brownian motion of water molecules
- In a tissue the motion is not unrestricted because tissue has structure, so diffusion varies with structure
- Diffusion gradients applied on either side of a 180° pulse
- The first pulse dephases and the second one rephases if no net movement
- Otherwise signal attenuation occurs depending on movement and diffusion weighting (b-value)
- The strength, the duration and the time between gradients determines the diffusion weighting

**What is REVEAL?**
- EPI diffusion with GRAPPA for reduced susceptibility artifacts
- Typically high b-values (600-1000) for signal suppression of normal tissue
- Dark Vessel REVEAL with low b-values (50)
- Breathhold, free breathing with multiple averages or free breathing PACE

**Diffusion Weighted Imaging:**
• DWI b50
• TSE T2

Conclusion

• Exponential rise in clinical applications of MRI in abdomen in pelvis
  • Radiation issues with CT (despite speed advantage)
• If this trend needs to be maintained
  • Thorough understanding of all novel MR software and hardware
  • Push the envelope