MRI Protocol Basics

Outline
• MRI protocols in general
• Protocol team: radiologists, physicists and technologists
• Divided into specific anatomic areas: Neuro, Body, MSK and Cardiac
• Pulse sequences - general types:
  ✓ Gradient-Echo (GRE)
  ✓ Spin-Echo (SE) and Fast/Turbo Spin-Echo (FSE/TSE)
  ✓ Inversion-Recovery (IR) types
  ✓ Diffusion-Weighted Echo-Planar Imaging (DWI EPI)

Protocol team
• Team for coordinating and updating the MRI protocols
  ✓ Key radiologists, physicists and technologists
• Meetings for protocol setup and updates
  ✓ Field strength and vendor specifics
  ✓ Accommodation for different software versions
  ✓ Updates and changes due to recent developments in pulse sequences
• Off-line work
  ✓ Coordinating the changes/updates with the entire team of radiologists of specific subspecialties
  ✓ Finalizing the protocols and publishing in the Institutional Intranet (share drive)

Division into Anatomic Areas
• Distribution of the protocols into different subgroups
  ✓ Neuro
  ✓ Body
  ✓ Musculoskeletal
  ✓ Cardiac
• Screenshots of anatomy specific slice prescriptions from sample MR images
• Constant communication (via e-mail to the groups) with any changes (e.g. adding/eliminating sequences, contrast administration specifics, etc.)

Pulse Sequences – Basics
• Sufficiently fill k-space to make an image
• Provide necessary tissue contrast/image weighting (T1, T2, T2*, proton-density, etc.)
• Fulfill some other necessary functions, such as navigation, quick localization, bolus timing, etc.

Pulse Sequences – Basics
• T1-weighted images show anatomy well
• T2-weighted images show the pathologic changes
• Proton-density images show both anatomy and pathology
Gradient Echo

- Simple sequence
- Low transmit RF power
- Main applications: 3D – localizer, timing bolus, MRA, etc.
- Additional more advanced sequences based on GRE: FIESTA, TrueFISP, Steady-State Gradient Echo, etc.
- Sensitive to:
  - $B_0$ – inhomogeneities
  - Magnetic susceptibilities

MR Signal Intensities

- Solid mass: Bright, Bright, Dark
- Cyst: Bright, Dark, Dark
- Subacute blood: Bright, Bright, Bright
- Acute & chronic blood: Dark, Dark, Grey
- Fat: Dark, Bright, Bright

Sequence diagram slides are courtesy of Robert Prost, Ph.D.
Spin Echo
• 90-degree initial RF pulse
• Follow up 180-degree refocusing RF pulse
• Echo signal

Spin Echo
• Adds 180-degree RF pulse to the GRE
• Removes magnetic susceptibility artifacts
• Best for refining contrast: T1, T2, PD
• Fills one line of k-space for each TR
• Slow: e.g., for TR = 2000 ms and imaging matrix 256 x 256, sequence time exceeds 8 minutes

Spin Echo
• Short TR and short TE – T1-weighted
• Long TR and short TE – PD-weighted
• Long TR and long TE – T2-weighted
• Short TR and long TE – not used

Spin Echo
Fast Spin Echo
• Fast method of approximating the spin echo contrast
• More efficient k-space filling allows choices
✓ Shorter scan times
✓ Higher SNR

Fast Spin Echo
Pros:
• Acquisition time decreases by a factor of ETL
• More SNR per unit acquisition time
Cons:
• Higher ETL numbers – higher SAR (Specific Absorption Rate)
• Induces tissue T2 dependent blurring
• Fat shows as a hypersignal

MR Images are courtesy of Robert Prost, Ph.D.
Inversion Recovery

- 180-degree pulse prior to 90-degree in Spin Echo
- Depending on the Time of Inversion (TI) the sequence suppresses the signal from a specific tissue
- Example: STIR (Short Tau Inversion Recovery) – nulls fat

Echo Planar Imaging (EPI)

- Short imaging time
- Performed with single or multiple excitation pulses
- Increased sensitivity to off-resonance effects
- Gradient echo EPI ✓ fMRI
- Spin echo EPI ✓ Diffusion weighted imaging

Echo Planar Imaging

- Multiple lines of data acquired after a single RF excitation.
- After 180-degree pulse FEG blips on PEG axis
- GRE EPI shorter TR can be used without large signal loss.

Diffusion Weighted Imaging EPI

- Multiple lines of data acquired after a single RF excitation.
- After 180-degree pulse FEG blips on PEG axis
- GRE EPI shorter TR can be used without large signal loss.

References


Thank you!

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