Magnetic Resonance Review Course
Outline

Overview

This online asynchronous self-study learning module will provide up to date review of principles and practices in Magnetic Resonance Imaging for the Technologist. Upon successful completion from this course the technologist will earn 50 Hours of SNMMI-TS Voice Credits. This course meets the ARRT requirements for MR Structured Education.

This course will provide a thorough understanding of MR Techniques, Methodologies, Safety Issues, Patient Care, Instrumentation, Quality Control, and MR Imaging Protocols.

Module I: Fundamentals of MR

- MR Terminology ......................................................... Lecture 1 180 min
- MR Fundamentals ....................................................... Lecture 2 90 min
- MR Instrumentation .................................................... Lecture 3 60 min
- MR Gradients ............................................................... Lecture 4 90 min
- MR Imaging Parameters ............................................... Lecture 5 90 min
- MR Pulse Sequences ................................................... Lecture 6 90 min
- MR Contrast Agents .................................................... Lecture 7 90 min

Module II: MR Safety

- MR Safety (Part I) ......................................................... Lecture 8.1 90 min
- MR Safety (Part II) ....................................................... Lecture 8.2 90 min
- MR Safety (Part III) ..................................................... Lecture 8.3 90 min

Module III: MR Methodology

- MR Image Quality ....................................................... Lecture 9 90 min
- MR Brain ................................................................. Lecture 10 120 min
- MR Face ................................................................. Lecture 11 90 min
- MR Neck ................................................................. Lecture 12 90 min
- MR Chest ................................................................. Lecture 13 120 min
- MR Cardiac .............................................................. Lecture 14 120 min
- MR Breast .................................................. Lecture 15  90 min
- MR Abdomen ............................................. Lecture 16  120 min
- MR Lumbar ................................................ Lecture 17  120 min
- MR Pelvis .................................................. Lecture 18  120 min
- MR Hip ...................................................... Lecture 19  120 min
- MR Upper Extremity .................................... Lecture 20  90 min
- MR Lower Extremity .................................... Lecture 21  90 min
- MR Spectroscopy ....................................... Lecture 22  120 min
- MRA ......................................................... Lecture 23  120 min

**Module IV: MR Procedures**

- MR Pathology (Part I and II) .......................... Lecture 24  120 min
- MR Accreditation Standards .......................... Lecture 25  60 min
- Professional and Communication Skills for the Imaging
  Technologist ............................................. Lecture 26  40 min
- Introduction to HIPAA for the Imaging Technologist ........ Lecture 27  40 min
- MR Contrast Agents Treatment and Reactions Part II .. Lecture 28  60 min
- Standards of Ethics for the Imaging Technologist .... Lecture 29  40 min
- Introduction to PET and MR Artifacts .................. Lecture 30  60 min
MR Review Course

Lecture 1

Title: Terminology (180 minutes)

Keywords: Glossary, MRI Terms

Objectives:
• Discuss Glossary of MRI Terms
• Define Terminology from "A" to "Z"

Content:
I. “A"
   1. Absorption mode
   2. Acceleration factor
   3. Acoustic noise
   4. Acquisition matrix
   5. Acquisition Time
   6. Acquisition window
   7. Active shielding
   8. Active shimming
   9. ADC
   10. Adiabatic fast passage (AFP)
   11. Adiabatic rapid passage
   12. AFP
   13. Aliasing
   14. Analog to digital converter (ADC)
   15. Angiography
   16. Angular frequency (ω)
   17. Angular momentum
   18. Annotation
   19. Antenna
   20. Apodization
   21. Array coil
   22. Array processor
   23. Artifacts
   24. Asymmetric sampling
   25. Attenuation
   26. Attenuator
   27. Axial plane
   28. Autotuning

II. “B"
   1. Bo
   2. B1
   3. BOLD
   4. Balanced gradient
   5. Balanced steady-state free precession
   6. Bandwidth
   7. Baseline
   8. Baseline correction
   9. Bilateral imaging
   10. Birdcage coil
   11. Bloch equations
12. Blood oxygen level dependent effect (BOLD)
13. Bolus tracking
14. Boil off rate
15. Boltzmann distribution

III. “C”
1. CBF
2. CBV
3. Cardiac gating
4. Cardiac phase
5. Carr-Purcell (CP) sequence
6. Carr-Purcell-Meiboom-Gill (CPMG) sequence
7. Cerebral blood flow (CBF)
8. Cerebral blood volume (CBV)
9. Chemical shift ($\delta$)
10. Chemical shift artifact
11. Chemical shift imaging
12. Chemical shift reference
13. Chemical shift spatial offset
14. Cine acquisition
15. C/N
16. Circularly polarized coil
17. CNR
18. Coherence
19. Coherent
20. Coil
21. Coil loading
22. Complex conjugate
23. Composite excitation
24. Continuous wave NMR (CW)
25. Contrast
26. Contrast agent
27. Contrast-to-noise ratio
28. Convolution differencing
29. Coronal plane
30. Correlation time
31. Coupled array coils
32. Coupling
33. Coupling constant
34. CP
35. CPMG
36. Crossed-coil
37. Cryogen
38. Cryomagnet
39. Cryoshielding
40. Cryostat
41. CSI
42. CW

IV. “D”
1. DAC
2. Data system
3. dB
4. dB/dt
5. DC artifact
6. Decibel (dB)
7. Decoupling
8. Demodulator
9. Dephasing
10. Dephasing gradient
11. Depth pulses
12. Detector
13. Diamagnetic
14. Diffusion
15. Diffusion-weighted imaging (DWI)
16. Digital to analog converter (DAC)
17. Digitization
18. Digitization noise
19. Digitizer
20. Dipole
21. Dipole-dipole interaction
22. Dipole field
23. DWI
24. Dynamic range

V. “E”
1. Echo
2. Echo offset
3. Echo planar imaging (EPI)
4. Echo spacing
5. Echo time
6. Echo train length (ETL)
7. Eddy current compensation
8. Eddy currents
9. Electron paramagnetic resonance (EPR)
10. Electron spin resonance (ESR)
11. Energy level
12. EPI
13. Epoch
14. EPR
15. ESR
16. Ernst angle
17. ETL
18. Even echo rephasing
19. Excitation
20. Exponential weighting

VI. “F”
1. f
2. Faraday shield
3. Fast Fourier transform (FFT)
4. Fat Suppression
5. Ferromagnetic
6. FFT
7. FID
8. Field echo
9. Field gradient
10. Field lock
11. Field of view (FOV)
12. Filling factor
13. Filter
14. Filtered back projection
15. Flip angle
16. Flow compensation
17. Flow effects
18. Flow-related enhancement
19. Flow void
20. fMRI
21. Fourier transform (FT)
22. Fourier transform imaging
23. FOV
24. Free induction decay (FID)
25. Frequency (f)
26. Frequency encoding
27. Frequency offset
28. Frequency selective RF pulse
29. Fringe field
30. FT
31. Full-width at half-maximum (FWHM)
32. Functional magnetic resonance imaging (fMRI)
33. FWHM

VII. “G”
1. G
2. Gx, Gy, Gz
3. Gadolinium
4. Gating
5. Gauss (G)
6. Gaussian line shape
7. Gaussian noise
8. Gibbs phenomenon
9. Gigahertz (GHz)
10. Golay coil
11. Gradient
12. Gradient and spin-echo imaging (GRASE)
13. Gradient coils
14. Gradient-echo
15. Gradient-echo pulse sequence
16. Gradient magnetic field
17. Gradient moment nulling
18. Gradient pulse
19. Gradient recalled echo
20. Gyromagnetic ratio (γ)

VIII. “H”
1. Ho
2. H1
3. Hahn echo
4. Half Fourier
5. Hardware
6. Helmholtz coil
7. Hertz (Hz)
8. Homogeneity
9. Homospoil
10. Hybrid magnet
11. Hz
IX. “I”
1. I
2. Isotropic Imaging
3. Image acquisition time
4. Imaginary signal
5. Impedance matching
6. Incoherent spins
7. Inductance
8. Induction (B)
9. Inhomogeneity
10. In-phase image
11. Interleaved image acquisition
12. Interleaved k-space coverage
13. Interpulse times (t)
14. Inverse Fourier transform
15. Inversion
16. Inversion-recovery (IR)
17. Inversion-recovery-spin-echo (IRSE)
18. Inversion time
19. Inversion transfer
20. IR
21. IRSE
22. Isocenter, magnetic
23. Isochromat
24. Isotopes
25. Isotropic motion
26. Isotropic voxel

X. “J”
1. J
2. J-coupling
3. J-modulation

XI. “K”
1. k
2. Keyhole imaging
3. kHz
4. Kilohertz (kHz)
5. k-space
6. k-space filling
7. k-space trajectory

XII. “L”
1. Larmor equation
2. Larmor frequency (\(\omega_0\) or fo)
3. Lattice
4. Line imaging
5. Line scanning
6. Line shape
7. Line, spectral
8. Line spread function (LSF)
9. Line width
10. Linearity
11. Linearly polarized coil (LP coil)
12. Liquifier
13. LMR
14. Loading
15. Localization techniques
16. Localized magnetic resonance (LMR)
17. Lock
18. Longitudinal magnetization (Mz)
19. Longitudinal relaxation
20. Longitudinal relaxation time
21. Lorentzian line
22. LSF

XIII. “M”
1. M
2. Mxy
3. Mz
4. Mo
5. Macroscopic magnetic moment
6. Macroscopic magnetization vector
7. Magnet stability
8. Magnetic dipole
9. Magnetic field (H)
10. Magnetic field gradient
11. Magnetic forces
12. Magnetic fringe field
13. Magnetic induction (B)
14. Magnetic moment
15. Magnetic resonance (MR)
16. Magnetic resonance angiography (MRA)
17. Magnetic resonance imaging (MRI)
18. Magnetic resonance spectroscopy (MRS)
19. Magnetic shielding
20. Magnetic susceptibility (χ)
21. Magnetization
22. Magnetization transfer
23. Magnetization transfer contrast (MTC)
24. Magnetogyric ratio
25. Magnitude calculation
26. Matching
27. Matching network
28. Matrix size
29. Maximum intensity projection (MIP)
30. Maxwell coil
31. Megahertz (MHz)
32. Meiboom-Gill sequence
33. MHz
34. Moment
35. MPR (multiplanar reconstruction)
36. MR
37. MR Signal
38. MRA
39. MRI
40. MRS
41. MTC
42. Multiple coil array
43. Multiple echo imaging
44. Multiple line-scan imaging (MLSI)
45. Multiple quantum coherence
46. Multiple sensitive point
47. Multiple slice imaging
48. Multiple spin echo
49. Multiplet
50. Multiply tuned coil

XIV. “N”
1. N(H)
2. NEX
3. NMR
4. NMR imaging
5. NMR signal
6. NOE
7. Noise
8. Noise figure
9. NSA
10. Nuclear magnetic resonance (NMR)
11. Nuclear Overhauser effect (NOE)
12. Nuclear spin (see also Spin)
13. Nuclear spin quantum number (I)
14. Nucleon
15. Nutation
16. Nx, Ny, Nz
17. Nyquist limit

XV. “O”
1. Off resonance
2. On resonance
3. Opposed-phase image
4. Orientation

XVI. “P”
1. Pacemaker effect
2. Paradoxical enhancement
3. Parallel imaging
4. Paramagnetic
5. Partial Fourier imaging
7. Partial saturation spin echo (PSSE)
8. Partial volume effect
9. Passive shielding
10. Passive shimming
11. PD
12. Peak
13. Permanent magnet
14. Permeability (µ)
15. Phantom
16. Phase
17. Phase correction
18. Phase cycling
19. Phase encoding
20. Phase encoding order
21. Phase sensitive detector
22. PIN diode
23. Pixel
24. Planar imaging
25. Point spread function (PSF)
26. Pole piece (or pole tip)
27. Population
28. Preamplifier
29. Precession
30. Precessional frequency
31. Preemphasis
32. Presaturation
33. Probe
34. Progressive saturation
35. Projection profile
36. Projection-reconstruction imaging
37. Prospective synchronization
38. Proton density (PD)
39. PS
40. PSF
41. PSSE
42. Pulse, 90° (\(\pi/2\) pulse)
43. Pulse, 180° (\(\pi\) pulse)
44. Pulse, gradient
45. Pulse, RF
46. Pulse length (width)
47. Pulse NMR
48. Pulse programmer
49. Pulse sequences
50. Pulsed gradients

XVII. “Q”
1. Q
2. Quadrature coil
3. Quadrature detector
4. Quadrupole moment
5. Quality factor (Q)
6. Quantization noise
7. Quenching

XVIII. “R”
1. R1
2. R2
3. ROI
4. Radian
5. Radiofrequency (RF)
6. Ramp time
7. Ramping
8. Random noiseRapid-excitation MR imaging
9. Raw data
10. Rayleigh noise
11. Readout delay
12. Real signal
13. Receiver
14. Receiver coil
15. Receiver dead time
16. Reconstruction from projections imaging
17. Reference compound
18. Refocusing
19. Refrigerator
20. Region-of-interest (ROI)
21. Relaxation
22. Relaxation rates
23. Relaxation times
24. Repetition time
25. Rephasing gradient
26. Resistive magnet
27. Resolution element
28. Resolution, spatial
29. Resonance
30. Resonance frequency
31. Resonance offset (β)
32. Respiratory gating
33. Respiratory ordering of phase encoding
34. Retrospective respiratory gating
35. Retrospective synchronization
36. RF
37. RF coil
38. RF pulse
39. RF shielding
40. RF spin echo
41. RF spoiling
42. Room shielding
43. Rotating frame of reference
44. Rotating frame zeugmatography

XIX. “S”
1. Saddle coil
2. Safety
3. Sagittal plane
4. Sampling
5. Sampling window
6. SAR
7. Saturation
8. Saturation pulses
9. Saturation recovery (SR)
10. Saturation transfer (or Inversion transfer)
11. Scalar
12. SE
13. Segmented k-space data acquisition
14. Selective excitation
15. Selective irradiation
16. Self-shielding
17. Sensitive plane
18. Sensitive point
19. Sensitive volume
20. Sequence time
21. Sequential line imaging (Line scanning, Line imaging)
22. Sequential plane imaging (Planar imaging)
23. Sequential point imaging (Point scanning)
24. SFP
25. Shaped pulse
26. Shielded gradient coils
27. Shielding
28. Shift reagents
29. Shim coils
30. Shimming
31. SI (International System of Units)
32. Signal averaging
33. Signal-to-noise ratio (SNR or S/N)
34. Signal suppression
35. Sinc interpolation
36. Single-shot imaging
37. Skin depth
38. Slice
39. Slice profile
40. Slice selection
41. Slice thickness
42. S/N
43. SNR
44. Solenoid coil
45. Solvent suppression
46. Spatial frequency
47. Spatial resolution
48. Spatially localized spectroscopy
49. Spatial-spectral (or spectral-spatial) excitation
50. Specific absorption rate (SAR) (W/kg)
51. Spectral editing
52. Spectral line
53. Spectral width
54. Spectrometer
55. Spectroscopy
56. Spectroscopic imaging
57. Spectrum Spin
58. Spin density (N)
59. Spin echo (SE)
60. Spin echo imaging
61. Spin-lattice relaxation time
62. Spin number, nuclear
63. Spin quantum number (I)
64. Spin-spin coupling
65. Spin-spin relaxation time
66. Spin tagging
67. Spin warp imaging
68. Spiral k-space coverage
69. Spoiler gradient pulse
70. SR
71. SSFP
72. Steady-state coherent
73. Steady state free precession (SFP or SSFP)
74. Stimulated echo
75. Superconducting magnet
76. Superconductor
77. Suppression
78. Surface coil
79. Surface coil MR
80. Susceptibility
81. Susceptibility artifact
82. Switchable coil
83. Synchronization, cardiac
84. Synchronization, prospective
85. Synchronization, respiratory
Synchronization, retrospective

XX. “T”
1. T
2. T1 or T1 (“T-one”)
3. T1-weighted (T1W)
4. T2 or T2 (“T-two”)
5. T2* (“T-two-star”)
6. T2-weighted (T2W)
7. TAD
8. Tagging
9. Tailored excitation
10. Tailored pulse
11. TD
12. TE
13. Temporal resolution
14. TER
15. Tesla (T)
16. Thermal equilibrium
17. Three-dimensional Fourier transform imaging (3DFT)
18. TI
19. Time-of-flight
20. Tip angle
21. Torque
22. TR
23. Transaxial plane
24. Transmit/receive (T/R) coil
25. Transmitter
26. Transmitter coil
27. Transverse magnetization (Mxy)
28. Transverse plane
29. Transverse relaxation
30. Transverse relaxation time
31. Traveling saturation pulse
32. Trigger delay time
33. Triggering
34. Truncation artifact
35. Two dimensional Fourier transform imaging (2DFT)
36. Tuning
37. Twister gradient
38. Two-dimensional MR

XXI. “V”
1. Variable flip angle
2. Variable TE
3. Variable TR
4. Vector
5. Velocity compensation
6. Vessel tracking
7. View
8. VOI
9. Volume coil
10. Volume of interest (VOI)
11. Volume imaging
12. Volume-selective excitation
13. Voxel
XXII. “W”
1. Wash-in effects
2. Wash-out effects
3. Water-suppression

XXIII. “X”
1. x
2. x’

XXIV. “Y”
1. y
2. y’
3. Yoke

XXV. “Z”
1. z
2. Zero filling
3. Zeugmatography

XXVI. Symbols and Abbreviations
1. 2DFT
2. γ
3. δ
4. μ
5. τ
6. χ
7. ω
8. ω₀

XXVII. Basic Quantities in Electricity and Magnetism

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MR Review Course

Lecture 2

Title: Fundamentals (90 minutes)


Objectives:
• List the advantages of using magnetic resonance (MR) imaging
• Discuss the history of MR imaging
• Name the researchers and pioneers in MR imaging
• Explain how an image is acquired using MR
• Describe how the MR signal is produced and detected
• Discuss the future of MR imaging

Content:
I. Introduction

II. Advantages of MR

III. MR vs. CT

IV. MR Scanners

V. Magnet Types
   1. Permanent Magnet
   2. Resistive Magnet
   3. Superconducting Magnet

VI. Magnetic Field Strength

VII. MR Safety

VIII. Planes
   1. Coronal
   2. Sagittal
   3. Axial

IX. MR Defined — Evolution

X. History of MR Imaging

XI. MR History — Clinical Application

XII. MR Innovation

XIII. MR Examination

XIV. MR Requirements
XV. MR Physics

XVI. The Faraday Law

XVII. Electromagnetism and MR

XVIII. Magnetic Induction

XIX. Vectors

XX. Hydrogen Atoms

XXI. No External Field Applied

XXII. External Field Applied

XXIII. Increasing Field Strength

XXIV. Net Magnetization Vector

XXV. Magnetic Fields

XXVI. Precession
   1. Precessional Frequency
   2. In-phase Precession
   3. Out-of-phase Precession

XXVII. Larmor Equation

XXVIII. Larmor Frequency and Magnetic Field Strength

XXIX. Radiofrequency

XXX. Resonance
   1. Generating MR Signal
      a. Longitudinal Direction
      b. Transverse Magnetization
   2. RF Excitation Pulse
   3. RF Energy Absorption

XXXI. Superconducting Magnet

XXXII. Coordinate System

XXXIII. Relaxation
   1. Types of Relaxation
      a. Longitudinal Relaxation (T1 Relaxation)
      b. Transverse Relaxation (T2 Relaxation)
   2. Relaxation Process
   3. Free Induction Decay (FID)
   4. T1-weighted Contrast
   5. T2-weighted Contrast
   6. Excitation
   7. T1 and T2 Relaxation
XXXIV. Computers in MR Imaging

XXXV. Advances in MR

XXXVI. Integrated Modalities

XXXVII. MR-safe Pacemakers

XXXVIII. Conclusion

XXXIX. Annex
1. Bibliography
2. Acknowledgements
3. MR Parameters: Actions and Associated Trade-offs
4. Optimizing Image Quality
5. MRI Fundamentals Glossary

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Lecture 3

Title: Equipment and Instrumentation (60 minutes)

Keywords: Equipment, MR gantry, Patient Table, Operator’s console, Computer, Magnetism, Magnetic Field Strength, Specific Absorption Rate (SAR), Chemical Shift, Dielectric Effect, Magnetic Susceptibility, Magnet Configurations, Shielding, Future

Objectives:
• Identify the major hardware components in magnetic resonance (MR) imaging
• Understand magnetism and magnetic properties
• Define gauss and tesla
• Describe the three basic types of magnets
• Discuss the differences in low-, mid-, high- and ultra-high field systems
• Explain the functionality of the shim system in MR imaging

Content:
I. Equipment
   1. MR gantry
      a. Coordinates
      b. MR Unit Length
      c. Laser Positioning Lights
      d. Patient Table
   2. Operator’s console
   3. Computer

II. Magnetism
   1. Diamagnetic Substances
   2. Paramagnetic Substances
   3. Superparamagnetic Substances
   4. Ferromagnetic Substances

III. Magnetic Field Strength
   1. The unit of measure for magnetic field strength
      a. Gauss
      b. Tesla
   2. Five categories of field strength
      a. Ultra-high field magnets
      b. High-field magnets
      c. Midfield magnetic
      d. Low-field strength
      e. Ultra-low field
   3. Specific Absorption Rate (SAR)
   4. Chemical Shift
   5. Dielectric Effect
   6. Magnetic Susceptibility
   7. High-Field vs. Low-Field

IV. Magnet Configurations
   1. Permanent Magnet
   2. Electromagnet
      a. Resistive Electromagnet
      b. Superconducting Electromagnet
3. Magnetic Field
4. Resistive Magnet
5. Cryogens
6. Superconducting Magnet
7. High-Field Open MR
8. Fringe Fields

V. Shielding
   1. Passive Shielding
   2. Active Shielding
   3. Magnetic Field

VI. The Future

VII. Conclusion

VIII. Annex
   1. References
   2. Bibliography
   3. Acknowledgements
   4. MR Parameters: Actions and Associated Trade-offs
   5. Optimizing Image Quality
   6. MRI Fundamentals Glossary

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Lecture 4

Title: Radiofrequency and Gradients (90 minutes)

Keywords: Gradients, RF Systems, Gradient Composition, Gradient Coils, RF Coils, RF Shielding, Gradient-echo Pulse Sequences, Safety

Objectives:
• Explain the functionality of the radiofrequency (RF) system in magnetic resonance (MR) imaging.
• Explain the functionality of the gradient system in MR imaging.
• Discuss how gradients alter magnetic fields.
• Describe the role of coils when applying gradients.

Content:
I. Introduction

II. Gradients and RF Systems

III. Gradient Composition

IV. Magnetic Isocenter

V. Gradient Coils and Amplifiers

VI. Applying Gradients

VII. Hardware — Gradient Coils

VIII. Example

IX. Gradient Axes

X. Partial Gradients

XI. Oblique Angle

XII. Gradients

XIII. Pulse Sequence

XIV. Slice-select Gradient

XV. Phase Encoding

XVI. Phase Shift

XVII. Frequency Encoding

XVIII. Frequency-encoding Gradient

XIX. Balanced Gradient System
XX. Gradient Strength

XXI. Gradient Rise Time and Slew Rate

XXII. Duty Cycle

XXIII. Eddy Current
  1. Eddy Current Compensation

XXIV. Safety
  1. Acoustic Noise

XXV. RF Systems

XXVI. Body Coil

XXVII. RF Production

XXVIII. Faraday Law of Induction

XXIX. Electromagnetic Spectrum

XXX. RF Production Steps

XXXI. Sampling

XXXII. Fourier Transform Algorithm

XXXIII. Facts About K-space

XXXIV. Filling K-space

XXXV. RF Transmitters

XXXVI. RF Coils
  1. Volume Coil
  2. Quadrature Coils
     a. Circular-polarized design
     b. Linear Polarized Design
  3. Surface Coils
  4. Phased-array Coils
  5. Multiple Coils

XXXVII. RF Shielding

XXXVIII. Magnetic Field Strength

XXXIX. Angular Momentum

XL. Precession

XLI. Active Nuclei

XLI. Resonance

XLI. Magnetism
XLIV. Net Magnetization Vector (NMV)

XLV. The MR Signal

XLVI. Gradient-echo Pulse Sequences
1. Coherent Gradient-Echo Pulse Sequences
2. Rewinder Gradient
3. Incoherent Gradient Sequence
4. Gradient Spoiling

XLVII. Using Gradients

XLVIII. T1 Recovery

XLIX. T2 Decay

L. Proton Density

LI. RF Safety
1. Tissue Heating
2. Specific Absorption Rate (SAR)
3. Burns

LII. Conclusion

LIII. Annex
1. Bibliography
2. Acknowledgements
3. MR Parameters: Actions and Associated Trade-offs
4. Optimizing Image Quality
5. MRI Fundamentals Glossary

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Lecture 5

Title: Image Production Parameters (90 minutes)

Keywords: MR Imaging, Intrinsic Parameters, T1 relaxation, T2 relaxation, Proton density, Extrinsic Parameters, Repetition time (TR), Echo time (TE), Inversion time, Flip angle, T1 Weighting, T2 Weighting, Proton-Density Weighting, Proton-Density Scans, Image Weighting Parameters, Image Contrast Comparisons, Pulse Sequences, Spin-Echo Pulse Sequences, Spin-Echo Sequence Steps, Fast Spin-Echo Sequences, Gradient, Recovery Sequences, Image Quality Comparison, Balancing Parameters

Objectives:
• Explain intrinsic parameters that affect image quality, such as proton density, T1 relaxation and T2 relaxation
• Explain extrinsic parameters that affect image quality, such as repetition time (TR), echo time (TE), inversion time and flip angle
• Define the use of gradient and radiofrequency (RF) pulses in acquiring MR images
• Described image contrast appearance according to image weighting

Content:
I. MR Advantages and Parameters

II. Intrinsic Parameters
1. T1 relaxation
2. T2 relaxation
3. Proton density

III. Extrinsic Parameters
1. Repetition time (TR)
2. Echo time (TE)
3. Inversion time
4. Flip angle
5. Signal and Flip Angle

IV. Manipulating Extrinsic Parameters
1. T1 Weighting in MR Imaging
   a. T1 Relaxation Time
   b. T1 Contrast Curve
   c. T1 Brain Images
   d. Contrast vs. T1 and TR
2. T2 Weighting in MR Imaging
   a. T2 Relaxation Time
   b. T2 Contrast Curve
   c. T2-weighted Images

V. TE Values and T2 Weighting
1. Contrast vs. T2 and TE
2. Summary of T1 and T2 Relaxation
3. Combined Effects of T1 and T2 Relaxation
4. T2* Weighting
5. Longitudinal Magnetization
6. Spin-Echo vs. Gradient-Echo
7. Shimming
8. Comparing T2 and T2* Images
VI. Proton-Density Weighting in MR Imaging
1. Proton-Density Weighting
2. Proton-Density Imaging
3. Hydrogen Content in Tissues
4. Uses of Proton-Density Scans

VII. Image Weighting Parameters
1. T1-weighted scan uses a short TE and a short TR
2. T2-weighted scan uses a long TE and a long TR
3. Proton-density scan uses a short TE and a long TR

VIII. Image Contrast Comparisons

IX. Introduction to Pulse Sequences
1. Saturation
2. T1-weighted Images and Saturation
3. Partial Saturation Sequence

X. Conventional Spin-Echo Pulse Sequences
1. Spin-Echo Pulse Sequences
2. Relaxation
3. Review of Spin-Echo Sequence Steps
   a. Flip the net magnetization vector
   b. Remove RF Pulse
   c. Free Induction Decay
   d. Rephase With 180-degree Pulse
      a. Spins Return to In-Phase
4. Spin-Echo
5. Parameter of Tau
6. Advantages of Spin-Echo
7. Disadvantages of Spin-Echo

XI. Fast Spin-Echo Sequences
1. Gradient-Echo Pulse Sequences
2. Magnetic Field Gradients
3. Advantages of Gradient Echo

XII. Inversion Recovery Sequences
1. Fast Spin-Echo Inversion Recovery
2. Inversion Time
3. Short Tau Inversion Recovery
4. Fluid-Attenuated Inversion Recovery

XIII. Image Quality Comparison

XIV. Balancing Parameters

XV. Conclusion

XVI. Annex
1. Bibliography
2. Acknowledgements
3. MR Parameters: Actions and Associated Trade-offs
4. Optimizing Image Quality
5. MRI Fundamentals Glossary

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Lecture 6

Title: Pulse Sequences (90 minutes)

Keywords: Image Quality, Image Balancing, Basic MR Imaging Principles, Longitudinal and Transverse Magnetization, Slice Selection, Number of Signals Averaged (NSA), Spin density, Relaxation, Repetition time, Echo time, Inversion time, Flip angle, Gradient, Echo, Pulse sequence

Objectives:

- List parameters related to tissue characteristics that affect image quality, such as spin density and T1 and T2 relaxation
- Identify other parameters that affect image quality, such as repetition time, echo time, inversion time and flip angle
- Apply pulse sequence principles to magnetic resonance (MR) imaging
- Explain the concepts of image formation in MR imaging
- Describe image contrast appearance according to image weighting

Content:

I. Image Balancing Act

II. Basic MR Imaging Principles
   1. Hydrogen Atoms
   2. Magnetic Field Effect
   3. Net Magnetization Vector
   4. Precession in the Magnetic Field
   5. The Larmor Equation
   6. The Gyromagnetic Ratio
   7. Calculating Precessional Frequency

III. Longitudinal and Transverse Magnetization
   1. Faraday Law of Induction
   2. T1 and T2 Relaxation Times
   3. Image Contrast
   4. Pulse Sequences
   5. Repetition Time (TR)
   6. Echo Time (TE)

IV. Scan Timing Parameter Chart

V. Pulse Sequence Diagram

VI. Slice Selection
   1. Gradients
   2. Phase and Frequency Encoding
   3. Phase-encoding Gradient
   4. Frequency-encoding Gradient
   5. Matrix Size
   6. K-space
   7. Spiral Filling
      a. Centric Filling
      b. Zero Filling

VII. Number of Signals Averaged (NSA)
VIII. Gradient Slew Rate

IX. Field of View

X. Echo Spacing

XI. Receive Bandwidth

XII. Single- or Dual-Echo Conventional Spin-echo
  1. Calculating Spin-Echo Scan Time

XIII. Fast Spin-Echo
  1. Fast Spin-Echo and K-space
  2. Calculating Fast Spin-Echo Scan Time
  3. Fast Spin-Echo Pulse Sequences
  4. Fast Spin-Echo Tradeoffs
  5. Fast Spin-Echo Sequence

XIV. Gradient-Echo Pulse Sequences
  1. Gradient-Echo and Spin-Echo Pulse Diagrams
  2. Gradient-Echo Pulse Sequences
  3. Inversion Recovery
  4. Calculating Gradient-Echo Scan Time
  5. Advantages of Gradient-Echo pulse Sequences

XV. Gradient-Echo T2-Weighting

XVI. Echo Planar Imaging
  1. Calculating EPI Scan Time

XVII. EPI vs. Fast Spin-Echo Imaging

XVIII. Increased Resolution

XIX. White Matter Sensitivity

XX. Faster Imaging Applications

XXI. Ultrafast EPI

XXII. EPI Sequences for Stroke

XXIII. Diffusion-weighted Imaging

XXIV. Dynamic Studies

XXV. Pulse Sequence Comparison

XXVI. Magnetic Susceptibility Artifacts

XXVII. Geometric Distortion

XXVIII. Conclusion

XXIX. Annex
1. Bibliography
2. Acknowledgements
3. MR Parameters: Actions and Associated Trade-offs
4. Optimizing Image Quality
5. MRI Fundamentals Glossary

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Lecture 7

Title: Contrast Media (90 minutes)

Keywords: History, Contrast-enhanced, Magnetism, MR Contrast Agents, Preparation of patients, Glomerular Filtration Rate (GFR), Contrast Preparation, Standard IV Procedural Steps, Adverse Reactions, MR Contrast Applications, Serious Adverse Events

Objectives:
• Discuss proper screening and preparation of patients for contrast-enhanced magnetic resonance (MR) imaging examinations
• Describe the use of MR contrast agents
• List potential adverse effects of contrast agents
• Explain the mechanism of action and effects of contrast media on images
• Describe how to prepare contrast materials for injection

Content:
I. History of Contrast

II. Contrast-enhanced MR Imaging

III. Magnetism
  1. Diamagnetic Substances
  2. Paramagnetic Substances
  3. Superparamagnetic Substances
  4. Ferromagnetic Substances

IV. MR Contrast Agents
  1. Types of MR Contrast
  2. Gadolinium-based Contrast
     a. Gadolinium Mechanism of Action
     b. Gadolinium Pharmacology
     c. Gadolinium-based Pharmacokinetics
  3. Blood Pool Agents
  4. Iron-oxide Contrast Agents
     a. Iron-oxide Mechanism of Action
  5. Manganese-based Agents
  6. Tissue-specific Contrast Agents

V. Preparation of patients
  1. Patient History
  2. Patient Prescreening
     a. Examples of questions
  3. Prescreening for Gadolinium-based Contrast
     a. Glomerular Filtration Rate (GFR)
  4. Contraindications
  5. ACR Recommendations
  6. Patient Preparation

VI. Contrast Preparation
  1. Contrast Administration
  2. Universal Precautions
  3. Blood Vessels
  4. IV Administration Sites
V. Power Injector Administration

VII. Standard IV Procedural Steps

VIII. Adverse Reactions
1. Local Injection-related Complications
2. Other Injection-related Complications
3. Reactions to Gadolinium
   a. Mild Reactions to Gadolinium
   b. Moderate-to-Severe Reactions
4. Nephrogenic Systemic Fibrosis (NSF)
5. Reactions to Blood-pool Agents
6. Reactions to Iron-oxide Agents
7. Reactions to Manganese Agents
8. Reactions to Secretin

IX. MR Contrast Applications
1. Extracellular Contrast Agents
2. Magnetic Resonance Angiography (MRA)
3. MRA Scans
4. MRA Renal Scan
5. Other Cardiovascular Applications
6. Breath-hold and Cardiac Gating
7. Breath-hold Image
8. Cardiac Gating Images
9. Hepatic Applications
10. Hepatic Imaging
11. Superparamagnetic Contrast Media
12. Iron-oxide Agents
13. MRCP Sequences
14. MRCP Scans
15. Oral Contrast for Abdomen
16. Imaging Lymph Nodes
17. Abdominal Images
18. Intracranial Images
19. MRA Imaging with Contrast
20. MR Arthrograms
21. New Contrast Agents

X. Reporting Serious Adverse Events

XI. Conclusion

XII. Annex
1. Bibliography
2. Acknowledgements
3. MR Parameters: Actions and Associated Trade-offs
4. Optimizing Image Quality
5. MRI Fundamentals Glossary

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Lecture 8.1

**Title:** Safety Essentials, part 1 (90 minutes)

**Keywords:** Safety, Magnetic Classification of Objects, Field Strength, Static Magnetic Field, Electromagnetic Spectrum, RF Radiation Exposure, Specific Absorption Rate (SAR), Thermal Increases, Thermal Burns, Gradient, Safety Zones, Safety Classifications of Personnel, Safety Screening, Contraindications and Precautions, Patient Preparation, Patient Monitoring, Patient Emergencies, Equipment or Environmental Emergencies, Ancillary Equipment, Cryogen Gas Monitoring

**Objectives:**
- Discuss the elements of safety that help ensure a magnetic resonance (MR) imaging facility operates safely
- Demonstrate proper screening and preparation of patients for MR imaging
- Explain how to monitor patients during procedures
- Describe when and how to quench the magnet and handle other emergencies in the MR environment

**Content:**
I. Importance of Safety

II. MR Safety Incidents

III. MR Safety Considerations

IV. Magnetic Classification of Objects
   1. Diamagnetic Substances
      a. Diamagnetic Objects
   2. Paramagnetic Substances
      a. Paramagnetic Materials
   3. Superparamagnetic Substances
   4. Ferromagnetic Substances
      a. Ferromagnetic Objects

V. Field Strength Measurement

VI. Field Strengths and Safety
   1. 5-Gauss Warning
   2. Static Magnetic Field
   3. Fringe Field
   4. Shielding
      a. Active shielding
      b. Passive shielding

VII. Translational Force

VIII. Rotational Force

IX. Screening and Testing Objects

X. Summary for Static Magnetic Field
XI. Electromagnetic Spectrum

XII. RF Radiation Exposure

XIII. Specific Absorption Rate (SAR)
   1. How a Scanner Estimates SAR

XIV. Heating

XV. Thermal Increases

XVI. Preventing Thermal Burns
   1. Implanted Medical Devices
      a. Medical Devices and Overheating
      b. Jewelry, Body Piercings and Tattoos

XVII. Gradient Magnetic Fields
   1. Nerve Stimulation
   2. Acoustic Noise
   3. Peripheral Nerve or Muscle Stimulation
   4. Magnetohemodynamic Effect

XVIII. Safety Zones
   1. Zone I
   2. Zone II
   3. Zone III
   4. Zone IV

XIX. Safety Classifications of Personnel

XX. Safety Screening
   1. Patient and Personnel Safety Screening
   2. Patient Screening — Referring Physician
   3. Pre-examination Screening
   4. Patient and Examination Identification
   5. Final Patient Screening
   6. Safety Questionnaire

XXI. Contraindications and Precautions
   1. Intracranial Vascular Clips
   2. Pacemakers and Other Implanted Devices
   3. Implanted Devices and Field Strength
   4. Intraocular Ferrous Foreign Bodies

XXII. Patient Preparation
   1. Objects With Metal
   2. Contrast Media and Pregnancy

XXIII. Patient Monitoring
   1. Verbal Monitoring
   2. Monitoring Unconscious or Sedated Patients

XXIV. Patient Emergencies

XXV. Equipment or Environmental Emergencies
XXVI. Ancillary Equipment

XXVII. Cryogen Gas Monitoring
   1. Quenching the Magnet
   2. Controlled Quench
   3. Uncontrolled Quench
   4. During a Quench
   5. Cryogen Gas Release
   6. Quench Response

XXVIII. Conclusion

XXIX. Annex
   1. Bibliography
   2. Acknowledgements
   3. MR Parameters: Actions and Associated Trade-offs
   4. Optimizing Image Quality
   5. MRI Fundamentals Glossary

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Lecture 8.2

Title: MRI Safety Policies & Procedures, part 2 (90 minutes)


Objectives:

• Examine the possible risks, associated with the MR Suite including but not limited to static, time-varying magnetic fields and RF Pulses
• Identify policies and procedures to be in compliance with the most up to date MR safety information provided by the Joint Commission and the ACR
• Discuss and be able to implement MRI safety for staff and patients
• Identify MR personnel and their responsibilities
• Describe how radiation and MRI are used in the healthcare setting
• List and explain the hazards of radiation and MRI
• Describe safeguards for healthcare staff who work with radiation or radioactive patients
• Detail safeguards for healthcare staff and patients involved in MRI

Content:

I. Introduction
   1. What is MRI?
   2. Basic Components of MRI
   3. MRI Safety Manual Acronyms

II. MRI Safety Manual General Policy
   1. MRI Safety Terminology

III. Site Access Restrictions
   1. Site Access for Zones I
   2. Site Access for Zone II
   3. Site Access for Zone III
   4. Site Access for Zone IV
   5. MRI Functional Zone Diagram: Example of a Standard ACR Zone

IV. EAR PLUGS and other TIME VARYING GRADIENT MAGNETIC FIELD-RELATED ISSUES
   1. Auditory Considerations
   2. Induced Voltage Considerations
   3. Thermal Considerations

V. Firefighters, Police & Safety Considerations

VI. Emergency Response Protocol
   1. Rescue
   2. Alarm
   3. Confine
   4. Extinguish
VII. Fire Extinguisher Protocol

VIII. Fire Alarm Activation Procedures

IX. MRI Emergency Procedures

X. Fire Prevention Plan

XI. Cryogen Related Issues

XII. MRI Personnel Screenings
   1. Non-MR Personnel
   2. Level 1 MR Personnel
   3. LEVEL 2 MR Personnel
   4. MRI Personnel & Non MRI Personnel

XIII. Family Members Safety/Screening

XIV. Device/Object Screening

XV. Gun Shot Wounds

XVI. General Outpatients MRI Screening

XVII. Inpatients MRI Screening

XVIII. Unresponsive Patients in MRI

XIX. Oxygen Cylinders

XX. Penile Implants

XXI. Foreign Body in Orbits
   1. Policy
   2. Procedure

XXII. Ordering & Scheduling Foreign Body X-ray of Orbits

XXIII. Cardiac Implantations
   1. Cardiac Valves
   2. Coronary Artery Stents
   3. Cardiac Leads

XXIV. Cardiac Pacemaker/ICD

XXV. Vascular Stents, Filters & Coils
   1. Embolization Coils
   2. Stents & Filters
   3. Aneurysm Clips

XXVI. Brain Stimulators
   1. Cyberonics Vagal Nerve Stimulator
   2. Medtronic Deep Brain Stimulator
   3. Neuropace RNS Therapy
XXVII. Programmable Shunt Process
   1. Common Shunt Processes

XXVIII. Implantable Devices
   1. Common Device List
      a. MEDTRONIC INTERSTIM bladder control
      b. 8637 MEDTRONIC SYNCHROMED II Baclofen Pain Pump
      c. 8626, 8627 MEDTRONIC SYNCHOMED EL Baclofen Pain Pump
   2. Orthodontic Dental Devices
      a. Prior to appointment
      b. Immediately prior to appointment
      c. During MRI
   3. Trans-Dermal Medication Patches and Wound Dressings
      a. Trans-Dermal Medication Patches
      b. Wound Dressings
   4. Miscellaneous Devices
      a. Bivona Trach
      b. Tissue Expander/Breast Expander
      c. Cardiac Loop Recorder Implantable Cardiac Monitor
      d. Perifix Polyamide Catheter
      e. Reveal XT 9529 DX 9528
      f. Reveal LINQ
      g. Scleral Buckle
      h. Swanz-Ganz Catheters
      i. Temperature Foley Catheters
      j. X-Stop Vertebrae Implant
   5. Miscellaneous Surgical Objects
      a. List of surgical objects safe on 1.5 & 3T

XXIX. Pregnant MRI Healthcare Providers & Pregnant Patients
   1. Pregnant Health Care Employees
   2. Pregnant Patients 1.5 and 3T
   3. Possible Pregnant Patients and NON Contrast
   4. Pregnant Companions

XXX. Administration of Contrast to Breast Feeding Patients

XXXI. IV and Oral Contrast Agents
   1. IV Contrast Agents
   2. Oral Contrast

XXXII. Gadolinium and eGFR Screening
   1. Outpatients
   2. Inpatients
   3. Patients on Dialysis
   4. Exceptions Regarding Contrast Usage in Patients
   5. Off Label Usage
   6. Documentation of Contrast Usage

XXXIII. Multiple Gadolinium Injections in a 24 Hour Period
   1. Time in between contrast injections
   2. Types of contrast given
   3. Patients Renal Function

XXXIV. MRI Emergency Department and STAT Requested Exams
   1. levels of “Stat” Ordered exams
a. Life-Threatening
b. Urgent
2. MRI Requests
   a. Life Threatening
   b. Urgent
   c. Routine
   d. Time Dependent
4. Overnight MRI Cases

XXXV. Magnet Room Cleaning

XXXVI. Latex Allergies in MRI

XXXVII. Patient Monitoring
   1. Monitoring By Nursing Staff: Critical Care Patients
   2. Monitoring By MRI Staff for Thermal Injury

XXXVIII. Code Procedure/Code Chart

XXXIX. Quench or Emergency Situation

XL. MRI Nursing Responsibilities

XLI. Ferrous Object in MR Scan Room
   1. If the object is inside the patient or in the imaging field
   2. If the object is pinning a patient or staff member
   3. If the object is solitary and not creating a life threatening situation

XLII. MRI Safety Officer Responsibilities

XLIII. MRI Medical Director Responsibilities

XLIV. MRI Safety/Wanding

XLV. Ear Plugs During an MRI Exam

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Lecture 8.3

Title: MR Safety, part 3 (90 minutes)

Keywords: Magnetic Resonance Imaging (MRI), Types of MR formats, MRI Scanner, Equipment Screening, OLD Terminology, Current Terminology, Access Restriction And Zoning, Types of Radiation, Health Effects, Types of Magnetic Fields, Effects Of Static Magnetic Field (Bo), Effects of Time-varying Magnetic Field (dB/dt), Effects of Radiofrequency Fields, MRI Labeling, Warning Sign, RF safety, Infection Control, Bio Effects Of Contrast Media, Emergency Buttons, Scan Room, Employees Safety, Magnet

Objectives:
• Brief review of Magnetic Resonance Imaging (MRI)
• Discuss Equipment Screening, MRI Safety Label old and Current Terminology
• Review Access Restriction And Zoning
• Review Types of Radiation
• Define Health Effects
• Determine Effects Of Static Magnetic Field (Bo), Effects of Time-varying Magnetic Field (dB/dt) and Effects of Radiofrequency Fields
• Understand MRI Labeling & Warning Sign
• Discuss RF safety
• Explain Infection Control
• Determine Bio Effects Of Contrast Media
• Understand Emergency Buttons

Content:
I. Introduction

II. Magnetic Resonance Imaging (MRI)
1. Types of MR formats
   a. Bore Format
   b. Open Style
   c. Stand Up
2. MRI Scanner
   a. MRI Scanner Properties
   b. MRI Scanner Static magnetic field
3. How MRI work?
   a. Superconducting Magnet

III. Equipment Screening
1. MRI Safety Label OLD Terminology
   a. MR Safe
   b. MR Compatible
2. MRI Safety Label Current Terminology
   a. MR Safe
      • Miscellaneous Implants and Devices
      • Vascular Access Ports, Infusion Pumps*, and Catheters
      • Coils, stents, filters and vascular grafts
      • Orthopedic Implants, Materials, and Devices
      • ECG (EKG) Electrodes
   b. MR Conditional
      • Conditional 1 (Heart Valves and Annuloplasty Rings)
• Conditional 1 (Dental Implants, Devices, and Materials)
• Conditional 2 (Filters, stents, clips, cardiac occludes)
• Conditional 3 (Transdermal patches or other metallic comp)
• Conditional 4 (Halo vest or cervical fixation device)
• Conditional 5 (Vendor or the manufacturer for further information)
• Conditional 6 (MRI-Related Heating)
• Conditional 6 (Artifact)
• Conditional 7 (Important Note)
• Conditional 8 (MRI-Related Heating)
• Conditional 8 (Artifact)

   c. MR Unsafe
      • Biopsy Needles, Markers, and Devices
      • Breast Tissue Expanders and Implants
      • Insulin Pumps
      • Neuro stimulation (Neuromodulation) Systems:
        • Cardiac Pacemakers, Implantable Cardioverter Defibrillators (ICDs), and Cardiac Monitors

3. Use of Terminology
   a. Terminology Applied to Implants and Devices
      • Field Strength

4. Terminology Regarding the List of Safe MRI

IV. Access Restriction And Zoning
1. Zone I
2. Zone II
   a. Security and Safety
3. Zone III
   a. Ferromagnetic Detector System
4. Zone IV

V. Types Of Radiation
1. Ionizing Radiation
2. Non-ionizing Radiation

VI. Health Effects
1. Types of Magnetic Fields
   a. High static magnetic field
   b. Gradient magnetic field
   c. Radio frequency electromagnetic wav
2. Effects Of Static Magnetic Field (Bo)
   a. Field Strength
   b. Projectile Effect
   c. Torsion and Translation Forces
   d. Attraction of ferromagnetic material towards the magnet
   e. Safety Measures
      • Poor screening
      • Potential Projectiles
   f. Magnetic Field Hazards
      • Displacement and Heating of Surgical Implants
      • Stents and Aneurysm Clips
   g. Biological changes
      • Cell Functions
      • Growth and healing of bone
      • Thrombolysis
      • Nerve Function
• Cardiovascular Effects
• Temperature
• Magnetophosphenes
h. Examples
i. Static Field Bio effects Summary

3. Effects of Time-varying Magnetic Field \((dB/dt)\)
a. Gradient Safety Concerns
   • Biological effects: Peripheral Nerve Stimulation
   • Acoustic Noise

4. Effects of Radiofrequency Fields
   a. Magnetic Field Hazards
      • Body Piercing Jewelry
      • Transdermal Patches
      • Tattoos
      • Pregnancy
      • Summary of MRI Hazards

VII. MRI Labeling & Warning Sign
1. Only MRI IV
2. Special MRI Equipment

VIII. RF Safety
1. Specific Absorption Rate (SAR)
2. Radio Frequency Safety Concerns
3. FDA SAR Limits
4. FDA Temperature Limits
5. Avoid Unwanted RF Antennas

IX. Infection Control

X. Bio Effects Of Contrast Media

XI. Emergency – Scan Room
1. Emergency Buttons
   a. Emergency Stop / Shut Off
   b. Quench or Emergency Run Down
2. Employees Safety
3. Remember, the magnet is ALWAYS on!
4. MRI Labeling & Warning Sign
5. Remember this mnemonic

XII. References

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Lecture 9

Title: Image Quality (90 minutes)

Keywords: Image Quality, Intrinsic parameters, Extrinsic parameters, Signal-to-noise ratio, Contrast-to-noise ratio, Artifacts, Hardware, Field Strength (B0), Coil configuration (B1), Positioning, Voxel Size, Slice Thickness, Field of View, Matrix, Sampling, Pulse Sequences, Image contrast, Temporal Resolution, Repetition time, Echo time, Inversion time, Flip angle, Motion Compensation, MR image formation

Objectives:
• List the imaging parameters that determine image contrast
• Describe how imaging parameters determine spatial resolution on magnetic resonance (MR) images
• Name the imaging parameters involved in MR image formation
• Explain parameters and imaging options to obtain diagnostic MR images with minimal image artifacts

Content:
I. Introduction to MR Image Quality
   a. Intrinsic and Extrinsic Parameters
   b. MR Parameters and Options
   c. Which Image Is Better?

II. Definitions
   1. Signal-to-noise ratio
   2. Contrast-to-noise ratio

III. MR Artifacts
   1. Physics Artifacts
   2. Sampling Artifacts
   3. Instrumentation Artifacts
   4. Technical Error Artifacts
   5. Beneficial Artifacts
   6. Nonbeneficial Artifacts
   7. Susceptibility Artifact

IV. Scan Parameters
   1. Hardware
      a. Field Strength (B0)
         • Field Strength and Noise
         • Susceptibility Artifact
      b. Coil configuration (B1)
         • RF Coils
      c. Positioning
   2. Voxel Size
      a. Voxel Characteristics
      b. Pixel Size
      c. Isotropic Voxel
      d. Partial Volume Averaging
      e. Non-Isotropic Voxels
      f. Slice Thickness
g. Field of View
   • Field of View and Aliasing
h. Matrix

3. Sampling
   a. Number of Signals Averaged
   b. Bandwidth
   c. 2-D vs. 3-D

4. Pulse Sequences
   a. Time and Quality
   b. Pulse Sequences and Quality
   c. Temporal Resolution
   d. Repetition Time
   e. Echo Time
   f. Quality and T1
   g. Flip Angle Effects
   h. Flip Angle and Noise
   i. Contrast Enhancement

5. Flow Motion Compensation
   a. Spatial presaturation
   b. Gradient moment nulling
   c. Respiratory Compensation (breath-hold techniques)
      • respiratory triggering and respiratory compensation
      • respiratory-ordered phase encoding

V. Conclusion

VI. Annex
   1. Bibliography
   2. MR Parameters: Actions and Associated Trade-offs
   3. Optimizing Image Quality
   4. MRI Fundamentals Glossary

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Lecture 10

Title: MRI Brain Protocol, Technique Planning (120 minutes)

Keywords: MRI Basic, Image contrast, Proton Density (PD) Images, Proton Density (PD) Fat Saturated Images, Fluid Attenuation Inversion Recovery (FLAIR), Fluid Movement and Image Types, MRI Technique, Resolution, Bandwidth, Number of Excitation (NEX/NSA), Signal to Noise Ratio (SNR), Structures of the Brain, Anatomy of Brain, Axial Cross Section, Coronal Cross Section, Sagittal Cross Section, Orbits and Paranasal Sinuses, Brain Pathology, Brain Imaging Sequence, Parameters and Planning, Magnetic resonance imaging (MRI), Magnetic Resonance Angiography (MRA), Magnetic Resonance Venography (MRV), Pediatric Brain, Orbits, Internal Auditory Meatus (IAMS), Diffuse Weighted Temporal Bone (DWI IAMS)

Objectives:
• Discuss Basic of MRI
• Review Technique of MRI
• Brief review of Resolution, Bandwidth, Number of Excitation (NEX/NSA) and Signal to Noise Ratio (SNR)
• Discuss Structures of the Brain
• Discuss Anatomy of Brain
• Understand the Axial Cross Section, Coronal Cross Section, Sagittal Cross Section, Orbits and Paranasal Sinuses
• Define the MRI Brain Pathology
• Determine Brain Imaging Sequence, Parameters and Planning

Content:
I. MRI Basic
   1. Introduction and Overview
   2. The MR Image
   3. Image contrast
      a. T1 contrast and weighting
      b. Repetition Time (TR) and T1 Weighting
      c. T2 contrast and weighting
      d. Echo Time (TE) and T2 Weighting
   4. Proton Density (PD) Images
      a. Tissue Characteristics and Image Types
      b. MRI image appearance
   5. Proton Density (PD) Fat Saturated Images
      a. MRI image appearance
      b. Pathological appearance
   6. Magnetic Relaxation Times — T1 and T2 Images
   7. Fluid Attenuation Inversion Recovery (FLAIR)
      a. MRI image appearance
      b. Tissues and their FLAIR appearance
      c. Pathological appearance
   8. Fluid Movement and Image Types
      a. Vascular Flow
      b. Percussion and Diffusion

II. MRI Technique
   1. Resolution and Image Quality
      a. Introduction
b. Basic Resolution
c. SNR and Basic Resolution
d. How to Manipulate a Grainy Image

2. Bandwidth and Image Quality
   a. Introduction
   b. Transmitter Bandwidth (tBW)
   c. Low SAR
   d. Normal
   e. Fast
   f. Practical Application of Low Transmitter Bandwidth (Low SAR mod)
   g. Practical Application of High Transmitter Bandwidth (Fast mod)
   h. Receiver Bandwidth (rBW)
   i. Practical Application of High Receiver Bandwidth (rBW)
   j. High Receiver Bandwidth (rBW)
   k. Practical Application of Low Receiver Bandwidth
   l. Receiver Bandwidth Manipulation
   m. Bandwidth and Resolution
   n. Bandwidth and Averages (Number of Excitation NEX/ Number of Signal Average NSA)
   o. Bandwidth and Field of View (FOV)
   p. Bandwidth and Oversampling

3. Number of Excitation (NEX/NSA) and Image Quality
   a. Introduction
   b. Practical Application of Number of Excitation (NEX)
   c. NEX and Slice Thickness
   d. NEX and Field of View (FOV)
   e. NEX and Resolution
   f. NEX and Bandwidth
   g. NEX and Artefact

4. Signal to Noise Ratio (SNR)
   a. Introduction
   b. Factor Affecting Signal to Noise Ratio (SNR)
      • Field Strength and SNR
      • Radiofrequency coil and SNR
      • Tissue Characteristics and SNR
      • TR and SNR
      • TE and SNR
      • Flip angle and SNR
      • Matrix Size and SNR
      • Field of View (FOV) and SNR
      • Receiving Bandwidth and SNR
      • Number of Excitation (NEX) and SNR
      • Phase Overlapping and SNR
      • Partial K Space Filling and SNR
      • Parallel Imaging Technique and SNR

III. Structures of the Brain
1. Superior Sagittal Sinus (the superior longitudinal sinus)
2. Falx Cerebri (the cerebral falx)
3. Frontal Lobe
4. Parietal Lobe
5. Central Sulcus
6. Superior Frontal Sulcus
7. Precentral Gyrus
8. Postcentral Gyrus
9. Cingulate Cortex
10. Middle Frontal Gyrus
11. Superior Frontal Gyrus (SFG)
12. Anterior Cerebral Artery (ACA)
13. Lateral Ventricle
14. Caudate Nucleus
15. Putamen
16. Genu/Splenium of Corpus Callosum
17. Foramen of Monro
18. Internal Capsule
19. Third Ventricle
20. Frontal Sinus
21. Vermis
22. Temporal Lobe
23. Ethmoid Sinus
24. Cerebellum
25. Nasal Septum
26. Sphenoid Sinus

IV. Anatomy of Brain
1. Axial Cross Section
2. Coronal Cross Section
3. Sagittal Cross Section
4. Orbits and Paranasal Sinuses

V. MRI Brain Pathology
1. Cerebrospinal fluid (CSF)
2. Grey and White Matter
3. Glioblastom
4. Acute MCA Infarction
5. Meningioma
6. Brain metastases
7. Pituitary Adenoma
8. Subdural Haemorrhage

VI. Brain Imaging Sequence, Parameters and Planning
1. Magnetic resonance imaging (MRI)
   a. Indication for MRI
   b. Contradiction for MRI Brain
   c. Patient Preparation for MRI Brain
   d. Positioning for MRI Brain
   e. Suggestive Protocols, Parameters and Planning
   f. Brain MRI localizer Image
   g. Brain MRI T2 Axial Image
2. Magnetic Resonance Angiography (MRA) Brain
   a. Introduction
   b. Time of Flight (TOF)
   c. Indication for MRA Brain
   d. Contradictions MRA Brain
   e. Patient Preparation
   f. Positioning
   g. Suggested Protocols, Parameters and Planning
   • Localizer
   • T2 tse Axial
   • 3D time of Flight (TOF)
   h. Maximum Intensity Project (MIP)
   i. Brain MRI localizer image
3. Magnetic Resonance Venography (MRV) Brain
   a. Indication
   b. Time of Flight (TOF)
   c. Phase Contrast (PC)
   d. Indications for MRV Brain
   e. Contraindication for MRV Brain
   f. Patient preparation
   g. Positioning
   h. Suggested Protocols, Parameters and Planning
      • Localizer
      • T2 tse Axial
      • 2D time of Flight (TOF) or 3D Phase Contrast (PC)
   i. Maximum Intensity Projection (MIP)
   j. MRV brain localizer image
   k. MRV brain T2 Axial Image
   l. MRV brain Phase Contrast 3D Image
   m. Post Processes MIP Image from 3D data
   n. TOF Sagittal PC 2D Image

4. Pediatric Brain
   a. Indication for Pediatric Brain MRI
   b. Contraindication for Pediatric Brain MRI
   c. Patient Preparation
   d. Patient Preparation for under 3 and neonates
   e. Positioning
   f. Suggested Sequence, Parameters and Planning
      • Localizer
      • T2+PC Duel Echo Axial Small FOV 3mm
      • T1 TSE Axial Small FOV 3mm
      • T2 FLAIR coronal Small FOV 3mm
      • T1 TSE Sagittal 3mm Small FOV
      • DWI epi Scan Trace Axial Small FOV 4mm
   g. Optional Scan
      • T1 MPRANGE 3D Axial Small FOV 1mm Isotopic
   h. Indication for Contrast Enhancement for Brain Scan
   i. Localized 3 Plan
      • PD+T2 Axial 3mm Small FOV
      • T1 TSE Axial 3mm Small FOV
      • T2 FLAIR Coronal 3mm Small FOV
      • T1 TSE Sagittal 3mm Small FOV
      • EPI DWI Axial 3mm Small FOV
      • Brain Axial T1 MPRANGE Image

5. ORBITS
   a. Indication
   b. Contraindication
   c. Patient Preparation
   d. Positioning
   e. Suggested Sequence, Parameters and Planning
   f. Indication For Contrast Enhancement Brain Scan
   g. Localized 3 Plan
      • T2 Axial Image
      • T2 STIR Coronal
      • T1 STIR Coronal
• T2 Sagittal Oblique RT
• T2 Sagittal Oblique LT
• STIR Axial Image
• Contrast Enhancement

6. Internal Auditory Meatus (IAMS)
   a. Indication
   b. Contraindication
   c. Patient Preparation
   d. Positioning
   e. Suggested Sequence, Parameters and Planning
   f. Localizer image
      • Internal auditory meatus (IAMS) MRI T2 axial whole brain images
      • Internal auditory meatus T2 coronal 2 mm images
      • T2 3D Axial Image
      • T1 TSE Axial 3MM Pre Contrast
      • T1 TSE Coronal 3MM Pre Contrast
      • T1 TSE Coronal 3MM Post Contrast
      • T1 TSE Axial 3MM Post Contrast

7. Diffuse Weighted Temporal Bone (DWI IAMS)
   a. Indication
   b. Contraindication
   c. Patient Preparation
   d. Positioning
   e. Suggested Sequence, Parameters and Planning
      • Localizer
      • T2 TSE Axial
      • T2 TSE Coronal 2mm FOV
      • T2 HASTE DWI Coronal 2 mm Small FOV Bo
      • T2 HASTE DWI Coronal 2 mm Small FOV B1000
   f. Localizer image
      • T2 TSE Axial Image
      • T2 Coronal 2MM
      • HASTE DWI Coronal Bo 2 mm
      • HASTE DWI Coronal B1000 2 mm

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Lecture 11

Title: MRI Planning and Techniques PNS, TMJ & Face (90 minutes)

Keywords: MRI Image Characteristics, Fat suppression, Orbits, Paranasal Sinuses (PNS), Pituitary Fossa (Sella), Brain Epilepsy Protocol, Temporomandibular Joint (TMJ), Trigeminal Nerve, Face

Objectives:
• Discuss MRI Image Characteristics
• Brief review Orbits and Paranasal Sinuses
• Review Paranasal Sinuses (PNS)
• Discuss Pituitary Fossa (Sella)
• Explain Brain Epilepsy Protocol
• Review Temporomandibular Joint
• Discuss Trigeminal Nerve
• Review Face

Content:
I. MRI Image Characteristics
1. T1 SE/ T1 TSE
   a. T1 Image Characteristics
   b. MRI Image Appearance
   c. Tissues and their T1 Appearance
   d. Pathological appearance
   e. Use
2. T1 SE/ T1 TSE/ T1 FSE FAT Saturated
   a. Five techniques for fat suppression in an MRI sequence
   • spectral fat saturation
   • short tau inversion recovery (STIR)
   • spectral presaturation with inversion recovery (SPAIR)
   • dixon method
   • water excitation method
   b. MRI Image Appearance
   c. Tissues and their T1 Appearance
   d. Pathological appearance
   e. Use
   f. T1 fat sat coronal sequence used in pituitary gland imaging
3. T1 SE/ T1 TSE/ T1 FSE Post Contrast
   a. MRI Image Appearance
   b. Tissues and their T1 post gadolinium appearance
   c. Pathological appearance
   d. Use
   e. T1 coronal post contrast sequence used in PNS imaging
4. T1 SE/ T1 TSE/ T1 FSE FAT Saturated Post contrast
   a. MRI Image Appearance
   b. Tissues and their T1 fat saturated post gadolinium appearance
   c. Pathological appearance
   d. Use
   e. T1 fat sat coronal post contrast sequence used in pituitary gland imaging
5. T2 SE/ T2 TSE/ T2 FSE
   a. MRI Image Appearance
   b. Tissues and their T2 appearance
   c. Pathological appearance
6. **Short TAU Inversion Recovery (STIR)**
   a. MRI Image Appearance
   b. Tissues and their STIR appearance
   c. Pathological appearance
   d. Use
   e. STIR axial sequence used in face imaging

7. **Long Tau Inversion Recovery/ FLAIR/ Turbo Dark Fluid**
   a. MRI Image Appearance
   b. Tissues and their FLAIR appearance
   c. Pathological appearance
   d. Use
   e. FLAIR axial sequence used in brain imaging
   f. FLAIR coronal sequence used in brain

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**II. Orbits and Paranasal Sinuses**

**III. Paranasal Sinuses (PNS)**

1. Indication for PNS MRI Scan
2. PNS Anatomy
3. Contraindication
4. Patient Preparation
5. Positioning
6. Suggested Sequence, Parameters and Planning
   a. Localizer
   b. T2 TSE Axial
   c. T2 STIR Coronal 3mm Small FOV
   d. T1 TSE Coronal 3mm Small FOV
   e. T2 STIR Axial 3mm Small FOV
   f. For Contrast Enhancement PNS Scan
7. MRI Localiser Image
   a. MRI PNS Axial T2 Image
   b. T1 STIR Coronal 3mm Small FOV
   c. T2 STIR Axial 3mm Small FOV
   d. T1 FAT Saturated Coronal 3mm Small FOV Post Contrast
   e. T1 FAT Saturated Axial 3mm Small FOV Post Contrast

**IV. Pituitary Fossa (Sella)**

1. Indication For Pituitary Fossa (Sella) MRI Scan
2. Anatomy
3. Contraindication
4. Patient Preparation
5. Positioning
6. Suggested Sequence, Parameters and Planning
   a. Localizer
   b. T2 TSE Axial
   c. T2 TSE Coronal 3mm
   d. T1 TSE FAT Saturated 3mm Coronal
   e. T1 TSE FAT Saturated 3mm Sagittal
7. MRI Localiser Image
   a. MRI Axial T2 Image
   b. T2 TSE Coronal 3mm
   c. T1 TSE FAT Saturated 3mm Coronal
   d. T1 TSE FAT Saturated Sagittal 3mm Post Contrast Gadolinium
   e. T1 TSE FAT Saturated Coronal 3mm Post Contrast Gadolinium
V. **Brain Epilepsy Protocol**  
1. Indication Brain Epilepsy Protocol MRI Scan  
2. Contraindication  
3. Patient Preparation  
4. Positioning  
5. Suggested Sequence, Parameters and Planning  
   a. Localizer  
   b. T2 TSE Axial  
   c. T2 FLAIR Axial  
   d. T2 TSE Coronal 3mm  
   e. T1 TSE Coronal  
   f. T1 TSE Sagittal  
   g. T2 TSE Coronal Oblique 2 mm  
   h. T1 TSE Coronal Oblique 2 mm  
6. MRI Localiser Image  
   a. MRI Axial T2 Image  
   b. T2 FLAIR Axial  
   c. T1 TSE Coronal  
   d. T2 TSE Sagittal  
   e. T2 TSE Coronal Oblique 2 mm  
   f. T1 TSE Coronal Oblique 2 mm  

VI. **Temporomandibular Joint (TMJ)**  
1. Introduction  
2. TMJ Anatomy  
3. Anatomy of Temporomandibular Joint  
4. Indication TMJs MRI  
5. Contraindication  
6. Patient Preparation  
7. Positioning  
8. Suggested Sequence, Parameters and Planning  
   a. Localizer  
   b. T2 TSE Axial  
   c. TMJ Planning Localiser  
   d. PD Coronal SFOV RT TMJ  
   e. PD Coronal SFOV LT TMJ  
   f. STIR Sagittal SFOV RT TMJ Close Mouth  
   g. STIR Sagittal SFOV LT TMJ Close Mouth  
   h. PD Sagittal SFOV RT TMJ Open Mouth  
   i. PD Sagittal SFOV LT TMJ Open Mouth  
9. MRI Localiser Image  
   a. MRI Orbits Axial T1 fat sat images  
   b. MRI TMJ Joint Axial T2 Image  
   c. Localiser 2 Plane  
   d. PD Coronal SFOV RT TMJ  
   e. PD Coronal SFOV LT TMJ  
   f. PD SE Sagittal SFOV RT TMJ Close Mouth  
   g. PD SE Sagittal SFOV LT TMJ Close Mouth  
   h. STIR Sagittal SFOV LT TMJ Close Mouth  
   i. PD SE Sagittal SFOV RT TMJ Open Mouth  
   j. PD SE Sagittal SFOV LT TMJ Open Mouth  

VII. **Trigeminal Nerve**  
1. Trigeminal Nerve Anatomy  
2. Indication Trigeminal Nerve MRI
3. Contraindication
4. Patient Preparation
5. Positioning
6. Suggested Sequence, Parameters and Planning
   a. Localizer
   b. T2 STIR Coronal 3mm Small FOV
   c. T1 TSE Coronal 3mm Small FOV
   d. T2 3D SPACE or CISS Axial 0.9mm
   e. T1 TSE Axial 3 mm
   f. For Contrast Enhancement trigeminal Never
7. MRI Localiser Image
   a. MRI trigeminal nerve localizer image
   b. T2 STIR Coronal 3mm Small FOV
   c. T1 TSE Coronal 3mm Small FOV
   d. T2 3D SPACE Axial 0.9mm
   e. T1 TSE Axial 3mm Small FOV
   f. MRI trigeminal T1 Coronal Post Contrast Images
   g. MRI trigeminal T1 CAxial Post Contrast Images

VIII. Face
1. Indication For Face MRI Scan
2. Contraindication
3. Patient Preparation
4. Positioning
5. Suggested Sequence, Parameters and Planning
   a. Localizer
   b. T2 STIR Coronal 3mm Small FOV
   c. T1 TSE Coronal 3mm Small FOV
   d. T1 TSE Axial 3 mm small FOV
   e. T2 STIR Axial 3mm Small FOV
   f. T2 TSE Sagittal 3mm Small FOV
   g. Optional Scan
   h. T2 SPACE STIR 3D Axial 1mm Small FOV
6. MRI Localiser Image
   a. MRI Face localizer image
   b. T2 STIR Coronal 3mm Small FOV
   c. T1 STIR Axial 3mm Small FOV
   d. T1 TSE Axial 3mm Small FOV
   e. T2 Sagittal 3 mm Small FOV
   f. T1 TSE Sagittal FAT Saturated Post Contrast Images
   g. T1 TSE Coronal FAT Saturated Post Contrast Images

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Lecture 12

Title: MRI NECK Planning and Techniques (90 minutes)


Objectives:
• Discuss neck and nerve supply
• Review the area of the neck, bones of the neck and organs of the neck
• Illustrate MRI Axial Anatomy of Neck
• Illustrate MRI Coronal Arterial Anatomy of Neck
• Illustrate MRI Axial Anatomy of Cervical Spine of Neck
• Discuss Sagittal Anatomy of Cervical Spine of Neck
• Brief review Anatomy of Brachial Plexus
• Discuss MRI Image Characteristics
• Review Soft Tissue Neck
• Explain MRI Cervical Spine
• Review Magnetic Resonance Angiography of Neck
• Discuss Brachial Plexus

Content:
I. Neck
   1. Introduction
   2. Nerve supply

II. Area of the Neck
   1. Anterior Triangle
   2. Subdivisions
      a. Carotid triangle
      b. Submental Triangle
      c. Submandibular Triangle
      d. Muscular Triangle
   3. The Posterior Triangle of the Neck Subdivisions
      a. Borders
      b. Contents
         • Muscles
         • Vasculature
         • Nerves
      c. Subdivisions

III. Bones of the Neck
   1. The Cervical Spine
      a. Characteristic Features
      b. Joints
      c. Ligaments
      d. Anatomical Relationships
   2. The Hyoid bone
      a. Structure
      b. Muscular Attachments
      c. Ligament Attachments
         • Stylohyoid
• Thyrohyoid
• Hyoepiglottic

IV. Organs of the Neck
1. Pharynx
   a. Muscles
      • Circular
      • Longitudinal
   b. Innervation
   c. Blood Supply
   d. Subdivisions of the Pharynx
      • Nasopharynx
      • Oropharynx
      • Laryngopharynx
2. Larynx
   a. Anatomical Position and Relations
   b. Vasculature
3. Laryngeal Cartilages
   a. Unpaired Cartilages
      • Thyroid Cartilage
      • Cricoid Cartilage
      • Epiglottis Cartilage
   b. Paired Cartilages
      • Arytenoid Cartilages
      • Corniculate Cartilages
      • Cuneiform Cartilages
4. Laryngeal Ligaments and Folds
   a. Membranes and Ligaments
   b. Laryngeal Folds
5. Oesophagus
   a. Anatomical Position
   b. Anatomical Structure
6. Thyroid Gland
7. Parathyroid Glands
8. Fascial Layers of the Neck
   a. Superficial Cervical Fascia
   b. Deep Cervical Fascia
      • Investing Layer
      • Investing Layer
      • Pretracheal Layer
      • Prevertebral Layer

V. MRI Axial Anatomy of Neck
VI. MRI Coronal Arterial Anatomy of Neck
VII. MRI Axial Anatomy of Cervical Spine of Neck
VIII. MRI Sagittal Anatomy of Cervical Spine of Neck
IX. Anatomy of Brachial Plexus
   1. MRI Anatomy of Brachial Plexus
X. MRI Image Characteristics
   1. T1 SE/ T1 TSE

2 | Lecture #12
• T1 Image Characteristics
• MRI Image Appearance
• Tissues and their T1 Appearance
• Pathological appearance
• Use
2. 1 SE/ T1 TSE/ T1 FSE FAT Saturated
   a. Five techniques for fat suppression in an MRI sequence
   b. MRI Image Appearance
   c. Tissues and their T1 Appearance
   d. Pathological appearance
   e. Use
3. T1 SE/ T1 TSE/ T1 FSE Post Contrast
   a. MRI Image Appearance
   b. Tissues and their T1 post gadolinium appearance
   c. Pathological appearance
   d. Use
4. T1 SE/ T1 TSE/ T1 FSE FAT Saturated Post contrast
   a. MRI Image Appearance
   b. Tissues and their T1 fat saturated post gadolinium appearance
   c. Pathological appearance
   d. Use
5. T2 SE/ T2 TSE/ T2 FSE
   a. MRI Image Appearance
   b. Tissues and their T2 appearance
   c. Pathological appearance
   d. Use
6. Short TAU Inversion Recovery (STIR)
   a. MRI Image Appearance
   b. Tissues and their STIR appearance
   c. Pathological appearance
   d. Use
   e. STIR Sagittal Sequence used in Cervical Spine Imaging

XI. Soft Tissue Neck
1. Indication
2. Contraindication
3. Patient Preparation
4. Positioning
5. Suggested Sequence, Parameters and Planning
   a. Localiser
   b. T2 STIR Coronal 4mm 280 FOV
   c. T1 TSE Coronal 4mm 280 FOV
   d. T1 TSE Axial 4mm 270 FOV
   e. T2 STIR Axial 4mm 270 FOV
   f. DWI EPI Scan Trace Axial 5mm (with 7 average (NXA))
   g. T2 TSE Sagittal 4 mm 280 – 300 FOV
6. MRI Localiser Image
   a. T2 STIR Coronal 4mm 280 FOV
   b. T1 TSE Coronal 4mm 280 FOV
   c. T1 TSE Axial
   d. T2 STIR Axial
   e. DWI EPI Scan Trace Axial 5mm (Bo))
   f. DWI EPI Scan Trace Axial 5mm (B800))
   g. DWI EPI Scan Trace Axial (ADC MAP))
   h. T2 TSE Sagittal
XII. MRI Cervical Spine
1. Indication
2. Contraindication
3. Patient Preparation
4. Positioning
5. Suggested Sequence, Parameters and Planning
   a. Localiser
   b. T2 TSE Sagittal
   c. T1 TSE Sagittal
   d. T2 TSE STIR Sagittal
   e. T2* (Medic) Axial
   f. T1 TSE Axial
6. Variation in Planning
   a. Planning for a patient with cervical spine crush fracture
   b. Planning for a patient with C3-C7 disc bulge
7. MRI Localiser Image
   a. Localiser 3Plane
   b. T2 TSE Sagittal
   c. T1 TSE Sagittal
   d. T2 TSE STIR Sagittal
   e. T2* (Medic) Axial
   f. T1 TSE Axial
   g. T1 TSE Sagittal FAT Saturated Post Contrast
   h. T1 TSE Axial FAT Saturated Post Contrast

XIII. Magnetic Resonance Angiography (MRA) of Neck
1. Indication
2. Contraindication
3. Patient Preparation
4. Positioning
5. Suggested Sequence, Parameters and Planning
   a. Localiser
   b. Phase Contrast (PC) 2D Sagittal Vessel Localiser
   c. 3D TOF Multi Slab Axial 1mm
   d. T1 TSE FAT Saturated 4mm FOV
6. Localiser Image
   a. Localiser 3Plane
   b. Phase Contrast (PC) 2D Sagittal Vessel Localiser
   c. 3D TOF Multi Slab Axial 1mm
   d. T1 TSE FAT Saturated 4mm FOV

XIV. Brachial Plexus
1. Indication
2. Anatomy
3. Contraindication
4. Patient Preparation
5. Positioning
6. Suggested Sequence, Parameters and Planning
   a. Localiser
   b. T2 STIR Coronal 3mm 320-350 FOV
   c. T1 TSE Coronal 3mm 320-350 FOV
   d. T1 TSE Axial 3mm 320-350 FOV
   e. T2 STIR Axial 3mm 320-350 FOV
   f. T2 TSE Sagittal 3mm 250 FOV Effected Side
   g. Optional Scan
h. T2 STIR Sagittal Oblique 3mm 250 FOV Effected Side

7. Localiser Image
   a. Localiser 3Plane
   b. T2 STIR Coronal 3mm
   c. T1 TSE Coronal 3mm
   d. T2 STIR Axial
   e. T1 TSE Axial
   f. T2 TSE Sagittal
   g. T2 TSE Sagittal Oblique

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Lecture 13

Title: MRI Chest Planning and Techniques (120 minutes)


Objectives:
- Discuss Anatomy of thorax
- Illustrate MRI Axial Anatomy of Chest
- Illustrate MRI Coronal Arterial Anatomy of Chest
- Illustrate MRI Axial Cross Sectional Anatomy of Heart
- Explain MRI Image Characteristics
- Discuss Suggested Sequence, Parameters and Planning
- Review MRA and MRV of Subclavians
- Define Chest
- Discuss Sternum or Sternocostoclavicular Joint
- Review Clavicle
- Discuss Thoracic Spine

Content:
I. Anatomy of Thorax
   1. Mediastinum
      a. Superior
      b. Inferior
   2. Borders
      a. Superior
      b. Inferior
      c. Anterior
      d. Posterior
      e. Lateral
   3. Contents
      a. Great Vessels
   4. Other Structures in the Superior Mediastinum
      a. Thymus
      b. Trachea
      c. Thoracic duct
      d. Muscles
   5. Bones
      a. Ribs
      b. Sternum
         • Manubrium
         • Body
         • Xiphoid Process
      c. The Thoracic Spine
         • Characteristic Features
         • Joints
         • Ligaments
   6. The Muscles of the Thoracic Cage
      a. Intercostals
• External Intercostals
• Internal Intercostals
• Innermost Intercostals
b. Transversus Thoracis
c. Subcostal
d. The Diaphragm
  • Functions
  • Anatomical Position and Attachments

7. The Organs
   a. The Thymus Gland
      • Anatomical Structure and Position

8. The Breasts - Surface Anatomy
   a. Regions
   b. Anatomical Structure
   c. Mammary Glands
   d. Connective Tissue Stroma
   e. Pectoral Fascia
   f. Lymphatics

9. The Lungs
   a. Anatomical Position and Relations
   b. Lung Structure
      • Apex
      • Lobes
      • Surfaces
      • Borders

II. MRI Axial Anatomy of Chest

III. MRI Coronal Arterial Anatomy of Chest

IV. MRI Axial Cross Sectional Anatomy of Heart

V. MRI Image Characteristics
   1. T1 SE/ T1 TSE
      a. T1 Image Characteristics
      b. MRI Image Appearance
      c. Tissues and their T1 Appearance
      d. Pathological appearance
      e. Use
   2. T1 SE/ T1 TSE/ T1 FSE FAT Saturated
      a. Five techniques fat suppression in an MRI sequence
      b. MRI Image Appearance
      c. Tissues and their T1 Appearance
      d. Pathological appearance
      e. Use
   3. T1 SE/ T1 TSE/ T1 FSE Post Contrast
      a. MRI Image Appearance
      b. Tissues and their T1 post gadolinium appearance
      c. Pathological appearance
      d. Use
   4. T1 SE/ T1 TSE/ T1 FSE FAT Saturated Post contrast
      a. MRI Image Appearance
      b. Tissues and their T1 fat saturated post gadolinium appearance
      c. Pathological appearance
      d. Use
5. T2 SE/ T2 TSE/ T2 FSE
   a. MRI Image Appearance
   b. Tissues and their T2 appearance
   c. Pathological appearance
   d. Use
6. Short TAU Inversion Recovery (STIR)
   a. MRI Image Appearance
   b. Tissues and their STIR appearance
   c. Pathological appearance
   d. Use

VI. MRA and MRV of Subclavians
1. Indication for MRA (Magnetic Angiography) and MRV (Venography of Subclavians)
2. Contraindication
3. Patient Preparation
4. Positioning for Arm down MRA and MRV of Subclavians
5. Suggested Sequence, Parameters and Planning
   a. Localiser Arm down MRA and MRV of Subclavians
   b. T1 flash 3D coronal 0.9 mm-1.1 mm pre contrast
   c. Parallel Acquisition Technique (IPAT)
   d. T1 FLASH Dynamic 3D Coronal 0.9 mm – 1.1 mm post contrast 2 measurements
6. Patient Preparation
7. Positioning for Arm UP MRA and MRV of Subclavians
8. Suggested Sequence, Parameters and Planning
   a. Localiser Arm Up MRA and MRV of Subclavians
   b. T1 flash 3D coronal 0.9 mm-1.1 mm pre contrast
   c. Planning Care Bolus
   d. T1 FLASH Dynamic 3D Coronal 0.9mm-1.1mm post Contrast 2 measurements
9. MRI Localiser Image
   a. MRA Arm Down
      • T1 flash 3D coronal 0.9 mm-1.1 mm pre contrast
      • Care Bolus
      • T1 flash 3D coronal 0.9 mm-1.1 mm post contrast
   b. MRA Arm Up
      • T1 flash 3D coronal 0.9 mm-1.1 mm pre contrast
      • Care Bolus
      • T1 flash 3D coronal 0.9 mm-1.1 mm post contrast

VII. Chest
1. Indication for Chest
2. Contraindication
3. Patient Preparation
4. Positioning for Chest
5. Suggested Sequence, Parameters and Planning
   a. Localiser
   b. T1 VIBE 3D FAT Suppressed Breath hold Coronal 4 mm
   c. T2 TSE Breath hold Coronal 6mm
   d. T1 VIBE 3D Axial Breath hold mm
   e. T1 VIBE 3D FAT Suppressed Breath hold Coronal 4mm
   f. Parallel Acquisition Technique
   g. T2 TSE Breath Hold Axial 6mm
   h. T2 TSE FAT SAT or HASTE Breath Hold Axial 6mm
   i. T2 TSE Breath Hold Sagittal 6mm Affected side
6. MRI Image
   a. Localizer 3 Plane
   b. T1 VIBE FAT Breath hold Coronal
c. T2 TSE Breath hold Coronal  
d. T1 VIBE FAT Breath hold Axial  
e. T2 TSE Breath hold Axial  
f. T2 TSE FAT SAT Breath Hold Axial  
g. T2 TSE Breath Hold Sagittal  
h. Contrast Enhancement  
i. T1 VIBE FAT Breath hold Coronal Post Contrast  
j. T1 VIBE FAT Breath hold Axial Post Contrast  

VIII. Sternum or Sternoclavicular Joint  
1. Indication for Sternal  
2. Contraindication  
3. Patient Preparation  
4. Positioning  
5. Suggested Sequence, Parameters and Planning  
   a. Localizer 1  
   b. Localizer 2  
   c. T2 TSE Sagittal 3mm SFOV  
   d. T1 TSE Coronal 3mm SFOV  
   e. T2 STIR Coronal 3mm SFOV  
   f. T1 TSE Axial 3mm SFOV  
   g. T2 STIR Axial 3mm SFOV  
6. MRI Image  
   a. Localizer 3 Plane  
   b. Localizer 2 Plane  
   c. T2 TSE Sagittal  
   d. T2 TSE Coronal  
   e. T2 STIR Coronal  
   f. T1 TSE Axial  
   g. T2 STIR Axial  
   h. T1 TSE Coronal Post Contrast  
   i. T1 TSE Axial Post Contrast  

IX. Clavicle  
1. Indication for Clavicle  
2. Contraindication  
3. Patient Preparation  
4. Positioning for Clavicle  
5. Suggested Sequence, Parameters and Planning  
   a. Localizer 1  
   b. Localizer 2  
   c. T2 STIR Axial 3mm SFOV  
   d. T1 TSE Axial 3mm SFOV  
   e. T1 TSE Coronal 3mm SFOV  
   f. T2 STIR Coronal 3mm SFOV  
   g. T2 STIR Sagittal 3mm SFOV  

X. Thoracic Spine  
1. Indication for T Spine  
2. Contraindication  
3. Patient Preparation  
4. Positioning for T Spine  
5. Suggested Sequence, Parameters and Planning  
   a. Localizer  
   b. T2 TSE Sagittal  
   c. T1 TSE Sagittal  

4. Lecture #13
d. T2 TSE STIR Sagittal  
e. T2 TSE Axial Block 4mm  
f. T1 TSE Axial Block 4mm

6. T Spine Variation in Planning  
   a. Cases Study  
      • T2 and T1 Axial Planning (Planning for a Patient with T3-T4 Disc Bulge)  
      • T2 and T1 Axial Planning (Planning for a Patient with T11 Fracture)

7. Indication for Contrast Enhancement Spine Scan

8. Suggested Sequence, Parameters and Planning  
   a. Thoracic Spine MRI Localizer 3 Plane  
   b. T2 TSE Sagittal  
   c. T1 TSE Sagittal  
   d. T2 TSE STIR Sagittal  
   e. T2 TSE Axial Block 4mm  
   f. T1 TSE Axial Block 4mm  
   g. T1 TSE Sagittal FAT SAT Post Contrast  
   h. T1 TSE Axial FAT SAT Post Contrast

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Lecture 14

Title: Heart Protocol, Planning and Technique (120 minutes)

Keywords: Anatomy of Heart, Thoracic Cavity, Electrical Conduction System of the Heart, Pericardium, Cardiovascular System, Structure and Function, Location and Seize, Heart Wall, Chambers, Cardiovascular System Circulation, MRI Axial Cross Sectional Anatomy of Heart, MRI Image Characteristics, MRI Cardiac, Indication, Cardiac MRI Technique, Contraindication, Patient Preparation, Positioning, Suggested Sequence, Parameters and Planning

Objectives:
- Discuss Anatomy of Heart
- Review The Cardiovascular System
- Illustrate MRI Axial Cross Sectional Anatomy of Heart
- Define MRI Image Characteristics
- Discuss MRI Cardiac
- Explain Cardiac MRI Technique
- Illustrate Suggested Sequence, Parameters and Planning

Content:

I. Anatomy of Heart
   1. Thoracic Cavity
      a. Structures
      b. Arteries and Veins
      c. Coronary Arteries
   2. Electrical Conduction System of the Heart
      a. Node and atria
      b. AV node and ventricles
      c. Sympathetic and parasympathetic nervous systems
   3. The Pericardium
      a. Functions
         - Fixes the heart
         - Prevents overfilling of the heart
         - Lubrication
         - Protection from infection
      b. Anatomical Structure
         - Fibrous pericardium
         - Serous pericardium

II. The Cardiovascular System
   1. Structure and Function
   2. Location and Seize
   3. Structure: Cardiac Anatomy
   4. Heart Wall
   5. Chambers
   6. The Cardiovascular System Circulation
      a. Heart valves
      b. Atrioventricular valves
      c. Semilunar valves

III. MRI Axial Cross Sectional Anatomy of Heart

IV. MRI Image Characteristics
1. T1 SE/ T1 TSE
   a. T1 Image Characteristics
   b. MRI Image Appearance
   c. Tissues and their T1 Appearance
   d. Pathological appearance
   e. Use

2. T1 SE/ T1 TSE/ T1 FSE FAT Saturated
   a. Fat suppression in an MRI sequence
   b. MRI Image Appearance
   c. Tissues and their T1 Appearance
   d. Pathological appearance
   e. Use

3. T1 SE/ T1 TSE/ T1 FSE Post Contrast
   a. MRI Image Appearance
   b. Tissues and their T1 post gadolinium appearance
   c. Pathological appearance
   d. Use

4. T1 SE/ T1 TSE/ T1 FSE FAT Saturated Post contrast
   a. MRI Image Appearance
   b. Tissues and their T1 fat saturated post gadolinium appearance
   c. Pathological appearance
   d. Use

5. T2 SE/ T2 TSE/ T2 FSE
   a. MRI Image Appearance
   b. Tissues and their T2 appearance
   c. Pathological appearance
   d. Use

6. Short TAU Inversion Recovery (STIR)
   a. MRI Image Appearance
   b. Tissues and their STIR appearance
   c. Pathological appearance
   d. Use

V. MRI Cardiac
1. Indication for Cardiac MRI
2. Cardiac MRI Technique
   a. Breath Holding Technique
   b. Navigator Technique
   c. ECG Gating
   d. Prospective Triggering
   e. Retrospective Triggering
   f. Triggering Parameters
      • RR Interval
      • Cardiac Frequency
      • Trigger Delay
      • RR Window
      • Arrhythmia Rejection
   g. Positioning the Electrodes in a Philips and GE Scanner
   h. Positioning the Electrodes in a Siemens Scanner
   i. Warning

3. Contraindication
4. Patient Preparation
5. Positioning
6. Suggested Sequence, Parameters and Planning
   a. Localiser Cardiac MRI
   b. Cardiac Planning Localiser
c. Dark Blood Axial
d. What are Dark Blood Sequences
e. Recommended Protocol
f. Two Chamber Localiser
g. Short axis Localiser
h. Four Chamber View localiser
i. Left Two Chamber Cine
j. What are Cine Sequences?
k. Four Chamber Cine
l. Short Axis Cine
m. Three Chamber (Left Ventricular Outflow Tract LVOT) Cine

7. Arrhythmia And Cardiac Image

8. Arrhythmia Correction in Cardiac Image

9. MRI Images
a. 3 plane Localiser
b. 3 plane Localiser Trigger
c. Axial Dark Blood
d. 2 Chamber Localiser
e. Short Axis Localiser
f. 4 Chamber Localiser
g. Left Ventricular Function
   • 2 Chamber Cine
   • Short Axis Cine
   • 3 Chamber Cine
h. Right Ventricular Function
   • 2 Chamber Cine
   • Short Axis Cine
   • Axis Cine
i. Pulmonary Valve
   • Coronal Cine
   • Axis Cine
j. Tricuspid Valve 2D Cine
k. Aortic Valve Coronal Cine
l. Aortic Valve 2D Axial Cine
m. Flow Quantification

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Lecture 15

Title: MRI Breast, Shoulder Planning & Techniques (90 minutes)

Keywords: Anatomy of Breast, Breast Implants, Anatomy of Shoulder, MRI and MRA of Shoulder, Breast MRI, MRI Axial Cross Sectional Anatomy of Shoulder, Coronal Cross Sectional Anatomy of Shoulder, MRI Image Characteristics, MRI Breast Implants, MRI Shoulder, Scapula, Arthrogram Shoulder, Indication, Contraindication, Patient Preparation, Positioning, Suggested Sequence, Parameters and Planning

Objectives:
• Discuss Anatomy of Breast
• Review Breast Implants
• Discuss Anatomy of Shoulder
• Review MRI and MRA of Shoulder
• Illustrate Breast MRI
• Illustrate MRI Axial Cross Sectional Anatomy of Shoulder
• Illustrate Coronal Cross Sectional Anatomy of Shoulder
• Explain MRI Image Characteristics
• Discuss Suggested Sequence, Parameters and Planning
• Review MRI Breast
• Review MRI Breast Implants
• Review MRI Shoulder
• Review Scapula
• Review Arthrogram Shoulder

Content:
I. Anatomy of Breast
   1. Tissues
      a. Adipose tissue
      b. Glandular tissue
   2. Cross-section scheme of the mammary gland

II. Breast Implants

III. Anatomy of Shoulder
   1. Bones
      a. The clavicle (collarbone)
      b. The scapula (shoulder blade)
      c. The humerus (upper arm bone)

IV. Breast MRI

V. MRI Axial Cross Sectional Anatomy of Shoulder

VI. Coronal Cross Sectional Anatomy of Shoulder

VII. MRI Image Characteristics
   1. T1 SE / T1 TSE
      a. T1 Image Characteristics
      b. MRI Image Appearance
      c. Tissues and their T1 Appearance
      d. Pathological appearance
2. T1 SE/ T1 TSE/ T1 FSE FAT Saturated
   a. Fat suppression in an MRI sequence
   b. MRI Image Appearance
   c. Tissues and their T1 Appearance
   d. Pathological appearance
   e. Use
3. T1 SE/ T1 TSE/ T1 FSE Post Contrast
   a. MRI Image Appearance
   b. Tissues and their T1 post gadolinium appearance
   c. Pathological appearance
   d. Use
4. T1 SE/ T1 TSE/ T1 FSE FAT Saturated Post contrast
   a. MRI Image Appearance
   b. Tissues and their T1 fat saturated post gadolinium appearance
   c. Pathological appearance
   d. Use
5. T2 SE/ T2 TSE/ T2 FSE
   a. MRI Image Appearance
   b. Tissues and their T2 appearance
   c. Pathological appearance
   d. Use
6. Short TAU Inversion Recovery (STIR)
   a. MRI Image Appearance
   b. Tissues and their STIR appearance
   c. Pathological appearance
   d. Use

VIII. MRI Breast
1. Indication for MRI Breast
2. Contraindication
3. Patient Preparation
4. Positioning
5. Suggested Sequence, Parameters and Planning
   a. Localiser
   b. T2 STIR Axial
   c. T1 FLASH 3D Axial Non FAT SAT 1mm
   d. T2 TSE Sagittal RT
   e. T2 TSE Sagittal LT
   f. T1 FLASH Axial 3D FAT SAT Dynamic 1 Pre and 5 Post
   g. T1 FLASH Coronal 3D FAT SAT Post Contrast 1mm
   h. DWI epi 3 scan Trace Axial
   i. Localizer 3 Planes
      • T2 STIR Axial
      • T1 FLASH 3D Axial Non FAT SAT 1mm
      • T2 TSE Sagittal RT
      • T2 TSE Sagittal LT
      • T1 FLASH Axial 3D FAT SAT Dynamic 1 Pre and 5 Post
      • T1 FLASH Coronal 3D FAT SAT Post Contrast 1mm
      • DWI epi 3 scan Trace Axial

IX. MRI Breast Implants
1. Indication for MRI Breast Implants
2. Contraindication
3. Patient Preparation
4. Positioning
5. Suggested Sequence, Parameters and Planning
   a. Localiser
   b. T2 STIR Axial
   c. T1 FLASH 3D Axial Non FAT SAT 1mm
   d. T2 STIR T1 130 Coronal
   e. T2 STIR T1 400 Coronal
   f. T1 FLASH Axial 3D FAT SAT Dynamic 1 Pre and 5 Post
   g. T1 FLASH 3D FAT SAT Post Contrast 1 mm
   h. DWI epi 3 scan Trace Axial
   i. Localizer 3 Planes
      • T2 STIR Axial
      • T1 FLASH 3D Axial Non FAT SAT 1mm
      • T2 STIR T1 130 Coronal
      • T2 STIR T1 400 Coronal
      • T1 FLASH Axial 3D FAT SAT Dynamic 1 Pre and 5 Post
      • T1 FLASH 3D FAT SAT Post Contrast 1 mm
      • DWI epi 3 scan Trace Axial

X. MRI Shoulder
   1. Indication for MRI Shoulder
   2. Contraindication
   3. Patient Preparation
   4. Patient Position
   5. Suggested Sequence, Parameters and Planning
      a. Localiser
      b. T2* medic or PD FAT SAT 3mm Small FOV
      c. T1 TSE 3mm Coronal Small FOV
      d. T2* medic or PD FAT SAT Coronal 3mm Small FOV
      e. T2 STIR Coronal 3mm Small FOV
      f. T2 TSE FAT SAT Sagittal 3mm Small FOV
      g. Localizer 3 Planes
         • T2* medic or PD FAT SAT 3mm Axial Small FOV
         • T1 TSE 3mm Coronal Small FOV
         • T2* medic or PD FAT SAT Coronal 3mm Small FOV
         • T2 STIR Coronal 3mm Small FOV
         • T2 TSE FAT SAT Sagittal 3mm Small FOV

XI. Scapula
   1. Indication for Scapula
   2. Contraindication
   3. Patient Preparation
   4. Patient Position
   5. Suggested Sequence, Parameters and Planning
      a. Localiser 1
      b. Localizer 2
      c. T2 STIR Axial
      d. T1 STIR Axial
      e. T1 TSE Coronal
      f. T2 STIR Coronal
      g. T2 TSE Sagittal

XII. Arthrogram Shoulder
   1. Indication for Arthrogram Shoulder
   2. Contraindication
   3. Patient Preparation
   4. Arthrography
5. Patient Position
6. Suggested Sequence, Parameters and Planning
   a. Localiser 1
   b. T1 Vibe 3D FAT SAT Axial 1 mm Small FOV
   c. T1 TSE FAT SAT Coronal 3 mm Small FOV
   d. T2 STIR Coronal 3 mm Small FOV
   e. T1 TSE FAT SAT Sagittal 3 mm Small FOV
   f. T1 Vibe 3D FAT SAT Axial 1 mm Small FOV
   g. T1 TSE FAT SAT Coronal 3 mm Small FOV
   h. T2 STIR Coronal 3 mm Small FOV
   i. T1 TSE FAT SAT Sagittal 3 mm Small FOV

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Lecture 16

Title: MRI Abdomen Planning and Techniques (120 minutes)

Keywords: Anatomy of Abdomen, Area of Abdomen, Bones of Abdomen, Muscles of the Abdomen, Gastrointestinal Tract of the Abdomen, Accessory Organs of the Abdomen, MRI Axial Cross Sectional Anatomy, MRI Coronal Cross Sectional Anatomy, MRI Arterial Anatomy, MRI Image Characteristics, MRI Kidneys, Magnetic Resonance Angiography (MRA) Renals, MRI Adrenal Glands, MRI Liver, Magnetic Resonance Cholangiopancreatography (MRCP), MRI Pancreas, Small Bowel MRI (ENTEROGRAPHY), MRA and MRV of Abdomen

Objectives:
- Discuss Anatomy of Abdomen
- Illustrate MRI Axial Cross Sectional Anatomy of Abdomen
- Illustrate MRI Coronal Cross Sectional Anatomy of Abdomen
- Illustrate MRI Arterial Anatomy of Abdomen
- Explain MRI Image Characteristics
- Discuss MRI Kidneys
- Review MRA Renals
- Discuss MRI Adrenal Glands
- Review MRI Liver
- Discuss Magnetic Resonance Cholangiopancreatography (MRCP)
- Review MRI Pancreas
- Discuss Small Bowel MRI (ENTEROGRAPHY)
- Review MRA and MRV of Abdomen

Content:
I. Anatomy of Abdomen
   1. Area of Abdomen
      a. Peritoneal Cavity
         • Subdivisions of the Peritoneal Cavity
         • Structure of the Peritoneal Cavity in the Pelvis
      b. Peritoneum
         • Structure of the Peritoneum
         • Intraperitoneal & Retroperitoneal Organs
         • Peritoneal Reflections
   2. Bones of Abdomen
      a. The Lumber Spine
         • Characteristic Features
         • Joints
         • Ligaments
   3. Muscles of the Abdomen
      a. Anterolateral Abdominal Wall
         • Superficial Fascia
         • Muscles of the Abdominal Wall
   4. Gastrointestinal Tract of the Abdomen
      a. Oesophagus
         • Anatomical Position
      b. Stomach
         • Anatomical Position
         • Anatomical Structure
         • Anatomical Relations
      c. Small Intestine
d. Cecum and Appendix  
   - Anatomical Structure and Relations

e. Colon (large intestine)  
   - Anatomical Position  
   - Anatomical Structure

f. Rectum  
   - Anatomical Structure

g. Anal Canal  
   - Anatomical Position  
   - Anatomical Structure

5. Accessory Organs of the Abdomen
   a. Liver: Anatomical Position  
      - Definition of Liver  
      - Liver Surfaces  
      - Ligaments of the Liver  
      - Hepatic Recesses
   b. Gallbladder: Anatomical Structure  
      - Definition of Gallbladder  
      - The Biliary Tree
   c. Pancreas: Anatomical Position  
      - Definition of Pancreas  
      - Head  
      - Uncinate process  
      - Neck  
      - Body  
      - Tail
   d. Spleen  
      - Definition of Spleen  
      - Anatomical Position  
      - Anatomical Structure  
      - Anatomical Relations
   e. The Adrenal Glands  
      - Definition of Adrenal Glands  
      - Anatomical Position  
      - Anatomical Structure
   f. Kidneys  
      - Definition of Kidneys  
      - Anatomical Position  
      - Anatomical Structure

II. MRI Axial Cross Sectional Anatomy of Abdomen

III. MRI Coronal Cross Sectional Anatomy of Abdomen

IV. MRI Arterial Anatomy of Abdomen

V. MRI Image Characteristics
   1. T1 SE/ T1 TSE  
      a. T1 Image Characteristics  
      b. MRI Image Appearance  
      c. Tissues and their T1 Appearance  
      d. Pathological appearance  
      e. Use
   2. T1 SE/ T1 TSE/ T1 FSE FAT Saturated
a. Fat suppression in an MRI sequence
b. MRI Image Appearance
c. Tissues and their T1 Appearance
d. Pathological appearance
e. Use

3. T1 SE/ T1 TSE/ T1 FSE Post Contrast
   a. MRI Image Appearance
   b. Tissues and their T1 post gadolinium appearance
   c. Pathological appearance
d. Use

4. T1 SE/ T1 TSE/ T1 FSE FAT Saturated Post contrast
   a. MRI Image Appearance
   b. Tissues and their T1 fat saturated post gadolinium appearance
c. Pathological appearance
d. Use

5. T2 SE/ T2 TSE/ T2 FSE
   a. MRI Image Appearance
   b. Tissues and their T2 appearance
   c. Pathological appearance
d. Use

6. Short TAU Inversion Recovery (STIR)
   a. MRI Image Appearance
   b. Tissues and their STIR appearance
c. Pathological appearance
d. Use

VI. MRI Kidneys
1. Indication for MRI kidney
2. Contraindication
3. Patient Preparation
4. Positioning
5. Suggested Sequence, Parameters and Planning
   a. Localiser
   b. T2 TSE Breath Hold (TRUFI of HASTE) Coronal 4mm
   c. T1 vibe FAT Breath Hold Coronal 4mm
   d. T1 In opposed phase Breath Hold Axial 4mm
e. T2 TSE Breath Hold 4mm Axial
   f. T2 TSE Breath Hold FAT SAT 4mm Axial
g. T1 VIBE Breath Hold FAT SAT 4mm Axial
h. Pouse for Contrast Injection
   i. 3 Plane Localiser
      • T2 TSE Breath Hold (TRUFI of HASTE) Coronal 4mm
      • T1 vibe FAT Breath Hold Coronal 4mm
      • T1 VIBE In opposed phase Breath Hold Axial 4mm
      • T2 TSE Breath Hold 4mm Axial
      • T2 TSE Breath Hold FAT SAT 4mm Axial
      • T1 vibe FAT Breath Hold Axial 4mm Post Contrast
      • T1 vibe FAT Breath Hold Coronal 4mm Post Contrast

VII. Magnetic Resonance Angiography (MRA) Renals
1. Indication for MRA Renals
2. Contraindication
3. Patient Preparation
4. Positioning
5. Suggested Sequence, Parameters and Planning
   a. Localiser
b. T1 FLASH 3D Coronal FAT Saturated 0.8 mm-0.9 mm Pre Contrast

c. Parallel Acquisition Technique (IPAT)

d. Contrast Administration and Timing of Scans
   • Guess Timing Technique
   • Care Bolus Technique
   • Planning Care Bolus Technique

e. T1 Flash 3D Coronal FAT Saturated 0.8 mm – 0.9mm Post contrast

f. Localizer 3 Plane
   • T1 Flash 3D Coronal FAT Saturated 0.8 mm – 0.9mm Pre contrast
   • Care Bolus Technique
   • T1 Flash 3D Coronal FAT Saturated 0.8 mm – 0.9mm Post contrast

VIII. MRI Adrenal Glands
1. Indication for MRI Adrenal Glands
2. Anatomy Adrenal Glands
3. Contraindication
4. Patient Preparation
5. Positioning
6. Suggested Sequence, Parameters and Planning
   a. Localiser
   b. T2 TSE Breath Hold (TRUEFISP of HASTE) Coronal 4mm
   c. T1 Vibe Breath Hold Coronal 4mm
   d. T1 In Opposed Phase Breath Hold Axial 4mm
   e. T2 TSE Breath Hold Axial 4mm
   f. T2 TSE Breath Hold FAT SAT Axial 4mm
   g. T1 Vibe 3D Breath Hold Axial 3mm
   h. Localizer 3 Plane
      • T2 TSE Breath Hold (TRUEFISP of HASTE) Coronal 4mm
      • T1 Vibe In Opp Axial
      • T2 TSE Breath Hold Axial 4mm
      • T2 TSE Breath Hold FAT SAT Axial 4mm
      • T1 Vibe 3D Breath Hold Axial 3mm
      • T1 Vibe 3D Breath Hold Coronal 3mm

IX. MRI Liver
1. Indication
2. Contrast Agent for Liver Imaging
   a. Extracellular Contrast Agent
   b. Hepatocyte –Specific Contrast Agent
3. Indication For Liver MRI
4. Contraindication
5. Patient Preparation
6. Positioning
7. Suggested Sequence, Parameters and Planning
   a. Localiser
   b. T2 TSE BLADER (PROPELLER) Axial Gated
      • Navigator
      • BLADE (PROPELLER)
   c. T2 TSE FAT SUPPRESSED BLADE or T2 STIR Axial Gated
   d. T1 VIBE 3D FAT Suppressed Breath Hold Coronal
   e. T1 In Opposed Phase Breath Hold Axial
   f. T2 TSE Breath Hold With TE 90 and TE 180
   g. T1 FLASH 3D FAT SAT Axial Breath Hold Per Contrast
      • Parallel Acquisition Technique
      • Parameters
Contrast Administration and Timing of Scan

- Guess Timing Technique
- Care Bolus Technique
- Planning Care Bolus

i. T1 FLASH 3D FAT SAT Axial Breath Hold Post Contrast
j. T1 FLASH 3D FAT SAT Axial Delayed 20 minutes

k. Localizer 3 Plane

- T2 TSE BLADER (PROPELLER) Axial Gated
- T2 TSE FAT SUPPRESSED BLADE or T2 STIR Axial Gated
- T1 VIBE 3D FAT Suppressed Breath Hold Coronal
- T1 In Opposed Phase Breath Hold Axial
- T2 TSE Breath Hold With TE 90
- T2 TSE Breath Hold With TE 180
- T1 FLASH 3D FAT SAT Axial Breath Hold Per Contrast
- T1 FLASH 3D FAT SAT Axial Delayed 20 minutes

X. Magnetic Resonance Cholangiopancreatography (MRCP)

1. Indication for MRCP
2. Contraindication
3. Patient Preparation
4. Positioning
5. Suggested Sequence, Parameters and Planning
   a. Localiser
   b. T2 TRUEFISP FAT SAT (HASTE) Breath Hold Coronal
   c. T2 TRUFI 4mm Breath Hold Axial
   d. T2 HASTE FAT SAT 4mm Breath Hold Axial
   e. T2 HASTE Thick 40 mm Breath Hold Coronal Oblique (Single Slice)
   f. T2 TSE 3D (or SPACE 3D) Coronal Gated
   g. Localizer 3 Plane
      - T2 TRUEFISP FAT SAT (HASTE) Breath Hold Coronal 4mm
      - T2 HASTE FAT SAT 4mm Breath Hold Axial
      - T2 HASTE Thick 40 mm Breath Hold Coronal Oblique (Single Slice)
      - T2 TSE 3D (or SPACE 3D) Coronal Gated

XI. MRI Pancreas

1. Indication for Pancreas
2. Anatomy Pancreas
3. Contraindication
4. Patient Preparation
5. Positioning
6. Suggested Sequence, Parameters and Planning
   a. Localiser
   b. T2 TRUEFISP Coronal Big FOV
   c. Small FOV T1 IN Opposed Phase Breath Hold Axial
   d. Small FOV T2 TSE Breath Hold
   e. Small FOV T2 TSE Breath Hold FAT SAT
   f. T2 TSE Coronal 3D FAT SAT 1 mm Gated
   g. T1 Vibe FAT SAT 3D Axial Breath Hold Pre Contrast
   h. Contrast Administration and Timing of Scans
      - Guess Timing Technique
      - Care Bolus Technique
      - Planning Care Bolus
   i. T1 VIBE 3D FAT SAT AXIAL Breath Hold Dynamic Post Contrast
   j. T1 VIBE 3D FAT SAT AXIAL Delayed 5 minutes
   k. Localizer 3 Plane
• T2 TRUEFISP Coronal Big FOV
• Small FOV T1 IN Opposed Phase Breath Hold Axial
• Small FOV T2 TSE Breath Hold FAT SAT
• T2 TSE Coronal 3D FAT SAT 1 mm Gated
• T1 Vibe FAT SAT 3D Axial Breath Hold Pre Contrast
• T1 VIBE 3D FAT SAT AXIAL Breath Hold Dynamic Post Contrast
• T1 VIBE 3D FAT SAT AXIAL Delayed 5 minutes

XII. Small Bowel MRI (ENTEROGRAPHY)
1. Indication for Small Bowel MRI
2. Contraindication
3. Patient Preparation
4. Oral Contrast
5. Positioning
6. Suggested Sequence, Parameters and Planning
   a. Localiser
   b. T2 TRUEFISP Coronal
   c. T2 TRUEFISP Axial
   d. T1 FLASH FAT SAT 3D 0.9-1 mm Coronal Pre-Contrast
   e. T2 HASTE 4mm Coronal
   f. T2 HASTE 4mm Axial
   g. T1 FLASH FAT SAT 3D 0.9-1mm Coronal Post Contrast
   h. T1 FLASH FAT SAT 3D 1-1.5mm Axial Post Contrast
   i. Localizer 3 Planes
      • T2 TRUEFISP Coronal
      • T2 TRUEFISP Axial
      • T1 FLASH FAT SAT 3D 0.9-1 mm Coronal Pre-Contrast
      • T2 HASTE 4mm Coronal
      • T2 HASTE 4mm Axial
      • T1 FLASH FAT SAT 3D 0.9-1mm Coronal Post Contrast
      • T1 FLASH FAT SAT 3D 1-1.5mm Axial Post Contrast

XIII. MRA and MRV of Abdomen
1. Indication
   a. MRA of Abdomen
   b. MRV of Abdomen
2. Patient Preparation
3. Positioning
4. Suggested Sequence, Parameters and Planning
   a. Localiser
   b. T1 VIBE 3D FAT SAT Axial Pre-Contrast 4mm
   c. T1 FLASH 3D Coronal 0.9-1.1mm Pre-Contrast
   d. Parallel Acquisition Techniques (IPAT)
   e. Contrast Administration and Timing of Scans
      • Guess Timing Technique
      • Care Bolus Technique
      • Planning Care Bolus
   f. T1 FLASH Dynamic 3D Coronal 0.9mm – 1.1mm Post Contrast 3 measurements
   g. T1 VIBE 3D FAT SAT Axial Post Contrast 4mm
   h. Localizer 3 Planes
      • T1 VIBE 3D FAT SAT Axial Pre-Contrast 4mm
      • T1 FLASH 3D Coronal 0.9-1.1mm Pre-Contrast
      • Care Bolus
      • T1 FLASH Dynamic 3D Coronal 0.9mm – 1.1mm Post Contrast 3 measurements
      • T1 VIBE 3D FAT SAT Axial Post Contrast 4mm
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Lecture 17

Title: MRI Pulse Sequence & Lumbar Spine Planning & Techniques (120 minutes)


Objectives:
• Discuss MRI Image Characteristics
• Review Anatomy of the Human Spine
• Illustrate MRI Cross Sectional Anatomy of Spine
• Illustrate Suggested Sequence, Parameters and Planning
• Discuss MRI Thoracic Spine
• Explain MRI Lumbar Spine
• Review Psoas MRI
• Discuss MRI Sacroiliac Joints
• Explain MRI Lumbosacral Plexus
• Understand Case Study

Content:
I. MRI Image Characteristics
   1. MRI Pulse Sequence
      a. Characteristics of MRI Pulse Sequence
      b. Sequences Acronyms
         • Table of the equivalent manufacturers’ acronyms with the corresponding type of sequence
      c. TR and TE
         • Repetition time
         • Echo time
   2. Spin Echo Variations
      a. Single Echo Spin Echo
      b. Multi-echo Spin Echo
      c. Fast (Turbo) Spin Echo (FSE)
      d. Image Contrast
         • Comparison of T1 vs. T2 – Spine
         • Parameter "weighting"
         • Short TE
         • T2W
         • Fluid Sensitive sequences
         • Sagittal plane
         • Transverse plane
      e. Duration of a spin echo sequence
      f. Contrast
      g. Proton Density
   3. Pulse Sequences
      a. Inversion Recovery (IR)
         • Introduction
         • Pros and Cons of IR
         • Phase-Sensitive IR
• Selecting IR Parameters  
b. Short TI Inversion Recovery (STIR)  
c. T1-weighted-Fluid-Attenuated Inversion Recovery (T1-FLAIR)  
d. T2-weighted-Fluid-Attenuated Inversion Recovery (T2-FLAIR)  
e. Double Inversion Recovery (DIR)  
f. Diffusion  
  • Apparent Diffusion (ADC)  
g. Dynamic Imaging  

4. T1 SE/ T1 TSE  
a. T1 Image Characteristics  
b. MRI Image Appearance  
c. Tissues and their T1 Appearance  
d. Pathological appearance  
e. USE  

5. T1 SE/ T1 TSE/ T1 FSE FAT Saturated  
a. Fat suppression in an MRI sequence  
b. MRI Image Appearance  
c. Tissues and their T1 Appearance  
d. Pathological appearance  
e. USE  

6. T1 SE/ T1 TSE/ T1 FSE Post Contrast  
a. MRI Image Appearance  
b. Tissues and their T1 post gadolinium appearance  
c. Pathological appearance  
d. USE  

7. T1 SE/ T1 TSE/ T1 FSE FAT Saturated Post contrast  
a. MRI Image Appearance  
b. Tissues and their T1 fat saturated post gadolinium appearance  
c. Pathological appearance  
d. USE  

8. T2 SE/ T2 TSE/ T2 FSE  
a. MRI Image Appearance  
b. Tissues and their T2 appearance  
c. Pathological appearance  
d. USE  

9. SHORT TAU INVERSION RECOVERY (STIR)  
a. MRI Image Appearance  
b. Tissues and their STIR appearance  
c. Pathological appearance  
d. USE  

10. VIBE FAT SAT  
a. MRI Image Appearance  
b. Tissues and their T1 VIBE fat saturated appearance  
c. Pathological appearance  
d. USE  

II. Anatomy of the Human Spine  
1. Spinal curves  
2. Muscles  
3. Vertebrae  
4. Cervical (neck)  
5. Thoracic (mid back)  
6. Lumbar (low back)  
7. Sacrum  
8. Coccyx region  
9. Intervertebral discs  

2 Lecture #17
10. Vertebral arch & spinal canal
11. Facet joints
12. Ligaments
13. Spinal cord
14. Spinal nerves
15. Coverings & spaces

III. MRI Cross Sectional Anatomy of Spine

IV. MRI Thoracic Spine
1. Indication for MRI Thoracic Spine
2. Contraindication
3. Patient Preparation
4. Positioning
5. Suggested Sequence, Parameters and Planning
   a. Localiser
   b. T2 TSE Sagittal
   c. T2 TSE STIR Sagittal
   d. T2 TSE Axial Block 4mm
   e. T1 TSE Axial Block 4mm
   f. T2 and T1 Axial Planning
6. Variation in Planning: T2 and T1 Axial Planning
   a. Planning for a Patient with T3-T4 Disc Bulge
   b. Planning for a Patient with T11 Fracture
7. Indication For Contrast Enhancement Spine Scans
8. Localizer 3 plane
   a. T2 TSE Sagittal
   b. T1 TSE Sagittal
   c. T2 TSE STIR Sagittal
   d. T2 TSE Axial Block 4mm
   e. T1 TSE Axial Block 4mm
   f. T2 and T1 Axial Planning
9. Variation in Planning: T2 TSE Axial and T1 TSE Axial Planning
   a. TB and Spinal Cord Compression at T10 and T12
   b. Huge Disc Bulge at L4-L5, L3-L4 and Tiny Disc Bulge at L2-L3 and L5-S1
   c. L2, L3, L4, L5 Disc Bulge aand T11 Fracture
   d. Huge Disc Bulge at L4-L5 and tiny Disc Bulge at L3-L4 and L5-Si
   e. Huge Disc Bulge at L4-L5 and tiny Disc Bulge at L3-L4, L2-L3 and L5-Si
   f. Collapsed L5 Vertebral
10. Indication For Contrast Enhancement Spine Scans
7. Localizer 3 plane
   a. T2 TSE Sagittal
   b. T1 TSE Sagittal

V. MRI Lumbar Spine
1. Indication
2. Contraindication
3. Patient Preparation
4. Positioning
5. Suggested Sequence, Parameters and Planning
   a. Localiser
   b. T2 TSE Sagittal
   c. T1 TSE Sagittal
   d. T2 TSE STIR Sagittal
   e. T2 TSE Axial Block and Multi angle
   f. T1 TSE Axial Block and Multi angle
9. Variation in Planning: T2 TSE Axial and T1 TSE Axial Planning
   a. TB and Spinal Cord Compression at T10 and T12
   b. Huge Disc Bulge at L4-L5, L3-L4 and Tiny Disc Bulge at L2-L3 and L5-S1
   c. L2, L3, L4, L5 Disc Bulge aand T11 Fracture
   d. Huge Disc Bulge at L4-L5 and tiny Disc Bulge at L3-L4 and L5-Si
   e. Huge Disc Bulge at L4-L5 and tiny Disc Bulge at L3-L4, L2-L3 and L5-Si
   f. Collapsed L5 Vertebral
c. T2 TSE STIR Sagittal
  d. T2 TSE Axial Block
  e. T1 TSE Axial Block
  f. T1 TSE Sagittal FAT SAT Post Contrast
  g. T1 TSE Axial FAT SAT Post Contrast

VI. Psoas MRI
1. Indication
2. Contraindication
3. Patient Preparation
4. Positioning
5. Suggested Sequence, Parameters and Planning
   a. Localiser
   b. T2 STIR Coronal 4mm Big FOV
   c. T1 STIR Coronal 4mm Big FOV
   d. T2 TSE (or STIR ) Axial 4mm 300 FOV
   e. T1 TSE Axial 300 FOV
6. Localizer 3 Plane
   a. T2 STIR Coronal 4mm Big FOV
   b. T1 TSE Coronal 4mm Big FOV
   c. T2 TSE (or STIR ) Axial 4mm 300 FOV
   d. T1 TSE Axial 300 FOV

VII. MRI Sacroiliac Joints
1. Indication
2. Contraindication
3. Patient Preparation
4. Positioning
5. Suggested Sequence, Parameters and Planning
   a. Localiser
   b. T2 STIR Coronal Oblique 3mm Small FOV
   c. T2 STIR Coronal 4mm Big FOV
   d. T1 TSE Coronal Oblique 3mm Small FOV
   e. T2 STIR Axial Oblique 3mm Small FOV
6. Localizer 3 Plane
   a. T2 STIR Coronal Oblique 3mm Small FOV
   b. T2 STIR Axial Oblique 3mm Small FOV

VIII. MRI Lumbosacral Plexus
1. Indication
2. Lumbosacral Plexus Anatomy
3. Contraindication
4. Patient Preparation
5. Positioning
6. Suggested Sequence, Parameters and Planning
   a. Localiser
   b. T2 TSE Sagittal 3mm
   c. T1 TSE Coronal 3mm
   d. T2 STIR Coronal 3mm
   e. T2 Space 3D 1mm Isotropic coronal
   f. T1 TSE Axial 4mm Small FOV
   g. T2 TSE Axial 4mm Small FOV
   h. Contrast Enhancement
7. Localizer 3 Plane
   a. T2 TSE Sagittal 3mm
   b. T1 TSE Coronal 3mm
c. 21 TSE Coronal 3mm  
d. T2 Space 3D 1mm Isotropic coronal  
e. T1 TSE Axial 4mm Small FOV  
f. T2 STIR Axial 4mm Small FOV  
g. T1 TSE FAT SAT Coronal Post Contrast  
h. T1 TSE FAT SAT Axial Post Contrast

IX. Case Study  
1. History  
2. Modic Changes  
3. Modic Changes on MRI  
4. Diagnosis  
5. Causes of back pain  
6. Diagnosing modic changes  
7. Modic changes and pain  
8. Treatment

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Lecture 18

Title: MRI Pelvis Planning and Techniques (120 minutes)

Keywords: Pelvis, Greater and Lesser Pelvis, Adaptation for Childbirth, Area of Pelvis, Bones, Hip Bones, Sacrum, Coccyx, Muscles of the Pelvis, Urinary tract, Male Urethra, Female Urethra, Urinary Bladder, Male Reproductive System, Penis, Testes and Epididymis, Scrotum, Prostate Gland, Bulbourethral Glands, Female Reproductive Tract, Vulva, Vagina, Cervix, Uterus, Ovaries, Axial Cross Sectional Anatomy, Sagittal Cross Sectional Anatomy, Male Pelvis, Female Pelvis, Image Characteristics, Rectal Cancer, MRI, Penile, Testis

Objectives:
• Discuss Anatomy of Pelvis and Structure of the Pelvic Girdle
• Review Area of Pelvis
• Brief review Bones and Muscles of the Pelvis
• Discuss Organs of the Pelvis
• Understand Male and Female Reproductive System
• Illustrate MRI Axial Cross Sectional Anatomy of Male and Female Pelvis
• Illustrate MRI Sagittal Cross Sectional Anatomy of Male and Female Pelvis
• Discuss MRI Image Characteristics
• Explain Suggested Sequence, Parameters and Planning
• Discuss Rectal Cancer
• Review Urinary Bladder
• Explain MRI Female Urethra
• Discuss Prostate Pelvis
• Review Penile MRI
• Explain MRI Testis

Content:
I. Anatomy of Pelvis
   1. Definition Pelvis
   2. Structure of the Pelvic Girdle
      a. Parts of the pelvic girdle
         • Hip bones (innominate or pelvic bones)
         • Sacrum
         • Coccyx
      b. Articulations pelvis
         • Sacroiliac Joints
         • Sacrococcygeal symphysis
         • Pubic symphysis
   3. Functions of the Pelvis
      a. Transfer of weight
      b. Provides attachment
      c. Contains and protects
   4. Greater and Lesser Pelvis
      a. Greater Pelvis (or false pelvis)
      b. Lesser Pelvis (or “true” pelvis)
      c. Pelvic Inlet
      d. Pelvic Brim
   5. Adaptation for Childbirth
      a. Gynaecoid pelvis vs the android pelvis
II. Area of Pelvis
   1. Perineum
   2. Boundaries
      a. Anatomical Borders
      b. Surface Borders
   3. Contents
      a. Anal Triangle
      b. Urogenital Triangle
      c. The Perineal Body

III. Bones of the Pelvis
   1. Hip Bones
      a. Articulations
         • Sacroiliac joint
         • Pubic symphysis
         • Hip joint
   2. Composition of the Hip Bone
      a. Lilium
      b. Pubis
      c. Ischium
   3. The Sacrum
      a. Bony Landmarks
         • Base
         • Apex
         • Auricular surfaces
         • Anterior and posterior surfaces
   4. The Coccyx
      a. Bony Landmarks
         • Base
         • Apex
         • Coccygeal cornua

IV. Muscles of the Pelvis
   1. The Pelvic Floor
      a. Levator ani muscles (largest component)
      b. Coccygeus muscle
      c. Fascia coverings of the muscles
   2. The Ureters
      a. Smooth muscle

V. Organs of the Pelvis
   1. Urinary tract
   2. Ureters
      a. Anatomical Course
         • Abdominal Part
         • Pelvic Part
      b. Male Urethra
         • Pre-prostatic (intramural)
         • Prostatic
         • Membranous
         • Spongy
      c. Female Urethra
         • Location of the external urethral orifice in the vestibule
   3. Urinary Bladder
      a. Functions of the Bladder
• Temporary store of urine
• Assists in the expulsion of urine

b. Shape of the Bladder
  • Apex
  • Body
  • Fundus (or base)
  • Neck

VI. The Male Reproductive System
1. Penis
   a. Functions
      • Sexual intercourse
      • Micturition
   b. Structure of the Penis
      • Root
      • Body
      • Glans
   c. Erectile Tissues
   d. Neurovascular Supply
      • Vasculature
      • Innervation

2. Testes and Epididymis
   a. Anatomical Position
   b. Anatomical Structure

3. Scrotum
   a. Testis
   b. Epididymis
   c. Spermatic cord
      • Anatomical Course
      • Fascial Coverings
      • Pampiniform Plexus

4. Prostate Gland
   a. Anatomical Position and Structure

5. Bulbourethral Glands
   a. Anatomical Position and Structure

VII. The Female Reproductive Tract
1. Vulva
   a. Functions
      • Sexual intercourse
      • Micturition
      • Defend
   b. Structures of the Vulva
   c. Innervation

2. Vagina
   a. Functions of the Vagina
   b. Anatomical Position
   c. Vascular Supply and Lymphatics

3. Cervix
   a. Anatomical Structure
   b. Functions
      • Passage of sperm
      • Maintains sterility

4. Uterus
   a. Anatomical Structure
b. Anatomical Position
5. Ovaries
   a. Functions
   b. Components of the Ovary
      • Surface
      • Cortex
      • Medulla

VIII. MRI Axial Cross Sectional Anatomy of Male Pelvis
IX. MRI Sagittal Cross Sectional Anatomy of Male Pelvis
X. MRI Axial Cross Sectional Anatomy of Female Pelvis
XI. MRI Sagittal Cross Sectional Anatomy of Female Pelvis
XII. MRI Image Characteristics
1. T1 SE/ T1 TSE
   a. T1 Image Characteristics
   b. MRI Image Appearance
   c. Tissues and their T1 Appearance
   d. Pathological appearance
   e. USE
2. T1 SE/ T1 TSE/ T1 FSE FAT Saturated
   a. Fat suppression in an MRI sequence
   b. MRI Image Appearance
   c. Tissues and their T1 Appearance
   d. Pathological appearance
   e. USE
3. T1 SE/ T1 TSE/ T1 FSE Post Contrast
   a. MRI Image Appearance
   b. Tissues and their T1 post gadolinium appearance
   c. Pathological appearance
   d. USE
4. T1 SE/ T1 TSE/ T1 FSE FAT Saturated Post contrast
   a. MRI Image Appearance
   b. Tissues and their T1 fat saturated post gadolinium appearance
   c. Pathological appearance
   d. USE
5. T2 SE/ T2 TSE/ T2 FSE
   a. MRI Image Appearance
   b. Tissues and their T2 appearance
   c. Pathological appearance
   d. USE
6. SHORT TAU INVERSION RECOVERY (STIR)
   a. MRI Image Appearance
   b. Tissues and their STIR appearance
   c. Pathological appearance
   d. USE

XIII. Rectal Cancer
   1. Indication for Rectal Cancer
   2. Contraindications
   3. Patient Preparation
   4. Positioning
   5. Suggested Sequence, Parameters and Planning
a. Localiser
b. T2 TSE Sagittal 3mm Small FOV
c. T2 TSE Axial 5mm Big FOV
d. T2 TSE Axial Oblique 3mm Small FOV
e. T2 TSE Coronal Oblique 3mm Small FOV
f. Rectal Cancer Variation in Planning
   • Cases Study
g. Localizer 3 Plane
   • T2 TSE Sagittal 3mm Small FOV
   • T2 TSE Axial 5mm Big FOV
   • T2 TSE Axial Oblique 3mm Small FOV

XIV. Urinary Bladder
1. Indication for Urinary Bladder
2. Contraindications
3. Patient Preparation
4. Positioning
5. Suggested Sequence, Parameters and Planning
   a. Localiser
   b. T2 TSE Sagittal 3mm Small FOV
c. T2 TSE Axial 3mm Small FOV
d. T2 TSE Coronal 3mm Small FOV
e. Localizer 3 Plane
   • T2 TSE Sagittal SFOV
   • T2 TSE Axial SFOV
   • T2 TSE Coronal SFOV
   • T1 TSE FAT SAT Axial SFOV Post Contrast

XV. MRI Female Urethra
1. Indication for Female Urethra
2. Contraindications
3. Patient Preparation
4. Positioning
5. Suggested Sequence, Parameters and Planning
   a. Localiser
   b. T2 TSE Axial 5mm Big FOV
c. T2 TSE FAT SAT (or STIR) Sagittal 3mm Small FOV
d. T2 TSE Sagittal 3mm Small FOV
e. T2 TSE FAT sar (or stir) Axial OBLIQUE 3mm Small FOV
f. T1 TSE Axial OBLIQUE 3mm Small FOV
h. T1 TSE FAT SAT Axial OBLIQUE 3mm Small FOV
i. T2 TSE FAT SAT (or STIR) Coronal OBLIQUE 3mm
j. Localizer 3 Plane
   • T2 TSE Axial 5mm Big FOV
   • T2 TSE FAT SAT (or STIR) Sagittal 3mm Small FOV
   • T2 TSE Sagittal 3mm Small FOV
   • T2 TSE FAT SAR (or STIR) Axial OBLIQUE 3mm Small FOV
   • T2 TSE Axial OBLIQUE 3mm Small FOV
   • T1 TSE FAT SAT Axial OBLIQUE 3mm Small FOV
   • T2 TSE FAT SAT (or STIR) Coronal OBLIQUE 3mm
   • T1 TSE FAT SAT Axial OBLIQUE 3mm Small FOV Post Contrast
   • T2 TSE FAT SAT (or STIR) Coronal OBLIQUE 3mm Post Contrast

XVI. Prostate Pelvis
1. Indication for Prostate Pelvis
2. Contraindications
3. Patient Preparation
4. Positioning
5. Suggested Sequence, Parameters and Planning
   a. Localiser
   b. T2 TSE axial 6mm big FOV
   c. T1 TSE axial 6mm big FOV
   d. T2 STIR coronal 5mm big FOV
   e. T2 TSE sagittal 3mm SFOV prostate
   f. T2 TSE axial oblique 3mm SFOV prostate
   g. T2 TSE coronal oblique 3mm SFOV
   h. DWI epi2scan trace axial 3mm SFOV
   i. Post I.V. Contrast: Most common indication for contrast enhanced pelvis scans
   j. T1 flash 3D fat sat axial dynamic 1 per 10 post
   k. T1 TSE FAT SAT Axial 3mm Small FOV
   l. Localizer 3 Plane
      • T2 TSE Sagittal 3mm Small FOV Prostate
      • T2 TSE Axial 6mm Big FOV
      • T2 STIR Coronal 5mm Big FOV
      • T2 TSE Axial Oblique 3mm Small FOV Prostate
      • T2 TSE Coronal Oblique 3mm Small FOV
      • DWI epi 3 Scan Trace Axial 3mm Small FOV
      • T1 FLASH 3D FAT SAT Axial Dynamic 1 Pre 10 Post
      • T1 TSE FAT SAT Axial 3mm Small FOV

XVII. Penile MRI
1. Indication for Penile MRI
2. Contraindications
3. Patient Preparation
4. Positioning
5. Suggested Sequence, Parameters and Planning
   a. Localiser
   b. T2 TSE Sagittal 3mm SFOV
   c. T2 TSE Coronal 5mm big FOV
   d. T2 STIR Axial 3mm SFOV
   e. T1 TSE Axial 3mm SFOV
   f. T2 STIR Coronal 3mm SFOV
   m. T1 TSE Coronal 3mm Small FOV
   n. Localizer 3 Plane
      • T2 TSE Sagittal 3mm Small FOV
      • T2 TSE Coronal 5mm Big FOV
      • T2 STIR Axial 3mm Small FOV
      • T1 TSE Axial 3mm Small FOV
      • T2 STIR Coronal 3mm Small FOV
      • T1 TSE Coronal 3mm Small FOV

XVIII. MRI Testis
1. Indications
2. Contraindications
3. Patient Preparation
4. Positioning
5. Suggested Sequence, Parameters and Planning
   a. Localiser
   b. T2 STIR coronal 5mm big FOV
   c. T2 TSE axial 5mm big FOV
d. T2 TSE sagittal 3mm Small FOV  
e. T2 STIR axial 3mm SFOV  
f. T1 TSE axial 3mm SFOV  
g. T2 TSE axial 3mm SFOV  
h. T2 TSE coronal 3mm SFOV  
i. T1 TSE coronal 3mm SFOV  
j. Localizer 3 Plane  
  • T2 STIR Coronal 5mm Big FOV  
  • T2 TSE Axial 5mm Big FOV  
  • T2 TSE Sagittal 3mm Small FOV  
  • T2 STIR Axial 3mm Small FOV  
  • T1 TSE Axial 3mm Small FOV  
  • T2 TSE Axial 3mm Small FOV  
  • T2 TSE Coronal 3mm Small FOV  
  • T1 TSE Coronal 3mm Small FOV  
  • T1 TSE FAT SAT Axial Post Contrast  
  • T1 TSE FAT SAT Coronal Post Contrast

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Lecture 19

Title: MRI Hips & Fistula Planning and Techniques (120 minutes)

Keywords: Recto Vaginal Fistula, MRI Axial Cross Sectional Anatomy of Hip, MRI Coronal Cross Sectional Anatomy of Hip, MRI Image Characteristics, Gynecology Pelvic Exams, Female Pelvic, Placenta, Rectovaginal Fistula, Anal Fistula, Defecating Proctogram, MRI Hips, Arthrogram Hips, Arthrography

Objectives:
• Discuss Anatomy of Hip
• Review Pelvis Fistulas
• Illustrate MRI Axial Cross Sectional Anatomy of Hip
• Illustrate MRI Image Characteristics
• Understand Suggested Sequence, Parameters and Planning
• Discuss MRI Gynecology Pelvic Exams
• Review Placenta MRI
• Explain Rectovaginal Fistula MRI
• Discuss Anal Fistula MRI
• Explain MRI Defecating Proctogram
• Discuss MRI Hips
• Review Arthrogram Hips
• Brief review Arthrography

Content:
I. Anatomy of Hip
1. Important Structures
   a. Bones and Joints
      • Articular cartilage
   b. Ligaments and Tendons
   c. Muscles
   d. Nerves
   e. Blood Vessels
   f. Bursae

II. Pelvis Fistulas
1. Fistula Definition
2. Areas of Fistulas
   a. Vesicovaginal fistula
   b. Rectovaginal fistula
   c. Cervical fistula
   d. Enterovaginal fistula
   e. Metroperitoneal fistula
   f. Recto-uterine fistula
   g. Vesico-uterine fistula
   h. Ureterovaginal fistulas
   i. Anal fistula
3. Types of Fistulas
   a. Blind
   b. Complete
   c. Horseshoe
   d. Incomplete
4. Urinary Fistula
5. Recto Vaginal Fistula

III. MRI Axial Cross Sectional Anatomy of Hip

IV. MRI Coronal Cross Sectional Anatomy of Hip

V. MRI Image Characteristics
   1. T1 SE/ T1 TSE
      a. T1 Image Characteristics
      b. MRI Image Appearance
      c. Tissues and their T1 Appearance
      d. Pathological appearance
      e. USE
   2. T1 SE/ T1 TSE/ T1 FSE FAT Saturated
      a. Fat suppression in an MRI sequence
      b. MRI Image Appearance
      c. Tissues and their T1 Appearance
      d. Pathological appearance
      e. USE
   3. T1 SE/ T1 TSE/ T1 FSE Post Contrast
      a. MRI Image Appearance
      b. Tissues and their T1 post gadolinium appearance
      c. Pathological appearance
      d. USE
   4. T1 SE/ T1 TSE/ T1 FSE FAT Saturated Post contrast
      a. MRI Image Appearance
      b. Tissues and their T1 fat saturated post gadolinium appearance
      c. Pathological appearance
      d. USE
   5. T2 SE/ T2 TSE/ T2 FSE
      a. MRI Image Appearance
      b. Tissues and their T2 appearance
      c. Pathological appearance
      d. USE
   6. SHORT TAU INVERSION RECOVERY (STIR)
      a. MRI Image Appearance
      b. Tissues and their STIR appearance
      c. Pathological appearance
      d. USE
   7. VIBE FAT SAT
      a. MRI Image Appearance
      b. Tissues and their T1 VIBE fat saturated appearance
      c. Pathological appearance
      d. USE

VI. MRI Gynecology Pelvic Exams
   1. Indication for MRI Female Pelvic Scans
   2. Contraindications
   3. Patient Preparation
   4. Positioning
   5. Suggested Sequence, Parameters and Planning
      a. Localiser
      b. T2 TSE Sagittal 3mm Small FOV
      c. T2 TSE Axial 6mm Big FOV
      d. T1 TSE Axial 6mm Big FOV
e. T2 TSE Coronal 5mm Big FOV
f. T2 TSE Axial Oblique 3mm Small FOV of Uterus

h. T1 TSE Axial Oblique 3mm Small FOV of Uterus

i. DWI epi 3 Scan Trace Axial 4mm Small FOV

j. Most Common Indication for Contrast Enhanced Pelvis Scans

k. T1 FLASH 3D FAT SAT Sagittal Dynamics 1 Pre 8 Post

l. T1 TSE FAT SAT Axial Oblique 3mm Small FOV of Uterus Post Contrast

m. Variation in Planning For Different Type of Endometrial Cancer
   • Cases Study

n. Localizer 3 Plane
   • T2 TSE Sagittal 3mm Small FOV
   • T2 TSE Axial 6mm Big FOV
   • T1 TSE Axial 6mm Big FOV
   • T2 STIR Coronal 5mm Big FOV
   • T2 TSE Axial Oblique 3mm Small FOV of Uterus
   • T2 TSE Coronal Oblique 3mm Small FOV
   • T1 TSE Axial Oblique 3mm Small FOV of Uterus
   • DWI epi 3 Scan Trace Axial 4mm Small FOV
   • T1 FLASH 3D FAT SAT Sagittal Dynamics 1 Pre 8 Post
   • T1 TSE FAT SAT Axial Oblique 3mm Small FOV of Uterus Post Contrast

VII. Placenta MRI

1. Indication
2. Contraindications
3. Patient Preparation
4. Positioning
5. Suggested Sequence, Parameters and Planning
   a. Localiser
   b. T2 Truefisp Sagittal 4mm Breath Hold
   c. T2 Truefisp Coronal 4mm Breath Hold
   d. T2 Truefisp Axial 5mm Breath Hold
   e. T1 Vibe Axial 6mm Breath Hold
   f. T2 Truefisp Axial Oblique 4mm Breath Hold
   g. Localizer 3 Plane
      • T2 Truefisp Sagittal 4mm Breath Hold
      • T2 Truefisp Coronal 4mm Breath Hold
      • T2 Truefisp Axial 5mm Breath Hold
      • T1 Vibe Axial 6mm Breath Hold
      • T2 Truefisp Axial Oblique 4mm Breath Hold

VIII. Rectovaginal Fistula MRI

1. Indication for MRI Rectovaginal Fistula Scans
2. Contraindications
3. Patient Preparation
4. Positioning
5. Suggested Sequence, Parameters and Planning
   a. Localiser
   b. T2 TSE Sagittal 3mm
   c. T2 STIR Sagittal 3mm Small FOV
   d. T2 TSE FAT SAT (or stir) Axial Oblique 3mm Small FOV
   e. T2 TSE FAT SAT (or stir) Coronal Oblique 3mm Small FOV
   f. Rectovaginal Fistula Variation in Planning
      • T2 TSE Sagittal 3mm Small FOV
      • T2 TSE Axial 3mm Small FOV
• T2 TSE Coronal 3mm Small FOV
  g. Localizer 3 Plane
    • T2 TSE Sagittal 3mm
    • T2 STIR Sagittal 3mm Small FOV
    • T2 TSE FAT SAT (or STIR) Axial Oblique 3mm Small FOV
    • T2 TSE FAT SAT (or STIR) Coronal Oblique 3mm Small FOV

IX. Anal Fistula MRI
  1. Indication for MRI Anal Fistula Scans
  2. Contraindications
  3. Patient Preparation
  4. Positioning
  5. Suggested Sequence, Parameters and Planning
    a. Localiser
    b. T2 STIR Sagittal 3mm
    c. T2 TSE Sagittal 3mm
    d. T2 TSE FAT SAT (or STIR) Axial Oblique 3mm
    e. T2 TSE FAT SAT (or STIR) Coronal Oblique 3mm
    f. T2 TSE FAT SAT (or STIR) Axial Oblique 3mm
    g. Localizer 3 Plane
      • T2 STIR Sagittal 3mm
      • T2 TSE Sagittal 3mm
      • T2 TSE FAT SAT (or STIR) Axial Oblique 3mm
      • T2 TSE FAT SAT (or STIR) Coronal Oblique 3mm

X. MRI Defecating Proctogram
  1. Indication for MRI Defecating Proctogram Scans
  2. Contraindications
  3. Patient Preparation
  4. Positioning
  5. Suggested Sequence, Parameters and Planning
    a. Localiser
    b. T2 TSE Sagittal 3mm Pre Proctogram
    c. T2 TSE Axial Oblique 3mm Small FOV Pre Proctogram
    d. T2 TSE Coronal Oblique 3mm Small FOV Pre Proctogram
    e. Pause For Proctogram
    f. T2 Trufi Cine Small FOV 10mm 1.5 Seconds 100 Measurements
    g. Localizer 3 Plane
      • T2 TSE Sagittal 3mm Pre Proctogram
      • T2 TSE Axial Oblique 3mm Small FOV Pre Proctogram
      • T2 TSE Coronal Oblique 3mm Small FOV Pre Proctogram
      • T2 Trufi Cine Small FOV 10mm 1.5 Seconds 100 Measurements

XI. MRI Hips
  1. Indication for MRI Hips Scans
  2. Contraindications
  3. Patient Preparation
  4. Positioning
  5. Suggested Sequence, Parameters and Planning
    a. Localiser
    b. T1 TSE Coronal 3mm
    c. T2 STIR Coronal 3mm
    d. T1 TSE Axial 3mm
    e. T2 TSE Axial 3mm
    f. T2 TSE Sagittal 3mm Small FOV Affected Side
g. PD FAT SAT Axial Oblique 3mm Small FOV Affected Side
h. Localizer 3 Plane
   • T1 TSE Coronal 3mm
   • T2 STIR Coronal 3mm
   • T1 TSE Axial 3mm
   • T2 TSE Axial 3mm
   • T2 TSE Sagittal 3mm Small FOV Affected Side
   • PD FAT SAT Axial Oblique 3mm Small FOV Affected Side

XII. Arthrogram Hips
   1. Indication for Arthrogram Hips Scans
   2. Contraindications
   3. Patient Preparation
   4. Positioning
   5. Suggested Sequence, Parameters and Planning
      a. Localiser
      b. T2 STIR Coronal 3mm Pre Arthrogram
      c. T1 TSE Axial 3mm Pre Arthrogram
      d. Localizer 3 Plane
         • T2 STIR Coronal 3mm Pre Arthrogram
         • T1 TSE Axial 3mm Pre Arthrogram
   6. Arthrography
   7. Positioning Post Joint Injection Scan
   8. Suggested Sequence, Parameters and Planning
      a. Localiser Post Arthrogram
      b. T1 Vibe 3D FAT SAT Coronal 1mm Small FOV
      c. T1 TSE FAT SAT Coronal 3mm Small FOV
      d. T1 TSE FAT SAT Axial 3mm Small FOV
      e. T1 TSE FAT SAT Sagittal 3mm Small FOV
      f. T1 Axial Oblique 3mm Small FOV
      g. T1 Sagittal Oblique 3mm Small FOV
      h. Localizer 3 Plane
         • T1 Vibe 3D FAT SAT Coronal 1mm Small FOV
         • T1 TSE FAT SAT Coronal 3mm Small FOV
         • T1 TSE FAT SAT Axial 3mm Small FOV
         • T1 TSE FAT SAT Sagittal 3mm Small FOV
         • T1 Sagittal Oblique 3mm Small FOV

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Lecture 20

Title: MRI Humerus, Elbow, Forearm, Wrist, Hand Planning & Techniques (90 minutes)


Objectives:
• Discuss Anatomy of Upper Arm (Humerus)
• Understand Suggested Sequence, Parameters and Planning of Upper Arm (Humerus)
• Discuss Anatomy of Elbow
• Illustrate MRI Cross Sectional Anatomy of Elbow
• Understand Suggested Sequence, Parameters and Planning of Elbow
• Review Anatomy of Forearm
• Explain Suggested Sequence, Parameters and Planning of Forearm
• Discuss Anatomy of Wrist
• Illustrate MRI Cross Sectional Anatomy of Wrist
• Describe Suggested Sequence, Parameters and Planning of Wrist
• Discuss Anatomy of Hand
• Review MRI Anatomy of Hand
• Understand Suggested Sequence, Parameters and Planning of Hand

Content:
I. Anatomy of Upper Arm (Humerus)
   1. Definition Upper Limb (Upper Extremity)
   2. Humerus
   3. Upper Arm

II. MRI Upper Arm (Humerus)
   1. Indications
   2. Contraindications
   3. Patient Preparation
   4. Positioning
   5. Suggested Sequence, Parameters and Planning
      a. Localizer
      b. T2 STIR Axial 3mm Small FOV
      c. T1 TSE Axial 3mm
      d. T1 TSE Coronal 3mm
      e. T2 STIR Coronal 3mm
      f. T2 TSE Sagittal 3mm
      g. Localizer 3 Plane

III. Anatomy of Elbow
   1. Bones
      a. Humerus
      b. Ulna
      c. Radius
   2. Ligaments
      a. Medial Collateral
      b. Lateral Collateral
      c. Annular
3. Muscles
   a. Biceps Brachii
   b. Triceps Brachii
   c. Brachialis
   d. Brachioradialis
   e. Pronator Teres
   f. Extensor Carpi Radialis Brevis

4. Nerves
   a. Radial nerve
   b. Ulnar nerve
   c. Medial nerve

IV. MRI Cross Sectional Anatomy of Elbow

V. MRI Elbow
   1. Indications
   2. Contraindications
   3. Patient Preparation
   4. Positioning
   5. Suggested Sequence, Parameters and Planning
      a. Localiser
      b. T2* MEDIC Axial 3mm SFOV
      c. T1 SE Axial 3mm SFOV
      d. T1 TSE Coronal 3mm
      e. T2 STIR Coronal 3mm
      f. T2* MEDIC Sagittal 3mm
      g. Localizer 3 Plane
         • T2* MEDIC Axial 3mm SFOV
         • T1 SE Axial 3mm SFOV
         • T1 TSE Coronal 3mm
         • T2 STIR Coronal 3mm
         • T2* MEDIC Sagittal 3mm

VI. Forearm
   1. Anatomy of Forearm
      a. Definition Forearm
      b. Reasons for MRI request
      c. Radioulnar joint
      d. Muscles
      e. Nerves
   2. MRI Forearm
      a. Indication for MRI Forearm
      b. Contraindications
      c. Patient Preparation
      d. Positioning
      e. Table Pads and Accessory Pads
      f. Table Straps
      g. Laser Localizer Beams
      h. Suggested Sequence, Parameters and Planning
         • Localiser
         • T2 STIR Axial 4mm Small FOV
         • T1 TSE Axial 4mm Small FOV
         • T2 STIR Coronal 3mm
         • T1 TSE Coronal 3mm
         • T2 TSE Sagittal 3mm
VII. Anatomy of Wrist
1. Definition Wrist
2. Reasons for MRI request
3. Bones
4. Ligaments
5. Nerves
   a. Median nerve compression
   b. Guyon’s canal syndrome

VIII. MRI Cross Sectional Anatomy of Wrist

IX. MRI Wrist
1. Indications for MRI Wrist
2. Contraindications
3. Patient Preparation
4. Positioning
5. Suggested Sequence, Parameters and Planning
   a. Localiser
   b. T2*(Medic) Axial 3mm SFOV
   c. T2 STIR Coronal 3mm SFOV
   d. T1 TSE Coronal 3mm SFOV
   e. T2* (Medic) Coronal 3mm Small FOV
   f. T2 Sagittal 3mm Small FOV
   g. Localizer 3 Plane
      • T2*(Medic) Axial 3mm SFOV
      • T2 STIR Coronal 3mm SFOV
      • T1 TSE Coronal 3mm SFOV
      • T2* (Medic) Coronal 3mm Small FOV
      • T2 Sagittal 3mm Small FOV
6. Scaphoid (Navicular) Fractures
   a. STIR, FatSat or FatSep sequences

X. Anatomy of Hand
1. Reasons for MRI request
2. Bones
3. Phalanges
4. Joints
5. Muscles
6. Injuries
   a. «Mallet finger» or «Baseball finger»
   b. «Boutonniere deformity»
   c. «Jammed» fingers
   d. «Gamekeeper’s thumb» or «Skier’s thumb»
7. Nerves
   a. Radial nerve
   b. Median nerve
   c. Ulnar nerve
8. Blood Vessels
   a. Radial artery
   b. Ulnar artery
   c. Other arteries

XI. MRI Anatomy of Hand
1. Dorsal extrinsic ligaments
2. Extensor tendons
3. Intertendinous connections
4. Intrinsics muscles
5. MCP joint anatomy
6. Extensor mechanism (apparatus)
7. Central band (slip) extensor mechanism
8. Collateral ligaments
9. Flexor digitorum superficialis
10. Volar plate
11. Pulley anatomy A2
12. Pulley anatomy A4
13. Distal interphalangeal joint

XII. MRI Hand
1. Indications for MRI Hand
2. Contraindications
3. Patient Preparation
4. Positioning
5. Suggested Sequence, Parameters and Planning
   a. Localiser
   b. T2 STIR Axial 3mm
   c. T1 TSE Axial 3mm
   d. T1 TSE Coronal 3mm
   e. T2 STIR Coronal 3mm
   f. T2 STIR Sagittal 3mm
   g. Localizer 3 Plane
      • T2 STIR Axial 3mm
      • T1 TSE Axial 3mm
      • T1 TSE Coronal 3mm
      • T2 STIR Coronal 3mm
      • T2 STIR Sagittal 3mm

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Lecture 21

Title: MRI Thigh, Knee, Lower Leg, Ankle and Foot Planning & Techniques (90 minutes)

Keywords: Anatomy, Thigh, Bones, MRI Cross Sectional Anatomy, Knee, Articular Cartilage, Ligaments, Tendons, Injuries, Fractures, Dislocation, Anterior Cruciate Ligament (ACL) Injuries, Posterior Cruciate Ligament Injuries, Collateral Ligament Injuries, Meniscal Tears, Tendon Tears, Lower Leg, MRI request, Muscles, Nerves, Arteries and Veins, Ankle, Structure

Objectives:
• Discuss Anatomy of Thigh
• Illustrate MRI Cross Sectional Anatomy of Thigh
• Explain Suggested Sequence, Parameters and Planning of Thigh
• Discuss Anatomy of Knee
• Illustrate MRI Cross Sectional Anatomy of Knee
• Explain Suggested Sequence, Parameters and Planning of Knee
• Discuss Anatomy of Lower Leg
• Illustrate MRI Cross Sectional Anatomy of Lower Leg
• Explain Suggested Sequence, Parameters and Planning Lower Leg
• Discuss Anatomy of Ankle
• Illustrate MRI Cross Sectional Anatomy of Ankle
• Explain Suggested Sequence, Parameters and Planning of Ankle
• Discuss Anatomy of Foot
• Explain Suggested Sequence, Parameters and Planning of Foot

Content:
I. Anatomy of Thigh
   1. Definition of Thigh
   2. Structure
      a. Bones
      b. Muscular compartments
      c. Blood supply

II. MRI Cross Sectional Anatomy of Thigh

III. MRI Thigh
   1. Indication for MRI Thigh
   2. Contraindication
   3. Patient Preparation
   4. Positioning
   5. Suggested Sequence, Parameters and Planning
      a. Localizer
      b. T2 STIR Coronal 5mm
      c. T1 TSE Coronal 5mm
      d. T1 TSE Axial 6mm
      e. T2 STIR Axial 6mm
      f. T2 TSE Sagittal 5mm Right
      g. T2 TSE Sagittal 5mm Left
      h. Localizer 3 Planes
         • T2 STIR Coronal 5mm
         • T1 TSE Coronal 5mm
         • T1 TSE Axial 6mm
• T2 STIR Axial 6mm
• T2 TSE Sagittal 5mm Right
• T2 TSE Sagittal 5mm Left

IV. Anatomy of Knee
1. Definition of Knee
2. Bones
3. Articular Cartilage
4. Ligaments
   a. Collateral Ligaments
   b. Cruciate ligaments
5. Tendons
6. Common Knee Injuries
   a. Fractures
   b. Dislocation
   c. Anterior Cruciate Ligament (ACL) Injuries
   d. Posterior Cruciate Ligament Injuries
   e. Collateral Ligament Injuries
   f. Meniscal Tears
   g. Tendon Tears

V. MRI Cross Sectional Anatomy of Knee

VI. MRI Knee
1. Indication for MRI Knee
2. Contraindication
3. Patient Preparation
4. Positioning
5. Suggested Sequence, Parameters and Planning
   a. Localizer
   b. PD FAT SAT Axial 3mm
   c. PD FAT SAT Coronal 3mm
   d. T1 TSE Sagittal
   e. T2 STIR Sagittal
   f. T2* (MEDIC) Sagittal
   g. Optional Scans
      • PD FAT SAT Coronal Oblique 2mm for Anterior Cruciate Ligament
      • PD FAT SAT Sagittal Oblique 2mm for Anterior Cruciate Ligament
   h. Localizer 3 Plane
      • PD FAT SAT Axial 3mm
      • PD FAT SAT Coronal 3mm
      • T1 TSE Sagittal
      • T2 STIR Sagittal
      • T2* (MEDIC) Sagittal

VII. Anatomy of Lower Leg
1. Reasons for MRI request
2. Bones of the Lower Leg
3. Ligaments of the Lower Leg
4. Muscles and Tendons of the Lower Leg
5. Nerves of the Lower Leg
6. Arteries and Veins of the Lower Leg

VIII. MRI Cross Sectional Anatomy of Lower Leg
IX. MRI Lower Leg
1. Indication for MRI Lower Leg
2. Contraindication
3. Patient Preparation
4. Positioning
5. Suggested Sequence, Parameters and Planning
   a. Localizer
   b. T2 STIR Coronal 4mm
   c. T1 TSE Coronal 4mm
   d. T1 TSE Axial 6mm
   b. T2 STIR Axial 6mm
   c. T2 TSE Sagittal 4mm Right
   d. T2 TSE Sagittal 4mm Left
   e. Localizer 3 Plane
      • T2 STIR Coronal 4mm
      • T1 TSE Coronal 4mm
      • T1 TSE Axial 6mm
      • T2 STIR Axial 6mm
      • T2 TSE Sagittal 4mm

X. Anatomy of Ankle
1. Structure
   a. Bones
   b. Joints
      • Talocrural joint
      • Subtalar joint
      • Inferior tibiofibular joint
   c. Ligaments
      • Muscles and Tendons of the Ankle
      • Nerves of the Ankle
      • Arteries and Veins of the Ankle

XI. MRI Cross Sectional Anatomy of Ankle

XII. MRI Ankle
1. Indication for MRI Ankle
2. Contraindication
3. Patient Preparation
4. Positioning
5. Suggested Sequence, Parameters and Planning
   a. Localizer
   b. PD TSE Axial 4mm
   c. T2 STIR Axial 4mm
   d. T1 TSE Sagittal 3mm
   e. T2 STIR Sagittal 3mm
   f. PD FAT SAT Coronal 4mm
   g. Licalizer 3 Plane
      • Long Axis Scans
      • Coronal Scans
      • Sagittal Scans

XIII. Anatomy of Foot
1. Definition of Foot
2. Reasons for MRI request
3. Bones of the Foot
4. Ligaments of the Foot
5. Muscles and Tendons of the Foot
6. Nerves of the Foot
7. Arteries and Veins of the Foot

XIV. MRI Foot
1. Indication for MRI Foot
2. Contraindication
3. Patient Preparation
4. Positioning
5. Suggested Sequence, Parameters and Planning
   a. Localizer
   b. T1 TSE Axial 3mm (Coronal in Anatomical Position)
   b. T2 STIR Axial 3mm
   c. T1 TSE Coronal 3mm
   d. T2 STIR Coronal 4mm
   e. T1 TSE Sagittal 3mm
   f. T2 STIR Sagittal 3mm
   g. Localizer 3 Plane
      • T1 TSE Axial 3mm (Coronal in Anatomical Position)
      • T2 STIR Axial 3mm
      • T1 TSE Coronal 3mm
      • T2 STIR Coronal 4mm
      • T1 TSE Sagittal 3mm
      • T2 STIR Sagittal 3mm

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Lecture 22

Title: MR Spectroscopy (120 minutes)

Keywords: Magnetic Resonance Spectroscopy (MRS), Nuclear Magnetic Resonance (NMR) Spectroscopy, Spectroscopy, Nuclear Paramagnetism, Spin, Resonance, Larmor Frequency, Relaxation processes, Bloch Equations, Energetics, Bulk, Magnetization, Alignment of Nuclear Magnetic Moments, Setting the Context, Typical Proton NMR Spectrum, Electron shielding, Chemical Shift, J-coupling, Echo Time, Repetition Time, Editing, Time Domain NMR Signal, +/- Frequency, Convention, Fourier Transforms, Hardware, Practical Considerations, Basic In Vivo Localization Technique, Single voxel spectroscopy (SVS), Water signal suppresion, Principles of volume selection, STEAM (STimulated Echo Acquisition Mode), PRESS (Point REsolved Spectroscopy), Chemical Shift, Compounds, Preparation, Procedure for NMR Spectroscopy, Risks, Data Acquisition, Planning a Magnetic Resonance Spectra, Acquisition Methods, Signal-to-Noise Ratio (S/N), Selecting the Region of Interest, Absolute Quantitation, Safety, Magnetic Resonance Spectroscopy at 3T, Clinical Applications, Questions, Answers

Objectives:
- Discuss Basics of MRS and Practical Considerations
- Review NMR Parameters
- Hardware Overview
- Understand how does MR spectroscopy work
- Explain Basic In Vivo Localization Techniques
- Understand what Can Be Measured with Magnetic Resonance Spectroscopy
- List Compounds
- Discuss Preparation and Procedure for NMR Spectroscopy
- Define Data Acquisition
- Brief review safety
- Review Magnetic Resonance Spectroscopy at 3T
- Discuss Clinical Applications
- Illustrate Basic Questions and Answers

Content:

I. Introduction
   1. Magnetic Resonance Spectroscopy (MRS) or Nuclear Magnetic Resonance (NMR) Spectroscopy
   2. Decay (Relaxation)

II. Basics of MRS
   1. Birth of NMR
   2. Brain and Water
   3. Nuclear Magnetic Resonance (NMR)
   4. Spectroscopy
   5. What is NMR?

III. NMR Parameters
   1. Nuclear Paramagnetism
   2. Spin
      a. Some facts about Spin
      b. Interaction of Spin with External Magnetic Field
   3. Resonance
      a. Resonance of a single spin I=1/2
b. The absorption of radiation by a nucleus in a magnetic field
   c. Larmor Frequency

4. Relaxation processes
   a. Spin - lattice (longitudinal) relaxation
   b. Spin - spin (transverse) relaxation

5. Bloch Equations

6. Energetics

7. Bulk Magnetization

8. Alignment of Nuclear Magnetic Moments

9. Setting the Context

10. Typical Proton NMR Spectrum

11. Electron shielding

12. Chemical Shift

13. J-coupling

14. Echo Time and Repetition Time

15. Editing

16. The Time Domain NMR Signal

17. The +/- Frequency Convention

18. Fourier Transforms

IV. Hardware Overview

1. Magnet

2. Field Lock

3. FIELD STRENGTH SHIMMING

4. Shim Coils

5. Head Coil

6. RF Coils

7. Gradient Coils

8. VOXEL POSITIONING

9. Quadrature Detector

10. Digital Filtering

11. Safety

V. The Basics of NMR (Practical Considerations)

1. Line widths, Line shapes, Integrals

2. Scalar Coupling

3. Coupling Pattern vs Chemical Shift Difference

4. $2\pi$ or not $2\pi$

5. Photons

6. Some Important Constants

7. What does a MR spectroscopy show?

8. How does MR spectroscopy work?
   a. Techniques
   b. Types of in vivo spectroscopy
      • Single voxel
      • Multi-voxel

VI. Basic In Vivo Localization Technique

1. Single voxel spectroscopy (SVS)

2. Water signal suppression

3. Principles of volume selection

4. PRESS and STEAM sequences
   a. STEAM (STimulated Echo Acquisition Mode)
   b. PRESS (Point RESolved Spectroscopy)

5. Chemical Shift
   a. Chemical shift value
b. Binomial Pulses
c. Chemical Shift Imaging (CSI)
d. Chemical Shift Selective Imaging Sequence (CHESS)
e. Depth Resolved Spectroscopy (DRESS)

VII. What Can Be Measured with Magnetic Resonance Spectroscopy?

VIII. Compounds
1. N-Acetylaspartic acid, or N-acetylaspartate (NAA)
   a. Function
   b. Applications
2. Choline
3. Creatine
4. Lactate
5. Glutamate and glutamine
6. Myo-inositol
7. Less commonly detected compounds

IX. Preparation/Procedure for NMR Spectroscopy
1. Prepare for the test
2. During the test
3. Risks

X. Data Acquisition
1. Planning a Magnetic Resonance Spectra
2. Acquisition Methods: Single-Voxel Versus Chemical Shift Imaging
   a. Single-Voxel (SV) Magnetic Resonance Spectroscopy (MRS)
   b. 2D or 3D Chemical Shift Imaging
   c. When to Use What Method?
3. Signal-to-Noise Ratio (S/N)
   a. Rules (and Qualifiers) for Signal-to-Noise Ratio
4. Selecting the Region of Interest
5. How to Acquire Good Quality Spectra
6. Processing and Quantitation
   a. Linebroadening
   b. Fourier transform
   c. Phasing
7. Absolute Quantitation
8. Summary
   a. Additional Steps
      • Shimming the magnetic field
      • Suppressing the water signal
      • Single Voxel Spectroscopy (SVS)
      • Chemical Shift Imaging (CSI)
      • Magnetic Resonance Spectroscopic Imaging (MRSI)
   b. Spectroscopy Evaluation
   c. Step by step for basic functionality
      • SVS
      • CSI
   d. Single Voxel Spectroscopy
      • Features
      • Step by step
   e. GeneRALized breast speCtroscopy Exam (GRACE)
   f. 3D CSI (Chemical Shift Imaging)
      • Features
      • Step by step
XI. Miscellaneous
1. Safety
2. Magnetic Resonance Spectroscopy at 3T

XII. Clinical Applications
1. Brain Tumors
2. Cerebral Ischemia and Infarction
3. Trauma
4. Infectious Diseases
5. Pediatric Metabolic Disorders
6. Alzheimer's Disease
7. Ischemic lesions
8. Hepatic encephalopathy

XIII. Basic Questions/Answers
1. What is the smallest voxel that can or should be measured?
2. What is the minimum S/N needed for a study to be conclusive?
3. If a spectrum is very noisy, how do I know whether this is due to technical problems or whether presents true biology (e.g., hypocellularity, necrosis, etc.)?
4. How much partial volume do I have?
5. What is the chemical shift artifact?
6. I see in the spectrum an unusual peak/signal. Is it real?
7. Scanner stability: Are there Monday morning and Friday afternoon peaks?
8. Can glutamate and glutamine be separated at 1.5 T?
9. Can we distinguish between glutamate and glutamine in spectra acquired at 3 T in individual patients?

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Lecture 23

Title: Magnetic Resonance Angiography (MRA) Whole Body (120 minutes)

Keywords: Magnetic Resonance Angiography (MRA), Methods, Dark Blood, Bright Blood, 2D TOF, 3D TOF, Parameter Selection, Magnetization Transfer (MT), Artifacts, Gated 3D-FSE, Contrast-enhanced MRA, Contrast-enhanced MR angiography (CE-MRA), Timing of Contrast Bolus, Time-Resolved, Brain, Magnetic Resonance Venography (MRV), Neck, Abdomen, Renals, Lower Leg, Upper Leg, Upper Arm, Whole Body

Objectives:
• Discuss Magnetic Resonance Angiography (MRA) and MRA Methods
• Explain Suggested Sequence, Parameters and Planning of MRA Brain
• Review Magnetic Resonance Venography (MRV) Brain
• Discuss MRA Neck
• Define MRA and MRV of Abdomen
• Review MRA Renals
• Explain MRA Leg
• Discuss MRA Upper Arm
• Understand MRA Whole Body

Content:
I. Magnetic Resonance Angiography (MRA)
   1. Definition MRA
   2. Uses of the procedure
      a. Brain
      b. Neck
      c. Heart
      d. Chest
      e. Abdomen (such as the kidneys and liver)
      f. Pelvis
      g. Legs and Feet
      h. Arms and Hands
      i. Aneurysms
      j. Atherosclerotic (plaque)
      k. Stents
      l. Dissection
      m. Coronary bypass
   3. MRA Methods
      a. How do you create an MR angiogram?
      b. Dark Blood MRA
         • Fast Spin Echo (FSE) Black Blood MRA
         • Inversion Recovery (IR) Black Blood MRA
         • Susceptibility-weighted (SW) Black Blood MRA
      c. Bright Blood MRA
         • Contrast-enhanced MRA
         • Non-contrast MRA
         • Time-of-Flight (TOF) MRA
      d. Dark vs Bright Blood MRA
      e. How does time-of-flight MRA work?
      f. 2D vs 3D MRA
• 2D TOF MR Angiography
• 3D TOF MR Angiography

g. MRA Parameter Selection
• Relationship between TR, slice thickness (d), and flow velocity (V)
• Effect of TR
• Effect of flip angle (α)
• Effect of TE

h. Magnetization Transfer (MT)
i. TOF MRA Artifacts
• Stair-Step Artifact (2D TOF only)
• In-Plane Saturation Artifact
• Shine-through Artifacts
• Flow-Reversal Artifact
• Venetian Blind Artifact (3D MRA only)
• Susceptibility Artifacts

j. Gated 3D-FSE MRA

k. Other/New MRA Methods
• Flow-Sensitive Dephasing (FSD)
• Quiescent-Interval Single-Shot (QISS) MRA
• Gated Time-of-Flight (TOF) Inflow MRA

4. Contrast-enhanced MRA
a. Contrast-enhanced MR angiography (CE-MRA)
• Single-phase methods
• Time-resolved methods
• Bolus-chase methods

b. Timing of Contrast Bolus
• Test Bolus Timing
• Fluoroscopic Triggering
• Time-resolved Imaging

c. Time-Resolved MRA
• TRICKS
• TWIST
• Keyhole imaging
• DISCO (Differential Subsampling with Cartesian Ordering)

d. Artifacts in Contrast MRA
• Subclavian Pseudo-stenosis Artifact
• Scanning Too Late: Venous Contamination
• Scanning Too Early: Ringing (Maki) Artifact

II. MRA Brain
1. Introduction
2. Time-of-Flight (TOF)
3. Contraindication
4. Patient Preparation
5. Suggested Sequence, Parameters and Planning
   a. Localizer
   b. T2 TSE Axial
   c. 3D Time of Flight (TOF)
   d. Maximum Intensity Projection (MIP)
   e. Localizer 3 Plane
      • T2 TSE Axial
      • 3D Time of Flight (TOF)
      • Post processing MIP images from 3D rawdata
III. Magnetic Resonance Venography (MRV) Brain
1. Introduction
2. Time-of-Flight (TOF)
3. Phase Contrast (PC)
4. Indication for MRV Brain
5. Contraindication
6. Patient Preparation
7. Positioning
8. Suggested Sequence, Parameters and Planning
9. Localizer
   a. 2D Time of Flight (TOF) or 3D Phase Contrast (PC)
   b. 2D Time of Flight (TOF)
   c. Maximum Intensity Projection (MIP)
   d. Localizer 3 Plane
      • T2 TSE Axial
      • 3D Phase Contrast (PC)
      • 2D Time of Flight (TOF)

IV. MRA Neck
1. Indication
2. Contraindication
3. Patient Preparation
4. Positioning
5. Suggested Sequence, Parameters and Planning
   a. Localiser
   b. Phase Contrast (PC) 2D Sagittal Vessel Localizer
   c. 3D TOF Multi Slab Axial 1mm
   d. T1 TSE FAT SAT 4mm 250 FOV
   e. Localizer 3 Plane
      • Phase Contrast (PC) 2D Sagittal Vessel Localizer
      • 3D TOF Multi Slab Axial 1mm
      • T1 TSE FAT SAT 4mm 250 FOV

V. MRA and MRV of Abdomen
1. Indication
2. Contraindication
3. Patient Preparation
4. Positioning
5. Suggested Sequence, Parameters and Planning
   a. Localiser
   b. T1 VIBE 3D FAT SAT Axial Pre-Contrast 4mm
   c. T1 FLASH 3D Coronal 0.9-1.1mm Pre-Contrast
   d. Parallel Acquisition Techniques (IPAT)
   e. Contrast Administration and Timing of Scans
      • Guess Timing Technique
      • Care Bolus Technique
      • Planning Care Bolus
   f. T1 FLASH Dynamic 3D Coronal 0.9mm – 1.1mm Post Contrast 3 measurements
   g. T1 VIBE 3D FAT SAT Axial Post Contrast 4mm
   h. Localizer 3 Planes
      • T1 VIBE 3D FAT SAT Axial Pre-Contrast 4mm
      • T1 FLASH 3D Coronal 0.9-1.1mm Pre-Contrast
      • Care Bolus
      • T1 FLASH Dynamic 3D Coronal 0.9mm – 1.1mm Post Contrast 3 measurements
      • T1 VIBE 3D FAT SAT Axial Post Contrast 4mm
VI. MRA Renals
1. Indication for Magnetic Resonance Angiography (MRA) RENALS
2. Contraindication
3. Patient Preparation
4. Positioning
5. Suggested Sequence, Parameters and Planning
6. Localiser
   a. T1 FLASH 3D Coronal FAT Saturated 0.8 mm-0.9 mm Pre Contrast
   b. Parallel Acquisition Technique (IPAT)
   c. Contrast Administration and Timing of Scans
      • Guess Timing Technique
      • Care Bolus Technique
      • Planning Care Bolus Technique
   d. T1 Flash 3D Coronal FAT Saturated 0.8 mm – 0.9mm Post contrast
   e. Localizer 3 Plane
      • T1 Flash 3D Coronal FAT Saturated 0.8 mm – 0.9mm Pre contrast
      • Care Bolus Technique
      • T1 Flash 3D Coronal FAT Saturated 0.8 mm – 0.9mm Post contrast

VII. MRA Leg
1. Indication for Magnetic Resonance Angiography (MRA) LEG
2. Contraindication
3. Patient Preparation
4. Positioning
5. Suggested Sequence, Parameters and Planning
   a. Localiser MRA Lower Leg
   b. Localiser MRA Upper Leg
      • Phase Contrast (PC) Vessel Localiser Upper Leg
   c. Localiser MRA Abdomen
      • Phase Contrast (PC) Vessel Localiser Abdomen
   d. T1 FLASH 3D Coronal 0.9 mm- 1.1 mm Pre Contrast Abdomen
   e. Parallel Acquisition Technique (IPAT)
   f. T1 Flash 3D Coronal 0.9 mm – 1.1 mm Pre Contrast Upper Leg
   g. T1 Flash 3D Coronal 1 mm – 1.3 mm Pre Contrast Lower Leg
   h. Contrast Administration and timing of Scan
      • Guess Timing Technique
      • Care Bolus Technique
      • Planning Care Bolus
   i. Planning Care Bolus
   j. T1 Flash 3D Coronal 0.9 mm – 1.1 mm Post Contrast Abdomen
   k. T1 Flash 3D Coronal 0.9 mm – 1.1 mm Pre Contrast Upper Leg
   l. T1 Flash 3D Coronal 1 mm – 1.3 mm Pre Contrast Lower Leg
   m. Localizer 3 Plane Upper Leg
   n. Localizer 3 Plane Lower Leg
   o. Localizer PC 2D Sagittal Upper Leg
   p. Localizer 3 Plane Abdomen
   q. Localizer PC 2D Sagittal Abdomen
      • T1 Flash 3D Coronal Pre Contrast Abdomen
      • T1 Flash 3D Coronal Pre Contrast Upper Leg
      • T1 Flash 3D Coronal Pre Contrast Lower Leg
      • T1 Flash 3D Coronal Post Contrast Abdomen
      • T1 Flash 3D Coronal Post Contrast Upper Leg
      • T1 Flash 3D Coronal Post Contrast Lower Leg
VIII. MRA Upper Arm
1. Indication for MRA Upper Arm
2. Contraindication
3. Patient Preparation
4. Positioning
5. Suggested Sequence, Parameters and Planning
   a. Localiser
   b. T1 VIBE 3D FAT SAT Axial Pre Contrast 2mm
   c. T1 Flash 3D Coronal 0.9 mm – 1.1 mm Pre Contrast
   d. Parallel Acquisition Technique (IPAT)
   e. Contrast Administration and timing of Scan
      • Guess Timing Technique
      • Care Bolus Technique
      • Planning Care Bolus
   f. T1 Flash Dynamic 3D Coronal 0.9 mm – 1.1 mm Post Contrast 2 measurements
   g. T1 VIBE 3D FAT SAT Axial Post Contrast 2 mm
   h. Localizer 3 Plane
      • T1 Flash Dynamic 3D Coronal 0.9 mm – 1.1 mm Pre Contrast 2 measurements
      • T1 Flash Dynamic 3D Coronal 0.9 mm – 1.1 mm Post Contrast 2 measurements

IX. MRA Whole Body
1. Indication for MRA Whole Body
2. Contraindication
3. Patient Preparation
4. Positioning
5. Suggested Sequence, Parameters and Planning
   a. Localiser Chest, Neck and Head
   b. Localiser MRA Abdomen
      • Phase Contrast (PC) Vessel Localiser Abdomen
   c. Localiser MRA Upper Leg
      • Phase Contrast (PC) Vessel Localiser Upper Leg
   d. Localiser MRA Lower Leg
   e. T1 FLASH 3D Coronal 0.9 mm- 1.1 mm Pre Contrast Chest and Neck
   f. Parallel Acquisition Technique (IPAT)
   g. T1 FLASH 3D Coronal 0.9 mm- 1.1 mm Pre Contrast Abdomen
   h. T1 FLASH 3D Coronal 0.9 mm- 1.1 mm Pre Contrast Upper Legs
   i. T1 FLASH 3D Coronal 1 mm- 1.3 mm Pre Contrast Lower Legs
   j. Parallel Acquisition Technique (IPAT)
   k. Contrast Administration and timing of Scan
      • Guess Timing Technique
      • Care Bolus Technique
      • Planning Care Bolus
   l. T1 FLASH 3D Coronal 0.9 mm- 1.1 mm Post Contrast Chest and Neck
   m. T1 FLASH 3D Coronal 0.9 mm- 1.1 mm Post Contrast Abdomen
   n. T1 FLASH 3D Coronal 0.9 mm- 1.1 mm Post Contrast Upper Leg
   o. T1 FLASH 3D Coronal 1 mm- 1.3 mm Post Contrast Lower Leg
      • Localizer 3 Plane Head And neck
      • Localizer 3 Plane Chest and abdomen
      • Localizer 3 Plane PC 2D abdomen
      • Localizer 3 Plane Upper Leg
      • Localizer 3 Plane PC 2D Upper Leg
      • Localizer 3 Plane Lower Leg
      • T1 FLASH 3D Coronal Pre Contrast Head, Neck and Chest
      • T1 FLASH 3D Coronal Pre Contrast Chest and Abdomen
      • T1 FLASH 3D Coronal Pre Contrast Upper Leg
• T1 FLASH 3D Coronal Pre Contrast Lower Leg
• T1 FLASH 3D Coronal Post Contrast Head, Neck and Chest
• T1 FLASH 3D Coronal Post Contrast Chest and Abdomen
• T1 FLASH 3D Coronal Post Contrast Upper Leg
• T1 FLASH 3D Coronal Post Contrast Lower Leg

“MR Review Course”:
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MR Review Course

Lecture 24

Title: MR Pathology, part I and II (120 minutes)


Objectives:
• Differentiate between the axial, coronal and sagittal planes of the body on magnetic resonance (MR) images
• Distinguish between normal and pathologic tissues on MR scans
• Locate pathology as demonstrated on MR images
• Describe the origin of each pathology presented in the module
• List symptoms associated with each pathology and condition
• Describe the disease progression for specific pathologies
• Discuss treatment options for certain pathologic conditions

Part I

Content:
I. Introduction
   1. Definition of Pathology
   2. Magnetic Resonance Imaging (MRI)
   3. Pulse Sequences
      a. T1 relaxation time
      b. T2 relaxation time
      c. Proton density
   4. Imaging Planes
      a. Axial
      b. Coronal
      c. Sagittal

II. Brain Anatomy
   1. Brain Stem
   2. Diencephalon
   3. Cerebrum
   4. Cerebellum
III. Brain Pathologies
1. Cavernoma or Cerebral Cavernous Malformation (CCM)
   a. Definition and Localisation
   b. Symptoms
   c. Case Study
2. Neuroglial Cyst
   a. Definition and Localisation
   b. Types
      • Astrocytes
      • Oligodendrocytes
      • Microglia
      • Ependymal
   c. Case Study
3. Meningioma
   a. Definition and Localisation
   b. Symptoms
   c. Case Study
4. Encephalomalacia
   a. Definition and Localisation
   b. Classification
      • Leukoencephalomalacia
      • Polioencephalomalacia
      • Red
      • Yellow
      • White
   c. Symptoms
   d. Case Study
5. Leukoencephalopathy
   a. Definition and Localisation
   b. Symptoms
   c. Case Study
6. Cerebral Infarction
   a. Definition and Localisation
   b. Symptoms
   c. Case Study
7. Small Vessel Occlusive Disease
8. Arnold-Chiari Malformation
   a. Definition and Localisation
   b. Four Types
   c. Case Study
9. Dandy-Walker Syndrome
   a. Definition and Localisation
   b. Symptoms
   c. Case Study
10. Acoustic Neuroma (Vestibular Schwannoma)
    a. Definition and Localisation
    b. Symptoms
    c. Case Study
11. Pituitary Adenoma
    a. Definition and Localisation
    b. Symptoms
    c. Groups
       • Functioning
       • Nonfunctioning
    d. Case Study
12. Brain Metastasis
   a. Definition and Localisation
   b. Symptoms
   c. Case Study
13. Subarachnoid Hemorrhage
   a. Definition and Localisation
   b. Symptoms
   c. Case Study
14. Subdural Hemorrhage
   a. Definition and Localisation
   b. Symptoms
   c. Case Study
15. Sinusitis
   a. Definition and Localisation
   b. Symptoms
   c. Case Study

IV. Cranial Vessels
   1. Basic Anatomy
      a. The circle of Willis
      b. Arteries and their Function
         • Anterior Cerebral Arteries (ACA)
         • Middle Cerebral Arteries (MCA)
         • Posterior cerebral arteries (PCA)
   2. Magnetic Resonance Angiography
   3. Cerebral Aneurysm
      a. Definition and Localisation
      b. Symptoms
      c. Case Study

V. Cervical Arteries
   1. Basic Anatomy
      a. Brachiocephalic artery
      b. Left common carotid artery
      c. Left subclavian artery
   2. Vertebral Artery Stenosis
      a. Definition and Localisation
      b. Symptoms
      c. Case Study

VI. Vertebral Column
   1. Vertebral Column Anatomy
      a. Vertebral Column Curvatures
         • Cervical spine
         • Lumbar spine
         • Thoracic spine
         • Sacrum curve
      b. Cervical Vertebrae
      c. Thoracic and Lumbar Vertebrae
      d. Sacrum and Coccyx
   2. Herniated Cervical Disc
      a. Definition and Localisation
      b. Symptoms
      c. Case Study
   3. Syringomyelia
a. Definition and Localisation
b. Symptoms
c. Forms
   • Communicating
   • Noncommunicating
d. Case Study
4. Herniated Lumbar Disc
   a. Definition and Localisation
   b. Symptoms
   c. Case Study
5. Tethered Cord
   a. Definition and Localisation
   b. Symptoms
   c. Case Study

VII. Summary

Part II

Content:
I. Introduction
   1. Definition of Pathology
   2. Magnetic Resonance Imaging (MRI)
   3. Pulse Sequences
data. T1 relaxation time
db. T2 relaxation time
c. Proton density
   4. Imaging Planes
da. Axial
db. Coronal
c. Sagittal
II. Abdominopelvic Cavity
   1. Abdominal and Pelvic Quadrants
   2. Abdominal and Pelvic Regions
III. Abdominal Pathologies
   1. Spleen
      a. Location and Functions
      b. Splenomegaly
         • Definition
         • Case Study
   2. Adrenal Glands
      a. Location and Functions
      b. Hormones
      c. Adrenal Tumor
         • Benign
         • Functioning
         • Malignant
         • Case Study
   3. Liver
      a. Location and Functions
      b. Liver Hemangioma
      c. Case Study
4. Magnetic Resonance Cholangiopancreatography (MRCP)
5. Biliary System
   a. Gallbladder
   b. Gallstones
      • Cholesterol
      • Pigment
   c. Case Study

IV. Magnetic Resonance Angiography (MRA)
   1. Definition and Functions

V. Celiac, Superior Mesenteric and Iliac Arteries
   1. Basic Anatomy
      a. Celiac Artery
      b. Superior Mesenteric Artery (SMA)
      c. Iliac Artery
   2. Arterial Stenosis and Sclerosis
      a. Definition
      b. Case Study

VI. Pelvis Pathologies
   1. Basic Anatomy of Female Reproductive Organs
      a. Uterus
      b. Ovaries
   2. Endometriosis
      a. Definition
      b. Symptoms
   3. Unicornuate Uterus
      a. Definition
      b. Symptoms
      c. Case Study
   4. Ovarian Cyst
      a. Definition
      b. Symptoms
      c. Case Study
   5. Ovarian Teratoma
      a. Definition
      b. Types
      c. Symptoms
      d. Case Study

VII. Appendicular Skeleton Pathologies
   1. Appendicular Skeleton
      a. Shoulder Girdle
         • Scapula
         • Clavicle
         • Glenohumeral Joints
         • Acromioclavicular Joints
         • Rotator Cuff
         • Labrum
      b. Bones of the Upper Extremities
         • Humerus
         • Radius
         • Ulna
         • Carpals
• Metacarpals
• Phalanges (fingers)

c. Pelvic Girdle (Bony Pelvis)
  • Location and Functions
  • Bones of Hip

d. Bones of the Lower Extremities
  • Femur
  • Neck of the Femur
  • Tibia
  • Fibula
  • Tarsals
  • Metatarsals
  • Phalanges (toes)

2. Labral Tear
   a. Definition
   b. Symptoms
   c. Case Study

3. Lipoma
   a. Definition
   b. Symptoms
   c. Case Study

4. MR Arthrogram
   a. Void Artifact

5. Rotator Cuff Tear
   a. Symptoms
   b. Case Study

6. Elbow joint
   a. Humeroulnar joint
   b. Humeroradial joint
   c. Radioulnar joint

7. Venous Hemangioma (Avernum hemangioma or Venous malformation)
   a. Definition
   b. Symptoms
   c. Case Study

8. Abscess
   a. Definition
   b. Symptoms
   c. Case Study

9. Cellulitis
   a. Definition
   b. Symptoms
   c. Case Study

10. Wrist and Hand

11. Ganglion Cyst
    a. Definition
    b. Symptoms
    c. Case Study

12. Triangular Fibrocartilage Complex
    a. Location and Functions
    b. Triangular Fibrocartilage Complex Tear
       • Types
       • Symptoms
       • Case Study

13. Case Study: Multiple Ligament Tears of the Wrist

14. Case Study: Fracture of the Superior Pubic Ramus
15. Case Study: Femoral Neck Fracture
16. Knee Joint
   a. Location and Functions
   b. Joints
      • Intermediate patellofemoral
      • Lateral tibiofemoral
      • Medial tibiofemoral
17. Meniscus Tear
   a. Definition
   b. Symptoms
   c. Case Study
18. Collateral Ligaments
   a. Definition
   b. Lateral Collateral Ligament Tear
      • Symptoms
      • Case Study
19. Ankle and Foot
   a. Basic Ankle Anatomy
20. Osteomyelitis
   a. Definition
   b. Symptoms
   c. Case Study

VIII. Fetal Magnetic Resonance Imaging
1. Advantages
2. Common Uses
3. Congenital Cystic Adenomatoid Malformation
   a. Definition
   b. Diagnostics
   c. Case Study
4. Sacrococcygeal Teratoma
   a. Definition
   b. Types
   c. Case Study
5. Diastematomyelia
   a. Definition
   b. Symptoms
   c. Case Study
6. Cystic Hygroma (Lymphangioma)
   a. Definition
   b. Function of the Lymphatic System
   c. Symptoms
   d. Case Study

IX. Summary

“MR Review Course”:
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MR Review Course

Lecture 25

Title: MRI Accreditation Program Requirements (60 minutes)

Keywords: American College of Radiology (ACR), Accreditation Program, Personnel Qualifications, Quality control program, Safety Policies, Image quality, Facilities, Medicare Improvement for Patients and Providers Act (MIPPA), Medicare, Time Requirements, Units, Physician responsibility, Radiologists, Physicians Supervising and Interpreting MRI Examinations, Physicians Supervising and Interpreting Cardiac MRI Examinations, Nuclear Medicine Physicians (Cardiac Only), Technologist, Medical Physicist/MR Scientist, Equipment, Quality Control, Acceptance Testing, Quality Control Testing, Accreditation Fees, Practice Parameters, Technical Standards

Objectives:
• Briefly review any modifications that the ACR has made and explain how patterns of practice and use of units have evolved
• Discuss the Improvement for Patients and Providers Act of 2008 (MIPPA)
• Understand the Mandatory Accreditation Time requirements and know the materials required and the date that they are due
• Discuss withdrawn, added or replacement units and understand how the amount of time left on the certificate determines the facility needs to submit
• Determine all the personnel qualifications of all interpreting physicians, medical physicists, and technologists working in MRI and understand how they must meet and document specific requirements in order for their facility to be accredited by the ACR

Content:
I. Introduction
   1. American College of Radiology (ACR)
   2. MRI Accreditation Program evaluates
      a. Qualifications of personnel
      b. Quality control program
      c. MR Safety Policies
      d. Image quality specific to MRI

II. Facilities and Accreditation

III. Changes in the MRI Accreditation Program
   1. Head
   2. Spine
   3. Body
   4. Musculoskeletal (MSK)
   5. Cardiac
   6. Magnetic Resonance Angiography (MRA)

IV. Medicare Improvement for Patients and Providers Act of 2008 (MIPPA)

V. Mandatory Requirements for Medicare Reimbursed Facilities

VI. Mandatory Accreditation Time Requirements

VII. Withdrawn, Added, or Replacement Units

VIII. Loaner Unit
IX. Emergency Use of Units

X. Personnel Qualifications
1. Emergency Use of Units
2. Physician responsibility
3. Initial Qualifications for Radiologists
4. Initial Qualifications for Other Physicians
5. Requirements for Physicians Supervising and Interpreting MRI Examinations
   a. Continuing Experience
   b. Continuing Education
6. Requirements for Physicians Supervising and Interpreting Cardiac MRI Examinations
   a. Initial Qualifications for Radiologists
   b. Initial Qualifications for Other Physicians
   c. Cardiologists 5 (Cardiac Only)
   d. Level 2 Requirements
   e. Level 3 Requirements
   f. Nuclear Medicine Physicians (Cardiac Only)
7. Continuing Experience and Education
   a. Radiologists
   b. Other Physicians
8. Technologist
   a. Minimum Criteria for Technologists
   b. Initial Qualifications for a Technologist
   c. Initial Qualifications for a Technologist: For Cardiac Module
   d. Initial Qualifications for a Technologist
   e. Continuing Education for a Technologist
   f. Registered technologists
   g. State Licensed Technologists
9. Medical Physicist/MR Scientist
   a. Minimum criteria
   b. Initial Qualifications for Medical Physicists
   c. Board Certified
   d. Not Board Certified in Required Subspecialty
   e. Grandfathered
   f. Qualifications for Continuing Experience: Medical Physicist and MR Scientist
   g. Qualifications for Continuing Education: Medical Physicist and MR Scientist

XI. Equipment
1. Quality Control
2. Acceptance Testing
3. Quality Control Testing
   a. Technologist's Weekly QC Tests
   b. Physicist/MR Scientist's Annual QC Tests
   c. Preventative Testing
4. Quality Assurance
   a. Physician Peer-Review Requirements
   b. MRI Safety
5. Accreditation Testing
   a. Clinical Images
      i. Head/Neck
      ii. Spine
      iii. MSK
      iv. Body
      v. MRA
      vi. Cardiac
b. Clinical Images Rules
  c. Phantom Testing and Image Quality

XII. Accreditation Fees

XIII. Additional Information

XIV. ACR Practice Parameters and Technical Standards

XV. Bibliography
MR Review Course

Lecture 26

Title: Professional and Communication Skills for the Imaging Technologist (40 minutes)

Keywords: Cultural Competence, Behavioral signs, Trust, Respect, Genuineness, Anxiety, Patient Education, Satisfaction, Patient Centered Teaching, Listening Skills, Body Language, Patient Education Guidelines, Essential Functions of the Technologist, Physical Requirements, Data Conception, Color Discrimination, Manual Dexterity/ Motor Coordination, Physical Communication, Language Development, Numerical Ability, Form/ Spatial Ability, Personal Temperament

Objectives:
• Discuss Cultural Competence
• Review Behavioral Signs of a good listener and Effective Listening Skills
• Brief review Trust, Respect, and Genuineness
• Understand Learning & Anxiety
• Explain Patient Satisfaction, Patient Centered Teaching, Body Language Patterns
• Discuss Patient Education Guidelines
• Define Technical Standards and Minimum Qualifications

Content:
I. Cultural Competence
   1. Principles of Cultural Identity
      a. Communication Skills
         • Culture
         • Ethnicity
      b. Cultural Blindness
   2. Personal Attributes
   3. Knowledge
   4. Skills
   5. Recognizing your cultural programming
   6. Where Cultural Differences Exist?
      a. Values & norms
      b. Beliefs & Attitudes
      c. Relationship Patterns
      d. Communication & Language
      e. Daily Activities

II. Behavioral signs of a good listener
   1. Eye Contact
   2. Postural Position
   3. Verbal Quality
   4. Verbal Messages

III. Trust, Respect, and Genuineness
   1. Verbal and Non-verbal communications
   2. Establishing Trust
      a. Global Behaviors
      b. Specific communication techniques

IV. Learning & Anxiety
   1. Level of Anxiety
      a. Mild
      b. Moderate
c. Severe
d. Panic

2. Patient Education & Learning “ASSURE”

V. Patient Satisfaction

VI. Patient Centered Teaching

VII. Effective Listening Skills

VIII. Body Language Patterns
   1. Aggressive Patterns
   2. Appeasing pattern
   3. Non-defensive pattern

IX. Teaching Health Information

X. Patient Education Guidelines Written Materials

XI. Technical Standards
   1. Essential Functions of the Technologist
      a. Monitor a patient's condition
      b. Maintaining the equipment
      c. Making sure that all necessary supplies are available
      d. Preparing and administering Radiopharmaceuticals
      e. Administering emergency procedures
   2. Physical Requirements
   3. Data Conception
   4. Color Discrimination
   5. Manual Dexterity/ Motor Coordination
   6. Physical Communication

XII. Minimum Qualifications
   1. Reasoning Development
   2. Language Development
   3. Numerical Ability
   4. Form/ Spatial Ability
   5. Personal Temperament

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Lecture 27

Title: Introduction to HIPAA for the Imaging Technologist (40 minutes)

Keywords: Health Insurance Portability and Accountability Act (HIPAA), Patient Health Information, Patient privacy, Violations, Privacy Rule, Protected health information (PHI), Permitted Uses and Disclosures, Written permission, Incidental Disclosures, Request Amendment, Business Associates, Technologist Training, Public Law, Individually Identifiable Health Information (IIHI), CMU, Civil Penalties, Criminal Penalties, Lawsuits

Objectives:
- Discuss Importance of Protecting Patient Health Information
- Overview General HIPAA and Privacy Rule
- List Permitted Uses and Disclosures
- Review Patients' Rights to Control their Health Information
- Define Personal HIPAA Compliance Checklist Discuss Administrative Requirements
- Explain Basic HIPAA Training for Technologist with access to PHI

Content:

I. Introduction
   1. Health Insurance Portability and Accountability Act (HIPAA)

II. The Importance of Protecting Patient Health Information
   1. General Rules
   2. Additional examples of actions to protect patient privacy
   3. Consequences of Violations
   4. HIPPA rules and good care

III. General HIPAA and Privacy Rule
   1. Administrativ Simplification
   2. Protected health information (PHI)
   3. The Privacy Rule
      a. Parents and Minors

IV. Permitted Uses and Disclosures
   1. Purposes for Use or Disclose PHI
   2. Additional Permitted
   3. Written permission
   4. Specific procedures
   5. General Data Disclosures
   6. Incidental Disclosures
   7. Permitted Uses and Disclosures to Carry Out Treatment, Payment, and Health Care Operations
      a. Treatment
      b. Payment
      c. Health Care Operations
   8. "Public Good" Uses and Disclosures
      a. List for use or disclose PHI without the written authorization
      b. Authorization Requirements
      c. Additional Written Authorizations
   9. Incidental Disclosures
V. Patients' Rights to Control their Health Information
   1. Tracking Disclosures or the “Accounting of Disclosures Log”
   2. Right to Request Amendment

VI. Administrative Requirements
   1. Business Associates Overview
   2. Practical Examples of Appropriate Behavior Under HIPAA

VII. Personal HIPAA Compliance Checklist

VIII. Basic HIPAA Training for Technologist with access to PHI
   1. Who Needs Training and Why?
   2. Summary of the Law
   3. What is Protected by HIPAA?
      a. Individually Identifiable Health Information (IIHI)
      b. Examples of PHI
      c. Direct and Indirect identifiers
   4. Subject to HIPAA
   5. How HIPAA Protects PHI?
   6. Who May Use PHI?
      a. CMU workforce members trained on HIPAA privacy
      b. General Rule
      c. Permitted Uses For PHI
         • Treatment
         • Payment
         • Health care operations
      d. Minimum Necessary Rule
   7. Safeguarding PHI
   8. Why should we care about the HIPAA rules?
      a. CMU
      b. Civil Penalties
      c. Criminal Penalties
      d. Lawsuits
   9. HIPAA Web Links

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MR Review Course

Lecture 28

Title: MR Contrast Agents Treatment and Reactions Part II (60 minutes)

Keywords: Regulatory Authority, Imaging Agents or Tracers, Types of Medical Imaging Agents, Contrast Agents, MRI Contrast Agents, Gastrointestinal MRI contrast agents, Intravenous MRI contrast agents, Intravascular (blood pool) MRI contrast agents, Tumor specific MRI contrast agents, Hepatobiliary MRI contrast agents, Reticuloendothelial MRI contrast agents, Gadolinium Contrast Medium (MRI Contrast agents), Contrast Agent Nanoparticle, Risk of Contrast Agent, Treatment Of Contrast Reactions

Objectives:
• Discuss the Contrast agent for MRI and PET Scan
• Explain Various forms of contrast media have been used to improve medical imaging
• Describe Contrast agent reaction and Treatment
• Recognizing and managing the small but real risks inherent in the use of contrast media

Content:
I. Introduction

II. Regulatory Authority
1. European Medicines Agency (EMA)
2. Food and Drug Administration (FDA or USFDA)

III. Imaging Agents or Traders
1. Common Names
   a. Contrast Agent
   b. Radioactive Agent
   c. Radioactive Dye
   d. Radiopharmaceutical
2. Diagnosis or monitoring modalities
   a. Radiography, computed tomography (CT)
   b. Ultrasonography
   c. Magnetic resonance imaging (MRI)
   d. Radionuclide imaging
3. Categories of Medical Imaging Agents
   a. Diagnostic Radiopharmaceuticals
   b. Contrast Agents
      • 64Cu-ATSM
      • FDG (18F-fluorodeoxyglucose)
      • 18F-fluoride
      • FLT
      • FMISO
      • Gallium
      • Technetium-99m
      • Thallium
4. Contrast materials enter the body in one of three ways
   a. Swallowed
   b. Administered by enema
   c. Injected into a blood vessel
IV. MRI Contrast Agents
1. Definition of Contrast in MRI
2. History
3. Why we need Contrast Agents
4. Paramagnetic
5. Diamagnetism
6. Superparamagnetic
7. Ferromagnetic

V. Gastrointestinal MRI contrast agents
1. Positive Contrast Agents
   a. Paramagnetic Agents
   b. Short T1-relaxation Agents
   c. Combination Contrast Agents
2. Negative Contrast Agents
   a. Diamagnetic Agents
   b. Superparamagnetic Agents
   c. Perfluorochemicals Agents

VI. Intravenous MRI contrast agents
1. Ionics
2. Nonionics
   a. Gadodiamide
   b. Gadoteridol

VII. Intravascular (blood pool) MRI contrast agents
1. Advantages of Intravascular Agents
2. Types of Intravascular Contrast Agents
   a. Gd-DTPA labeled albumin
   b. Gd-DTPA labeled dextran
   c. Chromium-labeled red blood cells

VIII. Tumor specific MRI contrast agents
1. Monoclonal antibodies
2. Metalloporphyrins
3. Nitroxides
4. Ferrioxamine methanesulfonate

IX. Hepatobiliary MRI contrast agents
1. Manganese chloride
2. Hepatobiliary chelates

X. Reticuloendothelial MRI contrast agents
1. Liver and spleen imaging
2. Lymph node imaging

XI. Gadolinium Contrast Medium (MRI Contrast agents)
1. Gadolinium contrast medium
2. Why do I need to have gadolinium contrast medium?
3. The risks of gadolinium contrast medium injections
XII. MRI Contrast Agent Nanoparticle
   1. Nanoparticles (NPs)
   2. Effects of SPIONs on MRI contrast

XIII. Risk of Contrast Agent
   1. Gadolinium-Based Contrast Agents Linked to Brain Hypersensitivity
   2. Categories of Reactions
      a. Mild
      b. Moderate
      c. Severe
   3. Types of reactions
      a. Anaphylactoid
      b. Nonanaphylactoid
         • Hemotoxic reactions
         • Vasovagal reactions
         • Idiopathic reactions
      c. Combined (A and B)
   4. Incidence of Adverse Effects
   5. Patient Selection and Preparation Strategies
   6. Administration of contrast medium to breast feeding mothers
   7. Injection of Contrast Media
   8. Injection Discomfort / Pain
   9. Extravasation Risk Factors
   10. Extravasations of IV contrast
   11. Contrast Reactions In Children
   12. Adverse Reactions to Gadolinium-based Contrast Media
   13. Treatment
   14. Other Risk Factors
   15. Administration of IV Contrast Media
      a. Policy
      b. Procedure

XIV. Treatment Of Contrast Reactions
   1. Five important immediate assessments
   2. Administration Of Contrast Media To Pregnant Or Potentially Pregnant Patients
   3. Gadolinium-Based Contrast Agents (GBCAs)
      a. Mutagenic effect of GBCAs
      b. Risk of nephrogenic systemic fibrosis
      c. Recommendations for the use of GBCA-enhanced MRI examinations in pregnant patients
   4. Administration Of Contrast Media To Women Who Are Breast-Feeding
      a. Recommendation
   5. Organ and System-Specific Adverse Effects from the Administration of Iodine-Based or Gadolinium-Based Contrast Agents
   6. Treatment of Acute Reactions to Contrast Media in Children
   7. Management of Acute Reactions to Contrast Media in Adults
   8. Equipment for Contrast Reaction Kits in Radiology
   9. Warming of Gadolinium-Based Contrast Media—Suggestions
      a. Recommendation
MR Review Course

Lecture 29

Title: Standards of Ethics for the Imaging Technologist (40 minutes)

Keywords: Code of Ethics for the Imaging Technologist (ETHICS), Rules of ETHICS, Fraud, Deceptive Practices, Subversion, Unprofessional Conduct, Improper Management of Patient Records, Violation of State or Federal Law or Regulatory Rule, Duty to Report, Administrative Procedures, Ethics Committee, Hearings, Appeals, Publication of Adverse Decisions, Procedure to Request Removal of a Sanction, Amendments to the Standards of Ethics

Objectives:
• Discuss Code of Ethics for the Imaging Technologist (ETHICS)
• Define Rules of ETHICS
• Explain Administrative Procedures

Content:
I. Preamble

II. Statement of Purpose

III. Code of Ethics for the Imaging Technologist (ETHICS)

IV. Rules of ETHICS
1. Fraud or Deceptive Practices
   a. Fraud Involving Certification and Registration
   b. Fraudulent Communication Regarding Credentials
   c. Fraudulent Billing Practices
2. Subversion
   a. Examination / CQR Subversion
   b. CE Subversion
   c. Failure to Cooperate with ARRT Investigation
3. Unprofessional Conduct
   a. Failure to Conform to Minimal Acceptable Standards
   b. Sexual Misconduct
   c. Unethical Conduct
4. Scope of Practice
   a. Technical Incompetence
   b. Improper Supervision in Practice
   c. Improper Delegation or Acceptance of a Function
5. Fitness to Practice
   a. Actual or Potential Inability to Practice
   b. Inability to Practice by Judicial Determination
6. Improper Management of Patient Records
   a. False or Deceptive Entries
   b. Failure to Protect Confidential Patient Information
   c. Knowingly Providing False Information
7. Violation of State or Federal Law or Regulatory Rule
   a. Narcotics or Controlled Substances Law
   b. Regulatory Authority or Certification Board Rule
   c. Criminal Proceedings
8. Duty to Report
   a. Failure to Report Violation
   b. Failure to Report Error
V. Administrative Procedures

1. Ethics Committee
   a. Membership and Responsibilities of the Ethics Committee
   b. The Chair of the Ethics Committee
   c. Preliminary Screening of Potential Violation of the
   d. Alternative Dispositions
   e. Summary Suspensions
   f. Voluntary Surrender of Credentials
   g. Civil or Criminal Penalties

2. Hearings

3. Appeals

4. Publication of Adverse Decisions

5. Procedure to Request Removal of a Sanction

6. Amendments to the Standards of Ethics

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Lecture 30

Title: PET/MR Artifacts (60 minutes)

Keywords: Aliasing, Artifact (error), Patient Related, Motion Artefacts, Magnetic Susceptibility , Metal Artefacts, Chemical Shift Artefacts, Black Line, Partial Volume, Zebra Stripes, Entry Slice Artefacts, Magic Angle Artefacts, Zipper artifact, Noise, Bo Inhomogeneity, Gradient, Flow Artifact, Image Distortion, Integrating PET/MR System, Motion Correction, Implanted Material Artefacts, PET/MRI Respiratory motion Artifact

Objectives:
- Discuss what is Aliasing
- Review what is Artifact (error)
- Explain MRI Artifact
- Understand MRI Motion Artifact
- Discuss Integrating PET/MR System
- Understand what MR can do for PET and what PET can do for MR
- Review PET/MR Motion Correction
- Review PET/MR Implante Material Artifacts and PET/MRI Respiratory motion Artifact

Content:
I. Aliasing
   1. Definition
   2. How to avoid Aliasing?

II. Artifact (error)
   1. Definition
   2. Sources of Artifacts
      a. Hardware Issues
      b. Software problems
      c. Physiological phenomena
      d. Physics limitations

III. MRI Artifact
   1. Patient Related
      a. Motion Artefacts
      b. Magnetic Susceptibility Artefacts
         • Diamagnetic
         • Paramagnetic materials
         • Superparamagnetic
         • Ferromagnetic materials
      c. Metal Artefacts
      d. Chemical Shift Artefacts
      e. Black Line Artefacts
      f. Partial Volume Artefacts
      g. Zebra Stripes
         • Moire fringes
         • Zero-fill artifact
         • Spike in k-space
      h. Entry Slice Artefacts
      i. Magic Angle Artefacts
   2. Zipper artifact MRI
3. DC Offset and Quadrature Ghost
4. RF Noise
5. Bo Inhomogeneity
6. Gradient
7. Flow Artifact
8. Image Distortion in Clinical PET/MRI
9. PET/MR Imaging artifacts

IV. MRI Motion Artifact
   1. Motion Respiratory Motion Artifact
   2. Signal Averaging
   3. Respiratory Triggering/Gating
   4. Gradient moment nulling
   5. Fat Suppression Methods
   6. Cardiac Motion

V. Integrating PET/MR System
   1. PET effects on the MR
   2. MR effects on the PET
   3. What MR can do for PET
   4. What PET can do for MR
   5. Ways in Which MRI Can affect PET
   6. Ways in Which PET Can affect MRI
   7. MR and PET Can Help Each Other

VI. PET/MR Motion Correction

VII. PET/MR Implanted Material Artifacts
   1. Different appearances of artifacts

VIII. Effect of MRI-based PET AC
   1. Whole body [18 F]-FDG PET/MRI study with truncation artifact
   2. Coronal [18 F]-FDG PET/MRI of a Dementia Patient

IX. PET/MRI Respiratory motion Artifact
   1. Partial volume effects (PVE) affect PET data quantification
   2. Pitfalls in hybrid positron emission tomography/MRI