

12.2 MRI Registry Review

**Part II
Patient Care
&
Imaging Procedures Review**

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Outline

- Patient Care Review
 - MR Safety
 - General Patient Care
- Imaging Procedures Review
 - Sectional Anatomy Overview
 - Imaging Procedures

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Slide # 2

Objectives

Upon completion of this course, the attendee should...

1. Know aspects of MR safety
2. Understand General Patient Care
3. Understand Imaging Procedures & Anatomy

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Slide # 3

Categories of Questions

CONTENT SPECIFICATIONS FOR THE EXAMINATION IN MAGNETIC RESONANCE IMAGING

Publication Date: November 2005
Implementation Date: January 2006

Content Category	Number of Questions ¹
A. Patient Care	30
B. Imaging Procedures	65
C. Data Acquisition and Processing	43
D. Physical Principles of Image Formation	200

Part II 30

1. A special debt of gratitude is due to the hundreds of professionals participating in this project as committee members, survey respondents, and reviewers.

2. Each exam includes an additional 20 unscored (pilot) questions. On the pages that follow, the approximate number of test questions allocated to each content category appears in parentheses.

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Patient Care Category

MRI Safety & Patient Care

A. PATIENT CARE (30)

1. Legal and Ethical Principles

A. Confidentiality of Exam Requests

B. Release of patient information

C. Comparison of request to clinical indication

D. Legal Issues

1. informed consent (informed, not implied)

2. legal disclosure (informed, not implied)

3. patient's right to refuse

4. patient's right to privacy

5. patient's right to information (health care records, research participation)

6. patient's right to financial information

7. patient's right to financial information

8. patient's right to financial information

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30. patient's right to financial information

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Slide # 5

Patient Care Category ... MRI Safety Issues

II. MRI Screening and Safety (11)

A. Screening

1. biomedical implants (e.g., pacemakers, clips)

2. ferrous foreign bodies

3. medical conditions

4. prior diagnostic or surgical procedures

B. Equipment Safety

1. placement of conductors (e.g., ECG leads, coils, cables)

2. oxygen safety

3. ancillary equipment in proximity

4. emergency procedures (e.g., quench, fire)

C. Environment

1. climate control (temperature, humidity)

2. gauss lines

3. magnetic shielding

4. RF-shielding

5. warning signs

D. Biological Considerations

1. RF Field

a. specific absorption rate (SAR)

b. biological effects

c. FDA guidelines

III. Patient Assessment, Monitoring and Management (6)

A. Routine Monitoring

1. vital signs

2. physical signs and symptoms

B. Emergency Response

1. reactions to contrast

2. cardiac/respiratory arrest (CPR)

3. physical injury, trauma, or RF burn

4. other medical disorders (e.g., seizures, diabetic reactions)

5. life-threatening situations (e.g., quench, projectiles)

C. Patient Transfer and Body Mechanics

D. Assisting Patients with Medical Equipment

1. implantable devices (e.g., infusion catheters, pumps, pacemakers, others)

2. oxygen delivery systems

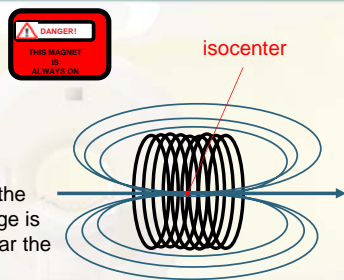
3. other (e.g., nasogastric tubes, urinary catheters)

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Magnetic Forces

- Rotational
 - Strongest at isocenter
- Translational
 - Greatest where the fringe field change is most severe (near the bore)
 - Contributes to “missile effects”



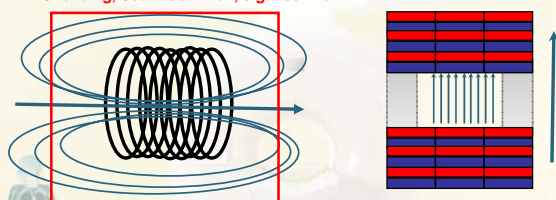
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Fringe Field Considerations

Shielding, Scan room wall, 5 gauss line



- Magnetic Field strength can be expressed in units of tesla (T) or gauss (g)
- $10,000 \text{ g} = 1 \text{ T}$
- The fringe field is generally expressed in units of gauss
- Isocenter is generally expressed in units of Tesla
- The General Public is to be kept outside the 5 gauss line – of the fringe field!

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Imager Considerations - Zoning

Zone I:

This includes all areas that are freely accessible to the general public

Zone II:

This area is the interface between the publicly accessible uncontrolled Zone I and the strictly controlled Zone III

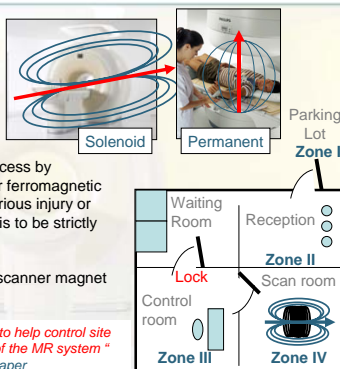
Zone III:

This area is the region in which free access by unscreened Non-MR Personnel and/or ferromagnetic objects and equipment can result in serious injury or death ... All access to at least Zone III is to be strictly restricted, with access ...

Zone IV:

This area is synonymous with the MR scanner magnet room itself;

“The concept of designating various zones to help control site access relative to the static magnetic field of the MR system”
Excerpt from the ACR white paper



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MR Personnel

• Level 1

Individuals who have passed minimal safety educational efforts to ensure their own safety as they work within Zone III regions will be referred to as Level One MR Personnel (e.g., M.R.I. department office staff, patient aides).

• Level 2

Individuals who have been more extensively trained and educated in the broader aspects of MR safety issues including issues related to the potential for thermal loading/burns, direct neuromuscular excitation from rapidly changing gradients, etc., will be referred to as Personnel (e.g., M.R.I. Technologists, Radiologists, Radiology Department nursing staff).

• Non-MR Personnel,

–Patients, visitors, or facility staff who do not meet the criteria of Level One or Level Two MR Personnel.

“The ACR White Paper indicates that the medical director should be primarily responsible for the MR-safety training program.” Excerpt from the ACR white paper

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Who needs Patient Screening

- Everyone who want to enter the MR environment
- Patient
- Family / Visitors
- Ancillary Staff Education
 - Transport personnel
 - Construction / Maintenance
 - Nursing
 - Patient Support
- Emergency Response
 - Security
 - Fire Department

Anyone who intends to enter The MRI Scan room!



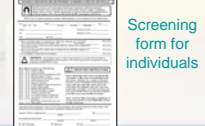
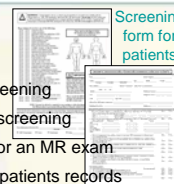
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How should MR Screening be done?

- Should be performed by trained individuals (Level 2)
- Screening should be performed more than once
- Screening with written, verbal interview & “visual” screening
- Screen all visitors as well as patients and document screening
- Screen and document each time a patient presents for an MR exam
- Document & Maintain screening documentation with patients records
- It is prudent to change all patients into a hospital gown, prior to the MR procedure, to avoid any metal from accidentally entering the MR scan room ... and/or to possibly notice surgical scars that the patient may have forgotten.
- Screen everyone that enters the room as if they are having the procedure themselves
- Forms available at www.mrsafety.com



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Why should screening be performed?

To determine...

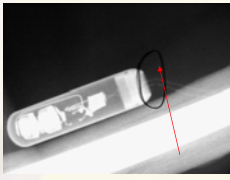
- MR Unsafe
- ...The big 3 contraindications
 - Pacemaker
 - Metal eyes
 - Aneurysm clip
- MR Safe
- MR Conditional



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Implants in MR

- Medical Risk vs. Benefit Decision
- Be sure to check field strength that the device / implant has been tested
- Up-to-date information is crucial
- Beware of blanket statements!**
 - Example: all stents are not safe
- www.mrisafety.com
- www.imrser.org
- www.drkanal.com
- Concerns for Implants & Devices
 - Torque / movement (translational forces)
 - Electrical current induction (burns)
 - Tissue Heating (burns)
 - Device Failure



Bone growth stimulator with broken leads


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Patient Emergency

All MR personnel should be familiar with the procedure for removing a patient from the MR scan room in the event of a medical emergency

- MR "safe" supplies for imaging
- Non-ferrous IV poles
- Non-ferrous Wheel chairs
- Non-ferrous IV poles
- Stretchers
- Non-ferrous IV poles
- MR "safe" monitoring devices & more!
- "Zone III & Zone IV site access restriction must be maintained during resuscitation and / or other emergencies" Excerpt from the ACR White paper on MRI Safety.




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Quench Potential for Superconducting Magnets

- Uses Cryogenics
 - Liquid Helium
- Helium Stable as gas
 - Helium 750 (air) to 1 liquid
 - 1,000 liquid liters per magnet
 - 750,000 liters of gas inside the magnet!
- Quench
 - Boil off of cryogen
- Quench Hazards in the MR Scan room
 - Increased pressure, can't open door
 - Reduced room Temperature – Frostbite
 - Reduced Oxygen – Asphyxia




Boil off of cryogen


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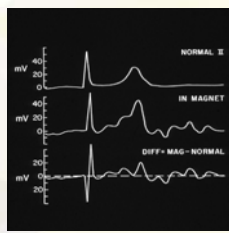
Magnet – Hemodynamic Effect



Blood flowing in the Aorta



MRA or the thoracic vasculature



ecg of patient outside the bore

ecg of patient within the bore

ecg of patient within the bore fixed

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Gradient Magnetic Fields

Produced by gradient Coils

FDA/CDRH

Criteria for Significant Risk Investigations of Magnetic Resonance Diagnostic Devices

Issued - 07/14/03

"Any time rate of change of gradient fields (dB/dt) sufficient to produce severe discomfort or painful nerve stimulation."

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Gradient Sounds

- Scans & options
 - high speed gradients
 - EPI
 - Diffusion
 - Perfusion
- No loops within the magnet



- Patients for increased risk of anxiety due to acoustic noise:
 - head trauma
 - elderly
 - pediatric
 - psychiatric disorders

Temporary hearing loss has been reported using conventional sequences.

- Earplugs** - can reduce noise by 10 to 20 dB
- Recommended for all patients
 - Recommended for anyone in scan room
 - To reduce temporary, and permanent acoustic damage

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FDA Limit for Static Field

July 14, 2003

Population	Limit
Adults, children and infants > 1 Month	8 T
Infants 1 month or less	4 T

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Imaging

Bioeffects of RF



Nonionizing Electromagnetic Radiation

- Most of the RF power used in MR imaging is transformed into heat that is absorbed in the patient's tissues
- Bioeffect of RF absorption is heating of tissue
- FDA limits to an increase in core body temperature of 1°C

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Imaging

Radiofrequency Fields

FDA/CDRH Criteria for Significant Risk Investigations of Magnetic Resonance Diagnostic Devices

Issued - 07/14/03

Specific Absorption Rate (SAR)

Site	Dose \geq (W/kg)	Time (min)	SAR
whole body	averaged over	15	4
head	averaged over	10	3
head or torso	per gram of tissue	5	8
extremities	per gram of tissue	5	12

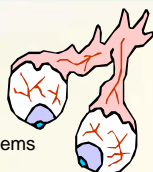
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Imaging

Scans with increased RF

- Scans & options
 - Magnetic Transfer MTI
 - Fast Spin Echo FSE
 - More heat / more RF pulses
 - Double the flip, 4 x the power
- Patients with compromised thermoregulatory systems
 - higher risk for RF effects
- Patients with higher risk
 - cardiovascular disease, hypertension, diabetes, fever, elderly & obese
 - Certain medications can alter thermoregulatory response to heat load.
- Areas of Particular Concern
 - Eyes
 - Testis



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Imaging

Other Burn Possibilities

- Tattoos
- Metal in transdermal patches
- Metallic leads/probes
 - Coil cables
 - ECG leads
- Risk increases with field strength



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Imaging

Contrast Safety

- Extravasation
- Nephrotoxicity
- Adverse Events



English Biol Foundation (2006) 11: 1740
doi:10.1007/s10238-006-0008-0

GD294 - Erratum

Gadolinium—a specific trigger for the development of nephrogenic fibrosis dermopathy and nephrogenic systemic fibrosis?

Thomas Griebner

Nephrol Dial Transplant April 2006; 21: 1104-1108

NDT

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ACR Recommendations for Claustrophobic Patients

1. Prepare the patient (explanation)
2. Allow a family member to accompany
3. Maintain verbal/visual contact
4. Headphones
5. Monitor – distraction
6. Virtual reality
7. Feet-first
8. Prone
9. Mirrors or prism glasses
10. Blindfold
11. Lights
12. Fan
13. Lemon or vanilla scent
14. Relaxation techniques
15. Systematic desensitization
16. hypnosis

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Monitoring Devices

MR compatible monitors & devices

- ECG
- Pulse Oximeters
- Blood Pressure
- Respiratory & Apnea
- Temperature
- Multi-parameter monitoring systems



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Slide # 27



Safety Category ... New Patient Care Issues

<p>I. Legal and Ethical Principles (4)</p> <p>A. Confirmation of Exam Requestion</p> <ol style="list-style-type: none"> 1. verification of patient identification 2. comparison of request to clinical indications <p>B. Legal Issues:</p> <ol style="list-style-type: none"> 1. common terminology (e.g., negligence, malpractice) 2. legal doctrines (e.g., respondent superior, res ipsa loquitur) <p>C. Patient's Rights</p> <ol style="list-style-type: none"> 1. informed consent (written, oral, implied) 2. confidentiality (HIPAA) 3. Patient's Bill of Rights (e.g., privacy, access to information, health care proxy, research participation) <p>D. ARRT Standard of Ethics</p>	<p>III. Patient Assessment, Monitoring and Management (6)</p> <p>A. Routine Monitoring</p> <ol style="list-style-type: none"> 1. vital signs 2. physical signs and symptoms 	<p>V. Infection Control (4)</p> <p>A. Terminology and Basic Concepts</p> <ol style="list-style-type: none"> 1. types of asepsis 2. sterile technique 3. pathogens (e.g., fomites, vehicles, vectors) 4. nosocomial infections <p>B. Cycle of Infection</p> <ol style="list-style-type: none"> 1. pathogen 2. source or reservoir of infection 3. susceptible host 4. method of transmission (contact, droplet, airborne, common vehicle, vector borne) <p>C. Standard Precautions (general patient contact)</p> <ol style="list-style-type: none"> 1. handwashing 2. gloves, gowns 3. masks 4. medical asepsis / disinfection <p>D. Additional or Transmission-Based Precautions (e.g., Hepatitis B, HIV, tuberculosis)</p> <ol style="list-style-type: none"> 1. airborne (e.g., negative ventilation) 2. droplet (e.g., particulate mask) 3. contact (e.g., gloves, gown) <p>E. Disposal of Contaminated Materials</p> <ol style="list-style-type: none"> 1. linen 2. needles 3. patient supplies
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Vital Signs

- Pulse
- Respiration
- Blood Pressure
- Temperature
- Oxygen Saturation



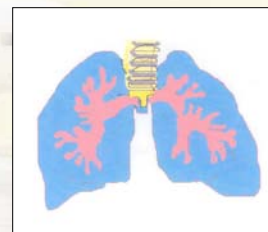
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Vital Signs - Respiration

- **Normal Adult**
 - 12-20 BPM
- **Bradypnea**
 - 12 or below
- **Tachypnea**
 - 25 or above
- **Description**



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Pediatric Respiratory Rate

- Average Ranges:
 - Ages 1-8 years:
 - 15-30 BPM
 - Infants (1-12 months):
 - 25-50 BPM
 - Neonates (1-28 days):
 - 40-60 BPM



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Vital Signs – Blood Pressure

• Normal Adult Range

- 90 - 120 mm Hg
- 60 - 80 mm Hg

• Hypertension

- Stage 1
 - Systolic 140-159
 - Diastolic 90-99
- Stage 2
 - Systolic 160 or higher
 - Diastolic 100 or higher



• Hypotension

- below 50 diastolic
- below 90 systolic

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Vital Signs - Temperature

- Normal
 - 96.8F-100.4F oral
 - 0.5 to 1 degree F higher(rectal)
 - 0.5-1 degree F lower (axillary)
- Low temperature
- High temperature



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Pulse Oximetry

- Monitors oxygen saturation of hemoglobin (SaO₂)
- Sensor is usually attached to finger tip
- Normal range
 - 95%-100%
- Mild Hypoxia
 - 91% - 94%
- Moderate Hypoxia
 - 86% - 90%
- Severe Hypoxia
 - 85% or below



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Oxygen Administration

- Oxygen is a medication
- In emergency situations administer 2L/min
- High L/min delivery requires a humidification system to preserve mucosal membranes



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Observation & Blood Lab values

- Observation
 - Actually look at and evaluate the patient.
 - Skin color
 - Skin temperature
 - Level of consciousness
 - Sudden change in mental acuity may indicate a serious problem occurring
 - Breathing
 - Anxiety
 - **ALWAYS NOTE ANY CHANGES**
- Blood Values!

Renal Function

BUN... Blood Urea Nitrogen

- Indicates gross glomerular function.
- The ability to produce and excrete urea.
 - Child 5 - 18 mg/dL
 - Adult 7 - 18 mg/dL
 - Adult 8 - 20 mg/dL over 60


Clotting Factors

- PT - less than 13 seconds
- PTT - less than 30-45 seconds
- Platelet count - 140,000/mm³ - 400,000/mm³


Creatinine

- Creatine breaks down to form creatinine
- Creatinine is excreted entirely by the kidneys and levels should remain constant
- Amount of nitrogenous waste
- Index for kidney disease
 - 0-3 yrs 0.3-0.7 mg/dL
 - 3-18yrs 0.5-1.0 mg/dL
 - 18 & up 0.6-1.3 mg/dL


Informed Consent



- Written form of consent
- Used for contrast administration and imaging guided biopsies
- Full explanation of procedure, risks and benefits by healthcare personnel determined to be an expert on the exam or procedure
- Explanations must be given and consent form signed prior to sedation administration
- Patient must be deemed competent to sign
- All blanks must be filled in before form is signed
- All conditions stated on form must be met
- **Consent can be revoked at any time!**





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Legal Issues for Imaging

Why should we care?

- Code of Ethics
- Practice Standards
 - ASRT www.asrt.org
 - ARRT www.arrt.org
 - JCAHO www.joint.commission.org
 - Institutional Policies





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Types of Law


- **CIVIL LAW**
 - Money
- **CRIMINAL LAW**
 - Fines and jail time
- **ADMINISTRATIVE LAW**
 - Loss of license



Plaintiff
vs.
Defendant





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Latin Terms

- **Respondeat superior**
 - Let the master answer
- **Res ipsa loquitur**
 - The thing speaks for itself
- **Stare decisis**
 - To stand by things decided
 - Prevents multiple suits based on the same evidence



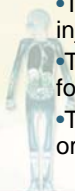



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Malpractice

- **To establish a claim of malpractice, four conditions must be proved true:**
 - The defendant had a duty to provide reasonable care to the patient
 - The patient sustained some loss or injury
 - The defendant is the party responsible for the loss
 - The loss is attributable to negligence or improper practice

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Health Insurance Portability Accountability Act


Increased incidence of breach of confidentiality
Easier access to patient records
HIPAA (1996)

Provides regulations to establish criteria in authorizing release of medical information

ANY INFORMATION THAT A HEALTHCARE PROVIDER LEARNS WHILE TAKING CARE OF A PATIENT IS CONFIDENTIAL, EVEN IF IT DOES NOT RELATE DIRECTLY TO TREATMENT OF THE PATIENT.



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Imaging Procedures... Now

B. IMAGING PROCEDURES (60)

TYPE OF STUDY	NUMBER OF QUESTIONS
1. Head & Neck	(16)
2. Spine	(10)
3. Thorax	(10)
4. Abdomen	(8)
5. Pelvis	(8)

B. IMAGING PROCEDURES (34)

TYPE OF STUDY	NUMBER OF QUESTIONS
1. Head & Neck	(16)
2. Spine	(10)
3. Thorax	(10)
4. Abdomen	(8)
5. Pelvis	(8)

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Basic Brain "Vanilla" Protocol with sprinkles

- Axial T1_pre**
Generally SE – can be GE
22 cm x 16 cm FOV
5 mm / 1mm
192 x 256
TR = 600 ms
TE = 10 ms
- Axial T1_post gadolinium**
Generally SE – can be GE for dynamic
22 cm x 16 cm FOV
5 mm / 1 mm
192 x 256
TR = 600 ms
TE = 10 ms
- Coronal T1_post gad. ("quasi delayed")**
Generally SE –
22 cm x 16 cm FOV
5 mm / 1 mm
192 x 256
TR = 600 ms
TE = 10 ms

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Overview Neuro Anatomy

Anterior Horns
Lateral Ventricles
3rd vent
IAC's
4th ventricle
Posterior Horns of the Lat. Vents
Genu
Corpus callosum
Anterior Horns
Lateral Ventricles
Caudate nucleus
Lentiform nucleus
3rd vent
Thalamus
pons
4th ventricle
Posterior Horns of the Lat. Vents

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Brain Anatomy: Circle of Willis

Anterior Cerebral Arteries
Anterior Communicating Artery
Middle Cerebral Artery
Posterior Communicating Artery
Posterior Cerebral Artery

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Spinal Anatomy Brachial Plexus & Lumbar Plexus

Fracture
Brachial plexus
Cervical vertebrae
Lumbar vertebrae
Lumbar plexus
Sacral plexus
Sacrum

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Imaging Planes

CT Images
Axial
Coronal Reformat
Sagittal Reformat

MRI Images
Axial
Coronal
Sagittal

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Axial chest

Axial slice #1
 Axial slice #2
 Axial slice #3

Pectoralis Muscle
 Aortic Arch
 Latissimus Muscle
 Spine (vertebral body)
 Ascending Aorta
 Pulmonary arteries
 Pulmonary veins
 Descending Aorta
 Heart

Axial slice #1
 Axial slice #2
 Axial slice #3

Slide # 49

Basic Body Protocol

3 plane GrE localizer
 40 – 49 cm FOV
 5 mm / 1
 128 x 256
 TR = min
 TE = min
 Flip = 90°

Liver
 Gall bladder
 Pancreas
 Spleen
 Kidneys

Axial T2 - axial
 Generally TSE (aka FSE or RARE)
 FOV = 32 cm (to fit anatomy)
 5 mm / 1
 192 x 256
 TR = 4000 ms
 TE = 100 ms ETL= 16

Axial T1 GE IN / OUT phase - axial
 22 cm X 16 cm FOV
 5 mm / 1
 192 x 256
 TR = 150
 TE = 2.1 / 4.2 ms
 Flip = 90°

T1 GE post gad DYNAMIC (axial or coronal)

In phase
 out of phase
 Resp triggered FSE
 SSFSE
 Fatsat BH post gad

Slide # 50

Basic “Vanilla” Knee Protocol

Sagittal T1 localizer- 400TR/min TE, 5mm/0 skip, 12 FOV, 128x256 matrix, 1 nex

Axial T1 - 600-800 TR/min TE, 4mm/.5 skip, 12 FOV, 192x256 matrix, 2 nex

Axial FSE T2- 4000 TR, 90 TE, 5 mm, skip .5 12 FOV, 192x256, 2 nex

T2 FSE - 4000 TR, min/80 TE, 5 mm, 12 FOV, 128x256, 2 nex

Coronal FSTIR - 4000 TR, 90 TE, 150 TI, 5mm, 12 FOV, 192x256, 2 nex

Sagittal FSE PD- 3000 TR, 2x min TE, 5 mm, 12 FOV, 192x256, 2 nex

Posterior horn Lateral meniscus
 Lateral collateral ligament
 Lateral meniscus

Slide # 51

Lower Extremity Anatomy

Upper Extremity Anatomy Tricks?

Anterior cruciate ligament (ACL)
 Posterior cruciate ligament (PCL)
 Femoral artery
 Quadriceps tendon
 Patello- Femoral Joint
 Patellar ligament
 Femoral condyles
 Meniscus (posterior horn, lateral meniscus)
 Patella
 Gastrocnemius muscle
 Tibia
 Fibula

Mid sagittal slice (MRI)
 Para sagittal slice (MRI)

Shoulder Rotator Cuff SITS
 Coronal reformatted CT

Slide # 52

Outline

- Patient Care Review
 - MR Safety
 - General Patient Care
- Imaging Procedures Review
 - Sectional Anatomy Overview
 - Imaging Procedures

Slide # 53

12.2 MRI Registry Review

Part II – Patient Care & Imaging Procedures Review

Thank you for your attention!

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Slide # 54