Magnetic Resonance Professional Curriculum

Sponsored by the American Society of Radiologic Technologists, 15000 Central Ave. SE, Albuquerque, NM 87123-3917.

Contents

Introduction

The goal of this curriculum is to provide the professional community with a cognitive base of entry-level education in the practice of magnetic resonance technology (MR) as well as sample clinical competency forms and suggestions. It is suitable for all programs in this specialty, including limited fellowships, short-term certificate programs as well as collegiate-based education programs. To enter an MR program, students must have completed an approved course as a radiographer or the equivalent and have completed general course work in medical ethics and law, methods of patient care, CPR, medical terminology and human structure and function.

This is a curriculum guide and educators are given latitude in its implementation. The intent is not to impose content, sequencing or educational philosophy on the educational community; it is expected that the educators will assume responsibility to adapt the guide to their needs. It is written in syllabus format, providing the educator with suggested subjects that the student is expected to know as the curriculum progresses. Educators are encouraged to expand these course offerings and develop additional course work, especially clinical applications, to enhance the overall learning process. No particular sequence is suggested.

The American Society of Radiologic Technologists is most grateful to the task forces and committees that developed this work. ASRT also recognizes other technologists, educators and physicians who contributed significantly to this guide by their review and critique. Without the efforts of these professionals, this publication would not be a reality.

1989 Task Force on Magnetic Resonance Imaging

Robert J. Walker, Ph.D., R.T.(R)(MR), FASRT
Linda Brittain, R.T.(R)(N)
Ann L. Hyde, B.S., R.T.(R)(MR)
Irene A. Szwarc, B.S., R.T.(R)

1990-91 Committee and Sub-committee on Magnetice Resonance Imaging

Michael Bohl, M.H.A., R.T.(R)
Luann Culbreth, M.Ed., R.T.(R)(MR)
Deborah Durham, B.S., R.T.(R)(MR)
Randall Vollrath, R.T.(R)(MR)
Michael Grey, M.S., R.T.(R)(MR)(CT)
Cynthia Falvo, R.T.(R), RDMS
Tom Fouts, R.T.(R)
Richard Helsper, R.T.(R)
Karen L. Pary, B.A., R.T.(R)(MR)
Stephen Wagner, B.S., R.T.(N)(MR) CNMT

1995-96 Committee on Magnetic Resonance Technology

Karen L. Pary, B.A., R.T.(R)(MR)
Ann L. Hyde, B.S., R.T.(R)(MR)
Bernadette M. Greenwood, R.T.(R)(MR)
Bartram Pierce, B.S., R.T.(R)(MR)
Colette Satler, R.T.(R)(MR)(M)
Randall Vollrath, R.T.(R)(MR)
Kathryn E. Withers, R.T.(R)(MR)

Orientation to the Educational Program

I. General Information

A. Policies
   1. Dress code
   2. Attendance/absences
   3. Vacations
   4. Grading
   5. Educational rights
   6. Disciplinary procedures
   7. Health
   8. Tuition/fees
   9. Other

B. Educational schedules
   1. Didactic
   2. Clinical

C. Program completion requirements

D. Other

II. Clinical Education Center(s)

A. Rules and regulations/orientation to the clinical center

B. Schedules
   1. Patient
   2. Staff
   3. Meetings

C. Equipment

D. Records

E. Patient care policies/procedures

F. Other

III. Duties/Responsibilities of the Student Technologist

A. Didactic
   1. Attendance
   2. Schedule
   3. Assignments
   4. Testing/evaluation

B. Laboratory
    1. Attendance
    2. Schedule
    3. Assignments
    4. Supervision

C. Clinical
    1. Attendance
    2. Schedule
    3. Assignments
    4. Patient care
    5. Testing/evaluation
    6. Supervision

MR Technology

Historical Development of MR

Unit Description

This unit provides an introduction to the theories of resonance properties and their founders. The first human clinical studies, subsequent developments and future uses of MR will be discussed.

Objective

At the completion of this unit, the student will:

1. Discuss the scientific discovery of the principles of NMR.
2. Discuss the development of MR imaging.
3. Explore future developments of MR imaging.

Content

I. Review of Electromagnetic Spectrum

A. Visible light region

B. X-radiation region

C. Radio wave region

II. Discovery of Resonance Properties

A. Studies of Bloch and Purcell

B. Bloch's equations

C. Experimental verification of Bloch's equations

III. Development of In Vivo Measurement

A. Studies of Damadian and Lauterbur

B. Development of cross-sectional imaging
   1. Contributions of Mansfield and Hinshaw
   2. First scan by EMI
   3. Subsequent improvements in MR scanning

C. Contrast media

D. Vascular imaging

E. Spectroscopy

Fundamental Principles of NMR

Unit Description
This unit will introduce the student to basic concepts of nuclear magnetic resonance. Types of magnets and the generation of a nuclear magnetic resonance signal will be discussed.

Prerequisite
Helpful courses include basic mathematics and basic physics.

Objective
At the completion of this unit, the student will:

1. Discuss the concepts of nuclear magnetic resonance.
2. Define nuclear magnetic resonance.
3. Discuss the production and measurement of the NMR signal.
4. Understand the concept of Fourier transformation of information.

Content
I. Magnet Types

II. Faraday's Law of Induction

III. Types of Magnetism

IV. Resonance

V. Larmour Equation

VI. Generations of the NMR Signal

A. Basic structure of the atom

B. Static magnetic field

C. Precession

D. RF interaction

E. Free induction decay

F. Net magnetization

VII. Fourier Transformation

A. Raw data vs. digitized image

B. K-space

MR Terminology

Unit Description

This unit will provide the student with basic MR terminology used routinely in clinical settings. Concepts of pulse sequencing, image parameters and artifact reduction techniques will be introduced.

Objective

At the completion of this unit, the student will:

1. Define briefly basic MR terminology.
2. State basic terminology used routinely in the clinical setting.
3. Explain the concept of variations in pulse sequences and parameters on the resultant image.

Content

I. RF Pulse Sequences

A. Spin echo; FID (free induction decay)

B. Inversion recovery

C. Fast spin echo, rapid imaging

D. MR angiography
   1. Time of flight and phase contrast

E. Gradient imaging techniques

F. Echo-planar imaging

G. 3-D imaging

H. Spectroscopy

I. Magnetization transfer techniques

J. Functional imaging

K. Perfusion and diffusion imaging

II. Parameters and Tissue Characteristics

A. TR or repetition time

B. Tl or spin lattice recovery

C. T2 or spin decay

D. T2*

E. TI or inversion time

F. TE or echo time; fractional TE

G. Flip angle

H. Slice thickness

I. Gap

J. Matrix

K. Field of view; asymmetric FOV

L. Voxel volume; isotropic and anisotropic

M. Number of acquisitions, number of samples acquired

N. Pixel

O. Echo train length

P. Echo train spacing

Q. Effective echo time

R. Receive bandwidth

S. Phase and frequency directions

T. Gradient relationships
   1. Physical and logical
   2. Phase, frequency and slice select

III. Magnets

A. Permanent

B. Resistive

C. Super conductive

D. Cryogens

IV. Anatomic and Imaging Planes

A. Transaxial/transverse

B. Coronal

C. Sagittal

D. Oblique/orthogonal

V. Contrast Media

A. Indications

B. FDA approved agents

C. Contraindications

D. Effect on image

E. Dosage and administration

F. Venipuncture

VI. Artifacts and Artifact Reduction Techniques

A. Gradient moment nulling

B. Presaturation techniques

C. Motion

D. Cardiac, respiratory and peripheral gating

E. Other

1. Aliasing, Nyquist
2. Gibbs, truncation
3. Chemical shift
4. Magnetic susceptibility
5. Radio frequency
6. Motion and flow

Development/Management of an MR Facility

Unit Description

This unit will provide the basics of imaging system selection and architectural design of an MR facility. Many unique factors must be considered in the development and management of an MR facility. Discussions regarding staffing needs and staff education will be included.

Objective

At the completion of this unit, the student will:

1. Understand the factors affecting imaging system selection.
2. Discuss briefly the limiting factors affecting system location and architectural design.
3. Outline the requirements for staffing and staff education necessary for start-up and routine peration of an MR facility.
4. Discuss the role of the facility's management and staff relative to system maintenance and quality assurance.

Content

I. Conception of Operation Flow Chart

A. Image/system selection
   1. High field vs. low field
   2. Mobile vs. fixed

B. Site selection
   1. Environmental considerations
   2. Magnetic field impact
   3. Permanent, resistive, super conducting

C. Facility design
   1. New construction
   2. Integration into existing structure
   3. Shielding; active and passive

D. Government regulations, certificate of need

E. Ancillary equipment

F. Staffing and staff training (when required/where applicable)
   1. Physician
   2. Technologist
   3. Clerical/support
   4. Nurse
   5. Anesthesiologist/anesthetist
   6. Physicist

II. Imager Maintenance

A. Maintenance contracts

B. Preventative maintenance

C. Repairs

D. Magnetic quench; emergency evacuation procedures

E. Quality assurance

Patient Relations and Safety Management

Unit Description

This unit presents basic principles of magnet safety. Patient, referring physician and ancillary staff education on magnet safety will be included. Patient and magnet-related emergencies represent a unique situation to an MR technologist. Knowledge of and recommended procedures for these situations will be discussed. Patient claustrophobia and patient sedation will be introduced.

Objective

At the completion of this unit, the student will:

1. Understand routine scheduling procedures and forms.
2. Discuss the importance of patient education and comfort to the successful completion of a scan.
3. Discuss the need for referring physicians and ancillary staff to have a working knowledge of MR safety.
4. Discuss the elements of safety management to ensure the safe operation of an MR facility.
5. Discuss the procedures taken when a quench of the magnet occurs.
6. Understand basic venipuncture techniques.
7. Understand routine conscious sedation and the issues of unconscious sedation.

Content

I. Patient Scheduling

A. Scanning schedule

B. Request forms

C. Patient history

D. Screening for contraindications

E. Patient instructions

F. Medications and sedation issues

II. Patient/Visitor Comfort at Scan Facility

A. Registration system

B. Accommodating for delays in schedule

C. Claustrophobia

D. Sedation

III. Patient/Physician/Health Professional Education

A. Patient brochure

B. Physician education

C. In-service education of ancillary personnel

D. FDA guidelines

IV. Safety Precautions

A. Posting of magnetic field warnings; safety zone/warning zones

B. In-service education of staff/ancillary personnel

C. Restrictive barriers, shielding

D. Screening of persons entering the magnetic field
   1. Identification of risk factors
      a. Magnetic field, biomedical implanted devices, other
   2. Restrictions of potential hazardous objects
   3. Restriction of instruments, etc. that may be damaged or dangerous
   4. Removal of artifact-creating objects
   5. Consent forms; acknowledment of contraindications
   6. Procedure for quench of magnet
   7. SAR requirements
   8. Use of monitoring devices and sedation issues
   9. Ear protection devices and techniques

E. Emergencies while patient is in the scanner
   1. Patient related
      a. Breathing or cardiac
      b. Equipment failure/quench
      c. Projectiles

V. Venipuncture

A. Patient interview for allergies

B. Extravasation

C. Injection techniques
    1. Vein
    2. IV tubin

Clinical Applications of MR

Unit Description

This unit provides an overview of MR use in the clinical setting. Pulse sequences, parameters, coils, coil positioning and patient positioning will be discussed as they relate to successful MR imaging. Image critique will introduce basic cross-sectional anatomy and pathology.

Prerequisites

Helpful courses include basic MR, fundamentals of MR physics and instrumentation, MR terminology, patient relations and safety issues.

Objective

At the completion of this unit, the student will:

1. Discuss the diverse clinical applications of MR imaging.
2. Critique MR images to identify pulse sequences/parameters.
3. Recognize basic anatomy and pathology as seen on the image.
4. Discuss coil selection, patient positioning and use of MR accessories and their effect on
5. image quality, patient comfort and safety.

Content

I. Central Nervous System

A. Brain and cranial nerves

B. Spinal column
    1. Cervical
    2. Thoracic
    3. Lumbar
    4. Spinal cord

II. Head and Neck

A. Orbits

B. Oropharynx, nasopharynx, pharynx, larynx

C. Temporomandibular joints (TMJ)

D. Thyroid gland; parotid gland

E. Soft tissues of head and neck

F. Vascular structures

G. Stereotaxic and other procedures

III. Thorax
A. Heart/great vessels

B. Mediastinum

C. Breasts

D. Brachial plexus

E. Other

IV. Abdomen and Pelvis
A. Liver/spleen/pancreas/biliary

B. Lymphatic structures

C. GI tract

D. Kidneys/adrenal glands

E. Bladder

F. Male reproductive system

G. Female reproductive system

H. Vascular

I. Other

V. Musculoskeletal System
A. Soft tissue

B. Shoulder girdle

C. Pelvic girdle

D. Extremities
1. Knee
2. Wrist and hand
3. Foot and ankle
4. Elbow
5. Vascular

VI. Miscellaneous and Other

MR Physics - Instrumentation and Imaging

Unit Description

This unit is intended as an overview of MR Physics.

Many of the concepts introduced in this unit will be covered in much greater detail in subsequent units.

Objective

At the completion of this unit, the student will:

1. Define gauss, Tesla and electromagnetic spectrum.
2. Describe the three basic types of magnets, giving advantages and disadvantages of each.
3. Define the horizontal field magnet.
4. Define the vertical field magnet.
5. Identify and compare advantages and disadvantages of horizontal and vertical field magnet systems.
6. Understand the mechanisms, components and be able to label the cross section of the various types of magnets.
7. Discuss the differences in low-, mid- and high-field systems.
8. Discuss field strength in relation to image contrast.
9. Discuss the purpose of gradients in MR.
10. Discuss the purpose of cryogens.
11. Discuss the types and purposes of shielding and shimming.
12. Discuss the construction, use and selection of transmit/receive coils and receive only coils.
13. Describe image postprocessing such as IVI, 3-D reconstruction and reformatting.
14. State the concept of MR imaging.
15. Explain the orientation of the hydrogen atoms when placed in a magnetic field and the reason antiparallel atoms have a higher energy level.
16. Discuss the concept that a magnetic force acts perpendicular to the line of propagation of the radio frequency wave.
17. Discuss the concept of frequency and its relationship to energy and wavelength.
18. Describe the location of radio waves on the electromagnetic spectrum.
19. Define angular magnetic moment, linear magnetic moment, magnetic vector, gradient magnetic field, spatial localization and dipole magnet.
20. Explain the magnetic moment of a nucleus and what affects it most.
21. Identify how a magnetic dipole is produced.
22. Describe net magnetization and what determines net magnetization of an atom.
23. Explain the effect of field strength on the energy of parallel and antiparallel protons.
24. Define precession, magnetic wobble and the Larmour equation.
25. Describe the factors that determine the precession of a spinning nucleus.
26. Describe the relationship between resonant frequency, proton energy and the strength of the magnetic field.
27. Discuss the importance of frequency and amplitude in relationship to MR spatial localization.

28. Describe natural frequency.
29. Discuss the principle of resonance.
30. Define equilibrium.
31. Explain the x, y and z axis and which designates the alignment of the static field.
32. Describe how a magnetic force applied to one axis affects the net magnetization of the tissue.
33. Discuss transmit and receive bandwidth and their importance to MR.
34. Discuss spatial encoding in relation to magnetic resonance.
35. Relate frequency and amplitude of an RF signal to spatial encoding.
36. Discuss Faraday's Law as it relates to the production of the MR signal.
37. Define paramagnetic, diamagnetic and super magnetic.
38. Describe the concept of k-space.
39. Discuss how k-space is filled in spin echo imaging, rapid imaging and respiratory ordered phase encoding.
40. Explain the Fourier transformation.
41. State the scan time equation for 2-D and 3-D imaging.
42. Differentiate between 2-D and 3-D imaging and reconstruction (2-DFT/3-DFT) methods.
43. Describe how a 90 degree RF pulse (flip angle) is achieved.
44. Describe how a 180 degree RF pulse (flip angle) is achieved.
45. Describe relaxation time.
46. Describe Tl relaxation and how it is acquired.
47. Describe T2 relaxation and how it is acquired.
48. Describe T2*.
49. Discuss the pulse sequence used to emphasize T2* contrast.
50. Explain what Tl measures.
51. Explain what T2 measures.
52. Explain what T2* measures.
53. Compare and contrast Tl, T2 and T2* and give examples of operator selected parameters such as TR and TE that would yield each type of image.
54. Explain free induction decay (FID).
55. Compare and contrast spin-lattice (Tl) relaxation, spin-spin (T2) decay and relative proton density (RPD) as to their definition, how they change in pathological conditions and how they change with the addition of contrast agents such as gadolinium.
56. Explain the relaxation times for small molecules vs. large molecules.
57. Describe the relationship between Tl and T2 in the imaging of solids and liquids.
58. Describe the partial saturation pulse sequence.
59. Describe the spin echo pulse sequence or technique.
60. Describe the inversion recovery pulse sequence or technique.
61. Describe the usages and limitations of the spin echo and inversion recovery pulse sequences.
62. Describe phase encoding and spin warp imaging.
63. Describe the gradient echo pulse sequence or technique.
64. Describe the fast spin echo pulse sequence or technique.
65. Describe usages and limitations of gradient echo and fast spin echo techniques.
66. Compare and contrast spin echo and gradient echo imaging techniques.

67. Explain the effects of field strength on Tl.
68. Differentiate between TI (inversion time), TE (echo time) and TR (repetition time).
69. Explain the effect of TR and TE parameters on the image gray scale.
70. Discuss the advantages and disadvantages of varying the TR and TE on the resultant image and on the total scan time.
71. Describe the effects of flip angle, TR and TE on gradient echo imaging.
72. Discuss the advantage of obtaining images at several TR and TE settings when studying a pathological condition.
73. Discuss the effect of a very long TR time on the Tl information of the image.
74. Identify the tissue parameters that affect tissue contrast.
75. Identify the extraneous factors that can affect tissue contrast.
76. Discuss the change in relaxation times caused by body composition and pathological conditions.
77. Describe the effect temperature and poorly hydrated tissue have on the Tl of those tissues.
78. Discuss the factors that affect contrast to noise (C/N) and how changes to each factor affect the image and total scan time.
79. Discuss the factors that affect signal to noise (S/N) and how changes to each factor affect the image and total scan time.
80. Explain how Tl-shortening contrast agents, such as gadolinium, affect the Tl and T2 of the tissues.
81. Discuss what tissues in the body normally take up gadolinium and why.
82. Compare STIR (short tau inversion recovery) and chemical saturation techniques.
83. Discuss gradient moment nulling and spatial presaturation techniques.
84. Define the cause and discuss the correction for the following artifacts: RF leak, aliasing, patient motion, Gibbs, truncation, chemical shift, magnetic susceptibility and flow motion.
85. Compare and contrast the basic components of magnetic resonance to other modalities.
86. Identify at least three advantages of using MR in making a diagnosis as compared to other modalities such as computed tomography, ultrasound, nuclear medicine, etc.
87. Explain the basic rationale for electing to use MR over other modalities for assisting with the diagnosis of various pathologies.
88. Describe the principle of electrocardiac gating and draw and label an ECG trace with the trigger window, trigger delay and R-R interval.
89. Explain how blood flow produces alterations in contrast on the image.
90. Explain the concepts of window and level in filming.
91. Describe the differences in precessional frequencies of fat, water and silicone.

Content

MR Instrumentation

I. Magnet

A. Types of magnets
   1. Permanent
   2. Resistive
   3. Super conductive

B. Magnetic and RF fields

C. Gradients

D. Cross section of a magnet
E. Transmit and receive coils

F. Shielding and shimming
   1. Active
   2. Passive

II. Terms

A. Hertz (HZ), megahertz (MHZ)

B. Tesla (T), Gauss (g)

C. Electromagnetic spectrum

III. Computer and Digital Imaging

A. Post processing

MR Imaging

I. Obtaining the MR Signal

A. Properties of hydrogen and molecular structure

B. Precession

C. Net magnetization

D. Angular momentum

E. Magnetic domain

F. Vector

G. Resonance

H. Larmour equation

I. Faraday's laws

J. RF pulses

K. Spatial localization

L. Paramagnetic

M. Diamagnetic

N. Super magnetic

O. K-space

P. Fourier transform, half and partial Fourier

Q. 2-D/3-D imaging

R. Magnetization transfer

S. Filming
   1. Windows and levels
   2. Region of interest (ROI)
   3. Annotations

T. Archiving and data storage

II. Tissue Contrast

A. Tl - spin-lattice relaxation/longitudinal magnetization

B. T2 - spin-spin relaxation/transverse magnetization

C. T2*

D. `RPD - relative proton density

E. TE - echo time

F. TR - repetition time

G. TI - inversion time

H. FID - free induction decay

I. Contrast to noise (C/N)

J. Signal to noise (S/N)

K. Artifacts

L. Gadolinium-based contrast

M. Flow and motion

III. Extrinsic Factors

A. Pulse sequences

B. Scan parameters

C. Other options
   1. STIR - short tau inversion recovery
   2. Chemical saturation techniques

D. Comparison to other modalities

E. Quality control and quality assurance tests

Computerized Imaging

Objective

At the completion of this section, the student will:

1. Define a computer and give examples of a special-purpose computer and a general-purpose computer.
2. Explain the historical development of the computer and identify the person who is known as the “father” of the modern computer.
3. Identify three categories of computers and give an example of each.
4. List the function of an input device and give examples of the more commonly used input devices.
5. Describe the central processing unit (CPU), the units housed within the CPU and the function of each.
6. Differentiate between the two types of memory storage.
7. Describe the operating system, the types of programs contained within an operating system and the function of each.
8. Identify the function of an output device and give examples of the more commonly used output devices.
9. Differentiate between an analog and digital computer.
10. Compare the binary system to Morse Code.
11. Differentiate between a bit and a byte.
12. Describe a computer program.
13. Differentiate between computer software and hardware.
14. Describe computer language and its use.
15. Describe a peripheral device and give some examples used in radiology.
16. Explain the basis of interfacing peripheral devices and the advantage of a “bus” structure.
17. Describe the purpose of an analog-to-digital converter.
18. Compare and contrast a pixel and a voxel.
19. Describe isotropic and anisotropic voxels.
20. Calculate the total number of pixels contained in a matrix size.
21. Compare and contrast the matrix size to detail within a reconstructed image.
22. Compare and contrast field size to matrix size.
23. Describe multiprogramming or multiplexing.
24. Identify and describe the functions of an array processor.
25. Explain how a graphic display image is generated.
26. Explain a “faster-scan” system.
27. Describe a laser optical storage and retrieval system.
28. Discuss window and level.
29. Describe the use of laser imagers for photographing MR images.
30. Explain the operation and function of laser images.
31. Discuss filmless radiology (digital viewing/archiving).
32. Discuss teleradiography.

Content

I. Computers

A. Definition

B. History

C. Special purpose

D. General purpose

E. Analog

F. Digital

G. Hardware
   1. Input devices
   2. CPU
   3. Memory
   4. Output devices

H. Software

II. Applications in Radiology

A. Peripheral devices

B. Analog to digital converter

C. Pixel/voxel

D. Matrix size

E. Field size

F. Multiplexing

G. Array processor

H. Laser optical system

I. Window and level

III. Laser Imagers

IV. Digital Viewing and Archiving

V. Teleradiology

Spectroscopy

Objective

At the completion of this unit, the student will:

1. Explain the NMR spectroscopy principles.
2. Discuss the current and future development of in vivo spectroscopic diagnosis of disease processes.
3. Discuss the hardware requirements for NMR spectroscopy.

Content

I. Spectroscopy
- A. Basic principle
- B. Equipment needed
- C. Use in clinical medicine
- D. Potential application
- E. Economic considerations
- F. Technical difficulties
- G. Special environment needed

II. The NMR Spectrum

III. Gyromagnetic Ratios

IV. Spectroscopic Properties
- A. Chemical shift
- B. Nuclear abundance
- C. J coupling

V. Reference Compounds and PM Scales

VI. Clinical Application
- A. Medically important nuclei
  1. Hydrogen
  2. Phosphorus
  3. Carbon
  4. Sodium

5. Fluorine
6. Nitrogen

B. Diagnosing metabolic disorders
   1. Current technology
   2. Future potential

VII. Spectroscopy Hardware

A. Magnetic field strength

B. Magnetic field homogeneity

C. Environmental specifications

Sectional Anatomy and Imaging Applications

Cross-sectional Anatomy

Unit Description

This unit provides the student with a basic knowledge of cross-sectional anatomy. The student will review various directional terms. Technical magnetic resonance terminology will be introduced.

Prerequisite

Helpful courses would be basic anatomy and physiology, introduction to MR, MR terminology and MR imaging.

Objective

At the completion of this unit, the student will:

1. Develop a sense for three-dimensional anatomy.
2. Define various directional terms.

Content

I. Identify Possible Methods to Use in Developing a Three-dimensional Sense of Anatomy.

II. Define the Following Terms:

A. Anterior or ventral

B. Posterior or dorsal

C. Distal

D. Proximal

E. Superior or cephalad

F. Inferior or caudal

G. Medial or mesial

H. Lateral

I. Supine

J. Prone

III. Define the Following Terms:

A. Coronal

B. Transverse or axial

C. Longitudinal

D. Median sagittal

E. Sagittal

F. Off axis (parasagittal, paraxial)

G. Oblique

H. Orthogonal

Central Nervous System

Unit Description

This unit provides the student with a review of the anatomy of the central nervous system (brain and spine) and its MR tissue characteristics. The student will review various imaging techniques and the design of specialized receiver coils. Magnetic resonance angiography of brain vasculature will be introduced. Pathology of the central nervous system will be discussed by case presentation.

Anatomy of the Central Nervous System (Brain and Spine)

Objective

At the completion of this unit, the student will:

1. Review the components of the central nervous system, including the brain and spinal cord.
2. Identify the normal anatomic location of the components of the central nervous system, including the brain and spinal cord on diagrams and scan images.

Content

I. Skull Vault and Base

A. Inner and outer tables

B. Diploic space

C. Petrous bones

D. Clivus

II. Brain - Soft Tissue

A. Gray and white matter

B. Cerebrospinal fluid

C. Dura or meninges

D. Ventricles

E. Cerebrum

F. Cerebellum

G. Brain stem

H. Corpus callosum

I. Optic chiasm

J. Pituitary gland

K. Cranial nerves I-XII

III. Brain - Vasculature

A. Circle of Willis

B. Basilar artery

C. Internal carotid arteries

D. Internal jugular veins

E. Vertebral arteries

F. Venous sinuses

IV. Spinal cord

A. Cervical

B. Thoracic

C. Lumbar

D. Sacrum

MR Tissue Characteristics of the Brain and Spine

Objective

At the completion of this unit, the student will:

1. Describe the normal MR tissue characteristics of the components of the brain and spine.
2. Describe the normal MR characteristics of blood as seen on arterial and venous magnetic resonance angiography.
3. Identify scan parameters by the tissue characteristics recorded.

Content

I. Skull Vault and Base

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IV. Spinal Cord

A. Cervical

B. Thoracic

C. Lumbar

D. Sacrum

V. Effects of Contrast Media

Imaging, Motion Suppression and Specialized Techniques

Objective

At the completion of this unit, the student will:

1. Describe how and explain why gated images are obtained.
2. Describe and discuss the various imaging planes and pulsing techniques that maximize the diagnostic value of an MR scan of the central nervous system including the brain and spine.
3. Describe the construction and use of special application receiver coils.
4. Describe when and why contrast media would be used and its resultant effect on the images.
5. Discuss the different types of magnetic resonance angiography and when they are used.
6. Discuss the current and future role of MR scanning of the brain and spine and its relationship with other imaging and treatment modalities such as:
   - Spectroscopy.
   - 3-D radiation therapy treatment planning.
   - Laser surgery.
   - Gamma surgery.
   - MR vs. CT.
   - MR vs. PET.

Content

I. Motion Suppression Techniques

A. Cardiac gating

B. Peripheral gating

C. Fast imaging techniques

D. Flow compensation

II. Imaging Techniques

A. Selection of optimum imaging planes
1. Ventricles and their foramen
2. Cerebrum
3. Cerebellum
4. Brain stem
5. Corpus callosum
6. Optic chiasm
7. Pituitary gland
8. Cranial nerves I-XII
9. Cervical spine and cord
10. Thoracic spine and cord
11. Lumbar spine and cord
12. Sacrum

B. Selection of optimum pulse techniques

C. Magnetic resonance angiography
1. 2-D time of flight
2. 3-D time of flight
3. 2-D phase contrast
4. 3-D phase contrast

D. Use of specialized receiver coils

Use of contrast media

MR Pathology of the Brain and Spine

Objective

At the completion of this unit, the student will:

1. Identify the common pathology of the brain.
2. Identify the common pathology of the spine and spinal cord.
3. Identify common vascular lesions on MRA images.
4. Recognize that the visualization of some pathological processes differ with field strength.
5. Describe the MR tissue characteristics of these pathological processes.

Content

I. Brain

A. Infarct
    1. Age-acute/subacute/chronic

B. Tumors
    1. Malignant
    2. Metastatic
    3. Non-malignant

C. Vascular abnormalities
    1. Aneurysm
    2. Arteriovenous malformation
    3. Venous thrombosis

D. White matter disease
    1. Ischemic

E. Infection

F. Edema

G. Hemorrhage
    1. Age-acute/subacute/chronic
    2. Location
    3. Field strength difference

H. Calcification

I. Trauma
    1. Fracture
    2. Shear injury

J. Demyelinating disease

K. Neuropathies

II. Spine and Spinal Cord

A. Tumors
    1. Malignant
    2. Metastatic
    3. Non-malignant
    4. Location

B. Vascular abnormalities
    1. Arteriovenous malformation

C. Infection

D. Edema

E. Hemorrhage
   1. Age-acute/subacute/chronic
   2. Location
   3. Field strength difference

F. Calcification

G. Trauma
   1. Fracture

H. Demyelinating disease

I. Neuropathies

J. Myelopathies

K. Herniated discs

L. Postoperative fibrosis

M. Degenerative disc disease

N. Degenerative joint disease
   1. Facet joint
   2. SI joint

Spinal fluid/CSF blockage

Head and Neck Imaging

Unit Description

This unit provides the student with a review of the anatomy of the head and neck with an understanding of the MR tissue characteristics. The student will review motion suppression techniques and the design of specialized receiver coils. Magnetic resonance angiography of the neck vasculature will be introduced. Pathology of the head and neck will be discussed by case presentation.

Anatomy of the Head and Neck

Objective

At the completion of this unit, the student will:

1. Review the soft tissue structures of the head and face, orbit, nasopharynx, oropharynx, neck and vasculature of the neck.
2. Identify the normal anatomic location of the soft tissue structures of the head and face, orbit, nasopharynx, oropharynx, neck and vasculature of the neck on diagrams and scan images.

Content

I. Soft Tissue Structures of the Head and Face

A. Skin and subcutaneous tissue

B. Muscle

C. Superficial vasculature

D. Pinna

E. Nose

F. Salivary glands

II. Orbit

A. Bony vault

B. Orbital fat

C. Extraocular muscles

D. Optic nerve

E. Sclera and cornea

F. Vitreous and aqueous

G. Lens

H. Vasculature

III. Nasopharynx, Oropharynx, Neck

A. Paranasal sinuses

B. Pharynx

C. Nasopharynx

D. Oropharynx

E. Larynx

F. Thyroid

G. Parathyroid

H. Salivary glands

I. Lymphatic structures

IV. Vasculature

A. Carotid arteries

B. Vertebral arteries

C. Jugular veins

D. Magnetic resonance angiography
   1. 2-D time of flight
   2. 3-D time of flight
   3. 2-D phase contrast
   4. 3-D phase contrast

MR Tissue Characteristics of the Head and Neck

Objective

At the completion of this unit, the student will:

1. Describe the normal MR tissue characteristics of the soft tissue structures of the head and face, orbit, nasopharynx, oropharynx and neck.
2. Describe the normal MR tissue characteristics of blood as seen on arterial and venous magnetic resonance angiography.
3. Identify scan parameters by the tissue characteristics recorded.

Content

I. Soft Tissue Structures of the Head and Face

A. Skin and subcutaneous tissue

B. Muscle

C. Superficial vasculature

D. Pinna

E. Nose

F. Parotid gland

II. Orbit

A. Bony vault

B. Orbital fat

C. Extraocular muscles

D. Optic nerve

E. Sclera and cornea

F. Vitreous and aqueous

G. Lens

H. Vasculature

III. Nasopharynx, Oropharynx, Neck

A. Paranasal sinuses

B. Pharynx

C. Nasopharynx

D. Oropharynx

E. Larynx

F. Thyroid

G. Parathyroid

H. Salivary glands

I. Lymphatic structures

IV. Vasculature

A. Carotid arteries

B. Vertebral arteries

C. Jugular veins

V. Magnetic Resonance Angiography

A. Arterial

B. Venous

Imaging, Motion Suppression and Specialized Techniques

Objective

At the completion of this unit, the student will:

1. Describe the different pulsing techniques and imaging planes used to maximize the diagnostic value of an MR scan of the soft tissue structures of the head and face, orbit, nasopharynx, oropharynx and neck.
2. Describe how magnetic resonance angiography works and discuss the different types of acquisition methods.
3. Describe the construction and use of special application receiver coils.
4. Describe when and why contrast media would be used and its resultant effect on the images.
5. Discuss saturation pulses, which help to identify arteries and veins.
6. Describe the effects of blood flow characteristics on image quality, including laminar turbulent, vortex and stationary or stagnant flow.

Content

I. Motion Suppression Techniques

A. Cardiac gating

B. Peripheral gating

C. Fast imaging techniques

D. Flow compensation

II. Imaging Techniques

A. Selection of optimum imaging planes
   1. Orbits
   2. Sinuses
   3. Nasopharynx
   4. Oropharynx
   5. Neck

6. Vasculature
    a. Arterial
    b. Venous

B. Selection of optimal pulse techniques
    1. Fat saturation
    2. Flow suppression techniques

C. Magnetic resonance angiography
    1. 2-D time of flight
    2. 3-D time of flight
    3. 2-D phase contrast
    4. 3-D phase contrast

D. Special application receiver coils

E. Use of contrast media

MR Pathology of the Head and Neck

Objective

At the completion of this unit, the student will:

1. Identify common pathology of the soft tissue structures of the head and face, orbit, nasopharynx, oropharynx and neck on MR images.
2. Identify common vascular lesions on MRA images.
3. Describe the MR tissue characteristics of these pathologic processes.

Content

I. Soft Tissue of the Neck, Head and Face

A. Neoplasia

B. Metastases

C. Benign processes

D. Vascular abnormalities

II. Orbit

A. Neoplasia

B. Benign processes

C. Demyelinating processes

D. Vascular abnormalities

III. Nasopharynx, Oropharynx, Neck

A. Neoplasia

B. Metastases

C. Benign processes

D. Adenopathy

IV. Vasculature

A. Aneurysm

B. Stenosis

C. Blockage

D. Malformations

Thorax and Mediastinal Imaging

Unit Description

This unit provides the student with a review of the anatomy of the thorax and mediastinum with an understanding of the MR tissue characteristics. The student will review motion suppression techniques, such as respiratory and cardiac gating, and the design of specialized receiver coils. The use of magnetic resonance angiography to visualize the blood vessels will be discussed. Pathology of the thorax and mediastinum will be discussed by case presentation.

Content

1. Anatomy of the thorax and mediastinum.
2. MR tissue characteristics of the thorax and mediastinum.
3. Imaging, motion suppression and specialized techniques.
4. MR pathology of the thorax and mediastinum.

Anatomy of the Thorax and Mediastinum

Objective

At the completion of this unit, the student will:

5. Review the components of the chest, heart, mediastinum, brachial plexus and breast.
6. Identify the normal anatomic location of the components of the chest, heart, mediastinum, brachial plexus and breast on diagrams and scan images.

Content

I. Chest

A. Chest wall

B. Mediastinum

C. Lungs

D. Pleura

E. Lymphatic structures

F. Breast

G. Brachial plexus/thoracic outlet

H. Soft tissue structures

II. Heart and Great Vessels

A. Heart chambers

B. Heart valves

C. Brachiocephalic vessels

D. Aorta

E. Vena cava

F. Pericardium

G. Coronary arteries

MR Tissue Characteristics of the Thorax and Mediastinum

Objective

At the completion of this unit, the student will:

1. Describe the normal MR tissue characteristics of the components of the chest, heart,
2. mediastinum, brachial plexus and breast.
3. Describe the normal MR characteristics of blood as seen on arterial and venous magnetic
4. resonance angiography.
5. Identify scan parameters by the tissue characteristic recorded.

Content

I. Chest

A. Chest wall

B. Mediastinum

C. Lungs

D. Pleura

E. Lymphatic structures

F. Breast

G. Brachial plexus/thoracic outlet

H. Soft tissue structures

II. Heart and Great Vessels

A. Heart chambers

B. Heart valves

C. Myocardial wall/intraventricular septum

D. Brachiocephalic vessels

E. Aorta

F. Vena cava

G. Pericardium

H. Coronary arteries

I. Blood

III. Magnetic Resonance Angiography

A. Arterial

B. Venous

Imaging, Motion Suppression and Specialized Techniques

Objective

At the completion of this unit, the student will:

1. Describe how and explain why gated images are obtained.
2. Describe and discuss imaging planes and pulsing techniques that maximize the diagnostic value of an MR scan of the chest, heart, mediastinum, brachial plexus and breast.
3. Describe the construction and use of special application receiver coils.

4. Describe when and why contrast media would be used and its resultant effect on the images.
5. Discuss the different types of magnetic resonance angiography and when they are used.
6. Discuss the various saturation techniques used in breast imaging.

Content

I. Motion Suppression Techniques

A. Cardiac gating

B. Peripheral gating

C. Fast imaging techniques

D. Flow compensation

II. Imaging Techniques

A. Selection of optimum imaging planes
   1. Bronchus
   2. Heart
   3. Mediastinum
   4. Great vessels
   5. Breasts, including augmented breasts
   6. Brachial plexus

B. Selection of optimal pulse techniques
   1. Cine

C. Magnetic resonance angiography
   1. 2-D time of flight
   2. 3-D time of flight
   3. 2-D phase contrast
   4. 3-D phase contrast

D. Special application receiver coils
   1. Breast
   2. Brachial plexus

E. Use of contrast media

F. Fat/water/silicone saturation techniques

MR Pathology of the Thorax and Mediastinum

Objective

At the completion of this unit, the student will:

1. Identify common pathology of the thorax on MR images.
2. Identify common vascular lesions on MRA images.
3. Describe the MR tissue characteristics of these pathologic processes.

Content

I. Thorax

A. Neoplasia

B. Metastases

C. Benign processes

D. Neuroma

E. Lymphadenopathy

F. Intracardiac pathology

G. Vascular abnormalities

II. Vasculature

A. Aneurysm

B. Blockage

C. Stenosis

Abdomen Imaging

Unit Description

This unit will provide the student with a review of the anatomy of the abdomen with an understanding of the MR tissue characteristics. The student will review motion suppression techniques, such as respiratory and cardiac gating, and the design of specialized receiver coils. The use of magnetic resonance angiography to visualize the blood vessels will be discussed. Pathology of the abdomen will be discussed by case presentation.

Anatomy of the Abdomen

Objective

At the completion of this unit, the student will:

1. Review the components of the abdomen.

2. Identify the normal anatomic location of the components of the abdomen on diagrams and scan images.

Content

I. Liver and Biliary Tree

II. Pancreas

III. Spleen

IV. Retroperitoneum

V. Abdominal Wall and Peritoneal Cavity

VI. Alimentary Tract

VII. Kidneys

VIII. Adrenal Glands

IX. Vasculature

A. Arterial

B. Venous

C. Portal

MR Tissue Characteristics of the Abdomen

Objective

At the completion of this unit, the student will:

1. Describe the normal MR tissue characteristics of the components of the abdomen.
2. Identify scan parameters by the tissue characteristic recorded.

Content

I. Liver and Biliary Tree

A. Pancreas

B. Spleen

C. Retroperitoneum

D. Abdominal wall and peritoneal cavity

E. Alimentary tract

F. Kidneys

G. Adrenal glands

H. Vasculature
   1. Arterial
   2. Venous
   3. Portal

Imaging, Motion Suppression and Specialized Techniques

Objective

At the completion of this unit, the student will:

1. Describe how and explain why gated images are obtained.
6. Describe and discuss imaging planes and pulsing techniques that maximize the diagnostic value of an MR scan of the abdomen.
7. Identify the advantages and disadvantages of MR imaging of the following:
   - Gallbladder.
   - Alimentary tract.
   - Spleen.
8. Compare and contrast MR imaging of the pancreas with other imaging modalities.
9. Describe the construction and use of special application receiver coils.
10. Describe when and why contrast media would be used and its resultant effect on the images.
11. Discuss the different types of magnetic resonance angiography, when they are used and the characteristics of the resultant images.

Content

I. Motion Suppression Techniques

A. Cardiac gating

B. Peripheral gating

C. Fast imaging techniques

D. Flow compensation

E. Respiratory compensation

F. Respiratory triggering

G. Breath hold techniques

II. Imaging Techniques

A. Selection of optimum imaging planes

1. Liver and biliary tree
2. Pancreas
3. Spleen
4. Retroperitoneum
5. Abdominal wall and peritoneal activity
6. Alimentary tract
7. Kidneys
8. Adrenal glands
9. Vasculature
    a. Arterial
    b. Venous
    c. Portal

B. Selection of optimal pulse techniques

C. Magnetic resonance angiography
1. 2-D time of flight
2. 3-D time of flight
3. 2-D phase contrast
4. 3-D phase contrast

D. Special application receiver coils

E. Use of contrast media
1. Positive
2. Negative
3. Organ specific
4. Oral

MR Pathology of the Abdomen

Objective

At the completion of this unit, the student will:

1. Identify common pathology of the abdomen on MR images.
2. Identify common vascular lesions on MRA images.
3. Describe the MR tissue characteristics of these pathologic processes.

Content

I. Liver, Gallbladder and Biliary Tree

A. Neoplasia
1. Hepatoma
2. Adenoma
3. Metastasis

B. Non-neoplastic processes

1. Hemangioma
2. Hepatitis
3. Cirrhosis
4. Hepatic iron overload

C. Miscellaneous

D. Vascular abnormalities
1. Arterial
2. Venous
3. Portal

II. Alimentary Tract, Spleen, Pancreas and Peritoneal Cavity

A. Neoplasia

B. Inflammatory disease

C. Metabolic disease

D. Non-neoplastic processes
1. Trauma
2. Hematomas

E. Lymphadenopathy

F. Vascular abnormalities
1. Arterial
2. Venous
3. Portal

III. Adrenal Glands and Kidneys

A. Neoplasia

B. Inflammatory disease

C. Metabolic disease

D. Non-neoplastic processes

E. Vascular abnormalities
1. Arterial
2. Venous

Pelvic Imaging

Unit Description

This unit provides the student with a review of the pelvis anatomy including the male and female reproductive systems with an understanding of the MR tissue characteristics. The student will review motion suppression techniques such as respiratory and cardiac gating, and the design of specialized receiver coils. The use of magnetic resonance angiography to visualize the blood vessels will be discussed. Pathology of the pelvis will be discussed by case presentation.

Anatomy of the Pelvis

Objective

At the completion of this unit, the student will:

1. Review the components of the pelvis including the male and female reproductive systems.
2. Identify the normal anatomic location of the components of the male and female pelvis on diagrams and scan images.

Content

I. Soft Tissue Structures

II. Muscles

III. Sigmoid/Rectum

IV. Bladder

V. Fat

VI. Lymphatic Structures

VII. Vasculature
- A. Arterial
- B. Venous

VIII. Male Reproductive System
- A. Prostate gland
- B. Seminal vesicles
- C. Penis
- D. Testes
- E. Urethra

IX. Female Reproductive System

A. Uterus
   1. Endometrium
   2. Junction zone
   3. Myometrium

B. Vagina

C. Cervix

D. Ovaries

E. Fallopian tubes

MR Tissue Characteristics of the Pelvis

Objective
At the completion of this unit, the student will:

1. Describe the normal MR tissue characteristics of the components of the male and female pelvis.
2. Identify scan parameters by the tissue characteristic recorded.

Content

I. Soft Tissue Structures

II. Muscles

III. Sigmoid/Rectum

IV. Bladder

V. Fat

VI. Lymphatic Structures

VII. Vasculature
A. Arterial

B. Venous

VIII. Male Reproductive System
A. Prostate gland

B. Seminal vesicles

C. Penis

D. Testes

E. Urethra

IX. Female Reproductive System

A. Uterus
   1. Endometrium
   2. Junction zone
   3. Myometrium

B. Vagina

C. Cervix

D. Ovaries

E. Fallopian tubes

Imaging, Motion Suppression and Specialized Techniques

Objective

At the completion of this unit, the student will:

1. Describe how and explain why gated images are obtained.
2. Describe and discuss imaging planes and pulsing techniques that maximize the diagnostic value of an MR scan of the pelvis including the male and female reproductive systems.
3. Describe the construction and use of special application receiver coils.
4. Describe when and why contrast media would be used and its resultant effect on the images.
5. Discuss the different types of magnetic resonance angiography, when they are used and the characteristics of the resultant images.

Content

I. Motion Suppression Techniques

A. Cardiac gating

B. Peripheral gating

C. Fast imaging techniques

D. Flow compensation

E. Compression

F. Respiratory compensation

G. Respiratory triggering

H. Breath hold techniques

II. Imaging Techniques

A. Selection of optimum imaging planes
   1. Soft tissue structures
   2. Muscles
   3. Sigmoid/rectum
   4. Bladder
   5. Fat
   6. Lymphatic structures
   7. Vasculature
      a. Arterial
      b. Venous
   8. Male reproductive system
      a. Prostate gland
      b. Seminal vesicles
      c. Penis
      d. Testes
      e. Urethra

9. Female reproductive system
    a. Uterus
        1) Endometrium
        2) Junction zone
        3) Myometrium
    b. Vagina
    c. Cervix
    d. Ovaries
    e. Fallopian tubes

B. Selection of optimal pulse techniques

C. Magnetic resonance angiography
    1. 2-D time of flight
    2. 3-D time of flight
    3. 2-D phase contrast
    4. 3-D phase contrast

D. Special application receiver coils

E. Use of contrast media
    1. Positive
    2. Negative

MR Pathology of the Pelvis

Objective

At the completion of this unit, the student will:

1. Identify common pathology of the pelvis, including the male and female reproductive systems on MR images.
2. Identify common vascular lesions on MRA images.
3. Describe the MR tissue characteristics of these pathologic processes.

Content

I. Neoplasia

II. Inflammatory Disease

III. Non-Neoplastic Processes

A. Trauma

IV. Soft Tissue Structures

V. Lymphadenopathy

VI. Vasculature Abnormalities

A. Arterial

B. Venous

Musculoskeletal Imaging

Unit Description

This unit provides the student with a review of the musculoskeletal system anatomy and an understanding of the MR tissue characteristics. The student will review the design of specialized receiver coils and peripheral magnetic resonance angiography. Pathology of the musculoskeletal system will be discussed by case presentations.

Anatomy of the Musculoskeletal System

Objective

At the completion of this unit, the student will:

1. Review the anatomy of the musculoskeletal system.
2. Identify the normal anatomic location of the components of the musculoskeletal system on diagrams and scan images.

Content

I. Upper Extremity

A. Wrist and hand
   1. Bones
   2. Muscles
   3. Nerves
   4. Ligaments and tendons
   5. Vascular structures

B. Forearm, elbow and humerus
   1. Bones
   2. Muscles
   3. Nerves
   4. Ligaments and tendons
   5. Vascular structures

C. Shoulder girdle
   1. Bones
   2. Muscles
   3. Nerves
   4. Ligaments and tendons
   5. Vascular structures

II. Lower Extremity

A. Foot and ankle
   1. Bones
   2. Muscles
   3. Nerves
   4. Ligaments and tendons
   5. Vascular structures

B. Lower leg and knee
   1. Bones
   2. Muscles
   3. Nerves
   4. Ligaments and tendons
   5. Vascular structures

C. Femur and hip
   1. Bones
   2. Muscles
   3. Nerves
   4. Ligaments and tendons
   5. Vascular structures

D. Pelvic girdle
   1. Bones
   2. Muscles
   3. Nerves
   4. Ligaments and tendons
   5. Vascular structures

MR Tissue Characteristics of the Musculoskeletal System

Objective

At the completion of this unit, the student will:

1. Review the anatomy of the musculoskeletal system.
2. Identify scan parameters by the tissue characteristics recorded.

Content

I. Extremities

A. Fat

B. Cortical bone

C. Bone marrow

D. Skeletal muscle

E. Cartilage

F. Tendons

G. Ligaments

H. Menisci

II. Pelvis

A. Fat

B. Cortical bone

C. Bone marrow

D. Skeletal muscle

E. Cartilage

F. Tendons

G. Ligaments

III. Vascular Structures

A. Arterial

B. Venous

Imaging, Motion Suppression and Specialized Techniques

Objective

At the completion of this unit, the student will:

1. Describe and discuss the imaging planes and pulsing techniques that maximize the diagnostic value of an MR scan of the upper extremity, lower extremity, shoulder girdle and pelvic girdle.
2. Describe the construction and use of special application receiver coils.
3. Describe and discuss the types of magnetic resonance angiography and when they are used.
4. Describe when and why contrast media would be used and its resultant effect on the images.

Content

I. Selection of Optimum Imaging Planes

A. Upper extremity

1. Wrist and hand

2. Forearm, elbow and humerus
3. Shoulder girdle

B. Lower extremity
1. Foot and ankle
2. Lower leg and knee
3. Femur and hip
4. Pelvic girdle

II. Selection of Optimum Pulse Techniques
A. Kinematic studies

III. Magnetic Resonance Angiography
A. 2-D time of flight

B. 3-D time of flight

C. 2-D phase contrast

D. 3-D phase contrast

IV. Selection of Special Application Receiver Coils
A. Linear

B. Quadrature

C. Phased array

D. Use of contrast media

MR Pathology of the Musculoskeletal System

Objective

At the completion of the unit, the student will:

1. Identify common pathological conditions seen in the musculoskeletal system on MR images.
2. Describe the MR tissue characteristics for each pathological process.

Content

I. Musculoskeletal System
A. Bony neoplasia

B. Soft tissue neoplasia

C. Metastasis

D. Avascular necrosis

E. Inflammatory processes

F. Vascular abnormalities

G. Soft tissue disease

H. Traumatic injuries
   1. Wrist and hand
   2. Forearm, elbow and humerus
   3. Shoulder girdle
   4. Foot and ankle
   5. Lower leg and knee
   6. Femur and hip
   7. Pelvic girdle

Pediatric Variances

Unit Description
This unit provides the student with a review of the differences in anatomy between adults and children and an understanding of how these differences will affect the MR tissue characteristics. The student will review specialized coils and optimal scanning techniques for use with children. Differences in pathology and specific pediatric pathology also will be discussed.

Objective
At the completion of this unit, the student will:

1. Recognize the various anatomic differences between children and adults.
2. Recognize the various differences in tissue characteristics between children and adults.
3. Recognize the various differences in pathologic conditions between children and adults.
4. Recognize various scanning techniques and receiver coils for use with children.

Content

I. Pediatric Variances

A. Anatomic differences

B. Tissue characteristics

C. Pediatric pathological conditions

D. Pediatric scanning
    1. Technique
    2. Equipment

Advanced Pathophysiology

Unit Description

This unit provides the student with an introduction to the disease processes of each system that might be encountered while performing MR scans or are most commonly seen on MR images. The goal is to familiarize the operator with the various body systems, the pathology seen in these systems and the basic definition of each disease process.

Prerequisite

Very helpful courses may include basic anatomy, pediatric anatomy, medical terminology and physiology.

Cardiac System

Objective

At the completion of this unit, the student will:

1. Discuss the cardiac cycle, the electrocardiogram and their relationship.
2. Describe and discuss the most commonly encountered diseases and pathological conditions of the cardiac system.

Content

I. Cardiac Function

A. Cardiac cycle

B. Electrocardiogram

II. Cardiac System Diseases and Conditions

A. Right ventricular failure

B. Left ventricular failure

C. Congestive heart failure (CHF)

D. Mitral stenosis

E. Aortic stenosis

F. Myocardial infarction (MI)

G. Acute angina

H. Atrial ventricular block (AV block)

I. Fibrillation

J. Ventricular ectopic beats (VEBs)

K. Aortic or mitral regurgitations

L. Rheumatic heart disease

M. Endocarditis

N. Cardiac arrest

O. Aneurysm

Digestive System

Objective
At the completion of this unit, the student will:

1. Describe the basic functions of the digestive system.
2. Describe and discuss the most commonly encountered diseases and pathological conditions of the digestive system.

Content

I. Functions of the Digestive System

A. Liver

B. Small intestine

C. Large intestine

D. Hepatic portal system

E. Biliary system

F. Pancreas

G. Splee

II. Digestive System Diseases and Conditions

A. Jaundice

B. Hepatitis A, B, C, etc.

C. Hepatic cysts

D. Hepatic adenoma

E. Cavernous hemangioma

F. Primary and secondary carcinoma

G. Bile and cholesterol stones

H. Cholelithiasis

I. Cholecystitis

J. Choledocholithiasis

K. Cholangitis

L. Biliary atresia

M. Pancreatitis

N. Cystic fibrosis

O. Splenomegaly

P. Budd Chiari

Immune System

Objective

At the completion of this unit, the student will:

1. Describe the basic functions of the immune system.
2. Describe and discuss the most commonly encountered diseases and pathological conditions of the immune system.

Content

I. Function of the Immune System

A. Defense mechanisms
   1. Nonspecific immunity
   2. Specific immunity
   3. Lymphocytes

B. Humoral immunity
   1. Antibodies

2. Complement system
3. Local inflammation

C. Cell mediated immunity
1. T-lymphocytes
2. Thymus gland

II. Immune System Diseases and Conditions

A. AIDS

B. Anemia

C. Rheumatoid arthritis

D. Lupus

E. Grave disease

F. Granulomas

G. Myasthenia gravis

H. Multiple sclerosis

Reproductive System

Objective

At the completion of this unit, the student will:

1. Describe the basic function of the reproductive system.
2. Describe and discuss the most commonly encountered diseases and pathological conditions of the reproductive system.

Content

I. Functions of the Reproductive System

A. Function of the male reproductive system

B. Functions of the female reproductive system

II. Reproductive System Diseases and Conditions

A. Endometriosis

B. Toxemia of pregnancy

C. Venereal diseases

D. Prostate gland disorders

Urinary System

Objective

At the completion of this unit, the student will:

1. Describe the basic functions of the urinary system.
2. Describe and discuss the most commonly encountered diseases and pathological conditions of the urinary system.

Content

I. Functions of the Urinary System

A. Glomerular filtration

B. Reabsorption of salts and water

C. Electrolyte balance

D. Acid-base balance

II. Urinary System Diseases and Conditions

A. Uremia

B. Blood urea nitrogen (BUN) and creatinine

C. Renal failure

D. Polycystic disease

E. Wilms tumor

F. Cushing syndrome

G. Addison disease

Pulmonary System

Objective

At the completion of this unit, the student will:

1. Describe the basic functions of the pulmonary system.
2. Describe and discuss the most commonly encountered diseases and pathological conditions of the pulmonary system.

Content

I. Functions of the pulmonary system

A. Ventilation

B. Gas exchange

C. Oxygen use

II. Pulmonary System Diseases and Conditions

A. Restrictive pulmonary disease

B. Obstructive pulmonary disease

C. Respiratory distress syndrome of the adult and child

D. Pneumonia

E. Pulmonary embolism

F. Pulmonary tuberculosis

G. Sarcoidosis

H. Atelectasis

I. Asthma

J. Bronchitis

K. Emphysema

Musculoskeletal System

Objective

At the completion of this unit, the student will:

1. Describe the basic function of the musculoskeletal system.
2. Describe and discuss the most commonly encountered diseases and pathological conditions of the musculoskeletal system.

Content

I. Functions of the Musculoskeletal System

A. Mechanical function of support, protection and body movement and metabolic functions of mineral storage and hemopoiesis

B. Functions of motion, heat production, posture and body support

II. Musculoskeletal System Diseases and Conditions

A. Osteoporosis

B. Osteomalacia

C. Osteomyelitis

D. Tuberculosis of the bone

E. Osteitis deformans

F. Osteogenesis imperfecta

G. Achondroplasia

H. Osteogenesis

I. Osteoma

J. Osteosarcoma

K. Ewing sarcoma

L. Giant cell tumor

M. Scoliosis

N. Spondylosis

O. Baker cyst

P. Meniscal tear

Q. Rotator cuff pathology
   1. Tear
   2. Tendinitis

Nervous System

Objective

At the completion of this unit, the student will:

1. Describe the basic function of the nervous system.
2. Describe and discuss the most commonly encountered diseases and pathological conditions of the nervous system.

Content

I. Functions of the Nervous System

A. Orienting the body to internal and external environments

B. Controlling and coordinating bodily activities

C. Memory, intelligence and learning

II. Nervous System Diseases and Conditions

A. Arnold Chiari I, II, III

B. Spina bifida

C. Meningiocyelocele

D. Meningitis, bacterial/viral

E. Subarachnoid hemorrhage

F. Extra dural hemorrhage

G. Subdural hemorrhage

H. Cerebrovascular accident

I. Encephalitis

J. Alzheimer disease

K. Parkinson disease

L. Huntington chorea

M. Tourette syndrome

N. Wilson disease

O. Dandy-Walker disease

P. Glioma

Q. Metastatic brain tumor

R. Transient ischemic attack

MR Clinical Practicum

Suggested Credit Hours

1. Variable length (suggest three hours of clinic for every one hour of didactic lecture).

Course Format

1. Cooperative clinical experience, preferably with clinical competencies.
2. Lab/simulations.
3. Film review sessions.

Course Description

1. Clinical experience in MR scanning, patient screening and related activities.
2. Individual research project.

Syllabus-Course Content

12. Clinical time (attendance).
13. Clinical examination record.
14. Competency evaluation.
15. Personal/professional evaluation.
16. Clinic objective.
17. Miscellaneous.

Since there are no essentials that govern the educational activities in MR education, there are no mandatory clinical requirements. However, the clinical education experience should be conducted on sound educational principles based on a competency evaluation system and should reflect both personal and professional growth of the student.

Suggestions include: 1) observations in the areas of patient screening 2) scanning (basic and customizing of protocols for specific diseases or areas of interest) 3) filming and storage of data 4) assisting the MR technologist in the areas listed. The final section should be in the area of standardized clinical competencies done with an MR technologist present where the 5) student completes the entire exam from request and chart review to patient screening, explaining the procedure to the patient, positioning the patient, using required accessories, programming the scan, completing the scan, releasing the patient, final paperwork, filming and storing the data.

Suggestions include having the student successfully perform all of the above steps on at least:

Four brain scans (can include TMJ's and IAC's).
Two MRA exams of the neck and brain.
Four spinal cord studies (one each cervical, thoracic and lumbar).
Three abdomen and pelvis scans.
Four extremity scans.
Two other MRA, either abdomen or extremity.
One chest or cardiac scan.

Clinical Practicum Forms

It is suggested each program have designated MR technologists who:

Implement the program's clinical requirements for each student.

Oversee the clinical competency exams of the students.

Write the student's performance evaluation.

Oversee the student's clinical performance, review the set-up of the exam before the actual scan is begun and assume control of the exam whenever necessary for patient safety or for the successful completion of the examination.

It is suggested that the student:

Spend three hours clinical to every hour of classroom instruction to observe, assist and perform MR examinations.

Spend time screening patients with supervision.

Spend time observing nursing procedures, such as preparation of syringes for contrast injections, types of sedation and venipuncture techniques.

To perform a successful examination as a competency, the student will, in the presence of the supervising technologist:

___ Observe, assist and/or simulate the entire exam before attempting to perform an exam for a competency.
___ Review the requisition and/or patient's chart before an the examination.
___ Communicate with the patient before, during and after the scan.
___ Ensure the patient has been thoroughly screened before the exam.
___ Select the proper scan parameters within a reasonable amount of time.
___ Recognize basic anatomy and imaging artifacts.
___ Perform the examination with a good working knowledge of basic MR theory.
___ Ask for assistance whenever necessary.
___ Finish the entire exam including filming, postprocessing and paperwork.

Sample forms for clinical competency, student evaluation and a log where students can keep a record of their clinical exams are included.

sample Student Clinical Experience Log

Each section should be checked with the date and the initials of the technologists assisting the student. Example:

STUDENT: _____ CLASSIFICATION: _____

COMPLETED: DATE _____

Screening - Two patients Brain - Four exams
Abdomen - Three exams Chest - One exam
Spine - Four exams Cardiac - One exam
Extremities - Four exams Pelvis - Three exams
MRA - Two exams, neck and brain
MRA - Two exams other than neck and brain

Patient ID#	Procedure/Site	Date	Observed Assisted or Performed			Evaluator's Initials	Comments
			O	A	P		

Permission is granted to make reproductions of this form for educational purposes.

sample Clinical Competency Form

Each student must perform the task with a competency level of four or higher on each competency step. A minimum of three (3) attempts is permitted per specific exam before the student must simulate the exam with the technologist before another attempt is made.

Competency levels:

4.Performed the task successfully with no corrective assistance from the supervising technologist.

3.Performed the task with one or two minor corrections from the supervising technologist.

2.Performed the task with more than two minor or one major correction from the supervising technologist.

1. Performed the task with more than one major correction or appeared very unsure during the examination.

0. Unable to perform the tasks or complete the examination.

Score	Task
_____	Demonstrates proper patient communication skills, practices safety, displays professional attitude throughout the examination, assures patient is screened for contraindications prior to entering the scan room.
_____	Maintains patient comfort, uses correct patient positioning while demonstrating environmental safety and exhibits proper use of pads, sponges, etc.
_____	Demonstrates proper selection and placement of surface coils and accessories.
_____	Prescribes proper information into the computer from the patient's request or department protocol after reviewing the patient's request and/or chart, if available.
_____	Demonstrates proper selection of offsets, FOV, TR, TE, flip angle, number of signals averaged, slice thickness and gap, pulse sequence and imaging options and with assistance, the slice coverage.
_____	Recognizes artifacts and knows how to make corrections.

_____ Recognizes basic cross-sectional anatomy and discerns basic pathology.

_____ Demonstrates correct follow-through with completion of exam and filming of images as to windows, levels, annotations and postprocessing, if necessary.

Student's comments:

_____ _____

Student's signature Date

Supervising technologist's comments:

Has the student successfully completed this competency in your professional opinion?

_____yes _____ no (please comment as to what needs to be done to successfully complete this exam)

Comments:

_____ _____

Supervising technologist's signature Date

Student Evaluation Form

sample: Could be used after each rotation, at midway and at the end of the course

_____ _____

Student's name Date of evaluation

To be completed by the supervising MR technologist. A separate form should be completed by the student to evaluate his/her progress.

In your professional opinion, please evaluate the student in the categories listed below for progress to date. Please feel free to make additional comments.

5 - Excellent. No problem areas noted.
4 - Above average. Some minor problems.
3 - Average. Satisfactory entry-level skills observed.
2 - Below average. Needs some major assistance, see comments.
1 - Not acceptable. See comments.
NA - I have not worked with the student in this area, or I have not rotated through this area.

1. Knowledge and ability to use independent and acceptable judgment in the following areas of entry-level skills:

Ability to perform safety screening, prepare patient and explain procedure.

Comments: _____

_____

_____ Ability to position the entire patient and area of interest while maintaining patient comfort.

Comments: _____

_____

_____ Ability to communicate professionally and appropriately with patient and staff.

Comments: _____

_____

_____ Ability to select and use the basic coils and accessories required.

Comments: _____

_____

_____ Ability to understand when and how to use the basic pulse selections of spin echo, gradient echo, inversion recovery and fast spin echo and the TR and TE's used in each.

Comments: _____

_____

___

_____ Ability to understand when and how to use the more advanced selections of MRA, time of flight, phase contrast, echo planar and the TR and TE's used in each.

Comments: _____

_____

_____ Ability to understand the principles of filming and post-processing.

Comments: _____

_____

_____ Ability to understand when and how to use basic imaging options, such as gradient moment nulling, spatial presaturation, no wrap options, swapping phase and frequency directions, gating and bandwidth.

Comments: _____

_____

_____ Ability to understand field of view selections, offsets, selecting slice locations and gaps.

Comments: _____

_____

_____ Ability to follow instructions and make necessary changes.

Comments: _____

_____

_____ Ability to understand and practice MR safety protocols.

Comments: _____

_____

_____ Production of a satisfactory examination in a reasonable amount of time.

Comments: _____

_____

_____ Ability to recognize basic artifacts and the corrective measures for each.

Comments: _____

_____

_____ Ability to recognize basic cross-sectional anatomy in all planes.

Comments: _____

_____

_____ Ability to recognize most common pathologies.

Comments: _____

_____

General comments:
This can include areas of strengths or weakness, as well as suggestions.

_____ _____

Supervising technologist Date

Introduction to Magnetic Resonance Practice Standards

The complex nature of disease processes involves multiple imaging modalities. Although an interdisciplinary team of radiologists, magnetic resonance technologists and support staff plays a critical role in the delivery of health services, it is the magnetic resonance technologist who performs the magnetic resonance examination that creates the images needed for diagnosis. Magnetic resonance technologists integrate scientific knowledge and technical skills with effective patient interaction to provide quality patient care and useful diagnostic information.

Magnetic Resonance Technologist

Magnetic resonance technologists must demonstrate an understanding of human cross-sectional anatomy, physiology, pathology, pharmacology and medical terminology.

Magnetic resonance technologists must maintain a high degree of accuracy in positioning and image formation. He or she must maintain knowledge about magnetic field safety. Magnetic resonance technologists prepare and administer contrast media and medications in accordance with state and federal regulations.

Magnetic resonance technologists are the primary liaison between patients and radiologists and other members of the support team. They must remain sensitive to the physical and emotional needs of the patient through good communication, patient assessment, patient monitoring and patient care skills.

Magnetic resonance technologists use professional and ethical judgment and critical thinking when performing their duties. Magnetic resonance quality improvement programs allow the magnetic resonance technologist to be a responsible member of the health care team by continually assessing professional performance. Magnetic resonance technologists embrace continuing education for optimal patient care, public education and enhanced knowledge and technical competence.

Education and Certification

Magnetic resonance technologists prepare for their role on the interdisciplinary team by satisfactorily completing an accredited educational program in radiologic technology, nuclear medicine or radiation therapy. Two-year certificate, associate degree and four-year baccalaureate degree programs exist throughout the United States.

Accredited programs must meet specific curricular and educational standards. The Joint Review Committee on Education in Radiologic Technology (JRCERT) is the accrediting agency for radiologic technology and radiation therapy programs recognized by the U.S. Department of Education. The Joint Review Committee on Educational Programs in Nuclear Medicine Technology (JRCNMT) is the accrediting agency for nuclear medicine programs.

Upon completion of a course of study in radiologic technology, radiation therapy or nuclear medicine technology, individuals may apply to take the national certification examination. The

American Registry of Radiologic Technologists (ARRT), the recognized certifying agency for radiographers and radiation therapists and a recognized certifying agency for nuclear medicine technologist, offers examinations three times per year. Those who successfully complete the certification examination in radiography may use the credential R.T.(R) following their name; the R.T. signifies registered technologist and the (R) indicates radiography. Those who successfully complete the certification examination in radiation therapy may use the credential R. T.(T) following their name; R.T. signifies registered technologist and the (T) indicates radiation therapy. Those who successfully complete the certification examination in nuclear medicine may use the credential R.T.(N); the R.T. signifies registered technologist and the (N) indicates nuclear medicine.

Eligibility to take the advanced-level examination in magnetic resonance requires certification as a registered technologist in radiography, radiation therapy or nuclear medicine for a minimum of one year. After successfully completing the magnetic resonance advanced-level exam, the credentials R.T.(R)(MR), R.T.(T)(MR) or R.T.(N)(MR), may be used.

To maintain ARRT certification, a level of expertise and awareness of changes and advances in practice, magnetic resonance technologists must complete 24 hours of appropriate continuing education every two years.

Practice Standards

The practice standards define the practice and establish general criteria to determine compliance. Practice standards are authoritative statements enunciated and promulgated by the profession for judging the quality of practice, service and education. They include desired and achievable levels of performance against which actual performance can be measured.

Professional practice constantly changes and actual practice varies from state to state as determined by local law and community custom. Recognizing this, the profession has adopted standards that are general in nature. The general format was favored over a "cookbook" style or "step-by-step" approach that would be difficult to maintain in a changing environment and confining for those practitioners with an expanded practice.

The standards focus on the dynamic nature of the health care delivery system. The standards are adaptable not only to the area of practice but also the locality of practice and institutional needs. While a minimum standard of acceptable performance is appropriate and should be followed by all practitioners in a specific area, it is unrealistic and highly inappropriate to assume that professional practice is the same in all regions of the United States.[1] State statute or regulation may dictate practice parameters. To conduct an appropriate review of the standards, one must look to the professional standard as well as local or state law that may impact the nature and scope of practice.

[1] The term "practitioner" is used in all areas of the standards in place of the various names used in medical imaging and radiation therapy, such as radiologic technologist, sonographer or radiation therapist. Practitioner is defined as any individual practicing in a specific area or discipline. The profession believes that any individual practicing in one of the defined disciplines or specialties should be held to a minimum standard of performance to protect the patients who receive professional services.

Format

The cohesive nature and inherent differences of medical imaging and radiation therapy are recognized in the general format of the standards. The standards are divided into three sections: clinical performance, quality performance and professional performance.

Clinical Performance Standards. The clinical performance standards define the activities of the practitioner in the care of patients and delivery of diagnostic or therapeutic procedures and treatments. The section incorporates patient assessment and management with procedural analysis, performance and evaluation.

Quality Performance Standards. The quality performance standards define the activities of the practitioner in the technical areas of performance including equipment and material assessment, safety standards and total quality management.

Professional Performance Standards. The professional performance standards define the activities of the practitioner in the areas of education, interpersonal relationships, personal and professional self-assessment and ethical behavior.

Each section of the standards is subdivided into individual standards. The standards are numbered and followed by a term or set of terms that identify the standards, such as "assessment" or "analysis/determination." The next statement is the expected performance of the practitioner when performing the procedure or treatment. A rationale statement follows and explains why a practitioner should adhere to the particular standard of performance.

Criteria. Criteria are used in evaluating a practitioner's performance. Each set of criteria is divided into two parts, the general criteria and the specific criteria. Both the measurement and specific criteria should be used when evaluating performance.

General Criteria. General criteria are written in a general style that applies to either medical imaging or radiation therapy practitioners. These criteria are the same in all sections of the standards and should be used for the appropriate area of practice. For example, a radiographer should use good professional judgment to make decisions concerning the adaptation of equipment and technical variables for a diagnostic procedure. Under these circumstances, the evaluation of the decision-making process concerning radiation therapy procedures would not be appropriate and should not be applied unless the procedure is diagnostic in nature, such as simulation.

Specific Criteria. Specific criteria meet the needs of the practitioner in the various areas of professional performance. While many areas of performance within medical imaging and radiation therapy are similar, others are not. The specific criteria are drafted with these differences in mind. For example, a criterion that calls for daily review of patient treatment records and doses to ensure that treatment does not exceed prescribed dose or normal tissue tolerance is imperative for those who practice in radiation therapy yet is not applicable to those who practice in the imaging professions.

A profession's practice standards serve as a guide for appropriate practice. Standards provide role definition for practitioners that can be used by individual facilities to develop job descriptions and practice parameters. Those outside the medical imaging and radiation therapy community can use the standards as an overview of the role and responsibilities of the practitioner as defined by the profession.

Magnetic Resonance Clinical Performance Standards

Standard One – Assessment
The practitioner collects pertinent data about the patient and the procedure.

Rationale
Information about the patient's health status is essential in providing appropriate imaging and therapeutic services.

General Criteria
The practitioner:

1. Uses consistent and appropriate techniques to gather relevant information from the medical record, significant others and health care providers. The collection of information is determined by the patient's needs or condition.
2. Reconfirms patient identification and verifies the procedure requested or prescribed.
3. Verifies the patient's pregnancy status when appropriate.
4. Determines whether the patient has been appropriately prepared for the procedure.
5. Assesses factors that may contraindicate the procedure, such as medications, insufficient patient preparation or artifacts.

Specific Criteria
The practitioner:

1. Screens patient for ferrous and RF-sensitive material before patient enters the magnetic field.

Standard Two – Analysis/Determination
The practitioner analyzes the information obtained during the assessment phase and develops an action plan for completing the procedure.

Rationale
Determining the most appropriate action plan enhances patient safety and comfort, optimizes diagnostic and therapeutic quality and improves cost effectiveness.

General Criteria
The practitioner:

1. Selects the most appropriate and cost-effective action plan after reviewing all pertinent data and assessing the patient's abilities and condition.
2. Uses his or her professional judgement to adapt imaging and therapeutic procedures to improve diagnostic quality and therapeutic outcome.
3. Consults appropriate medical personnel to determine a modified action plan when necessary.
4. Determines the need for accessory equipment.

Specific Criteria
The practitioner:

1. Selects appropriate image coil.
2. Determines optimum placement of ECG electrodes.
3. Selects appropriate patient immobilization devices.
4. Reviews the patient's chart and physician's request to determine optimal imaging parameters for suspected pathology.
5. Determines the appropriate type of contrast agent to be administered based on the patient's age and weight.

Standard Three – Patient Education
The practitioner provides information about the procedure to the patient, significant others and health care providers.

Rationale
Communication and education are necessary to establish a positive relationship with the patient, significant others and health care providers.

General Criteria
The practitioner:

1. Verifies that the patient has consented to the procedure and fully understands its risks, benefits, alternatives and follow-up. When appropriate, the practitioner verifies that written consent has been obtained.
2. Provides accurate explanations and instructions at an appropriate time and at a level the patient can understand. Addresses and documents patient questions and concerns regarding the procedure when appropriate.
3. Refers questions about diagnosis, treatment or prognosis to the patient's physician.
4. Provides appropriate information to any individual involved in the patient's care.

Specific Criteria
The practitioner:

1. Consults with other departments, such as patient transportation and anesthesia, for patient services.
2. Ensures that all procedural requirements are in place to achieve a quality diagnostic examination.
3. Explains precautions regarding administration of contrast agents to nursing mothers.
4. Responds to questions about MR risk factors.

Standard Four – Implementation
The practitioner implements the action plan.

Rationale
Quality patient services are provided through the safe and accurate implementation of a deliberate plan of action.

General Criteria

The practitioner:

1. Implements an action plan that falls within established protocols and guidelines.
2. Elicits the cooperation of the patient to carry out the action plan.
3. Uses an integrated team approach as needed.
4. Modifies the action plan according to changes in clinical situation.
5. Administers first aid or provides life support in emergency situations.
6. Uses accessory equipment when appropriate.
7. Assesses and monitors the patient's physical and mental status.

Specific Criteria

The practitioner:

1. Provides hearing protection to patient and others.
2. Enters necessary patient information to initiate scan.
3. Positions image coil when necessary.
4. Positions ECG electrodes when necessary.
5. Performs venipuncture, IV patency and maintenance procedures according to established guidelines.
6. Administers contrast agents according to established guidelines.
7. Monitors the patient for reactions to contrast agent.
8. Monitors the patient's specific absorption rate for variances from established guidelines.
9. Applies appropriate patient immobilization devices when necessary.
10. Completes routine camera operations such as switching from manual to automatic, changing formats, ensuring an adequate film supply for the procedure and verifying image location.
11. Completes documentation of procedures requiring informed consent.

Standard Five – Evaluation

The practitioner determines whether the goals of the action plan have been achieved.

Rationale

Careful examination of the procedure is important to determine that all goals have been met.

General Criteria

The practitioner:

1. Evaluates the patient and the procedure to identify variances that may affect patient outcome. The evaluation process should be timely, accurate and comprehensive.
2. Measures the procedure against established protocols and guidelines.
3. Identifies any exceptions to the expected outcome.
4. Documents any exceptions clearly and completely.
5. Develops a revised action plan to achieve the intended outcome if necessary.
6. Disseminates reasons for revisions to all team members.

Specific Criteria

The practitioner:

5. Evaluates the images to determine technical quality.

6. Reviews images to determine if additional scans will enhance the diagnostic value of the procedure.

Standard Six – Implementation
The practitioner implements the revised action plan.

Rationale
It may be necessary to make changes to the action plan to achieve the intended outcome.

General Criteria
The practitioner:
1. Bases the revised plan on the patient's condition and the most appropriate means of achieving the intended outcome.
2. Takes action based on patient and procedural variances.
3. Measures and evaluates the results of the revised action plan.
4. Notifies appropriate health provider when immediate clinical response is necessary based on procedural findings and patient condition.

Specific Criteria
The practitioner:
1. Reformats images.
2. Revises patient position or imaging parameters to better visualize the anatomy or pathology according to established guidelines.
3. Implements special filming or computer-generated information to improve the outcome of the procedure.

Standard Seven – Outcomes Measurement
The practitioner reviews and evaluates the outcome of the procedure.

Rationale
To evaluate the quality of care, the practitioner compares the actual outcome with the intended outcome.

General Criteria
The practitioner:
1. Reviews all diagnostic or therapeutic data for completeness and accuracy.
2. Determines whether the actual outcome is within established criteria.
3. Evaluates the process and recognizes opportunities for future changes.
4. Assesses the patient's physical and mental status prior to discharge from the practitioner's care.

Specific Criteria
None added.

Standard Eight – Documentation
The practitioner documents information about patient care, the procedure and the final outcome.

Rationale
Clear and precise documentation is essential for continuity of care, accuracy of care and quality assurance.

General Criteria
The practitioner:

1. Documents diagnostic, treatment and patient data in the appropriate record. Documentation must be timely, accurate, concise and complete.
2. Documents any exceptions from the established criteria or procedures.
3. Records diagnostic or treatment data.

Specific Criteria
The practitioner:

1. Archives images to data storage devices according to established guidelines.

Quality Performance Standards

Standard One – Assessment
The practitioner collects pertinent information regarding equipment, procedures and the work environment.

Rationale
The planning and provision of safe and effective medical services relies on the collection of pertinent information about equipment, procedures and the work environment.

General Criteria
The practitioner:
1. Ensures that services are performed in a safe environment in accordance with established guidelines.
2. Ensures that equipment maintenance and operation comply with established guidelines.
3. Assesses equipment to determine acceptable performance based on established guidelines.
4. Ensures that protocol and procedure manuals include recommended criteria and are reviewed and revised on a regular basis.

Specific Criteria
The practitioner:
1. Maintains controlled access to restricted magnetic field area to ensure safety of patients, visitors and hospital personnel.

Standard Two – Analysis/Determination
The practitioner analyzes information collected during the assessment phase and determines whether changes need to be made to equipment, procedures or the work environment.

Rationale
Determination of acceptable performance is necessary for the provision of safe and effective services.

General Criteria
The practitioner:
1. Assesses whether services, procedures and environment meet or exceed established guidelines. If not, the practitioner develops an action plan.
2. Evaluates equipment to determine if it meets or exceeds established standards. If not, the practitioner develops an action plan.
3. Analyzes information collected during the assessment phase to determine whether optimal services are being provided. If not, the practitioner develops an action plan.

Specific Criteria
The practitioner:
1. Monitors cryogens.

Standard Three – Education
The practitioner informs the patient, public and other health care providers about procedures, equipment and facilities.

Rationale
Open communication promotes safe practices.

General Criteria
The practitioner:
1. Elicits confidence and cooperation from the patient, the public and other health care providers by providing timely communication and effective instruction.
2. Presents explanations and instructions at the learner's level of understanding and learning style.

Specific Criteria
The practitioner:
1. Instructs health care providers and students regarding MR procedures.
2. Educates the public about MR procedures.

Standard Four – Performance
The practitioner performs quality assurance activities or acquires information on equipment and materials.

Rationale
Quality assurance activities provide valid and reliable information regarding the performance of materials and equipment.

General Criteria
The practitioner:
1. Performs quality assurance activities based on established protocols.
2. Provides evidence of ongoing quality assurance activities.

Specific Criteria
The practitioner:
1. Monitors image production to determine variance from established quality standards.

Standard Five – Evaluation
The practitioner evaluates quality assurance results and establishes an appropriate action plan.

Rationale
Materials, equipment and procedure safety depend on ongoing quality assurance activities that evaluate performance based on established guidelines.

General Criteria
The practitioner:
1. Compares quality assurance results to established acceptable values.

2. Formulates an action plan following verification of testing.

Specific Criteria
The practitioner:
1. Performs routine archiving status checks and deletes data according to established guidelines.

Standard Six – Implementation
The practitioner implements the quality assurance action plan.

Rationale
Implementation of a quality assurance action plan is imperative for quality diagnostic and therapeutic procedures and patient care.

General Criteria
The practitioner:
1. Obtains assistance from appropriate personnel to implement the quality assurance action plan.
2. Implements the quality assurance action plan.

Specific Criteria
None added.

Standard Seven – Outcomes Measurement
The practitioner assesses the outcome of the quality assurance action plan in accordance with established guidelines.

Rationale
Outcomes assessment is an integral part of the ongoing quality assurance plan to enhance diagnostic and therapeutic services.

General Criteria
The practitioner:
1. Reviews the implementation process for accuracy and validity.
2. Determines whether the performance of equipment and materials is safe for practice based on outcome assessment.
3. Develops and implements a modified action plan when testing results are not in compliance with guidelines.

Specific Criteria
None added.

Standard Eight – Documentation
The practitioner documents quality assurance activities and results.

Rationale
Documentation provides evidence of quality assurance activities designed to enhance the safety of patients, the public and health care providers during diagnostic and therapeutic services.

General Criteria
The practitioner:

1. Maintains documentation of quality assurance activities, procedures and results in accordance with established guidelines.
2. Provides timely, concise, accurate and complete documentation.
3. Provides documentation that adheres to current protocol, policy and procedures.

Specific Criteria
None added.

Professional Performance Standards

Standard One – Quality
The practitioner strives to provide optimal care to all patients.

Rationale
All patients expect and deserve optimal care during diagnosis and treatment.

General Criteria
The practitioner:

2. Works with others to elevate the quality of care.
3. Participates in quality assurance programs.
4. Adheres to the accepted standards, policies and procedures adopted by the profession and regulated by law.
5. Provides the best possible diagnostic study or therapeutic treatment for each patient by applying professional judgment and discretion.
6. Anticipates and responds to the needs of the patient.

Specific Criteria
None added.

Standard Two – Self-Assessment
The practitioner evaluates personal performance, knowledge and skills.

Rationale
Self-assessment is an important tool in professional growth and development.

General Criteria
The practitioner:

7. Monitors personal work ethics, behaviors and attitudes.
8. Monitors and evaluates orientation guidelines and recommends improvements or changes as needed.
9. Evaluates performance and recognizes opportunities for improvement.
10. Recognizes his or her strengths and uses them to benefit patients, coworkers and the profession.
11. Performs procedures only after receiving appropriate education and training.
12. Recognizes and takes advantage of opportunities for educational growth and improvement in technical and problem-solving skills.
13. Actively participates in professional societies and organizations.

Specific Criteria
None added.

Standard Three – Education
The practitioner acquires and maintains current knowledge in clinical practice.

Rationale
Advancements in medical science require enhancement of knowledge and skills through education.

General Criteria
The practitioner:
14. Demonstrates completion of the appropriate education related to clinical practice.
15. Maintains appropriate credentials and certification related to clinical practice.
16. Participates in educational activities to enhance knowledge, skills and performance.
17. Shares knowledge and expertise with others.

Specific Criteria
None added.

Standard Four – Collaboration and Collegiality
The practitioner promotes a positive, collaborative practice atmosphere with other members of the health care team.

Rationale
To provide quality patient care, all members of the health care team must communicate effectively and work together efficiently.

General Criteria
The practitioner:
1. Shares knowledge and expertise with colleagues, peers, students and all members of the health care team.
2. Develops collaborative partnerships with other health care providers in the interest of diagnostic and therapeutic quality and cost effectiveness and safety.

Specific Criteria
None added.

Standard Five – Ethics
The practitioner adheres to the profession's accepted Code of Ethics.

Rationale
All decisions and actions made on behalf of the patient are based on a sound ethical foundation.

General Criteria
The practitioner:
3. Provides health care services with respect for the patient's dignity and age-specific needs.
4. Acts as a patient advocate to support patients' rights.
5. Takes responsibility for professional decisions.

6. Delivers patient care and service without bias based on personal attributes, nature of the disease, sex, race creed, religion or socioeconomic status.
7. Respects the patient's right to privacy and confidentiality.
8. Adheres to the established practice standards of the profession.

Specific Criteria
None added.

Standard Six – Exploration and Investigation
The practitioner participates in the acquisition, dissemination and advancement of the professional knowledge base.

Rationale
Scholarly activities such as research, scientific investigation, presentation and publication advance the profession and thereby improve the quality and efficiency of patient services.

General Criteria
The practitioner:
9. Reads and critically evaluates research in diagnostic therapeutic services.
10. Investigates new, innovative methods and applies them in practice.
11. Shares information with colleagues through publication, presentation and collaboration.
12. Pursues lifelong learning.
13. Participates in data collection.

Specific Criteria
None added.

Magnetic Resonance Glossary

Artifact – False features in the image produced by patient instability or equipment deficiencies.

Archiving – The storage of image data for future retrieval.

Assess – To determine the significance, importance or value.

Coil – Single or multiple loops of wire (or other electrical conductor, such as tubing) designed either to produce a magnetic field from current flowing through the wire or to detect a changing magnetic field by voltage induced in the wire.

Contrast media – Substance administered to subject being imaged to alter selectively the image intensity of a particular anatomical or functional region.

Contraindicate – To make the indicated or expected treatment or drug inadvisable.

Cryogen – A cooling agent, often used at or near absolute zero.

Data storage device - Data may be archived on either magnetic tape or optical disk.

ECG – Electrocardiogram.

Ethical – Conforming to the standards of conduct of a given profession or group.

Ferrous – A substance containing or derived from iron that has a large positive magnetic susceptibility.

Magnetic field – A physical field that arises from an electrical charge in motion, producing a force on a moving electric charge.

Magnetic resonance (MR) – The integration of the minute magnetic properties of the tissue atoms with the static magnet field, to be in resonance with an applied external RF pulse, and in turn producing MR signals that are converted into tissue image.

Radio frequency (RF) – Wave frequency intermediate between auditory and infrared.

Specific absorption rate (SAR) – A measure of the rate of radio frequency disposition in the body; SAR is a measure of the RF power absorbed per unit time per unit mass.

Venipuncture – The puncture of a vein.

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