Imaging Assistant in Magnetic Resonance Curriculum

Sponsored by the American Society of Radiologic Technologists, 15000 Central Ave. SE, Albuquerque, NM 87123-3909.

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Introduction

The imaging assistant in magnetic resonance (MR) imaging is a medical imaging professional other than a radiologic technologist who provides patient care in the MR environment, including MR safety screening, venipuncture, the injection of MR contrast and emergency response in the MR environment.

The I.A.(MR) works as part of the MR team in conjunction with a registered MR technologist. The I.A.(MR) is a Level 2 MR Personnel as defined by the American College of Radiology's 2024 Manual on MR Safety. The I.A.(MR) shall not have responsibility for image acquisition in the MR environment.

This curriculum document is intended to establish national standardized educational guidelines for the I.A.(MR). The content and objectives should be organized to meet the mission, goals and needs of each I.A.(MR) program. Faculty members are encouraged to expand and broaden these fundamental objectives as they incorporate them into their curricula. Specific instructional methods were intentionally omitted to allow for programmatic prerogative as well as creativity in instructional delivery.

Advances in medical imaging and employer expectations demand independent judgment by I.A.(MR)s. Consequently, critical thinking skills must be fostered, developed and assessed in the educational process. Critical thinking has been incorporated in multiple content areas. It is expected that the faculty will develop and implement critical thinking throughout the curriculum.

In summary, the I.A.(MR) curriculum is based on data relevant to today's health care environment. The curriculum offers a foundation for lifelong learning and transition to further studies.

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Clinical Practice

Considerations:

Regulations practice vary by state and institution. The educational program shall ensure that:

- Professional liability coverage is adequate.
- Adequate supervision is provided.
- Appropriate, structured laboratory objectives are identified.
- Evaluation of competency occurs.

Objectives:

- Adhere to concepts of team practice that focus on organizational theories, roles of team members and conflict resolution.
- Adapt to changes and varying clinical situations.
- Provide patient-centered clinically effective service for all patients regardless of age, disability, special needs, ethnicity or culture.
- Integrate the use of appropriate and effective written, oral and nonverbal communication with patients, the public and members of the health care team (e.g., peers, licensed practitioners, administration, etc.) in the clinical setting.
- Apply the principles of total quality management to landmark phantoms.
- Report equipment malfunctions.
- Examine procedure orders for accuracy and follow up to make corrective changes when applicable.
- Demonstrate safe, ethical and legal practices.
- Integrate the I.A.(MR)'s scope of practice and practice standards into a clinical practice setting.
- Maintain patient confidentiality standards and meet Health Insurance Portability and Accountability Act (HIPAA) requirements.
- Demonstrate principles of transferring, positioning and immobilizing patients.
- Explain the role of health care team members related to the medical imaging environment.
- Describe and apply the delineation of tasks, including screening, emergencies, patient care, contrast injection, and ensuring safety within the MR environment, between the registered MR technologist and I.A.(MR) during remote scanning
- Demonstrate proper scheduling and sequencing of imaging procedures (e.g., multiple examinations in one day, 1.5 versus 3.0 tesla).
- Correlate requested imaging procedures with clinical history and reported physical examination findings.
- Assess patients (e.g., screening, monitoring, etc.).
- Educate patients, family members and other health care professionals about MR procedural preparation, screening and safety.
- Demonstrate charting and documentation.
- Apply infection control precautions to prevent disease transmission.

- Describe communicable disease terminology and required transmission-based precautions.
- Evaluate and respond to medical emergencies.
- Differentiate the functions of tubes, catheters, lines and infusion devices.
- List preprocedural considerations.
- Position and set up patients, MR coils, equipment, table accessories and cushioning.
- Apply national, organizational and departmental standards, protocols, policies and procedures regarding MR imaging and patient care.
- Explain environmental considerations (e.g., gauss lines, radiofrequency (RF) shielding and magnetic shielding, etc.).
- Apply safety practices to protect patients, employees and staff entering the MR environment.

Content:

I. Clinical Practice

A. Code of ethics/professional behavior
   1. Scope of practice
   2. Incident reporting mechanisms
   3. Standards for imaging assistant in MR supervision
      a. Precompetency assessment
      b. Postcompetency assessment
   4. The patient care partnership: understanding expectations, rights and responsibilities

B. Professional communication
   1. Patients
   2. Patient's family
   3. Caretaker or legal guardian
   4. Health care team
   5. Confidentiality of patient records (HIPAA compliance)

C. I.A.(MR) practice standards
   1. Technical
   2. Professional
   3. Equipment operation
   4. Ability to adapt to varying clinical situations
   5. Emergency response
   6. Total quality management

D. Values
   1. Personal
   2. Societal
   3. Professional

E. Culture, different backgrounds and needs
   1. Societal and individual factors
   2. Socioeconomic

3. Gender identity
4. Age
    a. Infant
    b. Child
    c. Adolescent
    d. Adult
    e. Middle-aged
    f. Geriatric
5. Family structure and dynamics
6. Geographical factors
7. Religion
8. Lifestyle choices and behaviors
9. Sexual orientation
10. Disability

II. Procedural Performance

A. Scheduling and sequencing of examinations

B. Order/requisition evaluation and corrective measures

C. Patient assessment, clinical history, education and care
1. Patient monitoring – emergent and nonemergent
2. Vitals signs
3. Assessment and clinical history
4. Equipment
5. Patient emergencies
6. Contraindications
7. Claustrophobia
8. Patient privacy and confidentiality
9. Documentation and charting
10. Infection control
11. Patient education
12. Communication style
13. Age-specific
14. Cultural and socioeconomic sensitivity
15. Patient-focused care
16. Medical error reduction

D. Positioning considerations for coil selection

E. Preparation of supplies and equipment for contrast media injections

F. Roles and responsibilities of health care team members
1. Registered MR technologist
2. I.A.(MR)
3. Remote scanning

a. Contrast administration
b. Screening
c. Emergencies
d. Ensuring the safety of personnel and patients in the MR environment

G. Suite and equipment preparation

H. Patient assessment and education
1. MR screening documentation form
a. Contraindications for MR imaging
b. Laboratory results – normal ranges and values
1) Oxygen (O2) saturation
2) Glomerular filtration rate calculation (GFR)
3) Creatinine
2. Adult vs. pediatric considerations
3. Patient monitoring – emergent and nonemergent
a. Vital signs – normal ranges and values
1) Temperature
a) Fahrenheit
b) Celsius
2) Pulse
3) Respiration
4) Blood pressure
b. Physiologic monitoring
1) Electrocardiogram (ECG)
2) Pulse oximetry
3) Temperature changes
4. Pregnancy status
a. Setup modifications
b. Institutional policies on magnet field strength for pregnant patients
c. Institutional polices on MR contrast and pregnant patients

I. Charting and documentation
1. Medical reconciliation
2. Surgical and medical history

J. I.A.(MR) pregnancy status
1. Institutional declaration process
2. Avoid being in the room when scanning

III. Infection Control

A. Centers for Disease Control and Prevention (CDC)
1. Purpose
2. Publications and bulletins

B. Occupational Safety and Health Administration (OSHA)

1. Purpose
2. Publications and bulletins

C. Cycle of infection
   1. Infectious pathogens
   2. Source or reservoir of infection
   3. Mode of transmission
      a. Direct
      b. Indirect

IV. Preventing Disease Transmission

A. Standard precautions
   1. Hand washing
   2. Personal protective equipment

B. Transmission-based precautions
   1. Airborne (e.g., negative ventilation)
   2. Droplet
   3. Contact

C. Health care worker
   1. Immunization
   2. Titer – booster
   3. Postexposure protocols (e.g., prophylaxis)

D. Asepsis
   1. Medical
      a. Definition
      b. Procedures
      c. Chemical disinfectants
   2. Surgical
      a. Definition
      b. Growth conditions for microorganisms
      c. Methods used to control microorganisms
         1) Moist heat
            a) Boiling
            b) Steam under pressure
         2) Dry heat
            a) Incineration
            b) Dry heat sterilized
         3) Gas
         4) Chemicals
      d. Procedures
         1) Opening sterile packaging
         2) Gowning and gloving
         3) Skin preparation

4) Draping
5) Dressing changes

3. Packing
4. Storage

E. Safe cleaning of equipment and disposal of contaminated materials

F. Linens
1. Needles
2. Patient supplies
3. Scanner, bore, coils, ancillary equipment
4. Wound dressing care
5. Handling and disposal of toxic or hazardous material

G. Precautions for compromised patient (e.g., neutropenic precautions)
1. Purpose
2. Procedure

H. Psychological considerations

V. Medical Emergencies

A. Terminology

B. Emergency equipment

C. Allergic reactions

D. Signs, symptoms and precautions
1. Shock
2. Diabetic emergencies
3. Respiratory and cardiac failure
4. Airway obstruction
5. Cerebrovascular accident (stroke)
6. Syncope
   a. Nausea
   b. Postural hypotension
   c. Vertigo
   d. Vasovagal response
7. Seizures
8. Epistaxis
9. Mental illness
10. Neurological
    a. Head injuries
    b. Spinal injuries
11. Extremity fractures
12. Wounds

13. Burns
14. Reactions to contrast agents
15. Other

VI. Tubes, Catheters, Lines and Infusion Devices

A. Terminology

B. Function of devices

C. Nasogastric, feeding and rectal tubes

D. IVs

1. Butterflies
2. Angiocatheters

E. Power injectors

F. Infusion pumps

G. Suction

H. Tracheostomy

I. Chest (thoracostomy) tube

J. Central venous lines

K. Postoperative drains

L. Oxygen administration using MR Conditional equipment

M. Other

1. Ostomies
2. Urinary catheters
3. Prosthetics
4. Continuous glucose monitoring (CGM) devices

VII. Patient Preparation and Positioning

A. Preprocedural considerations

B. Positioning

C. Screening

1. Patient

2. Personnel
3. General public

D. Metallic foreign body injuries

E. External metallic objects
   1. Implants and pacemakers
   2. Renal disease
   3. Asthma
   4. Pregnancy
   5. Dialysis

F. Claustrophobia

G. Contrast preparation
   1. Liver disease
   2. Chronic hypertension
   3. Diabetes

H. Equipment and accessories
   1. Coils
   2. Emergency alarm call button
   3. Earplugs and headphones
   4. Positioning sponges

I. MR Conditional equipment
   1. Patient monitoring devices
   2. Oxygen tanks
   3. IV pumps
   4. Wheelchairs and stretchers

J. Anesthesia equipment
   1. Suction
   2. Anesthesia machine
   3. Ventilators

K. Environment
   1. Gauss lines
   2. RF shielding and magnetic shielding
   3. Warning alarms and signs
   4. Safety zones 1-4
   5. Climate control (i.e., temperature, humidity)
   6. Ferromagnetic metal detector

L. Safety considerations
   1. RF field (B1)

2. Static magnetic field (B0)
3. Spatial magnetic field (dB/dx)
4. Gradient fields (dB/dt)

Computers in Imaging and Medical Informatics

Note: Digital imaging is a rapidly evolving technology. Every effort has been made to provide a curriculum outline that reflects as accurately as possible the state of the art of this discipline as of publication. Educators are encouraged to modify this outline with up-to-date information as it becomes available from vendors, clinical sites, textbooks and technical representatives.

Objectives

- Describe computer fundamentals.
- Explain how regulations, laws and standards related to informatics affect health care delivery.
- Describe the evolution and role of health care informatics.
- Recognize the ethical concerns related to health care informatics.
- Describe a medical image management and processing system (MIMPS, formerly PACS) and its function.
- Identify components of a MIMPS.
- Explain radiology information systems (RIS).
- Define digital imaging and communications in medicine (DICOM).
- Identify information systems and standards used to manage and transfer a patient's health information.
- Identify procedural factors (e.g., image identification, documentation of ordered imaging procedure, artifacts and image evaluation).
- Apply HIPAA standards regarding accountability and protection of patient information.
- Describe HIPAA concerns with electronic information.
- Identify common problems associated with retrieving/viewing images within a MIMPS.

Content:

I. Computer Fundamentals

A. Terminology
   1. Analog
   2. Digital

B. Types of computers
   1. Supercomputer
   2. Minicomputer
   3. Microcomputer

II. Health Care Informatics

A. Definition

B. History

C. Theories

D. Databases

E. Ethics

III. Regulations, Laws and Standards

A. Licensure and/or certification

B. Accreditation

C. National and international standards

D. Federal laws

E. State laws and statutes

IV. Decision Making

A. Administrative

B. Clinical

C. Evidence-based medicine

V. Health Care Informatics Applications

A. Information Systems
   1. Hospital information system (HIS)
   2. Radiology information system (RIS)

B. Medical image management and processing system (MIMPS, formerly PACS)

C. Teleradiology and telemedicine

D. Standards
   1. Digital imaging and communication in medicine (DICOM)
   2. Health level standards (HL7)

E. Health information exchanges (HIE)

F. Methods of obtaining patient health information
   1. Coding and standardization

G. Roles of the MR technologist and I.A.(MR)

Fundamentals, Ethics and Laws of Health Care

Objectives:

- Identify other health science professionals who participate in the patient's total health care.
- Describe the relationship of health science professionals to the integrated care of patients.
- Identify various settings involved in the delivery of health care.
- Describe relationships and interdependencies within health care.
- List patient services that might be available in a medical imaging department.
- Define *accreditation*, *credentialing*, *certification*, *licensure* and *regulations*.
- List the regulatory agencies relevant to the imaging sciences and health care.
- Identify the benefits of continuing education as related to improved patient care and professional enhancement.
- Identify professional development and advancement opportunities.
- Discuss the purpose, function, and activities of professional organizations at the local, state, national and international levels.
- Describe the moral, social and cultural basis of ethics.
- Explain the role of ethical behavior in health care delivery.
- Differentiate between empathetic rapport and sympathetic involvement in relationships with patients and relate these to ethical conduct.
- Explain concepts of personal honesty, integrity, accountability, competence and compassion as ethical imperatives in health care.
- List legal/professional standards and their relationship to practice in health professions.
- Identify specific situations and conditions that give rise to ethical dilemmas in health care.
- Employ a basic system of examination, clarification, determination of alternatives and decision making in addressing ethical questions.
- Explain select concepts embodied in HIPAA, principles of patients' rights, the doctrine of patient consent and other issues related to patients' rights.
- Explain the legal implications of I.A.(MR) liability, malpractice, negligence/carelessness and other legal doctrines applicable to I.A.(MR) scope of practice.
- Describe the importance of accurate, complete, correct methods of documentation as a legal/ethical imperative.
- Describe institutional and professional liability protection typically available to the I.A.(MR).

Content:

I. The Health Science Professions

A. Medical imaging
   1. Imaging Assistant (IA)
   2. Limited x-ray machine operator (LXMO)
   3. Radiography
      a. Fluoroscopy
      b. C-arm
      c. Operating room
   4. Computed tomography

5. Mammography
6. Cardiovascular-interventional radiography
7. Vascular-interventional radiography
8. Bone densitometry
9. Nuclear medicine
10. Multiskilled (fusion technology)
11. Diagnostic medical sonography
12. Magnetic resonance imaging
13. Quality management
14. Advanced practice roles in medical imaging
    a. Radiologist assistant
    b. Nuclear medicine advanced associate
    c. Advanced practice sonographers

B. Radiation oncology
1. Radiation therapy
2. Medical dosimetry
3. Advanced practice radiation therapy

C. Radiation safety officer

D. Magnetic resonance safety officer (MRSO)

E. Medical image management and processing system (MIMPS, formerly PACS)

F. Informatics

G. Education

H. Management

I. Allied health professions

II. The Health Care Environment

A. Health care settings
1. Hospitals
2. Clinics
3. Outpatient or ambulatory care

B. Quality management
1. Quality management and improvement
2. Quality assurance
3. Quality control

C. Benefits
1. Patient safety

2. Efficacy of patient care
3. Efficiency
4. Consistency
5. Cost effectiveness

III. Facility Organization

A. Philosophy, mission and vision

B. Administrative services
1. Governing board
2. Hospital administration
3. Human resources
4. Credentialing
5. Procurement
6. Accounting and billing
7. Patient registration
8. Information systems
9. Support services

C. Medical services
1. Physician
2. Clinical services
3. Clinical support services

IV. Medical Imaging Organization

A. Administrative personnel
1. Administrator
2. Director and manager
3. Supervisor

B. Clinical personnel
1. Imaging medical aide
2. I.A.(MR)
3. Medical imaging professionals, including LXMOs
4. Radiation therapy professionals
5. Medical image management and processing system (MIMPS, formerly PACS) administrator
6. Clinical informatics
7. Medical imaging nurse
8. Physician
9. Interpreting radiologist
10. Interventional radiologist
11. Ordering providers
12. Medical physicist
13. Radiation safety officer
14. Magnetic resonance safety officer

C. Support staff
    1. Clerical staff
    2. Technical assistant
    3. Transport staff

D. Educational personnel
    1. Program director
    2. Clinical coordinator
    3. Didactic instructor
    4. Clinical preceptors
    5. Clinical staff

V. Accreditation

A. Health care institutions
    1. Facility level
    2. Departmental level
    3. Intradepartmental (modality)

VI. Regulatory Agencies

A. Federal

B. State

VII. Professional Credentialing

A. Definition
    1. Certification
    2. Registration
    3. Licensure

B. Agencies
    1. National
    2. State

VIII. Professional Organizations

A. Purpose, function and activities

B. Types
    1. Local
    2. State
    3. National
    4. International

IX. Professional Development

A. Clinical experience requirements

B. Continuing education opportunities
   1. Continuing education
   2. Primary pathway medical imaging programs
   3. Postprimary certification
   4. Collegiate/educational programs

C. Continued qualifications

D. Employment considerations
   1. Geographic mobility
   2. Economic factors
   3. Workforce needs

X. Ethics in Health Care

A. Origins and history of medical ethics

B. Moral reasoning

C. Competence

D. Professional attributes

E. Responsibilities defined
   1. Lines of authority
   2. Areas of responsibility
   3. Limitations

F. Self-assessment and self-governance

G. Code of professional ethics

H. Ethical concepts

I. Systematic analysis of ethical problems

XI. Ethical Issues in Health Care

A. Individual and societal rights

B. Cultural considerations

C. Economic considerations

D. Access to quality health care

E. Technology and scarce resources

F. Medical/health care research

G. End-of-life decisions
   1. Living wills
   2. Advanced directives
   3. Health care power of attorney
   4. Nonintervention

H. Optimal wellness and quality care for all patients
   1. Barriers
   2. Health outcomes, including morbidity and mortality
   3. Social factors
   4. Patient and family centered care
   5. Adapting to patient needs
      a. Processes
      b. Interpersonal engagement
   6. Health literacy

XII. Legal Responsibilities

A. Parameters of legal responsibility
   1. Professional liability
   2. Intentional misconduct
      a. Libel and slander
      b. Assault and battery
      c. False imprisonment
      d. Invasion of privacy
      e. Breach of confidentiality
   3. Negligence/malpractice
      a. Definitions
         1) Gross negligence
         2) Contributory negligence
      b. Elements of malpractice
         1) Duty
         2) Dereliction (breach)
         3) Causation
         4) Damage
   4. Legal and professional standards
      a. Standard of care
      b. Patients' bill of rights
      c. HIPAA
         1) Individual
         2) Institutional

B. Legal doctrines (e.g., respondeat superior, res ipsa loquitur)
   1. Medical records
   2. Legal risk reduction and risk management

C. Responsibilities of the I.A.(MR)
   1. Definition
   2. Supervision
   3. State statute
   4. Limitations

XIII. Patient Consent

A. Rationale

B. Definition
   1. Implied
   2. Written
   3. Oral

C. Condition for legal or valid consent
   1. Legal age
   2. Competence
   3. Capacity
   4. Voluntary
   5. Provision of adequate information regarding case, procedure, alternatives and risk

D. American Hospital Association (AHA) and Joint Commission standards for disclosure

E. Documentation of consent

F. Right of refusal

Human Anatomy and Physiology

Objectives:

- Identify the location of anatomical structures using directional and orientation terms relevant for coil positioning.
- Indicate where various planes lie in relation to the body.
- Demonstrate the use of topographical landmarks to locate internal structures.
- Identify the structural limits, functions and contents of each of the body cavities.
- Identify and locate the bony landmarks for coil positioning.
- Describe the flow of blood through the body and identify the main vessels that are relevant to venipuncture and coil placement.
- Describe the structure and function of arteries, veins and capillaries.

Content:

I. Anatomical Nomenclature

A. Directional terms
   1. Anterior/posterior
   2. Ventral/dorsal
   3. Medial/lateral
   4. Superior/inferior
   5. Proximal/distal
   6. Cephalad/caudad

B. Body planes
   1. Median/midsagittal
   2. Sagittal
   3. Coronal
   4. Transverse
   5. Longitudinal

C. Body cavities – structural limits, function and contents
   1. Cranial
   2. Thoracic
   3. Abdominal/pelvic

II. Landmarks and Underlying Anatomy

A. Cranium

B. Neck

C. Spine

D. Thorax

E. Abdomen

F. Pelvis

G. Extremities

III. Cardiovascular and Respiratory System

A. Lungs

B. Heart

C. Aorta

D. Vena Cava

E. Mediastinum

F. Trachea

IV. Abdomen

A. Digestive system – structure, function and location
   1. Oral cavity
   2. Esophagus
   3. Stomach
   4. Small intestine
   5. Large intestine
   6. Rectum

B. Genitourinary system – structure, function and location
   1. Kidneys
   2. Ureters
   3. Bladder
   4. Urethra
   5. Prostate
   6. Uterus

Medical Terminology

Objectives:

- Apply the word-building process.
- Interpret medical abbreviations and symbols.
- Critique orders, requests and diagnostic reports.
- Define medical imaging terms.
- Translate medical terms, abbreviations and symbols into common language from a medical report.

Content:

I. The Word-Building Process

A. Basic elements
   1. Root words
   2. Prefixes
   3. Suffixes
   4. Combination forms

B. Parts of speech
   1. Nouns
   2. Verbs
   3. Adjectives
   4. Adverbs

C. Translation of terms into common language

D. Correct pronunciation of medical terms

II. Medical Abbreviations and Symbols

A. Role in communications

B. Approved abbreviations
   1. Examples
   2. Interpretations
   3. Restrictions (e.g., The Joint Commission's "Do Not Use" list)

C. Symbols
   1. Pharmaceutical symbols and terms
   2. Math and science symbols and constants
   3. Examples
   4. Interpretations

III. Understanding Orders, Requests and Diagnostic Reports

A. Procedure orders and requests
   1. Patient identification
   2. Procedures ordered

3. Patient history
4. Clinical indications
5. Ordering physician/provider

B. Diagnostic reports
   1. Content
   2. Interpretation

MR Safety

Note:
Education of patients and personnel is essential to prevent MR incidents. The ACR has developed guidelines for safe MR practices.

Objectives:

- List MR safety organizations and identify the role of each organization in MR safety.
- Define the different magnetic fields associated with MR imaging and list the safety concerns associated with each one.
- Apply safety measures to reduce the risk of safety incidents.
- Identify and discuss the various components of MR safety screening for patients and personnel.
- Describe the process of reporting MR safety incidents.
- Discuss the various components of MR safety screening for equipment.
- Recognize emergencies that can occur in MR imaging and explain appropriate reactions.
- Summarize the importance of proper positioning and centering for coil loading.
- Discuss the effect of patient preparation on the resulting MR image (e.g., prostate, enterography, MRCP).
- Identify common equipment malfunctions that affect image quality (e.g., dropping equipment, table positioning, plugging in coils correctly).

Content:

I. Introduction

A. Magnetic fields in MR
1. Main static field
2. Radiofrequency field
3. Gradient field

B. MR safety organizations
1. International Electrotechnical Commission (IEC)
2. U.S. Food and Drug Administration (FDA)
3. National Electrical Manufacturers Association (NEMA)
4. American Society for Testing and Materials (ASTM)
5. American College of Radiology (ACR)
6. International Society for Magnetic Resonance in Medicine (ISMRM) Safety Group
7. Institute for Magnetic Resonance Safety Education and Research (IMRSER)
8. Intersocietal Accreditation Commission (IAC)
9. American Board of Magnetic Resonance Safety (ABMRS)

II. Static Magnetic Field

A. Potential biological effects
1. Magnetophosphenes
2. Magnetohydrodynamic effect

3. Elevated/inverted T-wave
4. Vertigo/dizziness

B. Potential dangers
   1. Field strength
   2. Translational force
   3. Rotational force
   4. Lenz's forces
   5. Device interactions
   6. Magnetic shielding
      a. Active
      b. Passive
   7. Static magnetic field gradient (T/m, G/cm)

C. Guidelines for static field safety
   1. Safety policies and procedures
   2. Safety zones
   3. Warning signage
   4. Personnel
      a. Level 1
      b. Level 2
      c. Non-MR
   5. Patient screening

III. Time-varying Radio Frequency (RF) Magnetic Field

A. Potential dangers
   1. Thermal heating
      a. Core (whole body) and localized heating
      b. Implanted devices
   2. Burns
      a. Proximity
      b. Looping
      c. Resonant
      d. Reflective

B. Guidelines for RF safety
   1. Patient positioning
   2. Monitoring equipment
   3. Patient screening
   4. Patient monitoring
      a. Physiological conditions
      b. Sedation
      c. Pregnancy

IV. Time-varying Gradient Magnetic Fields

A. Potential dangers

B. Acoustic noise — regulations

C. Gradient coils

D. Guidelines for gradient safety
   1. Hearing protection
   2. Acoustic noise reduction
   3. Patient screening
   4. Patient monitoring

V. Patient and Personnel Safety Screening in MR

A. Safety screening questionnaire
   1. Trained personnel
   2. Documentation review
      a. Written
      b. Verbal
   3. Contraindications for entering the MR suite
      a. Implanted electronic devices
      b. Implanted metallic objects at risk of deflection
      c. Foreign bodies

B. Informed or special consent

C. Monitoring patients
   1. Verbal/auditory
   2. Visual
   3. Claustrophobia/anxiety disorder

D. Laser and alignment light (eye safety)

E. Reporting of MR safety incidents

VI. Equipment Safety Screening in MR Environment

A. MR safety labeling

B. MR Conditional and MR Unsafe equipment

C. Conductive equipment (e.g., ECG leads, coils, cables)

D. Monitoring
   1. Cryogen levels
   2. Climate control factors (e.g., temperature, humidity)

E. Identify gauss lines

F. Pulse receptor, ECG cables, and disposable electrodes check

G. Spills (e.g., phantom fluid)

H. Material safety data sheets (MSDS) forms
   1. First aid
   2. Mandatory reporting
   3. Disposal

I. Portable MR imaging

VII. Emergencies in the MR Environment

A. Emergency code (e.g., Code Blue)
   1. Evacuate patient
   2. Emergency plan
   3. Follow-up documentation

B. Fire emergency
   1. Patient and staff evacuation
   2. Institutional fire emergency procedure
      a. Suspending electricity to the MR scanner
      b. Quench protocol
   3. MR-safe fire equipment
   4. Training for local fire departments

C. Pinned metallic items
   1. Patient danger
   2. Pinned equipment

D. Emergency protocols
   1. Table-stop button
   2. Emergency shutdown
   3. Quench
      a. Causes
      b. Evacuation procedure
      c. Entry procedure for positive pressure seal
      d. Notifying support personnel
      e. Cryogen boil-off

VIII. Safety in MR Contrast Administration

A. Patient history

B. Preparation

C. Contrast administration

D. IV

1. Manual
2. Power injector

E. Oral
F. Rectal
G. Intrathecal
H. Intra-articular

I. Adverse reactions
   1. Local events
   2. Treatment and follow-up
   3. Systemic events

J. ACR Manual on Contrast Media

IX. Procedural Factors

A. Positioning
   1. Anatomical considerations
      a. Anatomy of interest
      b. Plane/baseline reference
      c. Anatomical variations
      d. Body habitus
      e. Pathology

   2. Positioning aids

B. Centering
   1. Localization
   2. Area of interest

C. Patient preparation

D. Artifacts

X. Corrective Action

A. Equipment malfunction

B. Technical factors

C. Procedural factors

D. Artifacts

Patient Screening and MR Instrumentation

Considerations:

Regulations practice vary by state and institution. The educational program shall ensure that:

- Professional liability coverage is adequate.
- Adequate supervision is provided.
- Appropriate, structured laboratory objectives are identified.
- Evaluation of competency occurs.

Objectives:

- Describe elements of patient screening.
- Demonstrate effective communication skills with patients, family members, and the health care team.
- Explain magnetism and magnetic properties.
- Describe the effect of field strength on screening approach.
- Relate the gradient system to patient safety in MR imaging.
- Demonstrate the use of ancillary equipment in MR imaging.
- Define gauss (g), tesla (T) and the electromagnetic spectrum.
- Recognize the basic types of commercially available clinical magnets, citing the advantages and disadvantages of each.
- State the main function of the radiofrequency system in MR imaging.
- Describe system shielding.
- Apply MR safety principles and protective practices associated with MR positioning.
- Recognize and use MR Safe monitoring devices.
- Describe the coils available for MR and their specific applications.
- Explain the use of contrast media in evaluating pathology.
- List positioning criteria for different areas of the body.
- Apply considerations for contrast studies (e.g., kidney function, anaphylaxis).
- List technical and practical considerations for special procedures, including functional techniques and procedures requiring sedation and anesthesia (e.g., working with the anesthesia team and other departments).

Content:

I. Magnetism

A. Magnetic properties

B. Diamagnetism
   1. Principles — slightly repels
   2. Materials
      a. Wood
      b. Glass
      c. Gold

d. Others

C. Paramagnetism
1. Principles — slightly attracts
2. Materials
a. Gadolinium
b. Others

D. Ferromagnetism
1. Principles — highly attractive
2. Materials

E. Magnetic field strength (units of measure)
1. Gauss (g)
2. Tesla (T)

II. Magnets

A. Types of magnets and magnet configurations
1. Permanent
a. Characteristics
1) Field strength (low field)
2) Magnetic field direction
3) Maintenance considerations
b. Ferromagnetic materials
1) Iron
2) Other materials
2. Electromagnets
3. Resistive
4. Superconductive
5. Characteristics
6. Maintenance considerations
7. Cryogens
8. Quench/emergency rundown
9. Hybrid

B. Magnetic field shielding
1. Regulations
2. 5 gauss line
3. Safety aspect (projectiles, torque)
4. Mechanisms for magnetic field shielding
a. Passive shielding
b. Active shielding

III. Radiofrequency Systems

A. Types of RF coils and RF configurations
1. Transmit coils

2. Receive-only coils
3. Transmit/receive coils

B. RF field configuration & safety considerations

C. RF and field strengths

D. RF field shielding

IV. Ancillary Equipment

A. Gating
1. ECG leads for gating
2. Peripheral gating
3. Respiratory bellows for respiratory triggering

B. Power injectors
1. Syringes
2. Tubing

C. Patient monitoring

D. Gas cylinders (oxygen tanks)
1. Patient transportation
2. Intravenous supplies
3. Step stools
4. Other MR Safe and Conditional supplies

E. MR Conditional anethesia machine and ventilator

V. Preprocedural Considerations

A. Evaluation of MR orders
1. Patient identification
2. Verification of procedure(s) ordered
3. Establish patient rapport
   a. Explain procedure
   b. Proper patient screening
      1) Screening for metal on patient
      2) Screening for metal inside of a patient
      3) Screening for physical contraindications
      4) Determine any contrast contraindications

B. Patient education
1. Clinical situations
2. Common MR safety issues and concerns
3. Length of procedure
4. Audio and visual intercommunication systems

5. Room noises
6. Immobilization devices
7. Machine type
8. Machine movement
9. Machine-patient contact
10. Application of auxiliary equipment

C. Patient preparation
    1. Appropriate disrobing and gowning
    2. Remove items that are contraindicated in the MR suite that could cause artifacts

D. Room preparation
    1. Maintain a clean and organized environment
    2. Ensure necessary supplies and accessory equipment are available

E. Patient assistance

F. Patient monitoring

G. Communication
    1. Verbal
        a. Presentation of material
        b. Voice tone and volume
        c. Effective listening
    2. Nonverbal
        a. Facial expression
        b. Physical appearance
        c. Touch
        d. Eye contact
    3. Written
    4. Cultural sensitivity
    5. Challenges of communication
        a. Language barriers
        b. Hearing, vision and speech impairments
        c. Impaired mental function
        d. Altered states of consciousness
        e. Age-specific communication
        f. Communicating under stress
        g. Varied backgrounds and needs of patients
    6. Other factors that impede communication
        a. Medical terminology
    7. Patient interactions
        a. Establishing communication guidelines
        b. Reducing distance
        c. Listening
        d. Feedback

1) Using therapeutic silence
2) Responding to the feeling and the meaning of the patient's statement
3) Restating the main idea
4) Reflecting the main idea
5) Making observations

8. Communicating with families
9. Communicating with other health care professionals

VI. Safety and Transfer Positioning

A. Body mechanics
1. Proper body alignment
2. Proper movement
3. Proper balance
4. Center of balance in the body

B. Patient transfer and movement
1. Assessing the patient's mobility
2. Rules for safe patient transfer
3. Wheelchair transfers
   a. Stretcher transfers
   b. Sheet transfer
   c. Log roll
   d. Positioning for safety, comfort and/or examinations
   e. Transfer devices
4. Patients with disabilities
5. Age-specific considerations

C. Patients with medical equipment
1. Tubes
2. Oxygen delivery
3. Catheters
4. Lines
5. Collection devices
6. Implated devices
7. Fall prevention

D. Patient positions
1. Supine
2. Prone

E. Immobilization techniques
1. Types
2. Applications
3. Devices
   a. Adult
   b. Pediatric

VII. Accident and Incident Reporting

A. Purpose
B. Legal considerations
C. Documentation
D. Procedures

VIII. Procedural Considerations for Contrast Studies

A. Equipment and materials needed

B. Contrast media
   1. Purpose
   2. Types
      a. Intravenous
      b. Oral
      c. Enteral
      d. Parenteral

IX. Considerations for MR Procedures

A. Patient instructions

B. Patient positioning

C. Protocol considerations

D. Equipment and accessories

E. Coil type, selection and positioning

F. Use of contrast agents
   1. Linear vs macrocyclic
   2. Nephrogenic systemic fibrosis (NSF)
   3. Gadolinium deposition

G. Patient comfort

H. Age-related

I. General anesthesia

J. Moderate sedation

K. Monitoring of conditional devices

L. Special considerations
   1. Atypical conditions

2. Anesthesia considerations
3. Ancillary staff considerations
4. Special needs patients
5. Trauma

Pharmacology and Drug Administration

Considerations:
Prior to introducing this educational content, students should have successfully completed patient care objectives (including CPR/BLS certification), as well as objectives related to anatomy and physiology of the circulatory and excretory systems.

Although regulations regarding the administration of contrast media and intravenous medications vary by state and institution, these skills should be included in the didactic and clinical curriculum, with demonstrated competencies, of all appropriate disciplines regardless of the state or institution where the curriculum is taught.

In states or institutions where students are permitted to perform intravenous injections, educational programs have specific ethical and legal responsibilities to the patient and the student. The educational program shall ensure that:

- Legal statutes allow I.A.(MR)s to perform this task.
- Professional liability coverage is adequate.
- Adequate supervision is provided.
- Appropriate, structured laboratory objectives are identified.
- Competency is verified before the student performs this task under indirect supervision.

Objectives:

- Distinguish between nonprescription drugs, prescription drugs and controlled substances.
- Explain the process of reporting adverse reactions to the FDA.
- List the six rights of drug administration.
- Describe the various routes of drug administration.
- Identify general drug actions, uses, adverse reactions, contraindications, precautions and interactions.
- Discuss specific considerations of MR contrast administration.
- Recall current practice standards regarding contrast administration.

Content:

I. Six Rights of Drug Safety

A. The right medication

B. The right dose

C. The right patient

D. The right time

E. The right location

F. The right documentation

II. Drug Categories of Relevance to MR Imaging (Adverse Effects, Uses and Impacts on Medical Imaging)

A. Analgesics

B. Anticoagulant and coagulant drugs

C. Anesthetic agents

D. Antiallergic and antihistamine drugs

E. Antianxiety drugs

F. Antiemetic drugs

G. Antiseptic and disinfectant agents

H. Diagnostic contrast agents

I. Sedative and hypotonic drugs

III. Routes of Drug Administration

A. Systemic
   1. Oral/sublingual
   2. Rectal
   3. Tube/catheter
   4. Inhalation
   5. Transdermal

B. Parenteral
   1. Intravenous
   2. Intra-arterial
   3. Intrathecal
   4. Subcutaneous
   5. Intramuscular

IV. MR Contrast Administration

A. Patient history
   1. Asthma
   2. Drug allergy
   3. Adverse reaction to contrast media
   4. Kidney function
   5. Cardiac function
   6. Pregnancy status

B. Patient education and I.A.(MR)'s responsibility

1. Standard procedure
2. Distribution of GCBA medication guides

C. Patient preparation for examination
   1. Diet
   2. Hydration
   3. Bowel preparation
      a. Laxatives
      b. Enemas
   4. Prostate preparation

D. Contrast media preparation
   1. Proper dose
   2. Expiration dates
   3. Vial retention (until patient release)
   4. Aseptic technique
   5. Venous access

E. Contrast administration
   1. Manual
      a. Integrity of venous access
      b. Extravasation monitoring
      c. Follow-up care
   2. Power injector
      a. Integrity of venous access
      b. Monitor angiocatheter gauge for rate of contrast media flow (angiocatheter manufacturer guidelines)
   3. Alternative access sites (e.g., venous access ports, central lines)

V. Adverse Reactions

A. Local events, extravasation
   1. Stop contrast administration
   2. Treatment/follow-up guidelines
   3. Compression (outlined by ACR)
   4. Written patient discharge instructions
   5. Physician notification
   6. Documentation and reporting

B. Systemic events
   1. Stop contrast administration
   2. Remove patient from MR suite
   3. Assess for breathing difficulty
   4. Physician notification
   5. Treatment/follow-up guidelines:
   6. Health care provider to administer medications
   7. Written patient discharge instructions

8. Documentation and reporting
9. Availability of emergency medications
10. Emergency contact phone numbers
11. Emergency code buttons or switches

C. Gadolinium-based MR contrast and NSF
   1. Gadolinium retention
   2. ACR guidelines regarding renal function and dialysis
   3. FDA guidelines

D. Monitoring and care during invasive procedures
   1. Preparation for MR-compatible cardiac monitoring
   2. Electrocardiogram (ECG) rhythms
      a. Normal
      b. Abnormal

VI. Current Practice Status

A. Professional standards
   1. Scope of practice
   2. Practice standards
   3. Professional liability and negligence

B. State statutes

C. Employer prerogative

Resources

This list of magnetic resonance references can assist educators in sampling the pool of resources that pertain to medical imaging. The list should be viewed as a snapshot of available materials. Omission of any title is not intentional. Because the creation of literature and media related to the field is dynamic, educators are encouraged to search additional sources for recent updates, revisions and additions to this title collection.

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Radiology. Radiological Society of North America, Oak Brook, IL.

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