



# Magnetic Resonance Imaging

The purpose of structured education is to provide the opportunity for individuals to develop mastery of discipline-specific knowledge that, when coupled with selected clinical experiences, helps to document qualifications. The *Structured Education Requirements for Magnetic Resonance Imaging* is provided to assist candidates with these requirements.

Candidates for magnetic resonance imaging certification and registration must document at least 16 hours of structured education<sup>1</sup>. The activities must be earned within the 24-month period immediately prior to submission of an application for certification and registration. Structured education activities may be academic courses from an institution accredited by a mechanism recognized by the ARRT<sup>2</sup>, CE opportunities approved by a RCEEM or RCEEM+, or a combination of the two.

Structured education documentation must include at least one CE credit or its equivalent in each content category listed below (i.e., Patient Care, Safety, Image Production, and Procedures). The remaining hours may be earned from any one or more of the content areas. Specific topics within each category are addressed in the content outline, which makes up the remaining pages of this document.

Content Category	Minimum Credit Hours
Patient Care (includes) <i>Patient Interactions and Management</i>	1
Safety (includes) <i>MRI Screening and Safety</i>	1
Image Production (includes) <i>Physical Principles of Image Formation</i> <i>Sequence Parameters and Options</i> <i>Data Acquisition and Processing</i>	1
Procedures (includes) <i>Neuro</i> <i>Body</i> <i>Musculoskeletal</i>	1
<b>Total</b>	<b>16</b>

## Acceptable Examples:

Example 1	Example 2	Example 3
Patient Care – 3 hours Safety – 2 hours Image Production – 4 hours Procedures – 7 hours	Patient Care – 1 hour Safety – 1 hour Image Production – 1 hour Procedures – 13 hours	Patient Care – 1 hour Safety – 5 hours Image Production – 5 hours Procedures – 5 hours
TOTAL – 16 hours	TOTAL – 16 hours	TOTAL – 16 hours

1. If there is a structured education requirement document with a newer effective date, you may either use the new document or continue to use this document if you have completed at least one educational activity prior to the effective date of the new version. For more information access the online clinical experience tool, where structured education is also reported.
2. Activities meeting the definition of an approved academic course will be awarded credit at the rate of 12 CE credits for each academic **quarter** credit or 16 CE credits for each academic **semester** credit. See the ARRT *Continuing Education Requirements* document for additional information.



## Patient Care

### 1. Patient Interactions and Management

#### A. Legal and Ethical Principles

1. confirmation of exam requisition
  - a. verification of patient identification
  - b. comparison of request to clinical indications
2. legal issues
  - a. common terminology (\*e.g., negligence, malpractice)
  - b. legal doctrines (e.g., respondeat superior, res ipsa loquitur)
3. patient's rights
  - a. informed consent (written, oral, implied)
  - b. confidentiality (HIPAA)
  - c. American Hospital Association (AHA) Patient Care Partnership (Patient's Bill of Rights) (e.g., privacy, access to information, health care proxy, research participation)
4. ARRT Standards of Ethics

#### B. Infection Control

1. terminology and basic concepts
  - a. types of asepsis
  - b. sterile technique
  - c. pathogens (e.g., fomites, vehicles, vectors)
  - d. hospital acquired infections
2. cycle of infection
  - a. pathogen
  - b. source or reservoir of infection
  - c. susceptible host
  - d. method of transmission (contact, droplet, airborne, common vehicle, vector-borne)

3. CDC Standard Precautions (general patient contact)
  - a. handwashing
  - b. gloves, gowns
  - c. masks
  - d. medical asepsis/disinfection
4. additional or transmission-based precautions (e.g., hepatitis B, HIV, tuberculosis)
  - a. airborne (e.g., negative ventilation)
  - b. droplet (e.g., mask)
  - c. contact (e.g., gloves, gown)
5. safe cleaning of equipment and disposal of contaminated materials
  - a. linens
  - b. needles
  - c. patient supplies
  - d. scanner, bore, coils, ancillary equipment

\* The abbreviation "e.g.," is used to indicate that examples are listed in parentheses, but that it is not a complete list of all possibilities.

(Patient Care continues on the following page.)



## Patient Care (continued)

### C. Interpersonal Communications

1. modes of communication
  - a. verbal, written
  - b. nonverbal  
(e.g., eye contact, touching)
2. challenges in communication
  - a. patient characteristics  
(e.g., cultural factors, physical or emotional status)
  - b. strategies to improve understanding
3. patient education
  - a. explanation of procedure  
(e.g., risks, benefits)
  - b. communication with patient during procedure
  - c. follow-up instructions
  - d. referral to other services
4. medical terminology

### D. Patient Assessment, Monitoring and Management

1. routine monitoring
  - a. vital signs
  - b. physical signs and symptoms
  - c. sedated patients
  - d. claustrophobic patients
2. emergency response
  - a. reactions to contrast
  - b. other allergic reactions (e.g., latex)
  - c. cardiac/respiratory arrest (CPR)
  - d. physical injury, trauma or RF burn
  - e. other medical disorders  
(e.g., seizures, diabetic reactions)
  - f. life-threatening situations  
(e.g., quench, projectiles)
3. patient transfer and body mechanics
4. assisting patients with medical equipment
  - a. implantable devices (e.g., infusion catheters, pumps, pacemakers)
  - b. oxygen delivery systems
  - c. other (e.g., nasogastric tubes, urinary catheters)

### E. Pharmacology

1. contrast media types (FDA approved)
2. contraindications
3. laboratory values  
(e.g., BUN, creatinine, eGFR)
4. dose calculation
5. administration route



## Safety

### 1. MRI Screening and Safety

#### A. Screening and Education (patients, personnel, non-personnel)

1. biomedical implants
  - a. identify and document device, year, make, model
  - b. research and verify device labeling (MRI safe, MRI conditional, MRI unsafe)
  - c. identify device specific parameters
2. ferrous foreign bodies
3. medical conditions (e.g., renal function, pregnancy)
4. prior diagnostic or surgical procedures
5. topical or externally applied items (e.g., tattoos, medication patches, body piercing jewelry, monitoring devices)
6. level 1 and level 2 MRI personnel

#### B. Equipment Safety

1. placement of conductors (e.g., ECG leads, coils, cables)
2. cryogen safety
3. ancillary equipment in proximity (MRI safe, conditional, unsafe)
4. emergency procedures (e.g., quench, fire)

#### C. Environment

1. climate control (temperature, humidity)
2. designated safety zones
3. gauss lines
4. magnetic shielding
5. RF shielding

#### D. Biological Considerations

1. RF field
  - a. specific absorption rate (SAR)
  - b. biological effects
  - c. FDA guidelines
2. static and gradient magnetic fields
  - a. biological effects
  - b. FDA guidelines
3. acoustic noise



## Image Production

### 1. Physical Principles of Image Formation

#### A. Instrumentation

1. electromagnetism
  - a. Faraday's law
  - b. types of magnets (superconductive, permanent, resistive)
  - c. magnetic field strength
2. radiofrequency system
  - a. coil configuration
  - b. transmit and receive coils
  - c. transmit and receive bandwidth
  - d. pulse profile
  - e. phased array
3. gradient system
  - a. coil configuration
  - b. slew rate
  - c. rise time
  - d. duty cycle

#### B. Fundamentals

1. nuclear magnetism
  - a. Larmor equation
  - b. precession
  - c. gyromagnetic ratio
  - d. resonance
  - e. RF pulse
  - f. equilibrium magnetization
  - g. energy state transitions
  - h. phase coherence
  - i. free induction decay (FID)
2. tissue characteristics
  - a. T1 relaxation
  - b. T2 relaxation
  - c. T2\* (susceptibility)
  - d. proton (spin) density
  - e. flow
  - f. diffusion
  - g. perfusion

#### 3. spatial localization

- a. vectors
- b. X, Y, Z coordinate system
- c. physical gradient
- d. slice select gradient
- e. phase-encoding gradient
- f. frequency (readout) gradient
- g. k-space (raw data)

#### C. Artifacts

1. cause and appearance of artifacts
  - a. aliasing
  - b. Gibbs, truncation
  - c. chemical shift
  - d. magnetic susceptibility
  - e. radiofrequency, zipper
  - f. motion and flow
  - g. partial volume averaging
  - h. crosstalk
  - i. cross excitation
  - j. Moiré pattern
  - k. parallel imaging artifacts
2. compensation for artifacts

#### D. Quality Control

1. slice thickness
2. spatial resolution
3. contrast resolution
4. signal to noise
5. center frequency
6. transmit gain
7. geometric accuracy
8. equipment handling and inspection (e.g., coils, cables, door seals)

(Image Production continues on the following page.)



## Image Production (continued)

### 2. Sequence Parameters and Options

#### A. Imaging Parameters

1. TR
2. TE
3. TI
4. number of signal averages (NSA)
5. flip angle (Ernst angle)
6. FOV
7. matrix
8. number of slices
9. slice thickness and gap
10. phase and frequency
11. echo train length
12. effective TE
13. bandwidth (transmit, receive)
14. concatenations  
(number of acquisitions per TR)

#### B. Imaging Options

1. 2D/3D
2. slice order  
(sequential, interleaving)
3. spatial saturation pulse
4. gradient moment nulling
5. suppression techniques  
(e.g., fat, water)
6. physiologic gating and triggering
7. in-phase/out-of-phase
8. rectangular FOV
9. anti-aliasing
10. parallel imaging
11. motion correction imaging technique
12. filtering

### FOCUS OF QUESTIONS

Questions will address the interdependence of the imaging parameters and options listed on the left, and how those parameters and options affect image quality and image contrast.

#### 1. Image Quality

- contrast to noise (C/N)
- signal to noise (S/N)
- spatial resolution
- acquisition time

#### 2. Image Contrast

- T1 weighted
- T2 weighted
- proton (spin) density
- T2\* weighted

(Image Production continues on the following page.)



## Image Production (continued)

### 3. Data Acquisition and Processing

#### A. Pulse Sequences

1. spin echo
  - a. conventional spin echo
  - b. fast spin echo (FSE)
2. inversion recovery
  - a. STIR
  - b. FLAIR
3. gradient recall echo (GRE)
  - a. conventional gradient echo
  - b. spoiled gradient echo
  - c. coherent gradient echo
  - d. steady state free precession
  - e. fast gradient echo
4. echo planar imaging (EPI)

#### B. Data Manipulation

1. k-space mapping and filling  
(e.g., centric, spiral, keyhole)
2. fast fourier transformation (FFT)
3. post processing
  - a. maximum intensity projection (MIP)
  - b. multiplanar reconstruction (MPR)
  - c. subtraction
  - d. apparent diffusion coefficient  
(ADC) mapping

#### C. Special Procedures

1. MRA/MRV
  - a. flow dynamics
  - b. time-of-flight
  - c. phase contrast
  - d. contrast enhanced
2. functional techniques
  - a. diffusion
  - b. perfusion
  - c. spectroscopy
3. dynamic imaging
4. contrast bolus detection
  - a. fluoro-triggering
  - b. timing bolus
  - c. automatic bolus detection



## Procedures

### 1. Neuro

#### A. Head and Neck

1. brain
2. head trauma
3. brain for stroke
4. brain for MS
5. brain for seizure
6. brain for CSF Flow
7. pediatric brain
8. IAC
9. pituitary
10. orbit
11. soft tissue neck  
(e.g., parotids, thyroid)
12. angiography
13. spectroscopy

#### B. Spine

1. cervical
2. thoracic
3. lumbar
4. sacrum/coccyx
5. brachial plexus

### 2. Body

#### A. Thorax

1. chest
2. breast
3. angiography

#### B. Abdomen

1. liver, spleen
2. pancreas
3. kidneys
4. adrenals
5. MRCP
6. angiography
7. enterography

#### C. Pelvis

1. soft tissue pelvis  
(bladder, rectum, anus)
2. female pelvis  
(uterus/cervix, ovaries, vagina)
3. male pelvis  
(prostate, testes)
4. angiography  
(iliac and run-off)

### FOCUS OF QUESTIONS

Questions about each of the studies listed on the left may focus on any of the following factors:

#### 1. Anatomy and Physiology

- imaging planes
- pathological considerations
- protocol considerations
- patient considerations  
(e.g., pediatric, geriatric, bariatric)

#### 2. Patient Set-Up

- patient data input
- coil selection and position
- patient orientation
- landmarking
- physiologic gating and triggering

#### 3. Contrast Media

- effect on images

(Procedures continue on the following page.)





## Procedures (continued)

### 3. Musculoskeletal

- A. Temporomandibular Joint
- B. Shoulder
- C. Elbow
- D. Wrist
- E. Hand/Fingers
- F. Thumb
- G. Hip
- H. Ankle
- I. Knee
- J. Fore Foot and Hind Foot
- K. Long Bones (humerus, forearm, femur, lower leg)
- L. Arthrography
- M. Angiography
- N. SI Joints
- O. SC Joints
- P. Sternum
- Q. Bony Pelvis

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