The Magnetic Resonance Imaging Examination

The purpose of The American Registry of Radiologic Technologists® (ARRT®) Magnetic Resonance Imaging Examination is to assess the knowledge and cognitive skills underlying the intelligent performance of the tasks typically required of the technologists who perform magnetic resonance imaging. Using a nationwide survey, the ARRT periodically conducts a practice analysis to develop a task inventory which delineates or lists the job responsibilities typically required of MRI technologists.¹ An advisory committee then determines the knowledge and cognitive skills needed to perform the tasks on the task inventory and these are organized into the content categories within this document. The document is used to develop the examination. The results of the most recent practice analysis have been applied to this document. Every content category can be linked to one or more activities on the task inventory. The complete task inventory is available at arrt.org.

The following table presents the major content categories covered on the examination, and indicates the number and percentage of test questions in each category. The remaining pages list the specific topics addressed within each category, with the approximate number of test questions allocated to each topic appearing in parentheses.

This document is not intended to serve as a curriculum guide. Although certification and registration programs and educational programs may have related purposes, their functions are clearly different. Educational programs are generally broader in scope and address the subject matter that is included in these content specifications, but do not limit themselves to only this content.

<table>
<thead>
<tr>
<th>Content Category</th>
<th>Percent of Test</th>
<th>Number of Scored Questions²</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Patient Care</td>
<td>16%</td>
<td>32</td>
</tr>
<tr>
<td>B. Imaging Procedures</td>
<td>28%</td>
<td>56</td>
</tr>
<tr>
<td>C. Sequence Parameters and Options</td>
<td>19%</td>
<td>38</td>
</tr>
<tr>
<td>D. Data Acquisition and Processing</td>
<td>17%</td>
<td>34</td>
</tr>
<tr>
<td>E. Physical Principles of Image Formation</td>
<td>20%</td>
<td>40</td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
<td>200</td>
</tr>
</tbody>
</table>

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

² Each exam includes an additional 20 unscored (pilot) questions.
A. Patient Care (32)

1. Legal and Ethical Principles (4)
   A. Confirmation of Exam Requisition
      1. verification of patient identification
      2. comparison of request to clinical indications
   B. Legal Issues
      1. common terminology
         (e.g., negligence, malpractice)
      2. legal doctrines (e.g., respondeat superior, res ipsa loquitur)
   C. Patient’s Rights
      1. informed consent (written, oral, implied)
      2. confidentiality (HIPAA)
      3. Patient’s Bill of Rights (e.g., privacy, access to information, health care proxy, research participation)
   D. ARRT Standards of Ethics

2. MRI Screening and Safety (15)
   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

*e.g., This is used here and in the remainder of this document to indicate examples of the topics covered, but not a complete list.

(Section A continues on the following page.)
A. Patient Care (continued)

3. Patient Assessment, Monitoring and Management (7)
   A. Routine Monitoring
      1. vital signs
      2. physical signs and symptoms
      3. sedated patients
      4. claustrophobic patients
   B. Emergency Response
      1. reactions to contrast
      2. other allergic reactions (e.g., latex)
      3. cardiac/respiratory arrest (CPR)
      4. physical injury, trauma, or RF burn
      5. other medical disorders (e.g., seizures, diabetic reactions)
      6. life-threatening situations (e.g., quench, projectiles)
   C. Patient Transfer and Body Mechanics
   D. Assisting Patients with Medical Equipment
      1. implantable devices (e.g., infusion catheters, pumps, pacemakers)
      2. oxygen delivery systems
      3. other (e.g., nasogastric tubes, urinary catheters)

4. Interpersonal Communications (3)
   A. Modes of Communication
      1. verbal, written
      2. nonverbal (e.g., eye contact, touching)
   B. Challenges in Communication
      1. patient characteristics (e.g., cultural factors, physical or emotional status)
      2. strategies to improve understanding
   C. Patient Education
      1. explanation of procedure (e.g., risks, benefits)
      2. communication with patient during procedure
      3. follow-up instructions
      4. referral to other services
   D. Medical Terminology

5. Infection Control (3)
   A. Terminology and Basic Concepts
      1. types of asepsis
      2. sterile technique
      3. pathogens (e.g., fomites, vehicles, vectors)
      4. hospital acquired infections
   B. Cycle of Infection
      1. pathogen
      2. source or reservoir of infection
      3. susceptible host
      4. method of transmission (contact, droplet, airborne, common vehicle, vector-borne)
   C. Standard Precautions (general patient contact)
      1. handwashing
      2. gloves, gowns
      3. masks
      4. medical asepsis/disinfection
   D. Additional or Transmission-Based Precautions (e.g., hepatitis B, HIV, tuberculosis)
      1. airborne (e.g., negative ventilation)
      2. droplet (e.g., mask)
      3. contact (e.g., gloves, gown)
   E. Safe Cleaning of Equipment and Disposal of Contaminated Materials
      1. linens
      2. needles
      3. patient supplies
      4. scanner, bore, coils, ancillary equipment
B. Imaging Procedures (56)

TYPE OF STUDY

1. Head and Neck (14)
   A. Brain
   B. Head Trauma
   C. Brain for Stroke
   D. Brain for MS
   E. Brain for Seizure
   F. Brain for CSF Flow
   G. Pediatric Brain
   H. IAC
   I. Pituitary
   J. Orbit
   K. Soft Tissue Neck (e.g., parotids, thyroid)
   L. Angiography
   M. Spectroscopy

2. Spine (12)
   A. Cervical
   B. Thoracic
   C. Lumbar
   D. Sacrum/Coccyx
   E. Brachial Plexus

3. Thorax (7)
   A. Chest
   B. Breast
   C. Angiography

4. Abdomen (7)
   A. Liver, Spleen
   B. Pancreas
   C. Kidneys
   D. Adrenals
   E. MRCP
   F. Angiography
   G. Enterography

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. Contrast
   - type of agent (FDA approved)
   - contraindications
   - dose calculation
   - administration route
   - effects on image

3. Patient Set Up
   - patient data input
   - coil selection and position
   - patient orientation
   - landmarking
   - physiologic gating and triggering

(Section B continues on the following page.)
B. Imaging Procedures (continued)

TYPE OF STUDY

5. Pelvis (6)
   A. Soft Tissue Pelvis (bladder, rectum, anus)
   B. Female Pelvis (uterus/cervix, ovaries, vagina)
   C. Male Pelvis (prostate, testes)
   D. Angiography (iliac and run-off)

6. Musculoskeletal (10)
   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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   • dose calculation
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3. Patient Set Up
   • patient data input
   • coil selection and position
   • patient orientation
   • landmarking
   • physiologic gating and triggering
C. Sequence Parameters and Options (38)

TYPE OF STUDY

1. Imaging Parameters (22)
   A. TR
   B. TE
   C. TI
   D. Number of Signal Averages (NSA)
   E. Flip Angle (Ernst angle)
   F. FOV
   G. Matrix
   H. Number of Slices
   I. Slice Thickness and Gap
   J. Phase and Frequency
   K. Echo Train Length
   L. Effective TE
   M. Bandwidth (transmit, receive)
   N. Concatenations
      (number of acquisitions per TR)

2. Imaging Options (16)
   A. 2D/3D
   B. Slice Order (sequential, interleaving)
   C. Spatial Saturation Pulse
   D. Gradient Moment Nulling
   E. Suppression Techniques (e.g., fat, water)
   F. Physiologic Gating and Triggering
   G. In-Phase/Out-of-Phase
   H. Rectangular FOV
   I. Anti-Aliasing
   J. Parallel Imaging
   K. Motion Correction Imaging Technique
   L. 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 contrast.

1. Image Quality
   • contrast to noise (C/N)
   • signal to noise (S/N)
   • spatial resolution
   • acquisition time

2. Contrast
   • T1 weighted
   • T2 weighted
   • proton (spin) density
   • T2* weighted
D. Data Acquisition and Processing (34)

1. Pulse Sequences (20)
   A. Spin Echo
      1. conventional spin echo
      2. fast spin echo (FSE)
   B. Inversion Recovery
      1. STIR
      2. FLAIR
   C. Gradient Recall Echo (GRE)
      1. conventional gradient echo
      2. spoiled gradient echo
      3. coherent gradient echo
      4. steady state free precession
      5. fast gradient echo
   D. Echo Planar Imaging (EPI)

2. Data Manipulation (7)
   A. K-space Mapping and Filling
      (e.g., centric, spiral, keyhole)
   B. Fast Fourier Transformation (FFT)
   C. Post-Processing
      1. maximum intensity projection (MIP)
      2. multiplanar reconstruction (MPR)
      3. subtraction
      4. apparent diffusion coefficient (ADC) mapping

3. Special Procedures (7)
   A. MRA/MRV
      1. flow dynamics
      2. time-of-flight
      3. phase contrast
      4. contrast enhanced
   B. Functional Techniques
      1. diffusion
      2. perfusion
      3. spectroscopy
   C. Dynamic Imaging
   D. Contrast Bolus Detection
      1. fluoro-triggering
      2. timing bolus
      3. automatic bolus detection
E. Physical Principles of Image Formation (40)

1. Instrumentation (8)
   A. Electromagnetism
      1. Faraday’s law
      2. types of magnets (superconductive, permanent, resistive)
      3. magnetic field strength
   B. Radiofrequency System
      1. coil configuration
      2. transmit and receive coils
      3. transmit and receive bandwidth
      4. pulse profile
      5. phased array
   C. Gradient System
      1. coil configuration
      2. slew rate
      3. rise time
      4. duty cycle

2. Fundamentals (14)
   A. Nuclear Magnetism
      1. Larmor equation
      2. precession
      3. gyromagnetic ratio
      4. resonance
      5. RF pulse
      6. equilibrium magnetization
      7. energy state transitions
      8. phase coherence
      9. free induction decay (FID)
   B. Tissue Characteristics
      1. T1 relaxation
      2. T2 relaxation
      3. T2* (susceptibility)
      4. proton (spin) density
      5. flow
      6. diffusion
      7. perfusion
   C. Spatial Localization
      1. vectors
      2. X, Y, Z coordinate system
      3. physical gradient
      4. slice select gradient
      5. phase-encoding gradient
      6. frequency (readout) gradient
      7. k-space (raw data)

3. Artifacts (10)
   A. Cause and Appearance of Artifacts
      1. aliasing
      2. Gibbs, truncation
      3. chemical shift
      4. magnetic susceptibility
      5. radiofrequency, zipper
      6. motion and flow
      7. partial volume averaging
      8. crosstalk
      9. cross excitation
      10. Moiré pattern
      11. parallel imaging artifacts
   B. Compensation for Artifacts

4. Quality Control (8)
   A. Slice Thickness
   B. Spatial Resolution
   C. Contrast Resolution
   D. Signal to Noise
   E. Center Frequency
   F. Transmit Gain
   G. Geometric Accuracy
   H. Equipment Handling and Inspection
      (e.g., coils, cables, door seals)