



# Nuclear Medicine Technology Examination

The purpose of *The American Registry of Radiologic Technologists® (ARRT®) Nuclear Medicine Technology Examination* is to assess the knowledge and cognitive skills underlying the intelligent performance of the tasks typically required of the nuclear medicine technologist. 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 nuclear medicine technologists.<sup>1</sup> 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](http://arrt.org).

The following table presents the four major content categories covered on the examination, and indicates the number 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 ARRT programs for certification and registration 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.

<b>Content Category</b>	<b>Number of Scored Questions<sup>2</sup></b>
Patient Care	20
Safety <sup>3</sup>	22
Image Production	38
Procedures	120
Radionuclides and Radiopharmaceuticals	
Cardiac Procedures	
Endocrine and Oncology Procedures	
Gastrointestinal and Genitourinary Procedures	
Other Imaging Procedures	
<b>Total</b>	<b>200</b>

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

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

<sup>3</sup> SI and conventional units of radiation measurement will continue to be used on the nuclear medicine technology examination.



## Patient Care (20)

### 1. Patient Interactions and Management (20)

#### A. Ethical and Legal Aspects

1. patient's rights
  - a. informed consent (\*e.g., written, oral, implied)
  - b. confidentiality (HIPAA)
  - c. American Hospital Association (AHA) Patient Care Partnership (Patient's Bill of Rights)
    1. privacy
    2. extent of care (e.g., DNR)
    3. access to information
    4. living will, health care proxy, advanced directives
    5. research participation
2. legal issues
  - a. verification (e.g., patient identification, compare order to clinical indication, exam coding)
  - b. common terminology (e.g., battery, negligence, malpractice, beneficence)
  - c. legal doctrines (e.g., respondeat superior, res ipsa loquitur)
  - d. restraints versus immobilization
3. ARRT Standards of Ethics

#### B. Interpersonal Communication

1. modes of communication
  - a. verbal/written
  - b. nonverbal (e.g., eye contact, touching)
2. challenges in communication
  - a. interaction with others
    1. language barriers
    2. cultural and social factors
    3. physical and sensory impairments
    4. age
    5. emotional status, acceptance of condition
  - b. explanation of medical terms
  - c. strategies to improve understanding

#### 3. patient education

- a. explanation of current procedure (e.g., risks, benefits)
- b. verify informed consent when necessary
- c. pre- and post-examination instructions (e.g., preparations, diet, medications, discharge instructions)
- d. respond to inquiries about other imaging modalities (e.g., CT, MRI, mammography, sonography, radiography, bone densitometry)

#### C. Physical Assistance and Monitoring

1. patient transfer and movement
  - a. body mechanics (e.g., balance, alignment, movement)
  - b. patient transfer techniques
2. assisting patients with medical equipment
  - a. infusion catheters and pumps
  - b. oxygen delivery systems
  - c. other (e.g., nasogastric tubes, urinary catheters, tracheostomy tubes)
3. Routine Monitoring
  - a. vital signs
  - b. physical signs and symptoms (e.g., motor control, severity of injury)
  - c. fall prevention
  - d. documentation
  - e. immobilization
  - f. sedation

#### D. Medical Emergencies

1. allergic reactions (e.g., pharmaceuticals, latex)
2. cardiac or respiratory arrest (e.g., CPR)
3. physical injury or trauma
4. other medical disorders (e.g., seizures, diabetic reactions)

\*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.

(Patient Care continues on the following page.)



## Patient Care (continued)

- E. Infection Control
  - 1. cycle of infection
    - a. pathogen
    - b. reservoir
    - c. portal of exit
    - d. mode of transmission
      - 1. direct
        - a. direct contact
        - b. droplet
      - 2. indirect
        - a. airborne
        - b. vehicle-borne – fomite
        - c. vector-borne – mechanical or biological
    - e. portal of entry
    - f. susceptible host
  - 2. asepsis
    - a. equipment disinfection
    - b. equipment sterilization
    - c. medical aseptic technique
    - d. sterile technique
  - 3. CDC Standard Precautions
    - a. hand hygiene
    - b. use of personal protective equipment (e.g., gloves, gowns, masks)
    - c. safe injection practices
    - d. safe handling of contaminated equipment/surfaces
    - e. disposal of contaminated materials
      - 1. linens
      - 2. needles
      - 3. patient supplies
      - 4. blood and body fluids
  - 4. transmission-based precautions
    - a. contact
    - b. droplet
    - c. airborne
  - 5. additional precautions
    - a. neutropenic precautions (reverse isolation)
    - b. healthcare associated (nosocomial) infections



## Safety (22)

### 1. Radiation Physics, Radiobiology, and Regulations (22)

#### A. Physical Properties of Radioactive Materials

1. decay of radioactivity
  - a. atomic structure
  - b. decay modes (e.g., alpha, beta, gamma)
  - c. decay rate
  - d. half-life
  - e. parent-daughter relationship
2. interaction of radiation with matter
  - a. photoelectric effect
  - b. Compton scattering
  - c. pair production and annihilation
  - d. internal conversion
  - e. Auger electron
  - f. bremsstrahlung

#### B. Biological Effects of Radiation

1. cellular biology
2. effects of radiation on cells
  - a. direct and indirect action
  - b. radiolysis of water
  - c. LET and RBE
3. stochastic and deterministic effects
4. acute effects of total body radiation
  - a. radiation sickness
  - b. hemopoietic syndrome
  - c. gastrointestinal syndrome
  - d. central nervous system syndrome
5. long term effects of radiation
  - a. somatic
  - b. genetic
6. relative tissue and organ sensitivity (e.g., law of Bergonié and Tribondeau)
7. effects of radiation on embryo/fetus

#### C. Basic Concepts of Radiation Protection

1. units of radiation exposure
2. principles of time, distance, and shielding
3. personnel protection equipment (e.g., gloves, lab coats)
4. personnel monitoring devices
  - a. types
  - b. use, care, and placement
5. ALARA
6. release of patients

#### D. NRC Regulations for Radiation Exposure

1. occupational
2. public
3. pregnancy or nursing
4. internal dosimetry and bioassays
5. personnel exposure records

#### E. Medical Events

1. definition
2. NRC regulations for reporting and notification

#### F. Area/Facilities Monitoring

1. Basic Concepts
  - a. units of measurement
  - b. exposure rates
  - c. definition of contaminated area
2. Survey Equipment and Techniques
  - a. well counters
  - b. survey meters
  - c. wipe test technique
3. NRC Regulations
  - a. frequency of surveys and wipes
  - b. classification of areas
    1. work
    2. treatment
    3. storage
  - c. posting of signs (e.g., types, locations)
  - d. documentation of survey and wipes results
    1. interpretation
    2. reporting (corrective action)
    3. record retention
4. Radioactive Spills
  - a. major spills
  - b. minor spills
  - c. processes for decontamination
  - d. reporting procedures

(Safety continues on the following page.)



## Safety (continued)

- G. Radioactive Materials
  - 1. inspection of incoming and outgoing materials (e.g., DOT and NRC regulations)
    - a. shipping labels
    - b. measurement of exposure rate
    - c. measurement of surface contamination
    - d. removable contamination limits/trigger levels
    - e. documentation
  - 2. storage
    - a. radiopharmaceuticals
    - b. sealed sources
    - c. consequences of improper storage
  - 3. disposal of radioactive waste
    - a. release to environment
    - b. decay in storage
    - c. transfer to authorized recipient
- H. Disposal of Pharmaceuticals
  - 1. expired pharmaceuticals
  - 2. partially used pharmaceuticals



## Image Production (38)

### 1. Instrumentation (38)

- A. Survey Meter
  - 1. operating principles
    - a. Geiger Müller
    - b. ionization chambers (cutie pies)
  - 2. quality control
    - a. frequency and types of checks
    - b. interpretation and record keeping
- B. Dose Calibrator
  - 1. operating principles
  - 2. quality control
    - a. frequency and types of checks
      - 1. accuracy
      - 2. constancy
      - 3. linearity
      - 4. geometry
    - b. interpretation and record keeping
- C. Scintillation Detector System
  - 1. operating principles
    - a. well counter
    - b. uptake probe (e.g., thyroid, surgical)
  - 2. quality control
    - a. radionuclide source
      - 1. energies
      - 2. type of source
    - b. parameters
      - 1. energy resolution
      - 2. efficiency
      - 3. high voltage calibration
      - 4. resolving time
      - 5. sensitivity
      - 6. energy linearity
      - 7. chi-square
    - c. interpretation and record keeping
- D. Gas and Aerosol Delivery Systems
  - 1. operating principles
  - 2. exhaust system (e.g., negative pressure, gas traps)
  - 3. interpretation and record keeping
- E. Gamma Camera
  - 1. operating principles
  - 2. quality control
    - a. frequency and types of checks
    - b. performance characteristics
      - 1. flood field uniformity
      - 2. high count uniformity correction
      - 3. spatial linearity
      - 4. spatial resolution
      - 5. energy resolution (e.g., FWHM)
      - 6. detector sensitivity
      - 7. extrinsic versus intrinsic methods
      - 8. center of rotation
      - 9. SPECT phantom measurements
    - c. interpretation and record keeping
  - 3. image acquisition
    - a. detector system
      - 1. count or time mode
      - 2. detector orientation
      - 3. photopeak energy setting and window width
      - 4. multi-energy acquisition
    - b. collimator selection
      - 1. types (e.g., parallel hole, pinhole)
      - 2. parameters (e.g., energy, resolution, sensitivity)
    - c. dynamic/static acquisition
      - 1. matrix selection
      - 2. framing (e.g., number and length)
      - 3. gating
      - 4. list mode
    - d. SPECT acquisition
      - 1. angular sampling/number of views (e.g., 180° versus 360°)
      - 2. matrix selection
      - 3. attenuation correction
      - 4. duration of acquisition

(Image Production continues on the following page.)



## Image Production (continued)

### F. PET/CT Scanner

1. PET operating principles
2. PET quality control
  - a. frequency and types of checks
  - b. characterization and correction calibration
    1. energy window calibration
    2. gain setting
    3. reference (blank) scan
    4. normalization calibration
    5. absolute activity (well counter) calibration
  - c. interpretation and record keeping
3. PET image acquisition
  - a. 2D versus 3D
  - b. list mode
  - c. respiratory gating
  - d. time-of-flight
4. CT operating principles\*
5. CT quality control\*
  - a. tube warm-up
  - b. CT number (water phantom)
6. CT image acquisition\*
  - a. kVp
  - b. mA
  - c. pitch
  - d. slice thickness
  - e. noise and uniformity
  - f. artifacts

### G. Data Processing

1. quantitative analysis (e.g., region of interest selection, ejection fraction, time activity curves, SUV)
2. reconstruction
  - a. registration (image fusion)
  - b. orientation
  - c. filter parameters
  - d. attenuation correction
  - e. gated images
  - f. motion correction
3. image management
  - a. archiving
  - b. PACS
  - c. HIS/RIS

\*Diagnostic CT is not assessed on the Nuclear Medicine Technology Examination. CT content is assessed for attenuation correction/anatomic localization.



## Procedures (120)

### 1. Radionuclides and Radiopharmaceuticals (24)

#### A. Production of Radionuclides

1. methods
  - a. reactor
  - b. accelerator
  - c. cyclotron
  - d. generator
2. purity
  - a. radionuclide
  - b. chemical
3. physical form (e.g., gas, solution, capsule)

#### B. Radiopharmaceutical Characteristics

1. method of localization
  - a. capillary blockade
  - b. active transport
  - c. phagocytosis
  - d. diffusion
  - e. compartmentalization
  - f. chemisorption
  - g. receptor binding
  - h. antigen antibody
  - i. filtration
  - j. metabolism
  - k. sequestration
2. half-life
  - a. physical
  - b. biological
  - c. effective
3. biodistribution
  - a. pharmacokinetics
  - b. critical organs
  - c. target organs

#### C. Preparation and Administration

1. kit preparation
  - a. labeling process
    1. principles
      - a. oxidation/reduction
      - b. pH
      - c. time for reaction
      - d. temperature
    2. compounding techniques
      - a. venting
      - b. heating
      - c. mixing
      - d. USP 797 regulations
    3. factors that affect labeling quality
  - b. shelf life and storage

- c. quality control
  1. radiochemical purity
  2. particle size
  3. specific activity (e.g., millicuries per mass)
  4. color and clarity
2. calculation of radiopharmaceutical and pharmaceutical dosage
  - a. units
    1. conversions
    2. calculations
  - b. volume determination
    1. formula
    2. decay tables
    3. concentration
    4. activity
3. pharmaceutical and radiopharmaceutical administration
  - a. preparation
    1. syringe
    2. needle selection
    3. shielding
  - b. radiopharmaceutical label
    1. name of radiopharmaceutical
    2. assay date and time
    3. lot number and expiration date
    4. concentration
    5. volume
    6. activity
  - c. administration techniques
    1. routes
    2. aseptic
    3. uniform distribution (e.g., mixing, agitation)
    4. complications and reactions
    5. documentation

(Procedures continue on the following page.)





## Procedures (continued)

### TYPE OF STUDY

#### 2. Cardiac Procedures (24)

- A. Gated Blood Pool
- B. Myocardial Perfusion
- C. Viability

#### 3. Endocrine and Oncology Procedures (28)

- A. Endocrine
  - 1. thyroid uptake/imaging
  - 2. parathyroid
  - 3. neuroendocrine
  - 4. adrenal imaging
- B. Tumor
  - 1. whole body
  - 2. SPECT or SPECT/CT
  - 3. PET/CT
  - 4. lymphoscintigraphy
- C. Therapy
  - 1. procedures
    - a. palliative bone
    - b. thyroid ablation
    - c. hyperthyroidism
    - d. non-Hodgkin lymphoma
    - e. selective internal radiation therapy with hepatic artery perfusion study (HAPS)
  - 2. regulations

### FOCUS OF QUESTIONS

Questions about a specific study or procedure may address any of the following factors:

- A. Instrumentation
  - detector system
  - data acquisition
  - data analysis
  - ancillary equipment
- B. Radiopharmaceuticals and Pharmaceuticals
  - selection
  - dosage
  - administration
  - biodistribution
- C. Patient Preparation, Monitoring, and Education
  - indications and contraindications
  - pregnancy and nursing
  - dietary restrictions
  - adverse reactions
  - medications
  - age specific considerations
  - lab values
- D. Imaging Techniques
  - anatomical landmarks
  - views
  - patient-detector orientation
  - fusion imaging
- E. Anatomy and Pathophysiology
  - general anatomy
  - cross-sectional anatomy

(Procedures continue on the following page.)



## Procedures (continued)

### TYPE OF STUDY

#### 4. Gastrointestinal and Genitourinary Procedures (20)

- A. Gastric Emptying
- B. Gastroesophageal Reflux
- C. Meckel Diverticulum
- D. GI Bleed
- E. Hepatobiliary
- F. RBC Hemangioma
- G. Damaged RBC Spleen
- H. Liver/Spleen
- I. Renal Function
- J. Renal Cortical
- K. Radionuclide Cystogram

#### 5. Other Imaging Procedures (24)

- A. Abscess/Infection
- B. Bone
  - 1. planar
  - 2. 3-phase
  - 3. whole body
  - 4. SPECT or SPECT/CT
  - 5. PET/CT
- C. Central Nervous System
  - 1. brain death
  - 2. SPECT or SPECT/CT
  - 3. PET/CT
  - 4. cisternography/CSF leak
  - 5. shunt patency
- D. Lung
  - 1. perfusion
  - 2. ventilation – gas and aerosol
  - 3. quantitative

### FOCUS OF QUESTIONS

Questions about a specific study or procedure may address any of the following factors:

- A. Instrumentation
  - detector system
  - data acquisition
  - data analysis
  - ancillary equipment
- B. Radiopharmaceuticals and Pharmaceuticals
  - selection
  - dosage
  - administration
  - biodistribution
- C. Patient Preparation, Monitoring, and Education
  - indications and contraindications
  - pregnancy and nursing
  - dietary restrictions
  - adverse reactions
  - medications
  - age specific considerations
  - lab values
- D. Imaging Techniques
  - anatomical landmarks
  - views
  - patient-detector orientation
  - fusion imaging
- E. Anatomy and Pathophysiology
  - general anatomy
  - cross-sectional anatomy



## Attachment A: Nuclear Medicine Pharmaceuticals\*

### Radiopharmaceuticals

1. Tc-99m sodium pertechnetate
2. Tc-99m HDP
3. Tc-99m MDP
4. Tc-99m sestamibi
5. Tc-99m tetrofosmin
6. Tc-99m labeled RBCs
7. Tc-99m DTPA
8. Tc-99m DMSA
9. Tc-99m MAG3
10. Tc-99m HMPAO (Ceretek™)
11. Tc-99m ECD (Neurolite®)
12. Tc-99m HMPAO (Ceretek™) tagged WBCs
13. Tc-99m MAA
14. Tc-99m sulfur colloid
15. Tc-99m disofenin
16. Tc-99m mebrofenin (Choletec®)
17. In-111 DTPA
18. In-111 oxine labeled WBCs
19. In-111 pentetreotide (OctreoScan™)
20. Tl-201 thallous chloride
21. Xe-133 gas
22. I-123 sodium iodide
23. I-131 sodium iodide
24. I-123 ioflupane (DaTscan™)
25. I-123 MIBG
26. Ga-67 gallium citrate
27. F-18 fluorodeoxyglucose (FDG)
28. F-18 sodium fluoride (F-18 NaF)

### Therapeutic Radiopharmaceuticals

29. Y-90 ibritumomab tiuxetan (Zevalin®)
30. Ra-223 dichloride (Xofigo®)
31. I-131 MIBG
32. I-131 sodium iodide
33. Y-90 microspheres (Therasphere®, Sir-Spheres®)

### Interventional Pharmaceuticals

34. Adenosine
35. Aminophylline
36. Dipyridamole (Persantine®)
37. Dobutamine
38. Captopril
39. Furosemide (Lasix®)
40. Sincalide (Kinevac®)
41. Morphine
42. Regadenoson (Lexiscan®)
43. Lugol solution
44. Heparin
45. Recombinant TSH (Thyrogen®)
46. Oral CT contrast media

\*This is a list of commonly used pharmaceuticals that may appear on the exam. However, other pharmaceuticals may appear as practice changes