



# Nuclear Medicine Technology

The purpose of the examination requirement is to assess whether individuals have obtained the knowledge and cognitive skills underlying the intelligent performance of the tasks typically required in nuclear medicine technology for practice at entry level.

ARRT determined the tasks that entry level nuclear medicine technologists typically perform by administering a comprehensive practice analysis survey to a nationwide sample of nuclear medicine technologists.<sup>1</sup> The *Task Inventory for Nuclear Medicine Technology* is found on ARRT's website ([www.arrt.org](http://www.arrt.org)).

The *Examination Content Specifications for Nuclear Medicine Technology* and attached content outline identify the knowledge areas underlying performance of the tasks on the *Task Inventory for Nuclear Medicine Technology*. Every content category links to one or more tasks on the [task inventory](#).

ARRT avoids content when there are multiple resources with conflicting perspectives. Educational programs accredited by a mechanism acceptable to ARRT offer education and experience beyond the minimum requirements specified in the content specifications and clinical requirements documents.

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 the content outline, but do not limit themselves to only this content. ARRT administers this examination on a computer at a standardized testing center.

The table below presents the major content categories and subcategories that the examination covers. The table lists the number of test questions in each category in bold and the number of test questions in each subcategory in parentheses. The content outline, which makes up the remaining pages of this document, addresses specific topics within each category.

| Content Category                                             | Number of Scored Questions <sup>2</sup> |
|--------------------------------------------------------------|-----------------------------------------|
| Patient Care                                                 | <b>26</b>                               |
| <i>Patient Interactions and Management (26)</i>              |                                         |
| Safety <sup>3</sup>                                          | <b>27</b>                               |
| <i>Radiation Physics, Radiobiology, and Regulations (27)</i> |                                         |
| Image Production                                             | <b>30</b>                               |
| <i>Instrumentation (30)</i>                                  |                                         |
| Procedures                                                   | <b>117</b>                              |
| <i>Radionuclides and Radiopharmaceuticals (28)</i>           |                                         |
| <i>Cardiac (25)</i>                                          |                                         |
| <i>Endocrine and Oncology (24)</i>                           |                                         |
| <i>Gastrointestinal and Genitourinary (20)</i>               |                                         |
| <i>Other Imaging (20)</i>                                    |                                         |
| <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> The exam includes an additional 30 unscored (pilot) questions.

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



## Patient Care

### 1. Patient Interactions and Management

- A. Ethical and Legal Aspects
  - 1. patients' rights
    - a. consent (e.g.,\* informed, oral, implied)
    - b. confidentiality (HIPAA)
    - c. American Hospital Association (AHA) Patient Care Partnership
      - 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 positioning aids used to prevent motion artifact
  - 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, sensory, or cognitive impairments
      - 4. age
      - 5. emotional status, acceptance of condition (e.g., mental health concerns)
    - b. explanation of medical terms
    - c. strategies to improve understanding

- 3. patient education
  - a. explanation of current procedure (e.g., purpose, risks, benefits, radiation dose)
  - b. pre- and post-examination instructions (e.g., preparations, diet, medications, discharge instructions)
  - c. review pertinent medical history
  - d. respond to inquiries about other imaging modalities (e.g., types of radiation, patient preparation)
  - e. communication with patient during the procedure
- C. Physical Assistance and Monitoring
  - 1. body ergonomics (e.g., balance, alignment, movement)
    - a. patient transfer techniques
    - b. safe patient handling devices (e.g., transfer board, Hoyer lift, gait belt)
  - 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)
    - d. medical equipment malfunctions
  - 3. routine monitoring and documentation
    - a. vital signs
    - b. physical signs and symptoms (e.g., motor control, severity of injury)
    - c. fall prevention
    - d. patient comfort and modesty
    - e. sedation
- D. Medical Emergencies
  - 1. allergic reactions (e.g., pharmaceuticals, latex)
  - 2. cardiac/respiratory arrest (e.g., CPR, AED)
  - 3. physical injury or trauma
  - 4. other medical disorders (e.g., seizures, diabetic reactions)
  - 5. communication of critical findings to the health care team

\*"e.g." indicates examples of the topics covered but is not a complete list.



## Patient Care (continued)

### E. Infection Control

1. chain of infection (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 (PPE)  
(e.g., gloves, gowns, masks)
  - c. safe handling of contaminated equipment and surfaces
  - d. disposal of contaminated materials
    1. linens
    2. needles
    3. patient supplies
    4. blood and body fluids
    5. IV supplies
  - e. safe injection practices
4. transmission-based precautions
  - a. contact
  - b. droplet
  - c. airborne
5. additional precautions
  - a. neutropenic precautions (reverse isolation)
  - b. healthcare-associated (nosocomial) infections

### F. Handling and Disposal of Toxic or Hazardous Material

1. types of materials  
(e.g., cleaning materials)
2. safety data sheet

### G. Pharmacology

1. patient history
  - a. medication reconciliation (current medications)
  - b. premedications
  - c. contraindications
  - d. lab values (e.g., glucose, TSH)
  - e. scheduling and sequencing examinations
2. complications/reactions
  - a. local effects (e.g., infiltration)
  - b. emergency medications
  - c. technologist's response and documentation



## Safety

### 1. Radiation Physics, Radiobiology, and Regulations

- A. Principles of Radiation Physics
  - 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. target interaction in CT
    - a. bremsstrahlung
    - b. characteristic
  - 3. interaction of radiation with matter
    - a. photoelectric effect
    - b. Compton (incoherent) scattering
    - c. coherent (Rayleigh) scattering
    - d. pair production and annihilation
    - e. internal conversion
    - f. Auger electron
    - g. bremsstrahlung (from beta particles)
  - 4. attenuation
- B. Biological Effects of Radiation
  - 1. units of measurement
    - a. absorbed dose
    - b. dose equivalent
    - c. exposure
    - d. effective dose
  - 2. radiosensitivity (e.g., law of Bergonié and Tribondeau)
    - a. dose-response relationships
    - b. relative tissue sensitivities (e.g., LET and RBE)
  - 3. somatic effects
    - a. cells
    - b. tissue (e.g., critical, target)
    - c. embryo and fetus
    - d. carcinogenesis
    - e. early versus late or acute versus chronic
    - f. deterministic versus stochastic
    - g. short-term versus long-term exposure
    - h. acute radiation syndromes
      - 1. hemopoietic
      - 2. gastrointestinal (GI)
      - 3. central nervous system (CNS)
  - 4. genetic effects
- C. Basic Concepts of Radiation Protection
  - 1. principles of time, distance, and shielding
  - 2. personal protection equipment (e.g., gloves, lab coats)
  - 3. personnel monitoring devices
    - a. types
    - b. use, care, and placement
  - 4. ALARA
  - 5. release of patients
  - 6. patient dose reduction and optimization
    - a. Image Gently®
    - b. Image Wisely®
- D. NRC Regulations for Radiation Exposure
  - 1. occupational
  - 2. public
  - 3. pregnancy or nursing
  - 4. internal dosimetry and bioassays
  - 5. personnel exposure records



## Safety (continued)

- E. Medical Events
  - 1. definition
  - 2. NRC regulations for reporting and notification
- F. Facilities and Area 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. documentation of survey and wipes results
      - 1. interpretation
      - 2. reporting (corrective action)
      - 3. record retention
    - c. posting of signs (e.g., types, locations)
  - 4. radioactive spills
    - a. major spills
    - b. minor spills
    - c. processes for decontamination
    - d. reporting procedures
- G. Radioactive Materials
  - 1. shipping and receiving materials (e.g., DOT and NRC regulations)
    - a. shipping categories
    - b. measurement of exposure rate
    - c. measurement of surface contamination
    - d. removable contamination limits / trigger levels
    - e. documentation
  - 2. handling and storage
    - a. radiopharmaceuticals
    - b. sealed sources
    - c. consequences of improper handling and storage
  - 3. disposal of radioactive waste
    - a. release to environment
    - b. decay in storage
    - c. transfer to authorized recipient
- H. Pharmaceuticals
  - 1. storage
  - 2. disposal



## Image Production

### 1. Instrumentation

- 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. tests
      - 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 sources
      - 1. energies
      - 2. type (e.g., rod, cylinder, button, flood)
    - 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 (continued)

### F. PET/CT Scanner

1. PET operating principles
2. PET quality control
  - a. frequency and types of tests
  - b. characterization and correction calibration
    1. energy window calibration
    2. reference (blank) scan
    3. normalization calibration
    4. absolute activity calibration
  - c. interpretation and record keeping
3. PET image acquisition
  - a. list mode
  - b. cardiac gating
  - c. respiratory gating
  - d. time-of-flight
4. CT operating principles\*
5. CT quality control\*
  - a. tube warm-up
  - b. CT number (Hounsfield unit)
  - c. air calibration
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. qualitative analysis
  - a. motion correction
  - b. gated images
3. reconstruction
  - a. CT windowing and leveling
  - b. registration (image fusion)
  - c. orientation
  - d. filter parameters
  - e. attenuation correction
  - f. trues, scatters, randoms

### H. Informatics

1. information systems (e.g., RIS, HIS, EMR, EHR)
2. networking
  - a. PACS/MIMPS
  - b. DICOM
  - c. teleradiology (e.g., off-site reading, third-party coverage)
3. downtime procedures

\*Diagnostic CT is not assessed on the Nuclear Medicine Technology Examination.



## Procedures

### 1. Radionuclides and Radiopharmaceuticals

- 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
  - 2. half-life
    - a. physical
    - b. biological
    - c. effective
  - 3. biodistribution
    - a. pharmacokinetics and pharmacodynamics
    - 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 regulations (e.g., USP 825)
      - 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 pharmaceutical and radiopharmaceutical dosage
    - a. units
      - 1. conversions
      - 2. calculations
    - b. volume determination
      - 1. formula
      - 2. decay tables
      - 3. concentration
      - 4. activity
  - 3. pharmaceuticals and radiopharmaceuticals
    - a. administration
      - 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 (continued)

### TYPE OF STUDY

#### 2. Cardiac

- A. Gated Blood Pool
- B. Myocardial Perfusion
- C. Viability
- D. Amyloid Imaging

#### 3. Endocrine and Oncology

- A. Endocrine
  - 1. thyroid uptake/imaging
  - 2. parathyroid
- B. Tumor
  - 1. limited static
  - 2. whole body
  - 3. SPECT or SPECT/CT (e.g., adrenal)
  - 4. PET/CT (e.g., neuroendocrine, prostate, lymphoma)
- C. Therapy
  - 1. procedures
    - a. palliative bone
    - b. thyroid ablation
    - c. hyperthyroidism
    - d. selective internal radiation therapy (SIRT)
    - e. targeted radiotherapy (e.g., neuroendocrine, prostate)
  - 2. regulations

### FOCUS OF QUESTIONS

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

- Instrumentation
  - detector system
  - data acquisition
  - data analysis
  - ancillary equipment
- Radiopharmaceuticals and Pharmaceuticals
  - selection
  - dosage (e.g., routine, pediatric, bariatric)
  - administration
  - biodistribution
- Patient Preparation, Monitoring, and Education
  - indications and contraindications
  - pregnancy and nursing
  - dietary restrictions
  - adverse reactions
  - medications
  - age specific considerations
  - lab values
- Imaging Techniques
  - anatomical landmarks
  - views
  - patient-detector orientation
  - fusion imaging
- Anatomy and Pathophysiology
  - general anatomy
  - cross-sectional anatomy
- Nationally Recognized Standards (e.g., ASRT Practice Standards, SNMMI Procedure Standards, The Joint Commission)



## Procedures (continued)

### TYPE OF STUDY

#### 4. Gastrointestinal and Genitourinary

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

#### 5. Other Imaging

- A. Abscess/Infection
- B. Bone
  - 1. limited static
  - 2. 3-phase
  - 3. whole body
  - 4. SPECT or SPECT/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. ventilation – gas and aerosol
  - 2. perfusion
  - 3. quantitative
  - 4. hepatic artery perfusion study (HAPS) for pretherapy lung shunt fraction
- E. Lymphoscintigraphy
  - 1. breast
  - 2. skin lesion
  - 3. lymphangiography (extremity)

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  - selection
  - dosage (e.g., routine, pediatric, bariatric)
  - administration
  - biodistribution
- Patient Preparation, Monitoring, and Education
  - indications and contraindications
  - pregnancy and nursing
  - dietary restrictions
  - adverse reactions
  - medications
  - age specific considerations
  - lab values
- Imaging Techniques
  - anatomical landmarks
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## Attachment A: Nuclear Medicine Pharmaceuticals\*

### Radiopharmaceuticals

1. Tc-99m sodium pertechnetate
2. Tc-99m medronate (MDP)
3. Tc-99m pyrophosphate (PYP)
4. Tc-99m sestamibi (Cardiolite®)
5. Tc-99m tetrofosmin (Myoview™)
6. Tc-99m labeled RBCs
7. Tc-99m pentetate (DTPA)
8. Tc-99m succimer (DMSA)
9. Tc-99m mertiatide (MAG3)
10. Tc-99m exametazime (Ceretek™)
11. Tc-99m bismuth (Neurolite®)
12. Tc-99m exametazime (Ceretek™) tagged WBCs
13. Tc-99m MAA
14. Tc-99m sulfur colloid
15. Tc-99m tilmanocept (Lymphoseek®)
16. Tc-99m mebrofenin (Choletec®)
17. In-111 pentetate (DTPA)
18. In-111 oxine labeled WBCs
19. Xe-133 gas
20. I-123 sodium iodide
21. I-131 sodium iodide
22. I-123 ioflupane (DaTscan™)
23. I-123 iobenguane (MIBG, AdreView™)
24. Cu-64 dotatate (Detectnet™)
25. Ga-68 dotatate (NETSPOT®)
26. Ga-68 gozetotide PSMA (e.g., Illuccix®)
27. F-18 fluorodeoxyglucose (FDG)
28. F-18 florbetapir (Amyvid®)
29. F-18 piflufolastat PSMA (Pylarify®)
30. F-18 florbetaben (Neuroceq®)
31. F-18 flutemetamol (Vizamyl™)
32. Rb-82 chloride

### Therapeutic Radiopharmaceuticals

33. Ra-223 dichloride (Xofigo®)
34. I-131 sodium iodide
35. Lu-177 dotatate (LUTATHERA®)
36. Lu-177 vipivotide tetraxetan (Pluvicto®)
37. Y-90 microspheres (TheraSphere™, SIR-Spheres®)

### Interventional Pharmaceuticals

38. Aminophylline
39. Atropine sulfate
40. Dobutamine
41. Beta blocker
42. Nitroglycerin
43. Fatty meal substitute
44. Furosemide (Lasix®)
45. Sincalide (Kinevac®)
46. Morphine sulfate
47. Regadenoson (Lexiscan®)
48. Potassium iodide (Lugol solution / SSKI)
49. Heparin
50. Recombinant TSH (Thyrogen®)
51. 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.