



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 at entry into the profession. ~~The tasks typically performed were determined by administering a comprehensive practice analysis survey to a nationwide sample of nuclear medicine technologists.¹ 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.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. The Task Inventory for Nuclear Medicine Technology may be found on the ARRT's website (www.arrt.org).~~

The *Examination Content Specifications for Nuclear Medicine Technology* and attached outline identify the knowledge areas underlying performance of the tasks on the *Task Inventory for Nuclear Medicine Technology*. 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 below presents the ~~four~~ major content categories and subcategories covered on the examination. ~~The number of test questions in each category are listed in bold and the number of test questions in each subcategory in parentheses. The remaining pages list the specific topics addressed within each category are addressed in the content outline, which make up the remaining pages of this document. 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.

Content Category	Number of Scored Questions ²
Patient Care	20 24
<i>Patient Interactions and Management</i> 24	
Safety ³	22 25
<i>Radiation Physics, Radiobiology, and Regulations</i> 25	
Image Production	38 33
<i>Instrumentation</i> 33	
Procedures	120 118
<i>Radionuclides and Radiopharmaceuticals</i> 2824	
<i>Cardiac Procedures</i> 2524	
<i>Endocrine and Oncology Procedures</i> 2528	



Gastrointestinal and Genitourinary Procedures **1820**

Other Imaging Procedures **2224**

Total

200

- 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 **3020**-unscored (pilot) questions. On the pages that follow, the approximate number of test questions allocated to each content category appears in parentheses.
- ³ SI and conventional units of radiation measurement will continue to be used on the nuclear medicine technology examination.

DRAFT



Patient Care ~~(20)~~

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

A. Ethical and Legal Aspects

1. patient's rights
 - a. ~~informed~~-consent (*e.g., ~~written informed~~, 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~~ ~~positioning aids used to prevent motion~~

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, ~~or~~ ~~cognitive~~ 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, ~~radiation dose~~)
 - ~~b. verify informed consent when necessary~~
 - ~~eb.~~ pre- and post-examination instructions (e.g., preparations, diet, medications, discharge instructions)
 - ~~ec.~~ respond to inquiries about other imaging modalities (e.g., ~~CT, MRI, mammography, sonography, radiography, bone densitometry~~ types of radiation, patient preparation, patient preps)

*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.



- C. ~~Physical Assistance~~ ~~Ergonomics~~ and
Monitoring ~~and Documentation~~
1. ~~patient transfer and movement~~ ~~body~~
mechanics (e.g., balance, alignment,
movement)
 - ~~a. body mechanics (e.g., balance,
alignment, movement)~~
 - ~~a~~b. patient transfer techniques
 - b. ergonomic 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)
 3. ~~Routine~~ ~~patient~~ ~~M~~onitoring ~~and~~
documentation
 - a. vital signs
 - b. physical signs and symptoms
(e.g., motor control, severity of
injury)
 - c. fall prevention
 - ~~d. documentation~~
 - ~~e. immobilization~~
 - ~~d~~f. sedation
- D. Medical Emergencies
1. allergic reactions
(e.g., pharmaceuticals, latex)
 2. cardiac ~~/or~~ respiratory arrest (e.g.,
CPR, ~~AED~~)
 3. physical injury or trauma
 4. other medical disorders (e.g.,
seizures, diabetic reactions)



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 (e.g., gloves, gowns, masks)
 - ~~e. safe injection practices~~
 - ~~c~~d. safe handling of contaminated equipment/surfaces
 - ~~d~~e. disposal of contaminated materials
 1. linens
 2. needles
 3. patient supplies
 4. blood and body fluids
 - 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 (e.g., material safety data sheets)

G. Pharmacology

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



Safety ~~(22)~~

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

A. ~~Physical Properties of Radioactive~~

~~Materials~~ ~~Principals 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

~~23.~~ 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
- f. ~~bremsstrahlung~~

4. attenuation

B. Biological Effects of Radiation

1. units of ~~measurement radiation~~ ~~exposure~~

- a. absorbed dose
- b. dose equivalent
- c. exposure
- d. effective dose

~~cellular biology~~

2. ~~effects of radiation on~~

~~cells~~ radiosensitivity (e.g., law of Bergonié and Tribondeau)

- a. ~~direct and indirect action~~ dose-response relationships

~~b. radiolysis of water~~

~~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 effects

g. acute ~~effects of total body~~ radiation syndromes

~~a. radiation sickness~~

1. hemopoietic syndrome

2. gastrointestinal syndrome (GI)

3. central nervous system

syndrome (CNS)

~~5. long term effects of radiation~~

~~a. somatic~~

~~43. genetic effects~~

~~6. relative tissue and organ sensitivity~~

~~7. effects of radiation on embryo/fetus~~

C. Basic Concepts of Radiation Protection

~~12.~~ principles of time, distance, and shielding

~~23.~~ personnel protection equipment (e.g., gloves, lab coats, ~~syringe shields~~)

~~34.~~ personnel monitoring devices

a. types

b. use, care, and placement

~~45.~~ ALARA

~~56.~~ release of patients

~~67.~~ 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

E. Medical Events

1. definition
2. NRC regulations for reporting and notification

F. ~~Area~~/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. classification of areas~~
 - ~~1. work~~
 - ~~2. treatment~~
 - ~~3. storage~~
 - ~~b~~d. 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

(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~~ storage
2. ~~partially used pharmaceuticals~~ disposal



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 sources
 1. energies
 2. type (e.g., rod, button) ~~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~~
 - ~~a~~b. 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~~ ~~water phantom~~)
 - 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~~2. reconstruction
 - a. CT windowing and leveling
 - ~~b~~a. registration (image fusion)
 - ~~c~~b. orientation
 - ~~d~~c. filter parameters
 - ~~e~~d. attenuation correction
 - ~~e~~. gated images
 - ~~f~~. motion correction
 - f. trues, scatter, randoms

~~H.3 image management~~ Imaging Informatics

- a. archiving
1. information systems (e.g., RIS, HIS, EMR, EHR)
2. networking
 - a. DICOM
 - b. PACS
 - c. HL7
 - ~~e~~. 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 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 797 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
 5. chromatography
2. calculation of radiopharmaceutical and pharmaceutical and radiopharmaceutical 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
- D. Amyloid Imaging

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

- A. Endocrine
 - 1. thyroid uptake/imaging
 - 2. parathyroid
 - 3. neuroendocrine
 - 4. adrenal imaging
- B. Tumor
 - 1. total/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)
 - f. targeted radiotherapy (e.g., neuroendocrine)
 - 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
- F. Nationally-Recognized Standards (e.g., ASRT Practice Standards, SNMMI Procedure Standards, The Joint Commission)

(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~~

~~G~~ H. Liver/Spleen

~~H~~ I. Renal Function

~~I~~ J. Renal Cortical

~~K. Radionuclide Cystogram~~

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

A. Abscess/Infection

B. Bone

- 1. planar
- 2. 3-phase
- 3. ~~total~~/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. ventilation – gas and aerosol
- 2. perfusion
- 3. quantitative

E. Lymphoscintigraphy

- 1. breast
- 2. skin lesion
- 3. extremity (e.g., lymphangiography)

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

F. Nationally Recognized Standards (e.g., ASRT Practice Standards, SNMMI Procedure Standards, The Joint Commission)



Attachment A: Nuclear Medicine Pharmaceuticals*

Radiopharmaceuticals

1. Tc-99m sodium pertechnetate
2. ~~Tc-99m HDP~~
3. Tc-99m MDP
4. ~~Tc-99m PYP~~
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 ~~exametazime~~ ~~HMPAO~~ (~~Ceretec™~~)
11. Tc-99m ~~ECD~~ ~~bicisate~~ (Neurolite®)
12. Tc-99m ~~exametazime~~ ~~HMPAO~~ (~~Ceretec™~~)
tagged WBCs
13. Tc-99m MAA
14. Tc-99m sulfur colloid
15. ~~Tc-99m disofenin~~
15. Tc-99m tilmanocept (Lymphoseek®)
16. Tc-99m mebrofenin (~~Choletec®~~)
17. In-111 DTPA
18. In-111 oxine labeled WBCs
19. In-111 pentetretotide (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. ~~Ga-68~~ Dotatate (Netspot™)
28. F-18 fluorodeoxyglucose (FDG)
29. F-18 sodium fluoride (~~F-18~~ NaF)
30. ~~F-18~~ Fluciclovine (Axumin™)
31. ~~Rb-82~~ chloride

Therapeutic Radiopharmaceuticals

29. ~~Y-90~~ ibritumomab tiuxetan (~~Zevalin®~~)
30. Ra-223 dichloride (Xofigo®)
- ~~I-131~~ MIBG
31. ~~32~~. I-131 sodium iodide
32. ~~Lu-177~~ Dotatate (Lutathera®)
33. Y-90 microspheres (Therasphere®,
Sir-Spheres®)

Interventional Pharmaceuticals

34. Adenosine
35. Aminophylline
36. ~~Atropine~~ Sulfate
37. Dipyridamole (Persantine®)
38. Dobutamine
39. ~~Beta~~ blocker
40. ~~Nitroglycerin~~
- ~~Captopril~~
41. ~~Fatty~~ meal substitute
42. Furosemide (Lasix®)
43. Sincalide (Kinevac®)
44. Morphine ~~sulfate~~
45. Regadenoson (Lexiscan®)
46. ~~Potassium~~ iodide (Lugol solution/~~SSKI~~)
47. Heparin
48. Recombinant TSH (Thyrogen®)
49. 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.