

Nuclear Medicine Technology Certification Board

CNMT Certification Examination Content Outline



Components of Preparedness

Domain I: Radiation Physics & Detection – 7%

Domain II: Radiation Safety & Regulations – 13%

Domain III: Pharmaceutical & Radiopharmaceutical Agents – 25%

Domain IV: Instrument Operations & Quality Control – 15%

Domain V: Clinical Procedures – 40%

I. Radiation Physics and Detection

7%

A. Understand the fundamentals of radiation physics and detection

1. Physical properties
 - a. Radioactive materials
 - i. Isotopes and their properties (e.g., half-life, energy)
 - ii. Modes of decay (e.g., gamma emitters, beta emitters, alpha emitters, positron emitters)
 - b. X-ray production
 - i. Bremsstrahlung
 - ii. Characteristic x-ray
2. Decay calculations and Counting statistics
3. Interactions of radiation with matter
 - a. Compton scatter
 - b. Photoelectric effect
4. Radiation detector types and basic principles
 - a. NaI well
 - b. Ion chamber
 - c. Solid state detector
 - d. GM meter

II. Radiation Safety and Regulations

13%

A. Identify biological effects of radiation exposure

1. Deterministic (e.g., due to amount, radiation burns)
2. Stochastic (e.g., cancer)
3. Exposure
 - a. Patient (e.g., imaging, treatment, diagnostic)
 - b. Technologist (e.g., imaging, treatment, diagnostic)
4. Short-term vs Long-term effects of radiation
5. Radiosensitivity (e.g., effects on the cell)

B. Recognize protection techniques and calculations

1. ALARA
 - a. Time
 - b. Distance (inverse square law)
 - c. Shielding (shielding equations)

C. Perform survey protocols and requirements (e.g., timing and frequency)

1. Radiation surveys (area monitoring) including:
 - a. Survey meters and well counters
 - b. Choice of radiation detection devices (e.g., Geiger Counters, sodium iodide detectors)
 - c. Frequency of surveys
 - d. Trigger limits of surveys
2. Personal monitoring devices
 - a. Types (e.g., ring badge vs collar badge)
 - b. Dosimeter report
 - c. Declaration of pregnancy
3. Personal protective equipment (e.g., lab coat, gloves, syringe shields)
4. Effective dose equivalent limits for:
 - a. Radiation workers
 - b. Declared pregnant radiation workers
 - c. General public

D. Comply with Nuclear Regulatory Commission (NRC) Regulations

1. Posted warnings and informational signs delineating restricted and unrestricted areas
2. Surveying and inventorying radioactive materials
3. Adverse event response
 - a. Trigger levels and monitoring methods
 - b. Radiation exposure
 - c. Radiation spills (e.g., major vs minor)
 - d. Protection during adverse events
 - e. Personnel, patient and/or public decontamination
 - f. Area/equipment decontamination
 - g. Recordable and reportable events
4. Adherence to radioactive waste storage requirements
5. Radioactive material disposal (e.g., liquids, solids, gasses, contaminated materials)
6. Record maintenance
 - a. Receipt, storage, and disposal of radioactive materials
 - b. Radiation monitoring and reporting
 - c. Equipment calibration and maintenance
 - d. Staff, patient, occupational and public exposure
 - e. Nuclear medicine diagnostic and therapeutic procedures
 - f. Leak test
7. Written directives
8. Shipping and Packaging Regulations
 - a. Department of Transportation (DOT)
 - b. Types of shielding containers

- c. Label requirements (e.g., transportation index, name, concentration, expiration date/time, total activity, assay date/time, limits)
- d. Types of packages (e.g., exempt, non-exempt)
- e. Package monitoring/receiving/returning

E. Comply with Other Regulations and Guidelines

- 1. Environmental Protection Agency (EPA)
- 2. Occupational Safety and Health Administration (OSHA)
- 3. Health and Human Services (HHS)/Health Insurance Portability and Accountability Act (HIPAA)
 - a. Protecting patient rights and privacy
 - b. Maintaining patient records
 - c. Releasing information to authorized parties
- 4. Food and Drug Administration (FDA)
- 5. United States Pharmacopeia (USP)
 - a. USP<797>
 - b. USP<825>
- 6. Institutional and Departmental Accreditation Organizations (e.g., SOP documents)

III. Pharmaceutical and Radiopharmaceutical Agents

25%

A. Elute radionuclide generator, perform, and evaluate quality control tests

- 1. Types of generators (e.g., $^{99}\text{Mo}/^{99\text{m}}\text{Tc}$, $^{82}\text{Sr}/^{82}\text{Rb}$)
 - a. Transient and secular
 - b. Eluate
 - c. Generator yield – volume and activity
 - d. Quality control procedures
 - i. Radionuclidic breakthrough (e.g., ^{99}Mo breakthrough)
 - ii. Chemical (e.g., Al^{+3} breakthrough)
- 2. Dose calibrator operation /units of radioactivity

B. Prepare radiopharmaceutical kits, perform quality control, and evaluate results

- 1. Radiopharmaceutical kits
 - a. Preparation techniques
 - b. Activity and volume limitations
 - c. Activity calculations
 - d. Particle size and number (e.g., MAA kit)
- 2. Radiopharmaceutical quality control
 - a. Visual inspection - color and clarity
 - b. Radiochemical purity (e.g., ITLC)
- 3. Labeling kits
- 4. Storage of kits before and after reconstitution
 - a. Expiration
 - b. Temperature requirements

C. Understand the characteristics (i.e., mechanism of localization), indications, contraindications, and administration of diagnostic radiopharmaceuticals

- 1. Tc-99m labeled radiopharmaceuticals
 - a. Tc-99m sodium pertechnetate

- b. Tc-99m oxidronate/HDP
 - c. Tc-99m medronate/MDP
 - d. Tc-99m pentetate/DTPA
 - e. Tc-99m macroaggregated albumin/MAA
 - f. Tc-99m sulfur colloid (e.g., filtered, unfiltered)
 - g. Tc-99m mebrofenin (Choletec®)
 - h. Tc-99m mertiatide/MAG3®
 - i. Tc-99m pyrophosphate/PYP
 - j. Tc-99m sestamibi/MIBI (Cardiolite®)
 - k. Tc-99m tetrofosmin (Myoview®)
 - l. Tc-99m succimer/DMSA (Nephroskan®)
 - m. Tc-99m exametazime/HMPAO (Ceretek®)
 - n. Tc-99m bicisate/ECD (Neurolite®)
 - o. Tc-99m labeled RBCs (UltraTag®/PYP)
 - p. Tc-99m HMPAO tagged WBCs
 - q. Tc-99m tilmanocept (Lymphoseek®)
2. Iodine labeled radiopharmaceuticals
 - a. I-123 sodium iodide
 - b. I-131 sodium iodide
 - c. I-123 lobenguane (MIBG) (AdreView®)
 - d. I-123 loflupane (DaTscan®)
 3. Indium labeled radiopharmaceuticals
 - a. In-111 chloride
 - b. In-111 oxine labeled WBCs
 - c. In-111 pentetate (DTPA)
 - d. In-111 pentetreotide (Octreoscan®)
 4. Miscellaneous diagnostic radiopharmaceuticals
 - a. Ga-67 gallium citrate
 - b. Tl-201 thallos chloride
 - c. Xe-133 gas
 5. Positron Emission Tomography
 - a. Cu-64 Dotatate (Detectnet®)
 - b. F-18 FDG
 - c. F-18 Florbetaben (Neuraceq®)
 - d. F-18 Florbetapir (Amyvid®)
 - e. F-18 Flutemetamol (Vizamyl®)
 - f. F-18 Sodium Fluoride (NaF)
 - g. F-18 Fluciclovine (Axumin®)
 - h. F-18 Flortaucipir (Tauvid®)
 - i. F-18 Piflufolastat (Pylarify®)
 - j. F-18 Fluorodopa
 - k. F-18 Fluoroestradiol (Cerianna®)
 - l. Ga-68 Dotatate (Netspot®)
 - m. Ga-68 Dotatoc
 - n. Ga-68 Gozetotide (Illuccix®, Locametz®)

- o. N-13 ammonia
- p. Rb-82 chloride (Rubyfill®, Cardiogen®)

D. Understand the characteristics (i.e., mechanism of localization), indications, contraindications, and administration of therapeutic radiopharmaceuticals

1. I-131 sodium iodide
2. Lu-177 dotatate (Lutathera®)
3. Lu-177 Vipivotide tetraxetan (Pluvicto®)
4. Ra-223 Radium dichloride (Xofigo®)
5. Sr-89 chloride (Metastron®)
6. Y-90 microspheres (SIR-Spheres®, TheraSphere®)

E. Understand the indications, contraindications, and administration of interventional and adjunct pharmaceutical agents used in conjunction with nuclear medicine procedures

1. Dipyridamole (Persantine®)
2. Adenosine
3. Dobutamine
4. Aminophylline
5. Regadenoson (Lexiscan®)
6. Captopril
7. Enalaprilat
8. Furosemide (Lasix®)
9. Insulin
10. Acetazolamide (Diamox®)
11. Cholecystokinin/ sincalide/CCK
12. Morphine
13. Cimetidine/famotidine
14. ACD solution
15. Heparin
16. Contrast media (oral and IV)
17. Lugol's solution/SSKI
18. Thyroid Stimulating Hormone (TSH)
19. Lidocaine
20. Lidocaine (EMLA®) cream
21. Atropine
22. Recombinant human TSH (Thyrogen®)
23. Amino acids (e.g., lys-arg)
24. Zofran/Emend
25. Beta blockers (e.g., Metoprolol)
26. Boost®/Ensure®

F. Radiolabel blood components with radiopharmaceutical according to protocol

1. Labeling procedures
 - a. Required lab equipment and supplies
 - b. Anticoagulants and other additives
 - c. Chemical reactions
 - d. Cell washing
 - e. Required radiopharmaceuticals

- f. Method (e.g., in vivo, in vitro)
- 2. Calculation of labeling efficiency and administered dosage
- 3. Reinjection patient and sample verification

G. Administer radiopharmaceuticals and non-radioactive agents

- 1. Administration routes (e.g., IV, oral, intrathecal)
- 2. Administration techniques (e.g., bolus, infusion, aseptic)

IV. Instrument Operations and Quality Control

15%

A. Operate Non-imaging equipment and components

- 1. Quality control and calibration for well counters and probes
 - a. Quality control and calibration for the sodium iodide scintillation detector
 - b. Gamma ray spectra and pulse height analysis
 - c. Formulas (e.g., energy resolution, sensitivity, Chi-square statistics)
- 2. Operational status of survey meter
 - a. Survey meter operations and components
 - b. Survey meter quality control and calibration
- 3. Dose calibrator constancy, accuracy, linearity, and geometry tests

B. Operate Imaging equipment and components

- 1. Gamma Camera quality control
 - a. Uniformity
 - b. Spatial resolution and linearity
 - c. Visual image quality
 - d. Phantoms
 - e. Artifacts
 - f. System sensitivity
 - g. Pulse height analysis
- 2. SPECT and SPECT/CT imaging system
 - a. Attenuation correction
 - b. SPECT camera quality control
 - i. Center of rotation
 - ii. Field uniformity requirements
 - iii. Pixel calibration
 - iv. 3-D uniformity and resolution (e.g., Jaszczak phantom)
 - v. Artifacts
- 3. PET and PET/CT imaging systems
 - a. Application of attenuation corrections
 - b. PET quality control (e.g., daily blank scan, normalization scan, 2-D/3- D well counter, artifacts)
- 4. CT imaging systems
 - a. Co-registration of images
 - b. CT quality control (e.g., contrast and spatial resolution, noise, uniformity, artifacts)
 - c. Safety alerts (e.g., pre-scan notification)
- 5. Computer equipment (e.g., monitors, matrix sizes, printers)
- 6. Networking and information systems (e.g., PACS and RIS)

C. Operate Auxiliary equipment

1. Laboratory equipment (e.g., pipette, fume hoods)
2. Patient care equipment
 - a. Intravenous infusion pump
 - b. ECG monitor
 - c. Pulse oximeter
 - d. Defibrillator
 - e. Glucose meter
 - f. Blood pressure equipment
 - g. Oxygen delivery equipment
 - h. Patient lifts
 - i. Lateral transfer equipment
3. Non-imaging equipment
 - a. Xenon delivery system and trap
 - b. Aerosol delivery system
 - c. Treadmill
 - d. Liquid scintillation counter
 - e. Rb delivery system (e.g. Rubyfill®, Cardiogen®)

V. Clinical Procedures and Therapies

40%

A. Perform nuclear medicine procedures

1. Pulmonary
 - a. Radioaerosol ventilation
 - b. Gas ventilation
 - c. Perfusion
 - i. SPECT
 - ii. SPECT/CT
 - d. Perfusion/Ventilation quantitation
2. Bone/Musculoskeletal scans
 - a. Limited
 - b. Whole-body
 - c. 3-phase
 - d. 4-phase
 - e. SPECT
 - f. SPECT/CT
 - g. NaF PET
3. Oncology
 - a. Ga-67 tumor imaging, planar and/or SPECT
 - b. SPECT/CT
 - c. Peptide imaging
 - d. Molecular breast imaging
 - e. Lymphoscintigraphy/sentinel lymph node localization
 - f. Tumor imaging, PET
 - i. Melanoma (e.g., whole body)
 - ii. PSMA

- iii. Neuroendocrine
 - iv. Neurology
 - v. General (e.g., skull-base to mid-thigh)
- g. Neuroendocrine tumor imaging
- 4. Infection
 - a. Ga-67 infection imaging
 - b. Tagged WBC imaging
- 5. Renal/Genitourinary
 - a. Cystogram, direct
 - b. Effective renal plasma flow (ERPF)
 - c. Glomerular filtration rate (GFR) imaging
 - d. Glomerular filtration rate (GFR) non-imaging
 - e. Renal anatomy, planar, SPECT (e.g., DMSA)
 - f. Renal flow
 - g. Renogram (Lasix®)
 - h. Renogram with ACE inhibitors
- 6. Endocrine
 - a. Adrenal imaging
 - b. Parathyroid imaging, planar and SPECT
 - c. SPECT/CT
 - d. Thyroid imaging
 - e. Thyroid uptake
 - f. Whole body survey for thyroid metastases
- 7. Hematopoietic
 - a. Bone marrow imaging
- 8. Cardiovascular
 - a. Myocardial perfusion, planar
 - b. Myocardial perfusion (gated and non-gated)
 - i. SPECT (e.g., supine, prone)
 - ii. SPECT/CT
 - iii. CT attenuation
 - iv. PET
 - c. Cardiac sarcoidosis
 - i. PET
 - d. First pass for EF and wall motion
 - e. Gated cardiac blood pool, rest
 - f. Gated cardiac blood pool, stress
 - g. Gated cardiac blood pool, SPECT
 - h. Cardiac shunt
 - i. Cardiac Amyloidosis
 - j. MIBG
 - k. Myocardial viability
 - i. Thallium
 - ii. FDG
- 9. Gastrointestinal

- a. Gastric emptying (liquid/solid)
 - b. Gastroesophageal reflux
 - c. Gastrointestinal bleeding
 - d. Hemangioma
 - e. Hepatobiliary with and without GBEF
 - f. Liver-lung shunt mapping (arterial)
 - g. Liver-spleen imaging, planar and SPECT
 - h. SPECT/CT
 - i. Meckel's diverticulum
10. Central Nervous System
- a. Brain flow, brain death
 - b. Brain imaging, planar and SPECT
 - i. Brain perfusion SPECT (Acetazolamide)
 - ii. Viability SPECT
 - iii. Tumor SPECT
 - c. SPECT/CT
 - d. Dopamine transporter DaTscan®
 - e. Cisternogram
 - f. CSF leak
 - g. CSF shunt patency
 - h. Amyloid
 - i. Ictal and interictal (e.g., SPECT/planar, PET)
11. Radionuclide Therapy
- a. I-131 sodium iodide for ablation
 - b. I-131 sodium iodide for hyperthyroid
 - c. Lu-177 Dotatate (Lutathera®)
 - d. Lu-177 PSMA (Pluvicto®)
 - e. Ra-223 Dichloride (Xofigo®)
 - f. Sr-89 Chloride (Metastron®)
 - g. Y-90 labeled microspheres
12. CT Imaging Procedures
- a. Attenuation correction
 - b. Anatomical localization
 - c. Diagnostic vs non-diagnostic

B. Schedule patient studies

- 1. Camera duration
- 2. Multiple radionuclide procedures for a single patient
- 3. Same-day multiple modality procedures for a single patient

C. Procure supply of radiopharmaceuticals

- 1. License parameters and limits (i.e., Institutional)
- 2. Reconciliation of schedule with radiopharmaceutical/adjunct pharmaceutical procurement

D. Educate patient, family, and personnel

- 1. Procedures
- 2. Precautions

3. Restrictions
4. Release criteria (e.g., inpatient, travel, therapy)
5. Consent (e.g., written and verbal)

E. Obtain patient information and provide patient care

1. Patient information and privacy (e.g., Healthcare Insurance Portability and Accountability Act (HIPAA))
2. Basic patient care (e.g., vital signs, basic first aid, infection control)
3. Patient transferring techniques
4. Patient support devices (e.g., Foley catheter and drainage bag)
5. Patient identification (e.g., armband, verbal, scan)
6. Orders for study
7. Pre-examination screening
 - a. Patient preparations and contraindications
 - b. Medical history
 - c. Current medications
 - d. Allergic and adverse reaction history
 - e. Review relevant lab values
8. Informed consent
9. Disposal of supplies and biohazardous material
10. Emergency procedures (e.g., fainting, seizure, cardiopulmonary arrest)
11. Post-procedure assessment

F. Select and administer prescribed radiopharmaceuticals

1. Patient/ radiopharmaceutical reconciliation
2. Calculation of appropriate volume to deliver prescribed dosage when needed
3. Radiopharmaceutical administration using appropriate route and technique

G. Prepare equipment and perform examinations

1. Patient positioning (e.g., anatomical markers, immobilization techniques)
2. Imaging parameters for data acquisition

H. Evaluate image quality

1. Normal and abnormal scan patterns
2. Artifacts and causes
3. Co-registration of images (SPECT/CT and PET/CT)
4. Study repetition and additional views

I. Perform image processing

1. Data storage, transfer, and retrieval
2. Image formation (e.g., static, dynamic, gating, list mode)
3. Image reconstruction (e.g., SPECT, PET/CT)
4. Image enhancement (e.g., filters, matrix, intensity)
5. Quantitative analysis
 - a. Regions of interest and quantification
 - b. Curve generation and analysis
 - c. Image normalization and subtraction
6. Display formatting (image size, number of images, intensity adjustments)

J. Prepare/perform stress testing

1. Basic electrocardiography (ECG) (e.g., cardiac monitoring)

- a. Cardiac conduction system
- b. Components of a normal ECG wave form
- c. Recognizing and responding to changes on a resting or stress ECG
- 2. ECG lead placements
- 3. Treadmill stress techniques (e.g., Bruce and modified Bruce) and bicycle stress techniques
 - a. Contraindications
 - b. Duration/termination parameters
- 4. Pharmacological stress protocols
 - a. Contraindications
 - b. Timing of pharmacological stress agent
 - c. Timing of radiopharmaceutical injection
 - d. Duration/termination parameters
 - e. Drug side-effects and appropriate treatment
 - f. Reversal agents and techniques

K. Obtain samples and/or data for non-imaging studies

- 1. Data specimen collection techniques, including timing, methods, containers, and storage
- 2. Background correction
- 3. External counting techniques

L. Evaluate the results of non-imaging studies

- 1. Error analysis
- 2. Calculations

M. Administer radiopharmaceutical therapies

- 1. Isolation room requirements
- 2. Surveys
- 3. Inpatient vs outpatient
- 4. Storage and waste disposal
- 5. Documentation and record keeping
- 6. Post-therapy scanning
- 7. Dosimetry