

NMTCB Positron Emission Tomography Specialty Examination Content Outline



- I. Diagnostic Procedures (~35%) [70 items]**
- II. Instrumentation/Quality Control (~30%) [60 items]**
- III. Radiation Protection (~10%) [20 items]**
- IV. Radiopharmaceuticals (~25%) [50 items]**

I. DIAGNOSTIC PROCEDURES (~35%) [70 items]

A. Administration of Radiopharmaceuticals, Pharmaceuticals, and Interventional Medications

1. Concepts of administration including indications, contraindications, adverse reactions, medication interactions, routes of administration and pediatric considerations
 - a. Indications
 - b. Contraindications
 - c. Adverse reactions
 - d. Medication interactions
 - e. Dosing and route of administration
 - f. Pediatric considerations
 - g. Routes of administration
2. Dosage determination, preparation and administration
 - a. Units – calculations and conversion
 - b. Verify correct radiopharmaceutical for exam
 - c. Calculation of radiopharmaceutical/pharmaceutical dose
 - d. Calculation of pediatric dose
 - e. Volume determination
 - f. Dose determination according to scan mode and equipment type
 - g. Preparation for administration
 - h. Assay in dose calibrator
 - i. Radiopharmaceutical labeling
 - j. Administration techniques
 - i. Oral
 - ii. Intravenous
 - k. Residual dose measurement
3. Pharmaceuticals and Interventional Medications
 - a. ACE inhibitors
 - b. Acetylcholine antagonists

- c. Adenosine agonists
 - d. Adenosine Deaminase Inhibitor
 - e. Anxiolytics/Hypnotics/Sedatives
 - i. Barbiturates
 - ii. Benzodiazepines
 - iii. Benzodiazepine antagonist
 - iv. Non-Benzo, benzo receptor agonist
 - f. Antiarrhythmics (by class)
 - i. Lidocaine (C1)
 - ii. Beta Blockers (C2)
 - iii. Amiodarone (C3)
 - iv. Calcium Channel Blockers (C4)
 - v. Digoxin (other)
 - vi. Adenosine (other)
 - g. Anticoagulants
 - i. Acetylsalicylic acid
 - ii. Heparin
 - h. Antiseizure
 - i. Beta Agonist
 - i. Dobutamine
 - j. Cholesterol-lowering drugs
 - k. Diabetic medications
 - l. Diuretics
 - i. Acetazolamide- cerebral perfusion
 - ii. Furosemide
 - m. Glucose
 - n. Growth stimulation hormone factor
 - o. Hematopoetins
 - p. Hyperinsulinemic-euglycemic clamp
 - q. Insulin
 - r. Methylxanthines
 - i. caffeine, aminophylline, theophylline
 - s. Nitrates
 - t. Steroids
4. Principles and administration of contrast media
- a. Oral
 - b. Non-ionic
 - c. Ionic
5. Factors affecting biodistribution of PET radiopharmaceuticals
- a. Disease states
 - i. Ictal vs. inter-ictal
 - ii. Infectious processes
 - iii. Inflammatory disease
 - iv. Mild cognitive impairment
 - b. Exercise
 - c. Hydration
 - d. Medicinal Factors
 - i. Chemotherapy
 - ii. Granulocyte colony-stimulating factors
 - iii. Erythropoiesis stimulating agents
 - iv. Psychotropics
 - v. Metformin

- vi. Steroids
- vii. SSRIs
- viii. TPN/ IV with dextrose or lactated ringers
- ix. Laxatives
- x. Serum insulin level/insulin pump
- xi. Fluoroquinolones
- e. Muscle tension
- f. Radiation therapy/Radiation treatment
- g. Serum glucose level
- h. Stimulation
- i. Surgery/biopsy
- j. Surgical variants
- k. Environment/Temperature
- 6. Emergency care
 - a. CPR
 - b. Contrast reactions
 - c. Diabetic complications
 - d. Emergency medications
 - e. Hypoglycemia

B. Gated Procedures (Cardiac and Respiratory)

- 1. Equipment
- 2. Lead placement
- 3. Sources of error
 - a. Patient
 - b. Equipment
 - c. User
- 4. Respiratory gating techniques

C. Imaging Techniques:

- 1. Cardiology:
 - a. History and assessment
 - b. Clinical Indications and contraindications
 - c. Patient preparation/instructions
 - i. pre-arrival
 - ii. pre-injection
 - iii. post-injection
 - iv. post-procedure– discharge instructions
 - d. ECG's
 - i. Patient preparation, electrode placement
 - ii. Rate calculation
 - iii. Normal and abnormal rhythms
 - e. Exercise
 - f. Uptake period
 - g. Patient positioning
 - i. Low dose scout
 - ii. Transmission
 - iii. Anatomical markers
 - h. Anatomy/Physiology/Imaging techniques
 - i. Myocardial Perfusion Imaging
 - ii. Myocardial Viability
 - ii. Myocardial Sarcoidosis

iv. Myocardial oxygen consumption/hypoxic imaging

2. Neurology:

- a. History and assessment
- b. Indications and contraindications
- c. Patient preparation/instructions
 - i. pre-arrival
 - ii. pre-injection
 - iii. post-injection
 - iv. post-procedure– discharge instructions
- d. Uptake time
- e. EEG monitoring
 - i. Patient preparation
 - ii. Seizure activity patterns
- f. Patient positioning
- g. Anatomy/physiology/Imaging Techniques
 - i. Alzheimer
 - ii. Brain Tumors
 - iii. Dementia
 - iv. Epileptic seizures
 - v. Movement disorders
 - vi. Other indications

3. Oncology:

- a. History and assessment
- b. Clinical indications and contraindications
- c. Patient preparation/instructions
 - i. pre-arrival
 - ii. pre-injection
 - iii. post-injection
 - iv. post-procedure – discharge instructions
- d. Uptake time
- e. Patient positioning
 - i. Arms up/down
 - ii. Head first/feet first
- f. Anatomy/physiology/Imaging techniques
 - i. Oncologic Indication
 - ii. Dosimetry exams for Theranostics/Therapy Planning

4. Inflammation/Infection:

- a. History and assessment
- b. Clinical indications and contraindications
- c. Patient preparation/instructions
 - i. pre-arrival
 - ii. pre-injection
 - iii. post-injection
 - iv. post-procedure – discharge instructions
- d. Uptake time
- e. Patient positioning
- f. Anatomy/physiology/Imaging techniques

5. Acquisition modes

- a. 2D
- b. 3D
- c. Time of Flight
- d. Emission

- e. Transmission
 - i. Measured
 - ii. CT
- f. Single bed position
 - i. Post-injection start time
 - ii. Scan duration
- g. Dynamic imaging
 - i. Framing rates
 - ii. Injection sites/techniques
- h. Whole body imaging
 - i. Post-injection start time
 - ii. Number of bed positions
 - iii. Scan duration/bed
 - iv. Slice overlap

II. Instrumentation/Quality Control (~30%) [60 items]

A. Survey Meter

1. Operating principles
2. Quality control
3. Source selection
4. Interpretation of QC results

B. Dose calibrator

1. Operating principles
2. Quality control (accuracy, linearity, geometry, constancy)
3. Frequency of quality checks
4. Source selection
5. Interpretation of results

C. Well Counter

1. Operating principles
2. Quality control (constancy, energy FWHM, chi-square)
3. Frequency of quality checks
4. Source selection
5. Interpretation of results

D. Scintillation Detector Systems

1. Principles of scintillation detection
2. Detector materials
 - a. BGO
 - b. LSO and LYSO
 - c. GSO
 - d. solid state detectors
3. System types
 - a. Dedicated PET
 - b. Integrated PET/CT
 - i. CT radiographic tube
 - ii. CT Data acquisition
 - iii. CT Collimation
 - iv. kVp and mAs

- v. CT detectors
- 4. Quality control
 - a. Normalization
 - b. Blank scan
 - c. Gains (Singles)
 - d. Calibration factors for quantification
 - e. cross-calibration/well counter calibration
 - f. Acceptance testing
 - g. Scanner failure/recognition of instrumentation artifacts
 - i. Detector failure
 - ii. High voltage drift
 - iii. Energy drift
 - iv. Gain drift
 - v. Power supply drift/failure
 - vi. Temperature drift (cooling system failure)
 - vii. Coincidence timing malfunction
 - viii. Transmission source malfunction
 - ix. Septa mis-positioning/alignment
 - x. Imaging table failure
 - h. CT scanner quality control
 - i. Artifact analysis
 - ii. CT Laser/Alignment light
 - iii. CT Number Accuracy and Noise
 - iv. Tube warm up and air calibration
 - v. Water phantom
- 5. System performance
 - a. Scatter fraction
 - b. Randoms fraction
 - c. Noise equivalent count rate (NEC)
 - d. NEMA standards and testing

E. Theory of Operation

- 1. Principles of Coincidence Detection
 - a. Trues
 - b. Randoms
 - c. Scatter
 - d. Lines of response (LORs)
 - e. Delayed event
 - f. Coincidence timing window
- 2. Image Formation and Reconstruction
 - a. Sinograms
 - i. 2D
 - ii. 3D
 - iii. Fourier rebinning
 - iv. Filtered back projection (FBP)
 - v. Iterative reconstruction
 - a. Ordered subset expectation maximization (OSEM)
 - b. Maximum likelihood expectation maximization (MLEM)
 - b. Image filters/cutoff frequencies
 - c. CT Image formation and data acquisition
 - i. Performing localizer scans
 - ii. Helical CT imaging

- iii. Axial scanning
 - 3. Data processing/corrections
 - a. Normalization
 - b. Decay correction
 - c. Attenuation correction
 - i. Calculated
 - ii. Measured
 - iii. Segmented
 - iv. No attenuation correction
 - d. Random correction
 - e. Scatter correction
 - f. CT image reconstruction and post-processing techniques

F. Data Analysis

- 1. Quantitative analysis
 - a. Region of interest
 - b. Time activity curves
 - c. Standardized Uptake Value (SUV)
 - i. Methods of calculation
 - ii. Sources of error
 - d. Metabolic flow rate measurement and analysis
 - e. R to L count profiles and histogram
 - f. Cardiac polar mapping
 - g. Other
- 2. Image reconstruction variants

G. Basic Principles of Image Fusion/Image Registration

- 1. Manual
- 2. Mechanical
- 3. Automated
 - a. Rigid
 - b. Deformable

H. Image Artifacts

- 1. Pre-procedure
 - a. Medications
 - b. Prosthetics
 - c. Therapeutic effects
 - d. Exercise
- 2. Injection/uptake
 - a. Muscle tension
 - b. Injection sites/tubing
 - c. Radioactive contamination
 - d. Environment (temperature, noise)
- 3. Scanning Procedure
 - a. Patient motion
 - c. Bed position overlap
 - d. Urinary catheter lines
 - e. IV lines
 - g. Filter/cutoff selection
 - h. Partial volume effect
 - i. Attenuation correction

- j. CT
 - i. Contrast
 - ii. Attenuation correction
 - iii. Transmission/emission (misalignment)
 - iv. High Z material
 - v. CT factors impacting image quality

I. Ancillary Equipment

1. Defibrillator/Emergency cart access
2. Dose Delivery systems
3. EEG monitor
4. EKG monitor
5. Gate Box/trigger
6. Glucose meter
7. Intravenous infusion pump
8. O2 saturation monitor
9. Radiopharmaceutical generators
10. CT contrast power injector

III. RADIATION PROTECTION (~10%) [20 items]

A. Personal protection/monitoring

1. Basic concepts (ALARA)
2. Personnel protection
 - a. Time
 - b. Distance
 - c. Shielding
 - i. Patient dose
 - ii. Dose calibrator
 - iii. Scanning room
 - iv. Waiting room
 - v. Control room
 - vi. Patient holding room
 - vii. Waste
3. Personnel monitoring devices (body/extremity)
4. Regulatory requirements including appropriate signage
5. CT Patient Dose reporting
 - a. CTDI
 - b. DLP

B. Area/facilities monitoring

1. Basic concepts
2. Survey equipment
3. Radiation surveys
4. Regulatory requirements

C. Packaging and storage of radioactive materials

1. Inspection of incoming/outgoing materials
2. Storage of radiopharmaceuticals

D. Records

1. Shipping of radioactive materials
2. Receipt of radioactive materials
3. Administration of radioactive materials
4. Storage of radioactive materials
5. Disposal of radioactive materials
6. Radiation surveys

E. Radioactive decontamination

1. Area
2. Personnel

F. Disposal of Radioactive Waste

1. Release to environment
2. Decay to storage
3. Incineration
4. Transfer to authorized recipient

G. Medical Events

1. Definitions
2. Reporting and notification

IV. RADIOPHARMACEUTICALS (~25%) [50 items]

A. Radiopharmaceutical Characteristics

1. Method of localization
2. Radiopharmaceutical kinetics
3. Radiopharmaceutical dosimetry
4. Radiopharmaceutical biodistribution and normal variants

B. Physical properties of radioactive materials

1. Types of emissions
2. Energies
3. Decay rate and half-life

C. Positron radionuclide principles

1. Positron decay
2. Positron energy
3. Annihilation reaction
4. Bremsstrahlung radiation
5. Decay factors
6. Exposure rates
7. Half value layer

D. Radionuclide production

1. Cyclotron
 - a. Principles of operation
 - b. Targetry
2. Generators – Ge-68/Ga-68, Sr-82/Rb-82
 - a. Principles of operation
 - b. Elution

3. Quality control
 - a. Sterility
 - b. pH
 - c. Apyrogenicity
 - d. Identity

E. Synthesis of radiopharmaceuticals

1. Basic chemistry
2. Synthesis modules

F. Quality control of radiopharmaceuticals

1. Purity
2. Stability

G. Regulatory Requirements for Radiopharmaceutical Preparation

1. Immediate use provisions
2. Dose pooling or splitting
3. Aseptic competency
4. Radiopharmaceutical Processing Environment

H. Radiopharmaceuticals

- a. C-11 Acetate
- b. C-11 Choline
- c. Cu-64 dotatate
- d. F-18 fluciclovine
- e. F-18 florbetaben
- f. F-18 florbetapir
- g. F-18 flortaucipir
- h. F-18 fluorodeoxyglucose (FDG)
- i. F-18 fluorodopa (F-Dopa)
- j. F-18 fluoroestradiol
- k. F-18 flutemetamol
- l. F-18 piflufolastat
- m. F-18 sodium fluoride
- n. Ga-68 dotatate
- o. Ga-68 dotatoc
- p. Ga-68 gozetotide (PSMA-11)
- q. N-13 ammonia
- r. Rb-82 chloride