

# 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**

1. Dosage determination
  - a. Calculation of pediatric dose
  - b. Calculation of radiopharmaceutical/pharmaceutical dose
  - c. Volume determination
  - d. Units – calculations and conversion
  - e. Dose determination according to scan mode and equipment type
2. Dose preparation and administration
  - a. Verify correct radiopharmaceutical for exam
  - b. Preparation for administration
  - c. Assay in dose calibrator
  - d. Radiopharmaceutical labeling
  - e. Administration technique
  - f. Residual dose measurement
3. Routes of administration
4. Intravenous injection techniques
5. Factors affecting biodistribution
  - a. Cardiology
    - i. Serum glucose level
    - ii. Serum insulin level
  - b. Neurology
    - i. Stimulation
    - ii. Surgical variants
    - iii. Radiation treatment
    - iv. Serum insulin/glucose levels
    - v. Psychotropic drugs
    - vi. Ictal vs. inter-ictal state
  - c. Oncology
    - i. Serum insulin/glucose levels

- ii. Exercise
- iii. Chemotherapy
- iv. Radiation therapy
- v. Surgery/biopsy
- vi. Hemopoietins
- vii. Muscle tension
- viii. Hydration
- ix. Inflammatory disease
- x. Infectious processes
- xi. SSRI medication

## **B. Administration of interventional pharmaceuticals, pharmaceuticals and contrast media**

1. Basic concepts
  - a. Indications
  - b. Contraindications
  - c. Adverse reactions
  - d. Medication interactions
  - e. Dosing and route of administration
  - f. Pediatric considerations
2. Emergency care
  - a. CPR
  - b. Emergency medications
  - c. Diabetic complications
  - d. Contrast reactions
  - e. hypoglycemia
3. Pharmaceuticals
  - a. Cardiology
    - i. Dobutamine
    - ii. Adenosine
    - iii. Dipyridamole
    - iv. Regadenoson
    - iv. Glucose
    - v. Insulin
    - vi. Hyperinsulinemic-euglycemic clamp
  - b. Neurology
    - i. Sedatives/Anxiolytics
    - ii. Antiseizure
  - c. Oncology
    - i. Diuretics
    - ii. IV/oral hydration
    - iii. Sedatives/ Anxiolytics
    - iv. Insulin
4. Contrast media
  - a. Oral
  - b. Non-ionic
  - c. Ionic

## **C. Gated Procedures**

1. Equipment
2. Lead placement
3. Sources of error
  - a. Patient

- b. Equipment
- c. User

#### **D. Imaging Techniques:**

##### **1. Cardiology:**

- 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. 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. Imaging techniques
  - i. Anatomy/physiology/clinical indications
  - i. Rest/Stress Perfusion
  - ii. Myocardial Viability

##### **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. Imaging techniques
- h. Anatomy/physiology/clinical indications
  - i. Epileptic seizures
  - ii. Dementia
  - iii. Tumor
  - iv. Movement disorders

##### **3. Oncology:**

- 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. Patient positioning
  - i. Arms up/down
  - ii. Head first/feet first
- f. Imaging techniques
- g. Anatomy/physiology/clinical indications
  - i. Colorectal cancer
  - ii. Head/Neck cancer
  - iii. Esophageal cancer
  - iv. Non-Small Cell Lung cancer
  - v. Single Pulmonary Nodule (SPN) evaluation
  - vi. Breast cancer
  - vii. Melanoma
  - viii. Lymphoma
  - ix. Thyroid cancer
  - x. Prostate cancer
  - xi. Other indications

#### 4. 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
  - c. GSO
  - d. NaI
3. System types
  - a. Dedicated PET
    - i. Full ring
    - ii. Partial ring
    - iii. Detector panels
  - b. Integrated PET/CT
4. Quality control
  - a. Normalization
  - b. Blank scan
  - c. Gains (Singles)
  - d. Calibration factors for quantification
  - e. 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
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
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. 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
  - b. Transmission/emission (misalignment)
  - c. Bed position overlap
  - d. Urinary catheter lines
  - e. IV lines
  - f. High Z material
  - g. Filter/cutoff selection
  - h. Partial volume effect
  - i. Attenuation correction
  - j. CT
    - i. Contrast
    - ii. Attenuation correction

### **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

#### **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
- c. Quality control

#### **E. Synthesis of radiopharmaceuticals**

1. Basic chemistry
2. Synthesis modules

#### **F. Quality control of radiopharmaceuticals/radiochemicals/chemicals**

1. Purity
2. Identity



3. Sterility
4. Apyrogenicity
5. pH
6. Stability

### **PROCEDURES LIST**

#### Cardiology

CMS approved indications, including but not limited to:

1. Rest/stress perfusion
2. Viability

#### Neurology

CMS approved indications, including but not limited to:

1. Alzheimer
2. Epileptic seizures
- Other indications
3. Dementia
4. Brain tumor
5. Movement disorder

#### Oncology

CMS approved indications, including but not limited to:

1. Colon cancer
2. Cervical cancer
3. Head/Neck cancer
4. Non-small cell lung cancer
5. Solitary pulmonary nodule (SPN) evaluation
6. Breast cancer
7. Melanoma
8. Lymphoma
9. Thyroid cancer
- Other indications:
10. Ovarian cancer
11. Pancreatic cancer
12. Sarcomas
13. Prostate
14. Neuroendocrine tumor

#### Other

1. F-18 sodium fluoride - skeletal imaging
2. F-18 FDG inflammation/infection imaging

### **DIAGNOSTIC RADIOPHARMACEUTICALS**

1. C-11 acetate
2. C-11 Choline
3. C-11 Palmitate
4. F-18 fluorodeoxyglucose (FDG)
5. F-18 fluorodopa (F-Dopa)
6. F-18 sodium fluoride
7. F-18 fluorothymidine (FLT)
8. F-18 fluoromisonidazole (FMISO)
9. N-13 ammonia
10. O-15 O2

11. O-15 water
12. Rb-82 chloride
13. F-18 sodium fluoride
14. F-18 florbetapir
15. F-18 flurpiridaz
16. F-18 choline
17. Ge-68
18. Ga-68 dotatoc
19. Ga-68 dotanoc
20. Ga-68 dotatate
21. I-124
22. Cu-64
23. C-11 choline
24. F-18 flutemetamol
25. F-18 florbetaben
26. F-18 fluciclovine

### **MISCELLANEOUS PHARMACEUTICALS**

1. Acetylsalicylic acid
2. Anticoagulants
3. Antiarrhythmics
4. Calcium channel blockers
5. ACE inhibitors
6. Cholesterol-lowering drugs
7. Digoxin
8. Nitrates
9. Beta blockers
10. Caffeine
11. Growth stimulation hormone factor
12. Hematopoietins
13. Diabetic medications
14. Steroids
15. Glucose

### **INTERVENTIONAL PHARMACEUTICALS**

1. Adenosine
2. Dipyridamole
3. Diuretics
4. Aminophylline
5. Dobutamine
6. Theophylline
7. Furosemide
8. Insulin
9. Glucose
10. Sedatives/Anxiolytics

### **CONTRAST MEDIA**

1. Oral
2. Non-ionic
3. Ionic

## **EQUIPMENT LIST**

1. Dedicated PET scanner and integrated PET/CT scanner
2. Dose calibrator
3. Well counter
4. Survey meter
5. Glucose meter
6. ECG monitor
7. Gate box/trigger
8. Defibrillator, emergency cart access
9. O2 saturation monitor
10. Intravenous infusion pump
11. EEG monitor
12. Radiopharmaceutical generator
13. Dose delivery system