

Nuclear Medicine Advanced Associate

Examination Content Outline

This content outline guides the Nuclear Medicine Advanced Associate (NMAA) Certification Examination, detailing the knowledge and procedures an NMAA is expected to competently perform under the supervision of a qualified physician.

It reflects current standards of practice and defines the advanced clinical skills and decision-making responsibilities essential to the NMAA role within a physician-led team.

This outline does not imply independent practice or final interpretive authority.

- I. **Patient Care** (Assessment, Management, Reporting, and Education)
 - a. Patient Based Decision Making
 - i. Patient and family education
 - ii. Patient history and physical examination
 1. Comprehensive
 2. Limited
 - iii. Evaluation of Diagnostic and Laboratory Results
 1. Cardiac function and myocardial injury
 2. Hepatic Function
 - a. Ex: CMP
 3. Pulmonary function
 - a. Ex: PFT, O₂
 4. Renal function and electrolytes
 - a. Ex: BMP, GFR
 5. Thyroid function
 6. Parathyroid function
 7. Complete Blood Count (CBC)
 8. Blood glucose
 9. Pregnancy tests (HCG)
 - iv. Identify and implement a plan of care
 1. Order and administer sedation
 - a. Understanding regulations
 2. Alternative options
 - v. Administration into existing catheters or routes
 - a. VP shunts
 - b. Central lines
 - c. Intra thecal
 - d. Intra arterial
 - vi. Establish additional routes of administration
 - a. Urinary catheter
 - b. Feeding tube
 - c. Rectal
 - d. Subcutaneous port
 - e. Intradermal
 - f. ACLS routes of administration
 - g. Port-O-Cath/Medi port access
 - vii. Perform, monitor, and understand vital signs and physiologic parameters
 - a. Ex. Stethoscopy
 - viii. Evaluate the need for and administration of contrast media
 - ix. Evaluate and monitor for adverse reactions by assessing physical signs, symptoms, and adjunct testing (i.e. laboratory results)

- x. Document patient information, procedures, reports, progress, and post-treatment observations accurately in the medical record
 - b. Systems Based Practice
 - i. Medical/Legal/Professional/Government/Regulatory
 - 1. Standards for Informed Consent
 - 2. Elements of written directives
 - 3. HIPAA
 - 4. Medical events and incidents
 - 5. Ethics, professionalism, and leadership
 - 6. Healthcare delivery / reimbursement
 - 7. Appropriate Use Criteria
 - ii. Quality Assurance and Management
 - 1. Patient safety
 - 2. Clinical coordination (i.e. tumor board, chart review, interdisciplinary communication)
 - c. Patient Emergency Management
 - i. Provide supportive medical management
 - 1. Basic and advanced life support
 - 2. Blood glucose management
 - 3. Contrast media reactions
 - 4. Allergic response
 - 5. Adverse response

II. Clinical Procedures

- a. Cross sectional imaging anatomy
- b. Pathophysiology
- c. Patterns of biodistribution for radiopharmaceuticals
- d. Identify, evaluate, interpret, and/or assess for each diagnostic procedure:
 - i. Indications and Contraindications
 - ii. Patient preparation
 - iii. Existing correlative examinations
 - iv. Complications
 - v. Limitations / Adverse reactions
 - vi. Appropriate Radiopharmaceutical
 - vii. Radiopharmaceutical dose optimization
 - 1. Adjustment for patient size and age
 - viii. Route of administration
 - ix. Imaging technique
 - x. Image quality and need for additional imaging
 - xi. Quantitative data analysis
 - xii. Need for pharmacological interventions in nuclear medicine procedures (Appendix B- Adjunctive Drugs)
 - xiii. Need for complementary/correlative lab and/or diagnostic imaging procedures
- e. Analyze Results
 - i. Assess exam quality and other associated data
 - 1. Adequacy
 - 2. Artifact
 - 3. Incidental findings
- f. Therapy / Theranostics
 - i. Identify, evaluate, interpret, consult, and/or assess for each therapeutic procedure
 - 1. Indications and Contraindications
 - 2. Patient preparation informed consent
 - 3. Existing correlative examinations
 - 4. Complications
 - 5. Limitations
 - 6. Appropriate Radiopharmaceutical
 - 7. Radiopharmaceutical dose range

8. Route of administration
 9. Dosimetry and implications of dosimetry
 10. Patient release requirements
 11. Need for complementary/correlative lab and/or diagnostic imaging procedures
- g. Stress Testing (Exercise and Pharmacological)
- i. Indications and Contraindications to stress testing
 - ii. Physiologic measures of stress capacity/performance
 - iii. Treadmill operation
 - iv. Patient assessment and monitoring
 - v. Isometric exercise protocols
 - vi. Pharmacologic stress protocols
 - vii. ECG (i.e. diagnostic and stress interpretation)
 - viii. Acquisition
 - ix. Rate calculation
 - x. Normal and abnormal rhythms
 - xi. Heart blocks
 - xii. Indicators of ischemia and infarction
 - xiii. Identification of significant cardiac events during stress test
 - xiv. Interpretation
 1. Diagnostic
 2. Exercise
 3. Pharmacological
 4. Image interpretation/assessment
 - xv. Interventions
 - xvi. Endpoints

Appendix A Procedures- Diagnostic & Therapy

III. Diagnostic and Therapeutic Pharmaceuticals

- a. Knowledge of drug characteristics:
 - i. Mechanism of action
 - ii. Delivery methods
 - iii. Dose considerations
 - iv. Indications of use
 - v. Contraindications
 - vi. Appropriate management of adverse events and/or side effects
 - vii. Appropriate follow-up and monitoring of pharmacologic effects
 - viii. Drug toxicity
 - ix. Cross reactivity of similar medications
- b. Special considerations for contrast media agents:
 - i. Premedication
 - ii. Hydration status
 - iii. Renal status
 - iv. Diseases of concern
 - v. Incompatible medications
 - vi. Allergies
 - vii. Appropriate management of adverse events and/or side effects
 - viii. Conflicts with other procedures (e.g. another contrast procedure)
- c. Methods to reduce medication errors
- d. Evaluating and reporting adverse drug events
- e. Pharmacology

Appendix B- Adjunctive Drugs

Appendix C- Radiopharmaceuticals

Appendix D- Contrast Agents

IV. Radiation Safety and Radiobiology in Clinical Practice

- a. Radiation Safety
 - i. Understanding of absorbed dose principles
 - 1. Knowledge of critical organ versus total body effective dose equivalent
 - 2. Typical values from routine nuclear medicine procedures
 - 3. Typical values from CT
 - a. Diagnostic versus attenuation correction
 - b. Pediatric versus adult
 - c. Dose units
 - d. Quality metrics
 - ii. Methods to reduce patient exposure
 - iii. Methods to reduce occupational exposure
- b. Radiobiology
 - i. Cell Growth and Division
 - ii. Radiosensitivity of cells
 - iii. Effects of radiation
 - 1. Deterministic effects versus stochastic effects
 - 2. Background radiation
 - 3. Dose-response relationships
 - 4. Skin effects
 - 5. Acute radiation syndrome
 - 6. Local tissue damage
 - 7. Hematological effects
 - 8. Carcinogenesis
 - 9. Fetal effects
 - 10. Genetic effects
 - 11. Fertility effects
 - iv. Dosimetry calculations
 - 1. Fetal calculations
 - 2. Organ calculations
 - 3. Occupational calculations
 - a. Dosimeter badge types (assigned badge position, electronic dosimeters, EDE1, EDE2, Webster, etc.)
 - b. SDE, DDE, LDE, TEDE, Extremities

APPENDIX A - PROCEDURES LIST

Pulmonary	Hematopoietic	Central Nervous System
Radioaerosol ventilation	Bone marrow imaging	Brain perfusion SPECT
Xenon ventilation	Red cell sequestration	Brain death imaging
Perfusion	Red cell survival	Cisternography
Perfusion/Ventilation quantitation	Spleen imaging	- CSF leak
	with labeled, denatured RBCs	- CSF shunt patency
Bone/Musculoskeletal		Brain PET
Tc99m Bone imaging		DaTscan (Parkinson's)
F18 Sodium fluoride bone imaging	Cardiovascular	Radionuclide Therapy
	Myocardial perfusion imaging	Thyroid carcinoma
Oncology	Myocardial sarcoidosis	Hyperthyroidism
Ga67 tumor imaging	Cardiac Amyloid Imaging	Metastatic bone pain
Monoclonal antibody imaging	First pass for EF and wall motion	Radium 223- Chloride
Neuroendocrine tumor imaging	Gated cardiac blood pool, rest and stress	Lutetium 177 Neuroendocrine Tx
Breast imaging	Cardiac shunt	Cu 64/Cu 67
Lymphoscintigraphy/ sentinel lymph node localization	Cardiac PET	Y90-DOTATOC (Peptide Receptor Radionuclide Therapy)
Tumor imaging	Myocardial viability	
Prostate imaging	Calcium Scoring	
	Cardiac MIBG for HF	
Renal/Genitourinary	Gastrointestinal	Infection
Cystogram, direct	Esophageal motility/transit	F-18 FDG infection imaging
Effective renal plasma flow (ERPF)	Lower Gastrointestinal motility/transit	Gallium 67 infection imaging
Glomerular filtration rate (GFR)	Gastric emptying (liquid/solid)	White Blood Cell (Tc99m and In111)
Renal cortical imaging	Gastroesophageal reflux	
Dynamic renal imaging	Gastrointestinal bleeding	
Captopril challenge	Hemangioma	
Furosemide challenge	Hepatobiliary with or without Ejection Fraction	
	Gall bladder ejection fraction	
ENDOCRINE	Peritoneal shunt patency	
Adrenal imaging	Liver-spleen imaging	
MIBG	Meckel's diverticulum	
Parathyroid imaging	Salivary (parotid) imaging	
Thyroid imaging	H. Pylori breath test	
Thyroid uptake		
Whole body imaging for thyroid cancer metastases		

APPENDIX B- Drug Classifications

I. Autonomic nervous system drugs

Cholinergic (parasympathetic) drugs

Ex. acetylcholine, bethanecol, neostigmine, guanidine

Cholinergic blocking drugs

Ex. Atropine, scopolamine

Adrenergic drugs (catecholamines, noncatecholamines)

Catecholamines

Ex. dobutamine, dopamine,

Noncatecholamines

Ex. albuterol, terbutaline

Adrenergic blocking drugs

Alpha-adrenergic blockers

Ex., doxazosin, tamsulosin

Beta-adrenergic blockers

Ex. propranolol, labetalol

II. Neurologic and Neuromuscular drugs

Skeletal Muscle relaxants

Ex. Baclofen, diazepam, Dantrolene

Neuromuscular blocking drugs

Ex. Pancuronium, tubocurarine, succinylcholine

Antiparkinsonian drugs

Ex. Benztropine, diphenhydramine, levodopa, carbidopa-levodopa

Anticonvulsant drugs

Ex. Phenytoin, Phenobarbital, Carbamazepine, Clonazepam, Valproic acid

Antimigraine drugs

Ex. Sumatriptan, rizatriptan, ergotamine

III. Pain medications

Nonopioid analgesics, antipyretics, and NSAIDS

Ex. Aspirin, acetaminophen, ibuprofen, naproxen

Opioid agonist and antagonist drugs

Ex. Codeine, morphine, meperidine, buprenorphine, naloxone

Anesthetic drugs

Ex. Halothane, nitrous oxide, barbiturates, propofol, fentanyl, lidocaine

IV. Cardiovascular drugs

Inotropics
Ex. Digoxin

Antiarrhythmic drugs (beta-blockers, calcium channel blockers, sodium channel blockers)
Ex. Disopyramide, quinidine, lidocaine, flecainide, propranolol, amiodarone, sotalol, verapamil

Antianginal drugs (Nitrates, beta-blockers, calcium channel blockers)
Ex. Nitroglycerine, atenolol, metoprolol. Propranolol, diltiazem, nifedipine

Antihypertensive drugs (beta-blockers, calcium channel blockers, diuretics, ACE inhibitors)
Ex. Clonidine, hydralazine, monoxidil, captopril, lisinopril, valsartan

Reductase inhibitors
Ex. statins (anti-cholesterol)

Phosphodiesterase Inhibitors
Ex. Viagra, Cialis

V. Hematologic drugs

Hematinic
Ex. Iron, cyanocobalamin, folic acid

Anticoagulant
Ex. Heparin, warfarin, aspirin, dipyridamole, Eliquis (apixaban)

Thrombolytic drugs
Ex. Streptokinase, Urokinase

VI. Respiratory drugs

Beta2-adrenergic agonists
Ex. Albuterol, terbutaline

Anticholinergics
Ex. Ipratropium bromide

Corticosteroids
Ex. Beclomethasone Budesonide

Leukotriene modifiers
Ex. Montelukast

Mast Cell Stabilizers
Ex. Cromolyn sodium

Methylxanthines
Ex. Aminophylline

Expectorants
Ex. Gualifenesin

Antitussives
Ex. Codeine, dextromethorphan

Mucolytics

Ex. Acetylcysteine

Decongestants

Ex. Ephedrine, Phenylephrine

VI. Gastrointestinal drugs

Antiulcer Drugs

Ex. antacids, H₂-receptor antagonists, proton pump inhibitors
Calcium-magnesium, cimetidine, ~~ranitidine~~, omeprazole

Antidiarrheal and laxative drugs

Ex. Diphenoxylate with atropine, loperamide, kaolin,
psyllium, docusate, bisacodyl, mineral oil

Antiemetic and emetic drugs

Ex. Chlorpromazine, ondansetron, ipecac syrup

Pancreatic enzyme replacement therapy

Ex. ~~Creon~~ pancrelipase

Synthetic Peptides

Ex: Sicalide

VII. Anti-infective drugs

Antibacterial drugs

Ex. Penicillins, Aminoglycosides, Cephalosporins, Tetracyclines

Antiviral drugs

Ex. Protease inhibitors, Reverse transcriptase inhibitors

Antitubercular drugs

Ex. Isoniazid, Rifampin

Antifungal drugs

Ex. Fluconazole, terbinafine, amphotericin B

Antiparasitic drugs

Ex. Chloroquine, Ivermectin

VIII. Anti-inflammatory, anti-allergy, and immunosuppressant drugs

Antihistamines

Ex. Diphenhydramine, hydroxyzine

Corticosteroids

Ex. Cortisone, Dexamethasone

Other immunosuppressants

Ex. Cyclosporine

Uricosurics and other gout drugs

Ex. Probenecid, sulfinpyrazone, allopurinol

IX. Psychotropic drugs

Sedative and hypnotic drugs (Benzodiazepines, Barbiturates)

Ex. zolpidem, phenobarbital

Antianxiety drugs

Ex. Buspirone

Antidepressant and mood stabilizer drugs

Ex. Selective serotonin reuptake inhibitors – fluoxetine, sertraline

Tricyclic antidepressants – amitriptyline, nortriptyline

Monoamine oxidase inhibitors – phenelzine, tranylcypromine

Miscellaneous – Lithium, trazodone

Antipsychotic drugs

Ex. Clozapine, olanzapine, risperidone

Stimulants

Ex. Dextroamphetamine, methylphenidate

X. Endocrine drugs

Antidiabetic drugs

Ex. Insulin, tolbutamide, glyburide, metformin

Estrogen

Ex. Estradiol

Testosterone

Ex. TRT

Pituitary drugs

Ex. Corticotropin, thyrotropin

Thyroid and Antithyroid drugs

Ex. Triiodothyronine, thyroxine, levothyroxine, propylthiouracil, methimazole

GLP-1 type drugs

Ex. Semaglutide, dulaglutide

XI. Drugs for fluid / electrolyte balance / renal protection

Amino acids

Ex. Arginine, Lysine

Electrolyte replacement drugs

Ex. Sodium, potassium, magnesium

Alkalinizing and acidifying drugs

Ex. Sodium bicarbonate, ammonium chloride

Long and short acting somatostatin compounds

Ex. Octreotide acetate, Octreotide LAR, Lanreotide

Diuretics

Ex: Furosemide, Hydrochlorothiazide

XII. Antineoplastic drugs

Alkylating drugs

Ex. Cyclophosphamide, carmustine, cisplatin

Antimetabolite drugs

Ex. Methotrexate, fluorouracil, fludarabine

Antibiotic antineoplastic drugs

Ex. Bleomycin, mitomycin

Anthracycline drugs

Ex. daunorubicin, doxorubicin, epirubicin

Hormonal antineoplastic drugs and hormone modulators

Ex. Tamoxifen, testosterone, flutamide, medroxyprogesterone

Monoclonal antibodies

Ex. rituximab, trastuzumab

Microtubule-stabilizing agents

Ex. epothilones, laulimalide, dictyostatin

Mitotic Inhibitors -Taxanes

Ex: Paclitaxel, Docetaxel

Targeted therapies

Ex. palbociclib, trastuzumab, imatinib, pembrolizumab, intravenous immunoglobulin

Unclassified antineoplastic

Ex. Interferons such as ropeginterferon, interferon alfa-2b

APPENDIX C- Isotopes /Radiopharmaceuticals

Please note: Only generic and/or commonly known drug names are used on the NMAA examination.

Isotopes

Tc-99m

I-123

I-124

I-131

C-11

C-14

Cu-64

Cu-67

F-18

Ge-68

Ga-68

N-13

Rb-82

Tl-201
Xe-133
Y-90
Lu-177
Ra-223
Sr-89
N-13
O-15
Pb-212
Pb-203
Ac-225

Tc99m Labeled Radiopharmaceuticals

Mo-99m/Tc99m Generators
Tc-99m sodium pertechnetate
Tc-99m oxidronate/HDP
Tc-99m medronate/MDP
Tc-99m pentetate/DTPA
Tc-99m macroaggregated albumin/MAA
Tc-99m sulfur colloid (filtered)
Tc-99m disofenin/mebrofenin
Tc-99m mertiatide/MAG3
Tc-99m pyrophosphate/PYP
Tc-99m sestamibi/MIBI
Tc-99m tetrofosmin
Tc-99m succimer/DMSA
Tc-99m exametazime/HMPAO
Tc-99m bicisate/ECD
Tc-99m labeled RBCs (in vivo, in vitro)
Tc-99m denatured radiolabeled RBCs
Tc-99m HMPAO tagged WBCs
Tc-99m tilmanocept
Tc-99m labeled carbon inhalation aerosol/Technegas

Iodine Labeled Radiopharmaceuticals

I-123 sodium iodide
I-123 MIBG
I-131 sodium iodide
I-123 ioflupane

Indium Labeled Radiopharmaceuticals

In-111 pentetate (DTPA)
In-111 oxine labeled WBCs
In-111 pentetreotide
In-111 Oxine— Labeled Platelets

PET Diagnostic Radiopharmaceuticals

C-11 choline
C-11 palmitate
Cu-64 dotatate
F-18 fluorodeoxyglucose (FDG)
F-18 fluorodopa (F-Dopa)
F-18 sodium fluoride
F-18 fluorothymidine (FLT)

F-18 fluoromisonidazole (FMISO)
F-18 fluciclovine
F-18 florbetapir
F-18 flortaucipir
F-18 fluoroestradiol
F-18 flurpiridaz
F-18 florbetaben
F-18 fluorocholine
F-18 flutemetamol
F-18 piflufolastat (DCFPyL)
F-18 flutufolastat (rhPSMA-7.3)
Ga-68 dotatoc
Ga-68 dotanoc
Ga-68 dotatate
Ga-68 gozetotide (PSMA-11)
I-124 Evuzamitde
N-13 ammonia
Rb-82 chloride
O-15 water

Miscellaneous Diagnostic Radiopharmaceuticals

C-14 urea
Ga-67 gallium citrate
Tl-201 thallous chloride
Xe-133 gas

Therapeutic Radiopharmaceuticals

Copper-67 for Targeted Radiotherapy
I-131 sodium iodide
Lutetium Lu-177 dotatate
Lutetium Lu-177 vipivotide tetraxetan (PSMA-617)
Ra-223 dichloride
Sr-89 chloride
Y-90 microsphere

APPENDIX D - CONTRAST AGENTS

Contrast Agents include general reference to contrast media commonly used in routine computed tomography (CT) imaging.

Reference to specific contrast agents does not currently appear on the NMAA exam.