

Radiology Resident Core Curriculum for Nuclear Medicine

Overview: The Nuclear Radiology Core Curriculum combined with the Cardiac Nuclear Medicine Core Curriculum is designed to provide the radiology resident with a foundation for developing the necessary skills to become competent in clinical nuclear medicine. The structured training provides the base for preparation for certification in Diagnostic Radiology by the American Board of Radiology and for the clinical practice of nuclear medicine, including eligibility for Authorized User status by the Nuclear Regulatory Commission or State (if the resident later practices in an agreement state).

General Goals: The goals include objectives required for every level of training with graduated levels of supervision and responsibility. All aspects of nuclear medicine imaging are incorporated into the residency, including cardiac nuclear medicine. During every rotation, the resident will read the required literature and study the teaching file in nuclear medicine. Over time, the resident will become progressively more knowledgeable about normal scintigraphic anatomy and physiology and about the scintigraphic appearance of disease processes. Residents will gain competence in interpreting dynamic and static nuclear imaging (planar, SPECT, and PET-CT) of physiologic and pathophysiologic processes, the utilization and handling of radiopharmaceuticals, and quality control of nuclear imaging instruments and radiopharmaceuticals. In addition, the resident will increasingly understand disease entities, their clinical presentations, and current modes of treatment. The resident will know how to supervise and perform radionuclide image-guided procedures at the completion of the final rotation. The resident will know how to function as an NRC Authorized User of radioisotopes for diagnostic use and for therapies involving <33 mCi and >33 mCi I-131 at the completion of the final rotation. The structured training provides the base for Board preparation and clinical practice of nuclear medicine.

NUCLEAR MEDICINE: Summary of Expectations

Welcome to Nuclear Medicine. Our primary goal is to provide excellent clinical service to our patients and our referring clinicians, and our secondary goal is to provide a good learning environment. A complementary goal is to provide the opportunity to participate in investigative endeavors for those who are inclined. You are integral to the success of both primary goals. Below please find a brief summary of our expectations for you while on Nuclear Medicine.

Please remember you will have a total of 4 4-week rotations in Nuclear Medicine during your residency, 3 before your CORE exam, so it will be important for you to be an aggressive learner throughout your rotations and at other learning opportunities.

When there are two or more residents, one resident will assume the responsibilities of the junior resident and the other the responsibilities of the senior resident, based on seniority. When there is only one resident, you will assume the responsibilities of both the junior and senior residents.

It is not possible to see all of the types of scans and procedures on service in four short months so we stress that self-directed learning is essential to your ultimate success. A suggested course of study is provided at the end of this document, as **NUCLEAR MEDICINE TOPICS FOR FOCUSED LEARNING BY ROTATION**. It may be appropriate for you to advance to topics listed under advanced rotations while on an earlier rotation, but that does not eliminate the need to master all the items listed for earlier rotations.

The outline below is a general schema, and it does not preclude your participating in cases or learning about topics listed for a future rotation. However, be sure in your self-study that you cover the early material before jumping to the next rotation's assignment. This will ensure you have covered everything and avoided gaps in knowledge when test time comes around.

Availability

Your presence in the RR also means you should be available for prompt reading and notification of ED studies and other "early read" studies. You should provide consultation with clinicians who frequently call or come to the reading room to review NM (and non-NM) imaging studies. This experience will prepare for your later radiology career when you will perform these consultative functions without supervision.

The nominal duty hours of the rotation are 8am to 5pm M-F. On occasion there may be a need to stay beyond 5 pm, in which case the "late person" can be decided among those on service. During these hours (except when attending or presenting conferences), you are expected to be in the Nuclear Medicine Reading Room.

Contrast Reactions and Codes

Although contrast is not used in NM, it is used at the CT scanner in the rear hall of ECCC, and that Staff (RN and CT tech) will contact NM for any related problems. During the hours of 8-5, one or more residents are assigned by the Chief resident this responsibility (see Qgenda).

Claiming and Dictating Studies

Perhaps more than other imaging services, we expect you to be familiar with the patient's prior NM and non-NM studies and electronic medical record. You should have an understanding of how the study you are reading relates to that patient's clinical care. If you are reading a study on a patient who has a disorder with which you are not familiar or is having a scan with which you are not familiar, take the time to look it up. (Your learning experience related to the case will be better for it.)

In order to facilitate the clinical workflow, at the BEGINNING of every workday all residents on service should parcel out the scheduled patients. Each patient should have a resident' name attached in the tech worklist in advance of the patient scan being completed. The time before the scan is completed is the time for the assigned resident to review the clinical and imaging data so the resident is prepared to evaluate the nuclear images when they are submitted by the NM tech for review for approval to discharge the patient. If questions arise before or during the scan, the tech will come to the assigned resident for direction.

Please see instruction on the set up of the tech worklist in order to "claim" patients.

In preparation for review with the attending, evaluate the images for adequacy, findings, diagnosis. You are encouraged to commit your interpretation to a dictated preliminary report, which can be reviewed along with the images during read-out with the attending. Arriving at your own interpretation BEFORE review with the attending will enhance your learning experience.

Your dictations are legal documents and reflect your knowledge and responsibility. Take notes during attending read-out if you need. Carestream dictation only catches spelling errors, NOT content errors. **Please carefully proofread your dictations.** Remember that patients often READ their reports.

Tending the Protocol Worklist

Protocoling all studies on the EPIC Protocol Worklist in advance on the appointment is part of the clinical work. This function ensures that the right test is done, at the scheduled time, with opportunity to obtain pre-authorization. Once the test is scheduled, it appears on the worklist and should be protocolled then,

regardless of the date of the study. In Nuclear Medicine, The process of MD protocoling is more critical than other modalities, because all radiotracers have to be ordered specific to the patient and in advance of the appointment.

The assignment to clear the protocol worklist will be a rotating responsibility on a weekly basis, starting with the most experienced resident who can “show” junior residents the process.

Radionuclide Therapy Experience

Patient scheduled for consideration of radionuclide therapy are scheduled for consultation (E/M office visit) and for other diagnostic studies as warranted based on the clinical scenario. Scheduled patients are listed on the white board, and on the **ECCC RAD NUC MED CL** schedule in EPIC. You are required to get therapy experience during your residency, which is documented to the ABR. Claim the patient by putting your initials on the white board. On the days that the patient has appointment, be aware and review the clinical and imaging data as it accumulates, see the patient in consultation with the attending, and issue a complete (progress) note in EPIC (use the template as appropriate to the patient). [The progress note must be entered under the correct account; the resident must be in the correct EPIC “*context*” to have access to the templates for the consults, and for the report of the office visit to be processed through the system appropriately. The correct EPIC “*context*” is **ECCC RAD NUC MED CL**. The report for the procedure (radionuclide therapy) should be completed by the same resident. You must complete the entire process of seeing the patient, deciding whether to treat and with how much, and reporting the therapy procedure to get “credit” for treating the patient.

Note- you have access to all functions if your EPIC *context* is **ECCC RAD NUC MED CL** throughout your time in NM. I suggest you make it your default while on NM rotation.

Cardiac Experience

While on NM you have the opportunity to participate in reading and reporting nuclear cardiac studies, including MUGAs, SPECTs and PETs. An NM attending is assigned to report/sign out these on Mon and Thurs, so those days resident involvement is convenient as all reading. A resident should “volunteer” to cover hearts on those days. The resident should learn the process of completing the report template in EPIC/CUPID, which automatically generates the report. Once knowing how to report in CUPID is known, the resident can enter a preliminary report prior to final review with the attending. On other days, depending on resident interest and resident availability, a resident could elect to read out cases with Cardiology attendings.

Continuity of Care

If you know about a case that will:

-run into after-hours, notify the covering resident.

-run until the next day, it is YOUR case until you pass it on. If you will be absent, pass the word on to a co-resident.

Tumor Boards

A number of case conferences and tumor boards occur during the week. They are listed on Qgenda. You are encouraged to attend for your own. Depending on resident number and training level, a resident may be assigned to a tumor board.

Read

Pick a recognized Nuclear Medicine text book, and read it cover to cover. Maybe read it more than once...

Our expectation is that your performance and your responsibilities will increase as you advance through rotations 1 through 4.

Key Responsibilities during NM Rotation

Be present 8-5 for clinical work and contrast reactions.

Throughout the rotation, make your EPIC context: **ECCC RAD NUC MED CL**

Claim studies on the tech worklist first thing each morning. (There should be equitable distribution, with some basis in prior training/experience.)

Prepare report for your studies and be ready to discuss.

If you start a case and cannot finish it (assigned other duties, personal issue, etc), hand off the case to a colleague and provide appropriate transfer information.

Protocol all studies on the NM protocol worklist first thing in the morning and at the end of the day. The goal is for the NM protocol worklist to be **EMPTY**.

Significant results should be called to the ordering LIP.

NUCLEAR MEDICINE CORE CURRICULUM

TOPICS FOR FOCUSED LEARNING BY ROTATION

SUBJECT	ROTATION			
	1	2	3	4
Bone Imaging				
Bone Scan	✓	+	++	+++
Marrow Scan	✓	+	++	+++
Brain and CSF Imaging				
Brain Scan	✓	+	++	+++
Brain SPECT		✓	+	++
PET brain imaging		✓	+	++
CSF imaging		✓	+	++
Cardiac				
Exercise and pharmacologic stress			✓	+
Myocardial perfusion SPECT			✓	+
Gated blood pool (MCCC-A)			✓	+
Cardiovascular studies				
Cardiac disease. Decisions on testing and utility based on pretest probability of disease			✓	+
Physical and pharmacologic stress testing, including risks			✓	+
Gated blood pool study			✓	+

Myocardial perfusion scan			✓	+
PET myocardial imaging			✓	+
Gastrointestinal imaging and absorption testing				
Meckel's or gastric mucosal imaging	✓	+	++	+++
GI bleeding scan	✓	+	++	+++
Gastric emptying study	✓	+	++	+++
Genitourinary Imaging				
Renal scan: flow and function	✓	+	++	+++
Diuretic and captopril renal scan	✓	+	++	+++
Transplant scan	✓	+	++	+++
Cortical renal scan	✓	+	++	+++
Radionuclide cystogram	✓	+	++	+++
Infection Imaging				
WBC's imaging	✓	+	++	+++
Gallium	✓	+	++	+++
Instrumentation				
Gamma camera	✓	+	++	+++
PET camera		✓	+	++
PET/CT camera		✓	+	++
Probe		✓	+	++
Radiation monitoring devices		✓	+	++
SPECT camera		✓	+	++
Liver, Hepatobiliary and Spleen Studies				

Hemangioma scan	✓	+	++	+++
Hepatobiliary imaging	✓	+	++	+++
Sulfur colloid scan	✓	+	++	+++
Lung Perfusion and Ventilation Imaging				
V/Q Scan	✓	+	++	+++
Quantitative Lung Perfusion	✓	+	++	+++
Lymph				
Lymphoscintigraphy – Breast	✓	+	++	+++
Lymphoscintigraphy – Melanoma	✓	+	++	+++
Lymphedema	✓	+	++	+++
PET				
FDG – Cancer		✓	+	++
FDG – Cardiac Viability			✓	+
FDG – Dementia		✓	+	++
FDG – Epilepsy		✓	+	++
F18 – Bone			✓	+
N-13 Myocardial perfusion			✓	+
Procedural Skills				
Obtaining consent for RN therapy		✓	+	++
Performing lymphoscintigraphy	✓	+	++	+++
Performing RN skin marking	✓	+	++	+++
Performing CSF studies		+	++	+++
Radionuclide cystogram	✓	+	++	+++

Radiopharmacy				
Methods of labeling RBC's			✓	+
Methods of labeling WBC's			✓	+
Radiopharmaceutical quality control			✓	+
Therapy – Dosimetry and Radiobiology				
Therapy of hyperthyroidism		✓	+	++
Therapy of thyroid cancer		✓	+	++
Radiation Safety		✓	+	++
Nuclear Medicine Regulations	✓	+	++	+++
Thyroid Studies	1	2	3	4
Thyroid diseases	✓	+	++	+++
Thyroid uptake measurements	✓	+	++	+++
Thyroid Scan	✓	+	++	+++
Parathyroid Scan	✓	+	++	+++
Tumor Imaging	1	2	3	4
Octreoscan		✓	+	++
MIBG		✓	+	++
I-131 Thyroid cA		✓	+	++

Key

- ✓ Reach basic competency
- Reach advanced competency

Resident Daily Work Responsibilities (OVERALL BENCHMARKS/OBJECTIVES for Self-Evaluation)

1. Residents assigned to nuclear medicine will be available for consultations by technologists, clinicians, and other health care providers, except during conference times, when the attending faculty will cover.
2. Resident questions will be referred to the supervising faculty covering nuclear medicine.
3. Resident review of cases with the supervising faculty will be conducted as many times in the day as necessary to keep an efficient workflow.
4. All resident examinations will be dictated by the end of every working day.
5. Residents will check and sign reports prior to final verification by supervising faculty.
6. Residents must be familiar with the operation of all nuclear medicine equipment.
7. Residents must acquire knowledge of radiation protection and ways to reduce radiation exposure to both patients and hospital personnel. The resident will be supervised to assure that safe practices are followed.
8. Residents will learn the techniques for performing high quality, state-of-the art diagnostic examinations throughout the body.
9. Residents must become proficient at detecting abnormalities and be able to generate meaningful differential diagnosis.
10. Residents will become knowledgeable about the use of different radiopharmaceutical agents (including their indications, contraindications, dosages, and side effects/complications).
11. Residents will acquire an understanding of the proper preparation of patients for examinations and appropriate follow-up if needed.
12. Residents will be familiar with the patient schedule at the start of every working day and anticipate need for and timing of any procedures.
13. Residents will check orders for the next working day to evaluate for appropriateness of the requested procedure or if additional exams/protocols need to be performed. Absent clinical indication or seemingly inappropriate requests will be clarified and discussed with the referring physician.
14. Residents will perform a quality check on commonly performed nuclear medicine exams as required per protocol, before the technologist allows the patient to leave, to ensure that the exam is complete, and request additional views or repeat imaging when necessary.
15. Residents will do in-depth reading and study, along with a review of teaching file cases, to become knowledgeable about the utilization and utility of nuclear medicine procedures and gain a general understanding of the disease entities, their clinical presentations, and management.
16. Resident will serve as a secondary consultant to referring physicians regarding nuclear medicine. This will strengthen the confidence of the resident in the very important role every radiologist must perform throughout his/her career as a consultant to clinicians.
17. Residents will become prepared to pass the core examination of the American Board of Radiology.
18. Residents will teach and share knowledge to medical students, radiologic and nuclear technologist students, and junior residents.
19. Residents will participate in the preparation and presentation of imaging studies at the monthly Interesting Case Conference and as teaching files.

Supervising Faculty Responsibilities:

1. Supervising faculty will be available at all times for any questions or consultations needed by the resident.
2. Supervising faculty will review all cases with the residents before the end of the day.
3. Supervising faculty will provide the resident with constructive feedback in any problem areas encountered during the rotation.
4. Supervising faculty will verify resident-generated reports in a timely manner and inform the resident of any major changes made.

Educational Goals and Objectives (R1 Rotation):

Patient Care:

PC1:Reporting; **PC2:**Clinical Consulting; **PC3:**Image Interpretation; **PC4:**Competence in procedures

- Demonstrate knowledge of the ACR practice guidelines and technical standards for nuclear medicine
- Understand the indications for and contraindications to use of the commonly used diagnostic and therapeutic radiopharmaceuticals, and be able to monitor administration
- Recognize and treat reactions to commonly used radiopharmaceuticals or scan-associated medications (ex. Lasix, Sincalide), and be able to monitor administration of ancillary drugs
- Develop a knowledge of the preparation and aftercare required for the common examinations, including instructions to the patient
- Know how to perform a quality check on commonly performed nuclear medicine exams, as required before the technologist allows the patient to leave to ensure that the exam is complete, and request additional views or repeat imaging when necessary
- Describe basic radiopharmaceutical preparation
- Know how to participate in outpatient and inpatient radionuclide therapies, be able to obtain history and physicals, informed consent, supervise therapy, and perform rounds with inpatients until discharge
- Understand the risk factors for allergic reaction to drugs and radiopharmaceuticals used in nuclear medicine

Medical Knowledge

MK1:Diagnostic Knowledge; **MK2:**Physics; **MK3:**Protocol selection and contrast agent selecting/dosing; **MK3:**Imaging technology and Image acquisition

- Comprehend basic concepts of nuclear tracers, nuclear imaging, and equipment
- Describe basic nuclear medicine physics and instrumentation
- Understand basic principles and rationale for using different radiopharmaceuticals
- Know the energies and half-lives of commonly used radioisotopes, biological half-life of commonly used radioisotopes
- Know how to supervise the acquisition and processing, and know how to interpret commonly performed nuclear medicine exams: bone (whole body, three phase, SPECT), lung (VQ, quantitative perfusion), thyroid scan and uptake, renal (MAG3, DMSA), GI bleeding, meckels,

- gastric emptying studies and brain death
- Describe the normal biodistribution of radiopharmaceutical for commonly performed nuclear medicine exams, itemized above
- Explain the impact of the nuclear examinations or findings on patient care, including what imaging studies may/may not be appropriate
- Protocol procedures, in consultation with the attending, to assure that the requested procedure is appropriate
- Demonstrate the ability to recommend additional nuclear or non-nuclear imaging studies as appropriate to patient management based on imaging and clinical information available
- Use a systematic approach to identify abnormalities on frequently performed nuclear medicine exams, itemized above, and generate a basic differential diagnosis
- Develop a knowledge of normal and abnormal anatomy as demonstrated on commonly performed nuclear medicine studies, itemized above
- Demonstrate the ability to recognize and describe abnormalities depicted on commonly performed nuclear medicine imaging studies, itemized above
- Discuss common types of pathology (and/or indications) for commonly performed nuclear medicine exams, itemized above
- Develop a knowledge of the differential diagnoses for the common abnormalities demonstrated on commonly performed exams, itemized above

Systems-based Practice

SBP1: Patient Safety; **SBP2:** Quality Improvement; **SBP3:** System navigation for patient-centered care; **SBP4:** Physician role in health care systems; **SBP5:** Contrast agent safety; **SBP6:** Radiation Safety; **SBP7:** Magnetic resonance (MR) safety; **SBP8:** Informatics

- Review equipment and quality assurance with assigned technologist once a week or as required
- Understand the mechanisms by which the Nuclear Medicine section maintains internal records in order to comply with NRC/state regulations
- Demonstrate knowledge of ACR appropriateness criteria and cost effective imaging evaluation of common disorders
- Show ability to interact with clinicians regarding cost effective and streamlined evaluation for differing clinical entities appropriate to the level of training

Practice-based Learning and Improvement

PBLI1: Evidence-based and informed practice; **PBLI2:** Reflective practice and commitment to professional growth

- Understand the basic principles of radiation protection in order to reduce as much as possible the radiation dose to the patient and reduce exposure to healthcare providers

- Understand the risk factors for allergic reaction to drugs used in nuclear medicine, and know appropriate actions to prevent or mitigate side-effects and/or reactions
- Show evidence of independent study using textbooks and material from reading list
- Demonstrate appropriate follow up of interesting cases
- Research interesting cases as directed by faculty
- Identify, rectify, and learn from personal errors
- Incorporate feedback into improved performance
- Efficiently use electronic and print sources to access information
- Participate in clinical conferences in which imaging studies are used to guide patient care/evaluations and be able to demonstrate understanding of how imaging relates to the clinical care of the patient
- Recognize limitations in knowledge and skills for making competent decisions

Professionalism

P1: Professional behavior and ethical principles; **P2:** Accountability/Conscientiousness; **P3:** Self-awareness and help seeking

- Demonstrate respect for patients, families, and all members of the healthcare team
- Respect patient confidentiality at all times; understand HIPAA requirements
- Present oneself as a professional in appearance and communication
- Demonstrate a responsible work ethic with regard to work assignments
- Promptness and availability at work are required of every resident

Interpersonal and Communication skills

ICS1: Patient and family-centered communication; **ICS2:** Interpersonal and team communication, **ICS3:** Communication within health care systems

- Adequately explain each examination to the patient in order to ensure that the patient feels comfortable and provide patient care that is compassionate, appropriate, and effective
- Communicate with the patient at all times (ex. during the examination, during consultation, post-procedure) to ensure that patient remains comfortable
- Communicate effectively with all members of the health care team (technologists, medical students, fellows, residents, allied health providers, support staff, and attending physicians/radiologists, inside and outside referring clinicians)
- Recognize the need to report significant findings to the referring physician (according to hospital/Radiology guidelines), fulfill and document your actions, and show ability to interact with referring physicians
- Interact with clinicians when reviewing cases and show ability to provide preliminary readings, follow up with attending radiologists, formulate a plan of complex cases, and

- communicate any changes to referring clinicians
- Participate in case check-outs and dictate most cases
- Use the PACS, voice recognition systems, and hospital information systems to become proficient in dictating reports of significant findings in a concise and clear manner

Monitoring and Assessment of Resident Performance

The resident's progress will be monitored by the faculty on the service. At the end of each rotation, the resident will receive a consensus evaluation of performance from faculty on service. Deficiencies or substandard performance will be discussed personally and privately with the resident and will be brought to the attention of the Residency Program Director by the attending radiologist. Resident performance is also evaluated through direct observation, case logs, multi-source professional evaluations, structured case discussion, review of patient outcomes, and other performance evaluation methods as determined by the program.

Educational Goals and Objectives (R2):

The objectives above as well as the following:

Patient Care:

PC1:Reporting; **PC2:**Clinical Consulting; **PC3:**Image Interpretation; **PC4:**Competence in procedures

- Act as a consultant to the clinical services
- Demonstrate knowledge of ACR practice guidelines and technical standards for nuclear medicine
- Develop a knowledge of the preparation and aftercare required for more complex procedures
- Continue to improve skills for supervising and performing nuclear medicine examinations, and tailor examinations to answer all questions being asked by the clinician; anticipate other pertinent clinical questions
- Participate in outpatient and inpatient radionuclide therapies; obtain history and physicals, informed consent, assisting/supervising therapy, and perform rounds with inpatients until discharge
- Perform a quality check on commonly performed nuclear medicine exams as required, before the technologist allows the patient to leave, to ensure that the exam is complete, and request additional views or repeat imaging when necessary
- Know the indications and patient preparations for routine procedures and be able to interpret scan procedures, including In-111 Octreoscan, I-123 MIBG, In-111 WBC, Tc-99m WBC, Tc-99m sulfur colloid marrow scan, Tc-99m DMSA renal, Tc-99m labeled perfusion brain SPECT, FDG brain PET

Medical Knowledge

MK1:Diagnostic Knowledge; **MK2:**Physics; **MK3:**Protocol selection and contrast agent selecting/dosing; **MK3:**Imaging technology and Image acquisition

- Understand the physics of radiation protection and how to apply it to routine studies
- Demonstrate knowledge of indications for the examinations requested (when the reason for the examination is not clear, the resident will effectively communicate with the patient and referring physician until clarified)
- Comprehend basic concepts of FDG PET and FDG PET-CT of the body, imaging, and commonly seen artifacts
- Have basic knowledge to begin to recommend the appropriate therapy and therapy dose, based on the patient-specific details and clinical setting
- Understand the relative strengths and limitations of each scan type and other available imaging options
- Protocol cases, in consultation with the attending, to assure that the examination is appropriate to the clinical question and of sufficient quality to address the clinical concerns of the patient and referring physician
- Demonstrate the ability to recognize and describe abnormalities depicted on nuclear medicine imaging studies itemized above appropriate to the level of training when presenting to the attending, and demonstrate improvement compared to the prior rotation
- Begin to develop meaningful differential diagnoses for findings on nuclear medicine imaging studies itemized above
- Familiarity with imaging findings of common acute and chronic diseases evaluated with nuclear medicine
- Correlate nuclear medicine studies with other imaging modalities
- Divide time between supervision and interpretation of commonly performed scans (as in Rotation 1), thereby developing more advanced skills and acquiring new skills concerning the scans enumerated above for this rotation
- Be able to develop appropriate differential diagnoses of a moderately advanced, rather than basic, level for commonly performed nuclear scans
- Review all studies with the supervisor faculty attending

Systems-based Practice

SBP1: Patient Safety; **SBP2:** Quality Improvement; **SBP3:** System navigation for patient-centered care; **SBP4:** Physician role in health care systems; **SBP5:** Contrast agent safety; **SBP6:** Radiation Safety; **SBP7:** Magnetic resonance (MR) safety; **SBP8:** Informatics

- Familiarity with departmental procedures, contrast safety, and sedation required in the performance of examinations
- Make suggestions to improve methods and systems utilized in radiology whenever appropriate
- Review equipment and quality assurance with assigned technologist once/week or as required
- Comprehend QC procedures, camera performance, and specific imaging techniques including SPECT acquisition and processing and wet lab procedures

- Demonstrate knowledge of ACR appropriateness criteria and cost-effective imaging evaluations
- Show ability appropriate to the level of training to interact with clinicians regarding cost effective and streamlined evaluation for differing clinical questions
- Thorough dictations will be made with indications, techniques, findings, and conclusions (impressions), for accuracy in reporting and compliance with billing guidelines

Practice-based Learning and Improvement

PBLI1: Evidence-based and informed practice; **PBLI2:** Reflective practice and commitment to professional growth

- Understand the risk factors for allergic reaction to drugs used in nuclear medicine, and know appropriate actions to prevent or mitigate side-effects and/or reactions
- Identify, rectify and learn from personal errors
- Incorporate feedback into improved performance
- Demonstrate evidence of independent reading and learning through use of printed and electronic resources
- Follow up on abnormal or interesting cases through personal communication with the referring physician or patient medical records
- Attend lectures/conferences, expand concepts, applications, and comparisons with other diagnostic methods
- Familiarity with available medical records and how to access them for the purposes of patient care

Professionalism

P1: Professional behavior and ethical principles; **P2:** Accountability/Conscientiousness; **P3:** Self-awareness and help seeking

- Demonstrate respect for patients and all members of the healthcare team (technologists, nurses, and other healthcare workers)
- Respect patient confidentiality at all times
- Present oneself as a professional in appearance and communication
- Demonstrate a responsible work ethic in regard to work assignments
- Observe ethical principles when recommending further work-up
- Promptness and availability at work are required of every resident
- Dress appropriately for work

Interpersonal and Communication skills

ICS1: Patient and family-centered communication; **ICS2:** Interpersonal and team communication, **ICS3:** Communication within health care systems

- Appropriately obtain informed consent
- Obtain consent for more complex procedures and answer all questions the patient may have
- Explain the nature of the examination or findings in an examination to patients and their families when needed
- Produce concise reports that include all relevant information
- Communicate effectively with all members of the healthcare team
- Communicate effectively the results of studies to referring clinicians whenever needed (for emergent studies, this will be accomplished in a timely manner, with documentation as per hospital and Radiology policy)
- Effectively convey the findings of examinations through accurate description and dictation of reports and participate in case check-outs
- Provide preliminary reports to all referring clinicians if needed before the final review of cases (when there is a significant discrepancy between the preliminary reading and final reading, the resident will notify the referring clinician immediately)
- Understand the clinical management of the conditions commonly encountered
- Use appropriate language in communicating to clinicians through reports or consultations so proper management decisions can be made
- Competent in using PACS, voice recognition systems, and the hospital patient information systems in the daily accomplishment of the workload and instruct others in their use
- Dictate and correct reports in a timely fashion to avoid delay in patient disposition

Monitoring and Assessment of Resident Performance

The resident's progress will be monitored by the faculty on the service. At the end of each rotation, the resident will receive a consensus evaluation of performance from faculty on service. Deficiencies or substandard performance will be discussed personally and privately with the resident and will be brought to the attention of the Residency Program Director by the attending radiologist. Resident performance is

also evaluated through direct observation, case logs, multi-source professional evaluations, structured case discussion, review of patient outcomes, and other performance evaluation methods as determined by the program.

Educational Goals and Objectives (R3):

The above objectives as well as the following:

Patient Care:

PC1:Reporting; **PC2:**Clinical Consulting; **PC3:**Image Interpretation; **PC4:**Competence in procedures

- Demonstrate knowledge of ACR practice guidelines and technical standards for nuclear medicine
- Act as a consultant in nuclear medicine to the clinical services
- Perform a quality check on commonly performed nuclear medicine exams as required, before the technologist allows the patient to leave, to ensure that the exam is complete, and request additional views or repeat imaging when necessary
- Know the indications and patient preparations for FDG PET-CT procedures complicated by patient circumstances (ex. broken arm in cast, diabetic patient), and be able to interpret the scans and recognize FDG PET-CT uncommon artifacts
- Know the proper preparation of patients for diagnostic and interventional procedures and the appropriate follow-up afterwards
- Know when and how to modify scan technique to accommodate patient circumstances (ex. patient cannot lie down)
- Know the indications and patient preparations for routine FDG PET-CT procedures, be able to interpret them and recognize FDG PET-CT artifacts

Medical Knowledge

MK1:Diagnostic Knowledge; **MK2:**Physics; **MK3:**Protocol selection and contrast agent selecting/dosing; **MK3:**Imaging technology and Image acquisition

- Protocol cases, in consultation with the attending, to assure that the examination is appropriate and of sufficient quality to address the clinical concerns of the patient and referring physician
- Understand the physics and principles of radiation protection and how to apply it to the CT component of PET-CT
- Know and be able to explain the methods of radionuclide cell labeling for leukocytes and red cells
- Understand, discuss, perform, explain, and interpret procedures performed in the hot lab
- Competently recommend appropriate radiologic workup for clinical presentations
- Demonstrate knowledge of indications for the examinations requested (when the reason for the examination is not clear, the resident will effectively communicate with the patient or referring physician until clarified)
- Develop appropriate differential diagnoses of an advanced, rather than basic, level for all types of nuclear scans for nuclear radiology and nuclear cardiology when presenting to the attending
- Distinguish between normal and abnormal anatomy with excellent accuracy according to the level of training when presenting to the attending and demonstrate improvement compared to the prior rotation
- Use a systematic approach to identify common abnormalities on FDG PET-CT performed for
- Review all studies with the supervising faculty attending common indications and generate an advanced differential diagnosis
- Be able to relate the imaging findings seen in FDG PET-CT performed for common clinical

indications to the clinical condition, its pathology and pathophysiology

- Develop a thorough knowledge of the differential diagnosis of abnormalities encountered
- Understand, discuss, and interpret nuclear radiology and nuclear cardiology procedures
- Divide time between supervision and interpretation of scans (as in Rotation 1 and 2), thereby developing more advanced skills in earlier components and acquiring new skills concerning the scans enumerated for this rotation
- Know how to perform and interpret less-commonly performed procedures, such as CSF leak, cisternography, Leveen shunt, liver-lung shunt, right to left shunt, VCUG, hemangioma, etc. for typical clinical indications, with appropriate basic differential diagnoses

Systems-based Practice

SBP1: Patient Safety; **SBP2:** Quality Improvement; **SBP3:** System navigation for patient-centered care; **SBP4:** Physician role in health care systems; **SBP5:** Contrast agent safety; **SBP6:** Radiation Safety; **SBP7:** Magnetic resonance (MR) safety; **SBP8:** Informatics

- Familiarity with departmental procedures, contrast safety, and sedation required in the performance of examinations
- Make suggestions to improve methods and systems utilized in radiology whenever appropriate
- Know how to supervise equipment and quality assurance monitoring performed by technologist staff
- Comprehend quality control procedures, camera performance, and specific imaging techniques including SPECT acquisition, processing, and wet lab procedures
- Show ability appropriate to the level of training to interact with clinicians regarding cost effective and streamlined evaluation for differing clinical questions
- Demonstrate knowledge of ACR appropriateness criteria and cost effective imaging practices in nuclear medicine
- Finalize understanding and knowledge regarding regulations of nuclear imaging by the NRC, State, and Hospital (Joint Commission)

Practice-based Learning and Improvement

PBLI1: Evidence-based and informed practice; **PBLI2:** Reflective practice and commitment to professional growth

- Identify, rectify, and learn from personal errors
- Incorporate feedback into improve performance
- Demonstrate evidence of independent reading and learning through use of printed and electronic resources
- Follow up on abnormal or interesting cases through personal communication with the referring physician or patient medical records

- Complete final preparations to pass the certifying examination of the American Board of Radiology

Professionalism

P1: Professional behavior and ethical principles; **P2:** Accountability/Conscientiousness; **P3:** Self-awareness and help seeking

- Demonstrate respect for patients and all members of the healthcare team (technologists, nurses, and other healthcare workers)
- Respect patient confidentiality at all times
Present oneself as a professional in appearance and communication
- Demonstrate a responsible work ethic in regard to work assignments
- Observe ethical principles when recommending further work-up for cases
- Promptness and availability at work are required of every resident
- Dress appropriately when reporting to work

Interpersonal and Communication skills

ICS1: Patient and family-centered communication; **ICS2:** Interpersonal and team communication, **ICS3:** Communication within health care systems

- Be able to explain the nature of the examination of findings in an examination to patients and their families when needed
- Appropriately communicate results to patients and clinicians whenever needed (for emergent studies, this will be done in a timely manner)
- Communicate effectively with all members of the healthcare team
- Produce concise reports that include all relevant information and be able to effectively convey the findings of examinations through accurate dictation of reports and participate in case check-outs
- Assist with supervision and teaching of medical students, radiologic and nuclear technologist students, and junior residents
- Familiarity with available medical records and how to access them for the purposes of patient care
- Provide preliminary reports to all referring clinicians if needed before the final review of cases (when there is a significant discrepancy between the preliminary reading and final reading, the resident will notify the referring clinician immediately)
- Develop a deeper understanding of the clinical management of the medical conditions encountered in routine practice
- Competent in using PACS, voice recognition systems, and the patient information systems in the daily accomplishment of the workload and instruct junior trainees in their use

- Use appropriate language in communicating to clinicians through reports or consultations so proper management decisions can be made
- Produce thorough dictations with indications, techniques, findings, and conclusions
- Dictate and correct reports in a timely fashion to avoid delay in patient disposition

Monitoring and Assessment of Resident Performance

The resident's progress will be monitored by the faculty on the service. Toward the end of each rotation, the resident will receive an evaluation of performance from each attending. Deficiencies or substandard performance will be discussed personally and privately with the resident and will be brought to the attention of the Residency Program Director by the attending radiologist. Residents are evaluated monthly by faculty. Resident performance is also evaluated through direct observation, case logs, multi-source professional evaluations, structured case discussion, review of patient outcomes, and other performance evaluation methods as determined.

"Recommended" Reading All Years and Rotations

Reading List

1. Nuclear Medicine: The Requisites, 4rd edn. Harvey A. Ziessman. Publisher: Elsevier Health Sciences. 2013.
<https://www.clinicalkey.com/#!/browse/book/3-s2.0-C2010065632X>
2. Essentials of Nuclear Medicine Imaging, 5th edn. Fred A. Mettler Jr., Milton J. Guiberteau. Publisher: Elsevier Health Sciences, 2012.
<http://search.lib.virginia.edu/catalog/u6188837>
3. PET Clinics. Elsevier, Published quarterly 2006-present. Clinical reviews on advances in the use of PET and combined PET/CT.
<https://www.clinicalkey.com/#!/browse/journal/15568598/latest>
4. Case Review: Nuclear Medicine. H Ziessman & P Rehm. Publisher: Mosby, 2011
5. Functional Cerebral SPECT and PET Imaging, 3rd Ed. Ronald L. Vanheertum, Ronald S. Tikofsky, Ronald S. Tikofsky. Publisher: Lippincott Williams & Wilkins, 2000. ISBN-13: 9780781718707.
6. Nuclear Medicine Physics: The Basics, 6th Ed. Ramesh Chandra. Publisher: Lippincott Williams & Wilkins, 2004.
<http://search.lib.virginia.edu/catalog/u6377212>.

7. Essential Nuclear Medicine Physics. R Powsner, E Powsner
<http://search.lib.virginia.edu/catalog/u5632973>
8. Thyroid Cancer. Leonard Wartofsky. 2006.
<https://link.springer.com/book/10.1007%2F978-1-59259-995-0>
9. Molecular Anatomic Imaging: PET-CT and SPECT-CT Integrated Modality Imaging, 2nd Ed. Gustav K von Schulthess. Publisher: Lippincott Williams & Wilkins, 2006. ISBN-13: 9780781776745.
10. Atlas of Nuclear Cardiology. Vasken Dilsizian, Jagat Narula. 2013.
<https://link.springer.com/book/10.1007%2F978-1-4614-5551-6>
11. Handbook of Nuclear Cardiology. Heller and Hendel. 2013.
<https://link.springer.com/book/10.1007%2F978-1-4471-2945-5>
12. Nuclear Medicine and PET/CT Technology and Techniques 6th Ed. Paul E. Christian, Kristen Waterstram-Rich. Publisher: Elsevier Health Sciences, 2007 ISBN-13: 9780323043953.
13. Faculty assigned supplemental reading list.

Peer-Reviewed Websites, in addition to material on UVA intranet

1. CardioVillage sponsored by UVA at <http://www.cardiovillage.com/> Requires free registration
2. ARRS GoldMiner® at <http://goldminer.arrs.org/>
3. Radiologyeducation.com provides listing of multiple peer reviewed and non-reviewed sources at <http://www.radiologyeducation.com/#RadiologyTeachingFiles>
4. ACR Case in Point at <http://caseinpoint.acr.org/>
5. Society of Nuclear Medicine Teaching files at <http://www.snm.org/index.cfm?PageID=2208>
6. Mallinckrodt Institute of Radiology Division of Nuclear Medicine digital teaching file at <http://gamma.wustl.edu/home.html>

Other Requirements

1. Completion of Radiation Safety module, UVA intranet, once/year of residency
2. Completion of > 3 patients for I-131 therapy < 33mCi, including consultation, therapy planning and oversight of I-131 therapeutic dose administration
3. Completion of > 3 patients for I-131 therapy < 33mCi, including consultation, therapy planning and oversight of I-131 therapeutic dose administration

Daily Work

The vast majority of your time will be spent in the clinical Nuclear Medicine area in the Emily Couric Cancer Center, and primarily in the NM reading room.

First year will be spent learning about and reviewing/dictating commonly performed diagnostic scans. During this rotation and future NM rotations, the resident will protocol exams in advance of the appointment and check scans to let the patient leave the department. The resident will have the opportunity to observe and participate in scan acquisition and processing, in conjunction with the technologist. If you are male, use common sense about patient contact. If the patient is in a gown, have a chaperone. This is for resident protection as well as for the patient. The resident will inform the patient and doctor of results as warranted. The resident will see patients referred for radionuclide therapy in consultation and collaborate with the attending to determine appropriate management. Lastly, the resident will serve as a consultant to other physicians and health care professionals.

Third year will be spent learning about and reviewing/dictating less commonly performed diagnostic scans, and beginning to learn about and review/dictate PET-CT cases.

Fourth year will be spent learning about and reviewing/dictating uncommonly performed diagnostic scans, and advancing your skills to review/dictate PET-CT cases. It will also be spent finalizing the resident's understanding of basic and complex nuclear medicine scans and procedures and therapies, and mastering the ability to dictate clear, concise reports.

Cases to be Read

- Emergency studies, inpatient and emergency department (to be continuously distributed as they come in and to be read as first priority)
- "Early read" or "STAT read" inpatient or outpatient requests (to be continuously distributed as they come in and to be read in priority after emergency studies)
- 9 a.m.: any unread studies that appear from prior day(s), regardless of how they got overlooked or where they came from
- 4 p.m.: check for studies from the day that slipped through and have not been read
- Outpatient studies (to be continuously distributed as they come in)

Distribution of Work:

- General nuclear studies to be split between the fellow, first-year resident and more advanced residents, with distribution based on level of training

- The first-year resident is reading simple cases and has a slightly lower workload compared to the more advanced residents
- The other residents and the Nuclear Radiology fellows share the remaining cases, both in terms of numbers and degree of difficulty.
- In general PET-CT studies to be split between the fellow and more advanced residents, with distribution based on level of training
- PET-CT studies concerning problems or diseases related to be split between the fellow and more advanced residents, with distribution based on level of training
- All resident examinations must be dictated by the end of every working day.
- Assignment of patients for Consultation (for radionuclide therapy evaluation) to be split between the fellow, first-year resident and more advanced residents, (and occasionally, visiting Radiation Oncology resident) with distribution based on level of training

Vacation/Meeting Time

Schedule Expectations and Vacations:

- All residents are expected to show up ON TIME at the beginning of the work day. If they foresee that they are going to be late, for whatever reason, they have to call the early attending to explain the reason of their being late.
- The resident should be on duty from 8:00 a.m. until the work is completed.
- When a resident is assigned to see a patient in consultation for radionuclide therapy, that resident should review the case in advance of the patient appointment, and be ready to see the patient at the designated appointment time.
- Attendance at noon conference is strongly recommended. Notify the attending before leaving for conference and before leaving for the day.
- Also, the residents cannot leave the reading-room for any appreciable period before the official end of their shift without the permission of the attending
- Among the residents rotating through Nuclear Medicine, there can be only one resident on vacation at a given time. Vacation is first come/first served, but we will be as flexible as possible. Total allowable vacation/meeting time during all of your months of Nuclear Medicine is 4 weeks, per department policy. This will maximize your experience and prepare you for practice as well as written and oral boards.

We hope your rotation on the Nuclear Medicine service is educational, productive and enjoyable. We are always striving to improve the rotation. Please let us know if you have an idea for improvement.

Core Knowledge Presentation Topics

More than one lecture is needed in most areas. Some subjects (ex. quality assurance, artifacts, instrumentation, biodistribution) will be developed under multiple subject headings listed below.

- Instrumentation. An organized review of the equipment used in nuclear medicine, including quality control procedures needed to demonstrate acceptable function and meet regulatory requirements
- Biologic handling and biodistribution of radiopharmaceuticals, including quality control

- procedures
- Review of regulatory agency requirements, and good radiation safety practices
 - Liver and hepatobiliary imaging including biliary atresia
 - Bone imaging, including three phase and SPECT
 - Brain SPECT
 - CNS and brain death imaging
 - GI bleeding scans

 - GU scintigraphy: DMSA, MAG3, radionuclide retrograde VCUG
 - Infection imaging: gallium, indium WBC, technetium WBC
 - Lung scans for pulmonary embolism, evaluation of right to left shunt, quantification of regional perfusion
 - Lymphoscintigraphy- breast CA, melanoma
 - Tumor imaging: Parathyroid, MIBG, OctreoScan, ProstaScint, breast specific gamma imaging (BSGI) with MIBI
 - PET-CT for cancer, body and brain
 - PET-CT of brain, including dementia and epilepsy
 - Quality assurance in nuclear medicine
 - Radiation safety in nuclear medicine
 - Radiobiology including application to radionuclide therapy
 - Radionuclide therapy for palliation of bone pain
 - Radionuclide therapy for treatment of hyperthyroidism
 - Radionuclide therapy for treatment of thyroid cancer
 - Thyroid imaging
 - Thyroid cancer imaging
 - Nuclear cardiology: MUGA, myocardial perfusion SPECT; PET

The Cardiac Nuclear Medicine Core Curriculum combined with the Nuclear Radiology Core Curriculum is designed to provide the radiology resident a foundation for developing the necessary skills to become competent in clinical nuclear medicine. The structured training provides the base for preparation for certification in Diagnostic Radiology by the American Board of Radiology and the clinical practice of nuclear medicine, including eligibility for Authorized User status by the Nuclear Regulatory Commission or State (if the resident later practices in an agreement state).

Educational Goals and Objectives (Cardiac Nuclear Medicine: Upper Level Resident):

The above objectives as well as the following:

Patient Care and Technical Skills:

PCTS1: Consultant

- Demonstrate knowledge of ACR practice guidelines and technical standards for nuclear medicine

- Act as a consultant in cardiac nuclear medicine to the clinical services
- Familiarity with available medical records and how to access them for the purposes of patient care

Medical Knowledge:**MK1: Protocol Selection and Optimization of Images**

- Comprehend imaging principles and imaging procedures including gated myocardial perfusion SPECT and gated blood pool studies
- Understand and be knowledgeable regarding stress or pharmacologic tests, and know the appropriate management of complications and/or side effects of the exercise or medications used in the test
- Know the proper preparation of patients for cardiac nuclear medicine and the appropriate follow-up afterwards
- Understand the underlying physiologic basis and procedure for cardiac PET
- Protocol cases, in consultation with the attending, to assure that the examination is appropriate and of sufficient quality to address the clinical concerns of the patient and referring physician
- Demonstrate knowledge of indications for the examinations requested (when the reason for the examination is not clear, the resident will effectively communicate with the patient or referring physician until clarified)

MK2: Interpretation of Examination

- Develop a thorough knowledge of the differential diagnosis of abnormalities encountered
- Review all studies with the supervising faculty attending
- Relate the imaging findings to the clinical condition and its pathology and pathophysiology
- Familiarity with the anatomy of the heart and cardiovascular system
- Familiarity with imaging findings of common acute and chronic diseases evaluated with cardiac nuclear medicine
- Distinguish between normal and abnormal cardiac anatomy with excellent accuracy according to the level of training when presenting to the attending
- Development of appropriate differential diagnostic lists will be well advanced
- Correlate procedures including cardiac catheterization, echocardiography as well as CT and MRI of the heart with nuclear cardiology studies
- Know how to interpret cardiac nuclear medicine imaging studies with accuracy appropriateness to the level of training and make appropriate presentation to the attending
- Develop appropriate differential diagnoses of a moderately advanced, rather than basic, level for commonly performed nuclear scans
- Interpret nuclear cardiology studies, specifically gated myocardial perfusion SPECT and gated blood pool studies

Systems-Based Practice:**SBP1: Quality Improvement (QI)**

- Become familiar with departmental procedures, contrast safety, and sedation required in the performance of examinations

- Perform a quality check on commonly performed nuclear medicine exams as required, before the technologist allows the patient to leave, to ensure that the exam is complete, and request additional views or repeat imaging when necessary
- Make suggestions to improve methods and systems utilized in radiology whenever appropriate
- Review equipment and quality assurance with assigned technologist once a week or as required
- Conduct SPECT acquisition and processing in conjunction with the technologist
- Review knowledge regarding regulations of nuclear imaging and radioisotope therapy by the NRC, State, and Hospital (Joint Commission), as specifically applicable in the cardiology setting

SBP2: Health Care Economics

- Demonstrate knowledge of ACR appropriateness criteria and cost effective imaging practices in nuclear medicine
- Show ability appropriate to the level of training to interact with clinicians regarding cost effective and streamlined evaluation for differing clinical questions

Practice-Based Learning and Improvement:**PBLI2: Self-Directed Learning**

- Identify, rectify, and learn from personal errors
- Incorporate feedback into improve performance
- Demonstrate evidence of independent reading and learning through use of printed and electronic resources
- Complete final preparations to pass the certifying examination of the American Board of Radiology
- Follow up on abnormal or interesting cases through personal communication with the referring physician or patient medical records
- Attend lectures/conferences, expand concepts, applications, and comparisons with other diagnostic methods
- Review cardiac teaching file

Interpersonal Skills:**ICS1: Effective Communication with Patients, Families, and Care Givers**

- Appropriately communicate results to patients and clinicians whenever needed (for emergent studies, this will be done in a timely manner)

ICS2: Effective Communication with Members of Health Care Team

- Communicate effectively with all members of the healthcare team
- Produce concise reports that include all relevant information and be able to effectively convey the findings of examinations through accurate dictation of reports and participate in case check-outs
- Assist with supervision and teaching of medical and radiologic and nuclear technologist students, and junior residents

- Be able to effectively convey the findings of examinations through accurate description during case check-out
- Provide preliminary reports to all referring clinicians if needed before the final review of cases (when there is a significant discrepancy between the preliminary reading and final reading, the resident will notify the referring clinician immediately)
- Understand the clinical management of the conditions encountered
- Supervise daily clinical work with a degree of independence as determined by faculty
- Use appropriate language in communicating to clinicians through reports or consultations so proper management decisions can be made
- Produce thorough dictations with indications, techniques, findings, and conclusions
- Dictate and correct reports in a timely fashion to avoid delay in patient disposition
- Competent in using PACS, voice recognition systems, and the patient information systems in the daily accomplishment of the workload and instruct others in their use

Monitoring and Assessment of Resident Performance

The resident's progress will be monitored by the faculty on the service. Toward the end of each rotation, the resident will receive an evaluation of performance from each attending. Deficiencies or substandard performance will be discussed personally and privately with the resident and will be brought to the attention of the Residency Program Director by the attending radiologist. Residents are evaluated monthly by faculty. Resident performance is also evaluated through direct observation, case logs, multi-source professional evaluations, structured case discussion, review of patient outcomes, and other performance evaluation methods as determined.

Reading List for Cardiac Nuclear Medicine

General Nuclear Medicine (sections on cardiac imaging)

1. Harvey A. Ziessman, Janis P. O'Malley, James H. Thrall. *Nuclear Medicine: The Requisites*. Mosby, 3rd Edition, 2005. (ISBN 9780323029469)
2. Fred A. Mettler and Milton J. Guiberteau. *Essentials of Nuclear Medicine Imaging*. Saunders, 5th Edition, 2005. (ISBN 9780721602011)
3. Harvey Z. Ziessman and Patrice K. Rehm. *Nuclear Medicine Case Review*. Mosby, 1st Edition, 2002.

Specialized Nuclear Medicine- Cardiac Nuclear Medicine

1. E. Gordon DePuey, Ernest V. Garcia, and Daniel S. Berman. *Cardiac SPECT Imaging*. Lippincott Williams & Wilkins, 2nd Edition, 2001. (ISBN : 0781720079)
2. Kevin Donohoe and Annick Van Den Abbeele. *Teaching Atlas of Nuclear Medicine*. Thieme Medical Publishers; 1st Edition, 2000. (ISBN: 2940003033606)
3. Vasken Dilisizian and Jagat Narula. *Atlas of Nuclear Cardiology*. Current Medicine Group,

- 3rd Edition, 2009. (ISBN: 9781573403108)
4. Guido Germano and Daniel Berman. *Clinical Gated Cardiac SPECT*. Wiley-Blackwell, 2nd Edition, 2006. (ISBN: 1405131551)
 5. Ami E. Iskandrian and Ernest V. Garcia. *Nuclear Cardiac Imaging: Principles and Applications*. Oxford University Press, 4th Edition, 2008. (ISBN: 9780195311198)
 6. Vasken Dilisizian and Gerald M Pohost. *Cardiac CT, PET and MR*. Wiley, John, and Sons, 2nd Edition, 2007. (ISBN: 9781405124478)
 7. Kim Allen Williams. *A Survey of Myocardial Perfusion Imaging*. Fujisawa Healthcare Inc, 2nd Edition, 2002.

Specialized Nuclear Medicine - Physics and Radiopharmacy

1. Gopal B. Saha. *Fundamentals of Nuclear Pharmacy*. Springer, 2009. (ISBN 9780387403601)
2. Walter Huda. *Review of Radiologic Physics*. Lippincott Williams & Wilkins, 3rd Edition, 2009. (ISBN: 9780781785693)
3. Ramesh Chandra. *Nuclear Medicine Physics: The Basics*. Lippincott Williams & Wilkins, 6th Edition, 2004. (ISBN 9780781747530)
4. Simon R. Cherry, James Sorenson, and Michael Phelps. *Physics in Nuclear Medicine*. Saunders, 3rd Edition, 2003. (ISBN: 9780721683416)
5. Gopal B. Saha. *Physics and Radiobiology of Nuclear Medicine*. Springer, 3rd Edition, 2006. (ISBN: 9780387307541)

Other Requirements/Expectations

Daily Work

The vast majority of the resident's time will be spent in the NM reading room, reviewing nuclear cardiology scans using the hospital intranet. Intranet connection to Cardiology PACS is available in through the hospital network.

During slack time, go to Nuclear Cardiology area (2nd floor) to observe the acquisition and processing of scans, as well as the performance of stress procedures. When arriving there, identify yourself to Mike Sobczak, the Chief Technologist in Nuclear Cardiology, who can direct the resident to where the action is taking place at that time. Also, identify yourself to other staff and inform them of your availability to review scans and procedures.

On Mondays, Thursdays and some Fridays, the scans are interpreted and reported by the Nuclear Medicine attending, Drs. Rehm, Lancaster, Blurton, respectively. Be prepared to present, review, and discuss the cases with the NM attending. Contact (page) each NM attending for the readout times for their assigned reading days.

On other days, the scans are interpreted and reported by Cardiology attendings. The resident can attend readout session for those days, depending on the resident's availability.

Lectures

The lectures are not intended to be a substitute for a thorough reading and comprehension of appropriate texts and lecture notes. Repetition of simple facts and characteristics contained in standard references is not the best use of lecture time. Rather lectures expand on concepts, applications, and comparisons with other diagnostic methods. A generous use of examples that demonstrate strengths and limitations of the procedures is encouraged, as well as a review of specific radiopharmaceuticals in each area.

Core Knowledge Presentation Topics

More than one lecture is needed in most areas. Some subjects (ex. quality assurance, artifacts, instrumentation, biodistribution) will be developed under multiple subject headings listed below.

1. Instrumentation. An organized review of the equipment used in nuclear medicine, including quality control procedures needed to demonstrate acceptable function and meet regulatory requirements
2. Biologic handling and biodistribution of radiopharmaceuticals, including quality control procedures
3. Review of regulatory agency requirements, and good radiation safety practices
4. Tc-99m myocardial perfusion tracers
5. Cardiac SPECT technique, processing, interpretation and common artifacts
6. Evaluation of ventricular function employing EKG gating using cardiac SPECT and MUGA
7. Cardiac stress procedures used in conjunction with nuclear imaging
8. PET radiotracers and PET procedures applicable for cardiac imaging

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