I. General Overview

Cardiovascular Nuclear Medicine has been evolving very rapidly over the past 3 decades with the indications for procedures, types of procedures utilized, relationship to other diagnostic modalities within cardiovascular medicine and interpretation and implication of results constantly evolving and changing along with the rapid advance in available commercial imaging equipment and new radiopharmaceuticals. Although initially nuclear angiography and myocardial infarction scanning were commonly employed techniques, other methods and digital imaging modalities have replaced them. Few first pass technique studies are performed today with the rapid advance of echocardiography, and is certainly comprises less than 5% of all examinations performed. Multigated nuclear angiography is commonly used for resting left ventricular function measurements at rest, particularly before oncology therapy, but rarely is used at exercise to diagnose ischemic cardiomyopathy, and typically also comprises less than 5% of all examinations performed. Planar myocardial perfusion imaging is used only as a last resort when single photon emission computerized tomography (SPECT) is unable to be performed, and multiple protocols are available at present to determine various degrees of myocardial perfusion in addition to evaluation left ventricular function and viability. Positron emission tomography (PET) is now more commonly available for the evaluation of the metabolic function of the heart, with the recent availability of cyclotron produce radiopharmaceutical production and on site or mobile PET imaging systems. And the ability to merge various digital imaging modalities (fusion imaging) is already present, so that it is expected to relate various nuclear medicine examinations with other forms of computed tomography.

The performance and interpretation of cardiovascular nuclear medicine procedures involves the administration of intravenous radiopharmaceutical and is strongly regulated by national and state regulations. A fellowship program must take into account the licensing regulations.

Training Requirements:
- Level I – 2 months; total number of examinations: 100 (a minimum of 35 cases with hands-on experience must be performed and interpreted under supervision)
- Level II – 4 – 6 months; total number of examinations: 300; experience in computer methods for analysis. This should include perfusion and functional data derived from technetium agents and ejection fraction and regional wall motion measurements from radionuclide angiographic studies.

Goals:
- Comprehensive knowledge of the indications for each type of examination in conformance with federal law governing the administration of a radiopharmaceutical and the necessary precautions in safety to those affected by the administration of a radiopharmaceutical
- Knowledge of skill to acquire the examinations, so that each fellow is able to perform them with superior technical results
- Demonstrated skill in the interpretation of cardiovascular nuclear medicine procedures with a demonstrated program of quality control.
- Demonstrated skill to related the results of the examinations to the clinical indications
- Demonstrated skill in the performance of various types of chemical and physical exertion stress testing
- Demonstrated skill in computer processing of all techniques across the multiple equipment platforms available using similar interactive software.

<table>
<thead>
<tr>
<th>Competency</th>
<th>Required Skill – Level I</th>
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<tbody>
<tr>
<td>Patient Care</td>
<td>Ability to tailor the proper form of stress testing to the individual patient</td>
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<td>Understand the patient’s problems and expectations as they are tested</td>
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<td>Understand various nuclear cardiology examinations and how they influence and affect patient care.</td>
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<tr>
<td>Medical Knowledge</td>
<td>Understand stress testing procedure, including multiple forms of treadmill and bicycle protocols, multiple forms of pharmaceutical stress tests and combinations of these tests.</td>
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<td>Understand potentials and limitations of the technique and indications for each technique</td>
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<td>Understand the role of various protocols of stress electrocardiography and nuclear cardiology in the clinical decision making process.</td>
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<td>Understand basic concepts of nuclear cardiology testing</td>
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<td>Accurate clinical readings of the data to correlate with the anatomy and pathology or lack of pathology delineated by the nuclear examination.</td>
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<td>Prepare cases for correlations with the cardiac catheterization laboratory in formal weekly combined nuclear cardiology/nuclear medicine/radiology departmental conferences.</td>
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<tr>
<td>Interpersonal Communication Skills</td>
<td>Knowledge of the standardized procedure reporting concept, as well as communicating the results of the exam to the requesting provider.</td>
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<td>There are multiple paths that are accepted as standard to generate reports from the nuclear cardiology laboratory. The paths chosen may be different when the fellow is reading with a predominantly nuclear medicine (Dept. of Radiology) physician versus those reports generated by a predominantly cardiovascular disease section physician.</td>
</tr>
<tr>
<td></td>
<td>The fellow is expected to learn and understand the various ways to communicate the information generated by the nuclear cardiology examinations so that it is compatible and acceptable to all physicians concerned.</td>
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</tbody>
</table>
### Systems-based Practice
- Learn the overall role of nuclear cardiology in the evaluation of the patient suspected of having cardiovascular disease as well as its unique contribution to health care.
- Understand the role of various protocols of stress electrocardiography and nuclear cardiology in the clinical decision making process.
- Participate in on-going quality improvement efforts.

### Professionalism
- Maintain objectivity in interpreting the results of the examinations of the laboratory while maintaining a caring and sensitive persona to the needs of the patient experiencing the nuclear and stress examinations.
- Demonstrate compassion and offer treatment to the patient discomfort and be able to interact with the patient to prevent distress.
- Demonstrate ethical behavior and correct unethical behavior when observed.

### Practice based learning and improvement
- Retrospective review of fellow cases (including regular non-imaging treadmill and perfusion studies) in reference to case outcomes and decision making.
- Random case review of patient studies from the perspective of hard outcomes (myocardial infarction or death) to determine impact of stress testing on patient management.

### Level II Competency Required Skill
<table>
<thead>
<tr>
<th>Competency</th>
<th>Required Skill</th>
</tr>
</thead>
</table>
| Patient Care | Conduction and administration of stress testing  
   Obtaining informed consent  
   Answering patient questions regarding the examinations  
   Treating the complications arising from the stress electrocardiographic (both treadmill and chemical) and nuclear examinations  
   Continue to improve the evaluation of nuclear cardiology results in relation to clinical findings of the patient and the various factors of the clinical situation contributing to the nuclear cardiology results  
   Learn and understand each of the difference commercial software packages available to process an exam as it applies to the individual patient.  
   Ability to adjust the program to the individual characteristics of the patient examined in order to optimize clinical results and thus provide the patient with as much information as possible.  
   Knowledge of disease state of ventricular dysfunction by the injection of radiotracer by first-pass technique, even when the radiotracer study was initially ordered for only perfusion |
<table>
<thead>
<tr>
<th>Medical Knowledge</th>
<th>Interpersonal and Communication Skills</th>
</tr>
</thead>
</table>
| - Understand the contribution of first-pass nuclear angiography to quantify intra-cardiac shunts.  
- Exposure to the performance and interpretation of PET imaging in the evaluation of patients with suspected hibernating (and not transmurally scarred) myocardium.  
- Optimize the performance and quality of examinations  
- Relate the acquisition of data to the clinical questions asked in referring the patient  
- Understand the relationships between the different causal-related results of the nuclear cardiology laboratory findings and the reason for referring the patient for nuclear cardiology examination.  
- Faculty-based over-reading of the fellow interpretations is to concentrate on the technical precision and performance of a result as it relates to the clinical status of a patient.  
- Improve the refinement of a diagnosis during a nuclear cardiology procedure.  
- Learn image smoothing processing technique, edge detection technique and region of interest placement technique.  
- Learn the relationships between image and data processing and various disease states.  
- Knowledge in first-pass technique and Positron Emission Tomography processing and interpretation.  
- Understand the different patterns of prograde nuclear angiography as it applies to cardiomyopathies and intracardiac shunt quantification.  
- Understand the potential of PET to assist in the evaluation of chronic ischemic cardiomyopathy.  
- Discuss the results of testing with the patient and referring physician, including limitations and advantages to the exam  
- Relate limitations and advantages to continuation of patient care  
- Understand the prognostic implications of the nuclear cardiology results and communicate this aspect of the results in addition to the anatomical and physiological findings.  
- Ability to communicate the implications of a nuclear cardiology laboratory result to the patient and medical provider.  
- Ability to explain in clear, concise language the reliability and degree of accuracy of the technical results and relate these factors to the clinical questions involving the patient with his medical providers. |
<table>
<thead>
<tr>
<th>Systems-based Practice</th>
<th>Professionalism</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communicate results of first-pass nuclear angiography and PET results.</td>
<td>Appropriately interact with other teams involved with the patient’s care</td>
</tr>
<tr>
<td>Ability to integrate the results of specialized procedures with other routine examinations in order to allow the patient and referring MD to better understand the patient’s cardiovascular status.</td>
<td>Lessen the patient’s suffering while developing a united approach to all of the patient’s complaints and medical problems</td>
</tr>
<tr>
<td>Study the cost-based structures of stress testing as it relates to other modes and techniques of cardiovascular examination</td>
<td>Continued development of response to the needs of patient and society</td>
</tr>
<tr>
<td>Understand the position and role of nuclear cardiology from a systems-based approach in providing patients with cardiovascular care.</td>
<td>Demonstrated competency in recognizing compassionately a patient’s complaints and needs.</td>
</tr>
<tr>
<td>Understanding of the overall role of nuclear cardiology examination results in the role of long term medical management.</td>
<td>Initiate action to reduce patient suffering.</td>
</tr>
<tr>
<td>Understand the role of nuclear cardiology in providing accurate and appropriate data for clinical management in cardiovascular disease.</td>
<td>Integrate knowledge of advanced and/or rarely performed nuclear cardiology techniques into a proper perspective of finding the most appropriate diagnostic test and balance the need for such an exam with the suffering it may cause the patient.</td>
</tr>
<tr>
<td>Integrate a knowledge base derived from examinations performed in nuclear cardiology laboratory to evaluate cardiovascular health status with other technical examinations of cardiovascular status.</td>
<td>Understanding and knowledge of how to explain the consequences of nuclear examinations performed to both the patient and other teams involved in the patient’s care.</td>
</tr>
<tr>
<td>Integrate knowledge of the proper place and perspective of the nuclear cardiology examinations with those of the history and physical exam, electrocardiographic, echocardiographic and cardiac catheterization laboratories, and computerized tomography and MRI laboratories.</td>
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</tbody>
</table>
| Practice-based learning and improvement | Continue to improve skills in interpretation  
- Organize weekly cardiac catheterization/coronary angiography conference to relate anatomical data to the data generated in the nuclear cardiology laboratory  
- Participate in the preparation of the patient before the examination, the administration of the radiopharmaceutical, the conduction of the exercise protocol, and the initial processing technique leading to a nuclear cardiology result.  
- Focus on the affects of the processing on the quantification of values obtained.  
- Increase skill in understanding results of each processing technique through repetitive practice.  
- Utilize archived studies on a continual basis for teaching, in addition to those patients to be examined per new medical request during the rotation.  
- Retrospective review of fellow’s cases with analysis of clinical thought process and outcomes in reference to cardiac imaging data outcomes.  
- Survey coronary artery disease event rate and outcomes from previous individual cases. |

II. Rotation Objectives

The cardiovascular fellowship cardiovascular nuclear medicine training program is designed to offer the fellow in cardiovascular disease the fundamental and basic knowledge to achieve the following objectives:

1. An absolute, comprehensive knowledge of the indications for each type of examination in conformance with federal law governing the administration of a radiopharmaceutical and the necessary precautions in safety to those affected by the administration of radiopharmaceutical.
2. An absolute knowledge of skill to acquire the examinations, so that each fellow is able to perform them with superior technical results.
3. A demonstrated skill in the interpretation of cardiovascular nuclear medicine procedures with a demonstrated program of quality control.
4. A demonstrated skill to relate the results of the examinations to the clinical indications for the examination and the overall pertinence to the clinical condition of the patient.
5. A demonstrated skill to communicate the results to the patient and to the referring physician.
6. A demonstrated skill in the performance of various types of chemical and active exertion stress testing.
7. A demonstrated skill in computer processing of all techniques across the multiple equipment platforms available using similar interactive software.

III. Current Procedures Performed in Cardiovascular Nuclear Medicine
1. Exercise and chemical stress electrocardiography. Dobutamine, Persantine, and Adenosine stress testing in addition to treadmill or bicycle stress testing are used as an integral part of most of cardiovascular nuclear medicine imaging and competency is required in all the variations of stress.

2. Myocardial perfusion imaging. This procedure is the most commonly used procedure but has multiple variations. They include planar imaging, SPECT imaging, gated SPECT imaging and PET imaging. There are multiple quality control issues in the acquisition of these clinical studies. Thus the prospective specialist must learn all aspects to the quality control issue of acquisition before attempting to define normalcy, and then understand the limitations in defining normalcy for individual patients. The major goals throughout the cardiovascular nuclear medicine rotations are to emphasize technique definition of normalcy and how to process digital information to delineate the normal study. Continued guided experience from multiple licensed and experienced preceptors is to be given to the fellowship physician on a constant schedule.

3. Nuclear angiography. There are multiple variations of this technique, including first pass nuclear angiography for the evaluation of right and left ventricular function, congenital heart disease, intravascular vascular system shunts, and nuclear angiography at rest and effort. Multigated nuclear (MUGA) angiography is used to evaluate right and left ventricular function and can be performed in either 2 dimensional or 3 dimensional (tomographic) technique.

4. PET imaging. This technique is able to analyze myocardial perfusion, myocardial metabolic function (including myocardial viability) and ventricular function, with the ability to significantly extent absolute quantification of measurements.

IV. Cardiovascular Nuclear Medicine Teaching Program

Cardiovascular nuclear medicine, like multiple other areas within cardiology, is defined by the COCATS with 2 significant established levels of competency for those who wish to pursue the utilization of the techniques in their practice of medicine, and a basic level of education for all cardiovascular disease section fellows. The definitions of the formal courses, to be given to all fellows on a yearly basis, are at the end of this document. In addition to the formal course of lectures by faculty, all fellows are required to have training in radiation safety and radiopharmaceutical handling in their first year of fellowship. The six core competencies of the ACGME including patient care, medical knowledge, practice-based learning and improvement, interpersonal communication skills, professionalism, and system-based practice knowledge are to be taught and monitored through the 6 month rotations of the formal years of fellowship training and monitored by 1:1 documented faculty-fellow daily teaching in the cardiovascular nuclear medicine departments (2 sites including the University of Wisconsin Hospital on campus and the University of Wisconsin Medical Foundation Cardiology Clinic at the Meriter Atrium, with 5 different types of imaging devices and 3 processing platforms). Teaching experience is to be strictly documented.

Listed below are goals for the nuclear cardiology rotation throughout the monthly rotations, to include the six core competencies of fellowship education as specified by ACGME.
Month 1 – Stress Laboratory, Nuclear Cardiology Rotation

The initial goal of the first month is to introduce the fellow to all manners of stress testing, to include the multiple forms of treadmill and bicycle protocols, the multiple forms of pharmaceutical stress tests, and combinations of all of the previous. The fellow is to gain knowledge of the potentials and limitations of the technique, the indications for each technique, and understanding of the patient’s problems and expectations as they are tested. The fellow is expected to know how to tailor the proper form of stress testing to the individual patient requirements and clinical question leading to the referral for testing. The fellow is also expected to learn the basic aspects of nuclear cardiology testing, with constant observation and work review by the attending nuclear cardiology and nuclear medicine physicians. All cases of both electrocardiogram and nuclear testing are to be subject to daily reviews by staff and fellow.

Interpersonal communication skills are to be developed by learning the role of various protocols of stress electrocardiography and nuclear cardiology in the clinical decision making process. The fellow is to learn the standardized procedure reporting concept, as well as to communicate the results of the examinations to the providers requesting the examinations.

The fellow is expected to start the process of learning the professional interaction process with the various members of the nuclear cardiology laboratory, including the nuclear pharmacy technicians, the nuclear medicine technicians, the exercise physiologists, and other members associated with the team, including quality assurance technicians.

Month 2 – Stress laboratory, Nuclear Cardiology Rotation

The expected goal of this rotation is to learn basic and advanced computer processing techniques of nuclear cardiology in addition to continuing the same goals listed for the first month of training. There are multiple computer processing programs used in the performance of nuclear imaging to derive results. The programs require direct physician involvement and thus constant supervision is to be given to the fellow in this rotation to demonstrate the various processing tools with direct hands-on experimentation and experience. Since a major part of the learning experience is to recognize artifact from actual finding of anatomy or physiology, multiple sessions of faculty teaching are to be directed at the fellow to understand the subject of nuclear examination artifact and possible solutions to derive accurate findings to drive the decision making process. Formal lectures are to be given on the subject in addition to the practical experience.

Medical knowledge. Medical knowledge to be acquired in this month is to focus on accurate clinical readings of the data to correlate with the anatomy and pathology or lack of pathology delineated by the nuclear examination. The fellow is expected to prepare cases for correlation with the cardiac catheterization laboratory in formal weekly combined nuclear cardiology/nuclear medicine/radiology departmental conferences.

Patient-based learning. The fellow is to focus on interpretation skills of the various nuclear cardiology examinations and to how they influence and affect patient care.
Interpersonal communication skills. There are multiple paths that are accepted as standard to generate reports from the nuclear cardiology laboratory. The paths chosen may be different when the fellow is reading with a predominantly nuclear medicine (Department of Radiology) physician versus those reports generated by a predominantly cardiovascular disease section physician. The fellow is expected to learn and understand the various ways to communicate the information generated by the nuclear cardiology examinations so that it compatible and acceptable to all physicians concerned.

Systems-based practice. The fellow will learn overall role of nuclear cardiology in the evaluation of the patient suspected of having cardiovascular disease as well as its unique contribution to health care.

Month 3 – Nuclear Cardiology Rotation

The major goals of month 3 are to learn the principles of quality control in the nuclear cardiology and to continue to gain experience in the interpretation of the standard tests. In particular, the fellow is expected to gain knowledge in the preparation and handling of radiopharmaceuticals, the delivery and safe administration of radiopharmaceuticals, radiation safety, and the proper techniques used in disposing of radiopharmaceutical waste.

Patient care. Patient care goals are to continue to focus on the conduction and administration of stress testing, obtaining the informed consent, answering patient questions regarding the examinations, and treating the complications arising from the stress electrocardiographic (both treadmill and chemical) and nuclear examinations.

Medical knowledge. The fellow is to continue to acquire knowledge to optimize the performance and quality of examinations and and relate the acquisition of data to the clinical questions asked in referring the patient.

Practice-based learning and improvement. By continuing to have all examinations reviewed by faculty staff, the fellow is expected to improve his skills in interpretation. The fellow is expected to continue to organize a weekly cardiac catheterization/coronary angiography conference to relate anatomical data to the data generated in the nuclear cardiology laboratory.

Interpersonal communication skills. The fellow is to continue learning how to discuss the results of the testing with the patient and his referring physicians. Discussion of results is to include limitations of examinations in addition to their advantages, and to relate these limitations and advantages to continuation of patient care.

Systems-based practice. The fellow is to study the cost–based structures of stress testing as it relates to other modes and techniques of cardiovascular examination. This is to allow a better understanding of the position and role of nuclear cardiology from a systems-based approach in providing patients with cardiovascular care.
Month 4 – Nuclear Cardiology Rotation

The major goals of this rotation are to continue to acquire the clinical skills in the interpretation of nuclear cardiology results.

Patient care. The fellow is to continue to focus on improving the evaluation of nuclear cardiology results in relation to the clinical findings of the patient and the various factors of the clinical situation contributing to the nuclear cardiology results.

Medical knowledge. Multiple disease entities and clinical situations are known to contribute and interfere with the findings of nuclear cardiology laboratory results. In this rotation the fellow is expected to find the relationships between the different causal-related results of the nuclear cardiology laboratory findings and the reason for referring the patient for the nuclear cardiology examination. Faculty-based over-reading of the fellow interpretations is to concentrate on the technical precision and performance of a result as it relates to the clinical status of a patient.

Practice-based learning. The emphasis of this rotation is on the technical limitations on performance and interpretation of nuclear cardiology results. The fellow is expected to be involved in the preparation of the patient before the examination, the administration of radiopharmaceutical, the conduction of the exercise protocol, and the initial processing technique leading to a nuclear cardiology result.

Communication skills. The fellow is to obtain technical skills to allow better evaluation of the validity and reliability of clinical results when communicating the results to the requesting provider of the nuclear cardiology examination as well as discussing the implication of the results to the patient. The fellow is continue to learn the prognostic implications of the nuclear cardiology results, and to be able communicate this aspect of the results in addition to the anatomic and physiologic findings.

Systems-based practice. Since many of the examinations performed in the nuclear cardiology laboratory have been associated with long term outcomes, particularly in ischemic heart disease, the fellow is expected to gain understanding on the overall role of nuclear cardiology examination results in the role of long term medical management.

Month 5 – Nuclear Cardiology Rotation

Major Goal: Focus on advanced computer processing technique.

Patient care. There are multiple computer processing packages available to interpret each type of nuclear cardiology examination. The fellow is to learn and understand each of the different commercial packages available to process an examination as it applies to the individual patient. He is to learn to adjust the program to the individual characteristics of the patient examined, in order to optimize clinical results and thus provide the patient as much information as is possible.
**Medical knowledge.** The rotation is to focus on acquiring skills to improve the refinement of a diagnosis during a nuclear cardiology procedure. This requires the fellow to learn image smoothing processing technique, edge detection technique, and region of interest placement technique as they apply to both normal patients and patients with disease. The fellow is to learn the relationships between image and data processing and various disease states.

**Practice-based learning.** The fellow is to learn and use all of the image processing techniques in this rotation, applying them to all applicable patients. The fellow is to focus on the affects of the processing on the quantification of values obtained. There is a known variance and accuracy to the result of each processing technique, and through repetitive practice, the fellow is expected to increase his/her skill in understating results.

**Communication skills.** During this month the fellow is to focus on communicating the implications of a nuclear cardiology laboratory result to the patient and requesting medical provider. The fellow is expected to gain knowledge in explaining the reliability and degree of accuracy of the technical results, and relate these factors to the clinical questions involving the patient with his medical providers.

**System-based practice.** The fellow is to understand the role of nuclear cardiology in providing accurate and appropriate data for clinical management in cardiovascular disease.

**Month 6 – Nuclear Cardiology Rotation**

Major Goal: Advanced nuclear cardiology procedures including first pass nuclear angiography at rest and effort, congenital heart disease, intra-cardiac shunts, and positron emission tomography (PET).

**Patient care.** The fellow is to focus on various modalities of nuclear cardiology to examine patients suspected or known to known to have ventricular dysfunction or intra-cardiac shunts. The technique of first-pass nuclear angiography provides rapid non-invasive assessment of right and left ventricular function as well as assessment of chamber-to-chamber shunting. In patients in whom ventricular dysfunction is suspected, fellows are expected to acquire knowledge of the disease state by the injection of radiotracer by first-pass technique, even when the radiotracer study was initially ordered for only perfusion scanning. This is to allow a more complete diagnostic profile to be created for the patient. The fellow is expected to learn the contribution of first pass nuclear angiography to quantify intra-cardiac shunts.

Although not used for routine myocardial perfusion imaging at this institution, PET imaging is routinely used for myocardial perfusion imaging in patients with severe resting left ventricular dysfunction. The fellow is to be exposed to the performance and interpretation of PET imaging in the evaluation of patients with suspected hibernating (and not transmurally scarred) myocardium.
Medical knowledge. The fellow is to acquire knowledge in first pass technique and Positron Emission Tomography processing and interpretation in this rotation. The fellow is expected to learn and understand the different patterns of prograde nuclear angiography as it applies to cardiomyopathies and intracardiac shunt quantification. The fellow is also expected to learn and understand the potential of Positron Emission Tomography to assist in the evaluation of chronic ischemic cardiomyopathy.

Practice-based learning. Since this month is based on learning new processing techniques, hands-on mentor/faculty teaching is to accompany all processing in addition to interpretation. Archived studies are to be used on a continual basis for teaching, in addition to those patients to be examined per new medical request during the rotation.

Communication skills. This month is to focus on the fellow developing effective skills to communicate the results of first pass nuclear angiography and Positron Emission Tomography results. The fellow is to be able to integrate the results of these specialized procedures with the other routine examinations that have involved the patient and thus allow the patient and referring physician to better understand the patient’s cardiovascular status.

Systems-based practice. The fellow is to integrate a knowledge base derived from the examinations performed in nuclear cardiology laboratory to evaluate cardiovascular health status with other technical examinations of cardiovascular status. This integration is to include finding the proper place and perspective of the nuclear cardiology examinations with those of the history and physical exam, electrocardiographic, echocardiographic, and cardiac catheterization laboratories, and Computerized Tomography and Magnetic Resonance Imaging laboratories.

Throughout the 6 months (and 3 years of fellowship in cardiovascular disease) of nuclear cardiology rotations, there are to be didactic lectures covering all aspects of nuclear medicine radiation safety, nuclear medicine physics, nuclear medicine mathematics, and image processing. Throughout the 3 years of cardiovascular disease fellowship, there are to be correlation conferences to relate nuclear cardiology laboratory findings to patients.

At the end of the third year of cardiovascular fellowship training, an extensive written test will be given to all fellows, covering all aspects of their nuclear cardiology learning experience. Fellows are encouraged to purchase the American Society of Nuclear Cardiology self-assessment test. Extensive review of both tests will be performed with faculty and fellows.

Full lecture schedules of the didactic lectures and laboratory hands-on practical schedules are provided as an addendums.

Month 7-12 Nuclear Cardiology Rotation
Major Goal: Advanced training for Level III nuclear cardiology privileges

**Patient care.** The fellow is to focus on the continuation of hands-on interpretive experience in a minimum of 600 cases and to participate in clinical imaging activities to bring the total training period to 12 months. This additional training is to include the supervised managing of all patients coming to the laboratory for testing.

**Medical knowledge.** The emphasis will include review and advanced training as specified by the *Task Force 5: Training in Nuclear Cardiology* (Cerqueira et al., JACC 47:898-904, 02/21/06), to include:

1. Quantitative analysis of perfusion and/or metabolic studies
2. Quantitative radionuclide angiographic and gated perfusion analyses, including measurement of global and regional function
3. SPECT perfusion acquisition, reconstruction, and display
4. ECG-gated SPECT perfusion acquisition, analysis, and display of functional data
5. Imaging of positron-emitting tracers using either dedicated PET systems or SPECT-like systems equipped with either high-energy photon collimators or coincidence detection

Lastly, a basic science course in radiation physics and imaging is to be completed in this period.

**Practice-based learning.** Two specific goals are to be realized, including refinement of processing techniques in digital imaging and most importantly, the supervision and administration of a nuclear cardiology laboratory. This is to be accomplished by participating not only at the University of Wisconsin Hospital, but also at the University Medical Foundation Outpatient Nuclear Cardiology Laboratory. The later area involves the use of cardiac dedicated small-field-of-view cameras, not available at the University of Wisconsin Hospital.

**Communication skills.** Emphasis will be placed on clinical research, resulting in publication of the research results in the medical literature. Analysis of statistical methods employed to interpret results, and writing skills to communicate results to other physicians are to be learned in continued practice and supervision with faculty.

**Professionalism.** One of the most major goals of this experience is to be able to administer a laboratory. Thus, continued interaction with all members of the multiple laboratories is designed to prepare the fellow to be able to supervise the laboratory. This experience is also designed for the fellow to be the primary link to all of the providers using the nuclear cardiology laboratory.

**Systems-based practice.** The fellow will understand the role of a director of a nuclear cardiology laboratory, as it relates to both hospital and outpatient testing clinics. The fellow is to understand the needs of the laboratory to provide service while maintaining mandated safety standards involving radiotracers. The fellow is to understand equipment needs to support and provide the adequate technical results and continued quality
control. The fellow is expected to be able to provide continuing medical education for the members of all nuclear cardiology staff associated with the laboratory.

**Nuclear Cardiology Training Program: Formal Course Guidelines**

**Background:**

The training program in nuclear cardiology for cardiovascular disease fellows historically has constantly changed. It has been especially hard to define a program when the licensing rules have changed so frequently over the past 5 years, with fighting to possess the “turf” of reading and charging for the procedures of cardiology being constantly fought over by internal medicine physicians, cardiology specialist physicians, radiologists, and nuclear medicine specialists. Five years ago, supervision of the licensing of physicians was reserved for the federally operated Nuclear Regulatory Commission (NRC). After lobbying temporarily gave control to the individual state regulated commissions, and in light of a certifying board examination for those specializing in nuclear cardiology alone, with no possibility to practice anything but nuclear cardiology, the individual states decided their own criteria, and set up a general agreement reciprocity arrangement (currently 40 states). In this situation, didactic classroom and laboratory mandatory teaching hours were constantly variable, ranging from 50 to 80 hours with time split between laboratory and classroom experience. The 50 to 80 hours was further confused by allowing such mandatory training occur with interactive internet training. In addition 700 hours of hands-on clinical training was required.

Nomenclature for training has also been very confused. Many programs referred to initial training to be an authorized user to as Level II training, and further training to operate an independent laboratory as Level III training. It is indeed surprising to see this nomenclature because it does **NOT** exist in any NRC document. There have been, and still exist, definitions of user types and the associated privileges with user types (which will be listed below).

This has generated a completely new business of for-profit education programs outside of academic institutions. This in turn has generated surveys on patient safety in calibrating, handling and administering radiopharmaceuticals by the federal government, which have shown extremely poor retention of any of the didactic/laboratory material, as well as a review of the certifying nuclear cardiology board exam showing very little questioning on basic safety knowledge, a major area the federal government should be closely regulated to protect patient and laboratory personnel. Many conferences at the national level have led the NRC to reexamine the rules. These **RULES** were finally published at the end March, 2005.

**State regulation:**

2. States with only tentative agreements: Pennsylvania, Minnesota, Virginia
3. The above states conform only to federal regulations regardless of the other states, with no reciprocity of criteria are not met.
User designations:
1. CFR 35.290 Authorized User who has completed *Training for imaging and localization of radiopharmaceuticals*. This is the only category that is needed to be called a nuclear cardiologist able to administer and interpret and charge for all nuclear cardiology procedures. The authorized user is not able to administer management of the radiopharmaceutical laboratory; it does require an authorized radiotracer physicist to calibrate instruments, a radiation safety officer, and a nuclear pharmacist to assist in running the laboratory. The physician can still serve as his own technician. This is the common pathway to train cardiovascular fellows.
2. CFR 35.390 An Authorized User who can administer a nuclear laboratory by himself with no need of the ancillary personnel required for a CFR 35.290 Authorized User. This is the pathway for certification for physicians completing a nuclear medicine training program. It does not encompass a training program for radiology residents to automatically give associated privileges.
3. CFRs for radiation physicist, radiation safety officer, and radiotracer pharmacist are not pertinent to list in this discussion.

CFR 35.290 requirements:
As of March 30, 2005, the NRC has asked to resume control of licensing and the states are expected to comply by June 2007, to include the following for the training of a nuclear cardiologist:
1. Eighty (80) hours of didactic classroom training that should include:
   A: 30-40 hours of hands-on laboratory training and
   B: 30 to 50 hours of formal lectures that can be even associated with interactive internet instruction (up to half of the time)
   C: The subject areas to be included are:
      1) Radiation Physics and Instrumentation
      2) Radiation Protection
      3) Mathematics pertaining to the use of measurement of radioactivity
      4) Chemistry of byproduct material for medical use
      5) Radiation Biology
2. Seven Hundred (700) hours of supervised clinical experience
3. The current CNBC nuclear certifying board exam has been suggested as eventually mandatory for a CFR 35.290 authorized user, but is currently under review due to questions as how it currently minimally tests for knowledge of the basic didactic training. The CNBC board certifying examination is expected to be reviewed and either changed or certified by the NRC by the national requirement of program training in January 2007.

If a cardiology fellow desires to be an authorized user covered by regulation CFR 35.390, it is recommended to do this in the 4th year of fellowship. It requires a broad based knowledge of all radiopharmaceuticals used in nuclear medicine, and 200 didactic hours of lectures/lab. The latter requirement is best served by the formal nuclear medicine course taken by nuclear medicine and radiology residents within the University of Wisconsin School of Medicine and Public Health Radiation Physics and Digital Imaging Graduate Program.
General guiding principals for formal lecture course design:
1. Since the major purposes of the licensing rules are to insure proper quality control of material, procedures, and instruments, thus the basic course is not designed to dwell prohibitively long on advanced physics and mathematics. Advanced mathematics including logarithmic analysis, derivatives, curve mathematics, integration, and advanced physics are to be reviewed and related to the cardiovascular disease clinical experience so that the information can be retained. This means, that even when a basic scientist is lecturing (e.g. physicist), that the lecture relate to nuclear cardiology, with a nuclear cardiologist present also in the room to help answer such questions.
2. Lectures have to be inter-related to sometimes review previous material (especially when combining lab and didactic), to retain the information. (see testing below)
3. Residents must actually be given the opportunity to measure out the radiopharmaceutical doses, perform the quality control on the doses, set up the patient on the nuclear medicine machines, start and finish the examinations, process the examinations instead of relying on a technician to do all of the work. Lastly after the examination of the patient, the cardiology resident must know how to properly dispose of the equipment and materials used in the exam, and perform radiation checks as required by federal law in operating a licensed laboratory. This, after all, is the direct purpose of the formal didactic and basic knowledge hours in becoming an authorized user. The NRC is very adamant on this, allowing 8 hours a day to be called a didactic/and/lab experience counting for the total of 80 hours.
4. Just as in a cardiology fellow coming in to see a patient and performing an echocardiography on call, who has to know how to turn the machine on/off and do the processing, so must an authorized user at least formally know such information in nuclear cardiology. More than 40 hours can certainly be formally fulfilled in didactic education as long as a preceptor is with the cardiology fellow. This requires the preceptor to be present. By having the chance to constantly relate safety/quality control/mathematics/ and physics material to the daily work, the formal knowledge required for a certified CFR 35.290 or 35.390 authorized user is more likely to be retained. Fellows should not just look at “pictures” in their training, and should know how to perform examinations, if no other reason than to learn safety and quality control. They must know how to position the patient, start and finish the exam, and look to the patients comfort in the exam. This has to include all procedures, including at least MUGA at rest and effort, myocardial perfusion studies planar, SPECT, and Gated SPECT, with or without attenuation correction, first pass nuclear angiography at rest, shunt studies, and PET scanning.
5. There has to be review testing every 3 to 4 lessons to re-emphasize the important points and it is required that during review exams, that they are give to review knowledge base with a preceptor present.
6. The course should be oriented to the proper education of nuclear Cardiologists, not certified nuclear medicine physicians. But, radiologists should and will be invited to talk on areas of expertise in nuclear cardiology (e.g., SPECT differentiations and technique, attenuation correction, abnormal radiopharmaceutical imaging errors, extra-cardiac radion tracer uptake (tumors, liver, spleen, bone and GI)
7. In addition to the formal “whiteboard” lectures, a four session formal (10 hours each session) laboratory training course is be given on an every other year basis to attain hands-on technical competence in managing the digital imaging machinery,
radiopharmaceuticals, and “hot lab” equipment, and to learn to precisely to measure radioactivity while maintaining safety control of nuclear material

7. There should be one standardized textbook used for the course: The Nuclear Physics for Physicians textbook by Sorenson, is the recommended text.

8. All fellows should rotate through each of the nuclear cardiology laboratories in the UWHC system for at least one day at each site, including Meriter Atrium and Hospital. A broad based experience is necessary to realize there may be more than one possibility to solve a clinical problem in the nuclear cardiology laboratory.

9. The didactic course should be given from July 1 to June 30 each academic year in 1 hour segments, hopefully in the early am time slot on Friday am (7:30 to 8:30) to all second and third year fellows. By giving it yearly and allowing all years of fellows to attend, missed lectures can be made up or reviewed.

10. Each October the American Society of Nuclear Cardiology certifying exam is held, and where it is possible, this should be taken in the 4th year of fellowship. It is strongly recommended that all fellows attend the 1 day ASNC review course (8 hours long) that is given before the exam at the exam site since every area is reviewed.

11. All fellows interested in becoming an authorized user are encouraged to become members of the American Society of Nuclear Cardiology. It is free for residents and fellows, cross correlates with other digital modalities, and constantly has case review studies that change in exam like questions that monthly appear new on the web site, www.asnc.org

12. There is also a self-assessment test that is interactive as an online course at the ASNC site; unfortunately it does not come on a CD.

13. Official Preceptor statements, conforming to national and state license requirements are to be updated on a yearly basis and reviewed by the nuclear cardiology, nuclear medicine and radiation safety committee staffs.
Course Outline

A. Radiation Physics: 5 hours in 5 sessions, with review exam at end
   1. Atomic Structure and Mass
      Mass and energy units: definitions of energy
   2. Mass and organization
      Radiation, origin and properties
   3. Nucleonic structure
      Particles: definitions, characterization, stability
      Forms: isotopes, isomers, isotomes
      Relationships: nucleide charting
      Energy charting
      Relationship to clinical usage, generators
   4. Nuclear Reactions
      Decay types, capture types, gamma emission and schemes
      Decay characterization, constants, half lives
   5. Basic science relation to the above
      Praktikum in UWHC radiopharmaceutical lab

B. Radiation Mathematics: 4 hours in 4 sessions, with review exam
   1. Concentrations and dilutions
   2. Inverse square and gamma constant concept
   3. Decay math: activity, constants, half-life, rates, units
   4. Theoretical (physical) decay versus biological decay
   5. Curves/Plots: fitting, theoretical distribution, types of fits,
      Including discussion of fourier analysis, polynomial,
      And logarithmic/exponential fits
   6. Relationship of the above to Clinical Cardiology procedures
      With praktikum at computer desktops

C: Radiation Biology: 5 hours in 5 sessions
   1. Effects of radiation: anatomic and cellular components
   2. Radiation measurements: Review of roentgens, Rads, REMs,
      LET, RBEs
   3. Detailed radiation effects on cells, radiopharmaceutical uptakes
   4. Radiation actions: direct, indirect
5. Sensitivities to radiation
6. Radiation responses: dose rates, energy transfer, chemical influence, somatic change
7. Radiation syndromes: organ response, cancers
8. Clinical relation to above responses
9. Comparison of nuclear medicine radiation to other types of radiation/imaging modalities
10. Review exam

D: Instrumentation: 6 hours in 6 sessions
1. Gas detectors: theory, curves, practical aspects
2. Scintillation detectors: liquid types, crystal (NaI), Cadmium-telluride, thin-wire detectors, probes
3. Connections: photomultipliers, voltages, amplifiers, pulse analyzers, correctors, spectrum analyzers
4. Display chain meters, probes, well counters
5. Instrumentation standards
6. Quality control, system assurance: performance testing, uniformities, spatial temporal and quantity resolution, linearity, artifact control, floods and phantoms
Praktikum at Meriter UWMF laboratory
7. SPECT considerations: acquisition, reconstruction, attenuation, filtrations
8. Center of rotation
9. Gating techniques; considerations of quality control, arrhythmia filtering
10. Background correction techniques
11. Image display techniques: digital zoom, extrapolation, interpolation, edge detection, smoothing, convolution technique
12. Hard copy output and storage: requirements and possibilities
13. Acquisition techniques: static, dynamic, list, frame, and time mode, phase gating modes, cut-offs
14: Praktikum in computer programming (to be done in
With a computer applications fro GE as a praktikum at Workstations

E: Radiation Safety: 8 hours in 4 to 6 sessions
1. Regulations: state, national
2. Definitions review
3. Prescribing: ordering radioactive material, dose calibrations, Measuring dose administration
4. Prevention and care of radiopharmaceuticals
5. Departmental procedure
6. Generator usage
7. Untoward Events
8. Radiation Safety officer role
9. Surveys: calibrations, leak tests. Waste tests, violation Monitoring
10. Radiation security: meters, calibrators, well detectors, wipe Tests, surveys, labeling, shielding
11. Radiation disposal
12. Radiation Records
13. Continued education rules, personnel monitoring
14. Radiation cleanup and Exposure
15. Comparison of spill or injection exposure to natural radiation
16. Precautions regarding pregnancy
17. Radiation Safety Committee: qualifications, duties, control
18. Praktikum and test
F: Radiopharmaceutical Chemistry: 2 hours in two session
   1. Generators: types, labs, requirements
   2. Cyclotron visit
   3. Isotopes in Use: yields, quality assurance, testing: review
   4. Additives, protectors, associations
G: Clinical comparisons: 4 hours in 4 sessions
   1. Various types of SPECT imaging
   2. Theoretical review of PET imaging
   3. Praktikum in PET imaging
   4. Extra-cardiac uptake considerations when performing nuclear Cardiology examinations

Nuclear Cardiology Rotations and Goals

a. As discussed above, Nuclear Cardiology Rotations are in fulfillment of COCATS Levels I-III. Briefly, Level I is the development of a basic understanding of Nuclear Cardiology techniques and applications. Level II training fulfills NRC licensure requirements and is the minimum level of competency for interpretation of studies professionally. Level III training is advance training applicable for an academic career in nuclear cardiology, a research career or the
directorship of a large nuclear cardiology laboratory. Each monthly rotation has goals specific for the level of training in nuclear cardiology. Educational experiences are specific to the ACGME six goals of residency training of 1) Patient Care, 2) Medical Knowledge, 3) Practice-Based Learning and Improvement, 4) Interpersonal and Communication, 5) Professionalism, and 6) Systems-Based Practice.

b. Number of months of training for each level is reflective of the COCATS guidelines. Level I training is mandatory for completion of cardiology fellowship and consists of 2-3 months. Level II training is 4-6 months while Level III training is 10-16 months. Each Level is sequential and inclusive, building on the previous months.

c. In addition to the clinical rotations, two separate didactic courses are given. A Nuclear Cardiology lecture series is held within the general fellowship didactic series of 22-24 lectures every two years. There is also a didactic lecture series for completion of NRC-mandated topics as described above which will be done on a two-year basis. A brief course is also given by the Safety Department on laboratory work which is mandatory for fellows prior to work in the radiopharmacy.

d. For continued review and image reading critique, monthly imaging sessions are held in conjunction with the weekly imaging conference for the fellowship.