Imaging Physics Residency
Program of Study

University of Texas M. D. Anderson Cancer Center

Division of Diagnostic Imaging

Department of Imaging Physics

Houston, Texas

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INTRODUCTION

The Imaging Physics Residency Program is a two- or three-year program, with 24 months of clinical training, at The University of Texas M. D. Anderson Cancer Center. The objective of the residency program is to provide structured training to individuals who intend to work in diagnostic imaging physics as a professional medical physicist. The residency program follows the recommendations outlined in the American Association of Physicists in Medicine (AAPM) Report 249 Essentials and Guidelines for Clinical Medical Physics Residency Training Programs and the Commission on Accreditation of Medical Physics Education Programs (CAMPEP) Guidelines for Accreditation of Medical Physics Residency Programs. The clinical experiences gained in this program may be applied toward the experience required to qualify for examination by the American Board of Radiology (ABR), the American Board of Medical Physics (ABMP) or the American Board of Science in Nuclear Medicine (ABSNM).

The three-year hybrid pathway provides combined clinical and research training to residents who aim to practice professional imaging physics in an academic environment. Residents enrolled in the hybrid pathway are named MD Anderson Fellow in Medical Physics. For fellows, research activities are of equal importance as clinical activities. Each fellow is matched with a dedicated member of the MD Anderson faculty who serves as his or her research mentor. This relationship is based upon a mutual interest in an area of research in biomedical imaging. An optional fourth year of full-time research is possible through the agreement between the fellow and the research mentor.

Requirements for Program Completion

The following constitute minimum requirements for completing the program:

1. Completion of 24 months (or 36 months for the hybrid pathway) in the residency program, including participation in the external rotations, with satisfactory performance documented in the program's evaluation system.

2. Completion of all mammography modality specific training requirements in the MQSA, including annual evaluations of 10 mammography units, in addition to one stereotactic breast biopsy system, and eight hours of training in digital breast tomosynthesis, under the direct supervision of an MQSA-qualified medical physicist.

3. Research requirement: (1) the two-year residents are required to participate in at least one clinically-related project and submit a manuscript as first author to a peer-reviewed journal, co-authored and approved in advance of submission by the clinical research mentor; (2) the three-year fellows are required to have two first-authored manuscripts, one accepted and one submitted, for publication in peer-reviewed journals, co-authored and approved in advance of submission by the research mentor.

4. Attendance of all required seminars

5. Participation in the annual Practice Oral Exam every year in the residency program.

6. Presentation of results of their research project in departmental or public seminars.

Any deviation from these requirements is at the discretion of the Residency Program Steering Committee. Upon satisfactory completion of all program requirements the resident will be issued a Certificate of Completion. Otherwise, a Letter of Participation will be issued.

New Resident Clinical Orientation

The residency training program will generally commence on July 1. Incoming residents and fellows will first participate in a two-month clinical orientation. The structure of the orientation is outlined in the clinical orientation section below. Briefly it consists of a written examination, followed by one week in each of the clinical areas covered in the residency and then a post-orientation written examination and an oral examination. The orientation serves two purposes, to provide the residents an opportunity to familiarize themselves with MD Anderson's Clinical operations as well as ensure they have the didactic foundations needed to succeed in the following rotations. All activities during the orientation are coordinated by the respective clinical coordinator for each rotation.

Residency Program Clinical Rotations

Each resident and fellow take two rounds of clinical rotations in each subject, except for Imaging Informatics and External rotations. Fellows spend 2/3 of their time in clinical training while maintaining 1/3 of their time for research during the rotation. The duration of each rotation is generally 1 month for 2-yr residents and 1.5 months for 3-yr fellows.

Optional specialization in Nuclear medicine (NM) physics is provided for residents that express interest in this area of specialization. In this case, residents must declare their interest by the end of their first round of clinical rotations (i.e., 11 months of clinical training). The second round is then subsequently adjusted to emphasize the NM and PET rotations of the residency program. This will be achieved by replacing the second round of General Radiography, Angiography/Fluoroscopy, MRI, and Ultrasound rotations by the NM and PET rotation, which will increase the duration of the second rotation of NM and PET from 2 to 6 months. Details are described in the Nuclear Medicine Emphasis Section in this Program of Study.

Clinical activities by the resident are broadly overseen by the designated Clinical Coordinator for each rotation. However, daily activities and routine tasks performed within the clinical rotation may be performed with specific rotation faculty. During each clinical rotation, the resident is responsible to the specific rotation faculty for daily activities, assignments, and schedule. At the conclusion of each clinical rotation, the clinical coordinator is responsible for evaluating the resident's performance. The resident is responsible for reviewing the faculty evaluation and for agreeing or disagreeing with comments. The resident is also responsible for evaluating the rotation program and faculty.

CLINICAL ORIENTATION

Rotation Title: Clinical Orientation

Supervising Physicists: Bill Erwin (Coordinator), Bill Geiser, Rick Layman, Thomas Nishino, Chris Walker

Duration: Two months full-time for both 2-yr residents and 3-yr fellows

Rotation Objectives:
The purpose of the orientation rotations is to introduce incoming residents and fellows to our various imaging modality clinics and operations and associated imaging physics practice, and to confirm that they have adequate medical physics knowledge required to enter clinical rotations. The resident will also gain familiarity with the clinical operations at MD Anderson through multiple clinical observations.

The orientation consists of a written examination, followed by one week in each of seven clinical topics (imaging informatics, general radiography & fluoroscopy, mammography, CT, NM/PET, MR, and US), and then a post-orientation written examination and an oral examination.

List of Competencies:
By the end of the clinical orientation, the resident is expected to have a foundational knowledge of and:

- Be familiar with type and number of imaging devices for each modality in the Division of Diagnostic Imaging at MD Anderson.
- Be familiar with locations of clinics and imaging equipment in the main campus of MD Anderson.
- Confirm access to each of the imaging facilities in the main campus of MD Anderson.
- Be familiar with and gain access to imaging physics test equipment, phantoms, and computation resources needed during residency training.
- Be familiar with imaging physics documentation and reporting systems.
- Complete all safety trainings required to enter clinical rotations.
- Achieve the level of knowledge in each imaging physics topic area as at successful completion of corresponding coursework in a CAMPEP-accredited medical physics graduate program.
- Be familiar with and obtain access to guidelines, reports, literature, and references needed for each clinical rotation.

Recommended References:

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2. AAPM Report 74: Quality Control in Diagnostic Radiology. Report of Task Group #12, Diagnostic X-ray Imaging Committee. Jul 2002.
3. AAPM Report No. 70: Cardiac Catheterization Equipment Performance, Task Group 17 of Diagnostic X-ray Imaging Committee. Feb 2001
4. American College of Radiology (ACR). Mammography Quality Control Manual, Committee on Quality Assurance in Mammography, 1999.
5. American College of Radiology (ACR). Mammography Accreditation Program documents http:/www.acr.org/accreditation
6. AAPM Report No. 39: Specification and Acceptance Testing of computed Tomography Scanners. Task Group 2 of the Diagnostic X-ray Imaging Committee. May 1993.
7. AAPM Report No. 96: The Measurement, Reporting, and Management of Radiation Dose in CT. Diagnostic Imaging Council CT Committee Task Group #23. 2008.
8. AAPM Report No. 111: Comprehensive Methodology for the Evaluation of Radiation Dose in
9. X-Ray Computed Tomography: Report of AAPM Task Group 111: The Future of CT Dosimetry. Computer Tomography Subcommittee Task Group #111. 2010.
10. AAPM Report No. 204: Size-Specific Dose Estimates (SSDE) in Pediatric and Adult Body CT

Examinations. Computer Tomography Subcommittee Task Group #204. 2011.
11. National Council on Radiation Protection and Measurements: Limitations of Exposure to Ionizing Radiations. Bethesda, MD, NCRP Report No. 116, 1993
12. Texas Regulations for Control of Radiation
    §289.227 Use of Radiation Machines in the Healing Arts and Veterinary Medicine
    §289.203 Notice to Workers
    §289.231 Standards for Protection
13. Cherry, et al. Physics in Nuclear Medicine, 4th Edition, Philadelphia: Saunders, 2012
14. American College of Radiology (ACR). MRI Quality Control Manual 2015. Reston, VA: ACR, 2015.
15. Jackson, et al. AAPM Report no. 100: Acceptance Testing and Quality Assurance Procedures for Magnetic Resonance Imaging Facilities: Report of AAPM MR Subcommittee Task Group 1, 2010.
16. Kanal et al (2013). ACR guidance document on MR safe practices: 2013. JMRI: 37:501-530.
17. American Association of Physicists in Medicine Medical Physics Monograph No. 27: Accreditation Programs and the Medical Physicist, "Performance Testing of Ultrasound Equipment", 2001
18. American College of Radiology (ACR). Ultrasound Accreditation Program and Breast Ultrasound Accreditation Program documents http:/www.acr.org/accreditation
19. AAPM TG270 Display Quality Assurances
20. AAPM TG18 Assessment of Display Performance for Medical Imaging Systems

Evaluation Scheme:

- Pre-orientation written examination to understand the baseline imaging physics knowledge of the resident.
- Post-orientation written examination and oral examination to evaluate the improvement in imaging physics knowledge during the clinical orientation and to determine if any remedial didactic learning is needed for any clinical rotation.

GENERAL RADIOGRAPHY

Rotation Title: General Radiography

Supervising Physicists: Frank Dong (Coordinator), Moiz Ahmad, Kyle Jones, Rick Layman, Thomas Nishino

Duration: One month full-time for 2-yr residents and 1.5 months at 2/3 time for 3-yr fellows in both of the 2 rounds.

Rotation Objectives:

Round 1 Training Objectives

The resident is to *assist* with the following:

Acceptance test of at least one general radiography unit (portable units do not apply toward this requirement). If a new unit is not available, the acceptance test may be performed on an existing unit.

Annual compliance testing of at least two units (no more than one portable unit can be applied toward this requirement).

Shielding calculation, if available

Shielding inspection, if available

Entrance skin dose calculation at least once, preferably twice

Fetal dose calculation and risk estimate

The resident is to *observe* the following:

Troubleshooting image quality or equipment performance issues

Round 2 Training Objectives

The resident is to *perform* the following with minimal supervision:

Annual compliance testing of at least one general radiography unit (participated in annual testing of at least three units by the end of residency)

Shielding calculation for at least one general radiographic room (a rad/fluoro room can be substituted)

Shielding inspection for at least one general radiographic room (a rad/fluoro room can be substituted)

Patient dose calculation

Fetal dose calculation and risk estimate

The resident is to *assist* with the following:

Troubleshooting image quality or equipment performance issues

List of Competencies:

By the end of the year 1 and year 2 clinical rotations, the resident is expected to master the following topics which are components of clinical competencies that will be evaluated by rotation faculty.

- Equipment and image formation
  - Definition of requirements for an RFP
  - Specifications
    - Manufacturer and model differences
  - System components and function
    - Define the different system components of radiographic systems
    - Understand film/screen imaging systems and explain the principles that govern their operation
    - Understand digital detectors and explain the principles that govern their operation
  - Imaging chain
    - Understand and be able to explain the underlying physical principles of image formation with screen-film, Computed Radiography (CR), and Digital Radiography (DR) systems
    - Understand image quality in stationary 2-D projection imaging
    - Measure, calculate, and explain the principles of Half Value Layer (HVL)
    - Measure, calculate, and explain the principles of focal spot size
    - Learn how to acquire images on general radiographic units:
      - Observe a technologist demonstrating the proper use of the x-ray unit
      - Learn to select kVp, mA/mAs, time, photocells, bucky, tabletop exposure, etc.
      - Learn to position the tube, table, and bucky (table, wall, and cross-table lateral, if applicable) for imaging
      - Learn to operate a portable system (on phantoms or with test equipment)
    - Know essentials of image formation
      - General
        - X-ray production and interactions
        - Subject contrast (inherent)
        - Scatter production and mitigation (at least two methods)
        - Exposure control systems
      - Screen-film systems
        - Review screen characteristics, such as spectral emission, speed, resolution, absorption efficiency, etc.
        - Review film characteristics, such as spectral sensitivity, speed/contrast, latent image formation, latent image fading, etc.
        - List the exposure parameters (user-selected: kVp, mA, s, or mAs, SID, etc.) used for the different exam types (skull, chest, abdomen, extremity, etc.)
      - CR systems
        - Learn the principles of imaging with storage phosphor plates (latent image formation and fading)
        - Describe how a plate reader works to produce an image
        - List the exposure parameters (user-selected: kVp, mA, s, or mAs, SID, etc.) used for the different exam types (skull, chest, abdomen, extremity, etc.). Note any differences from the imaging parameters used for screen-film systems and digital radiography systems

- DR systems
    - Learn the principles of imaging with various direct andindirect digital radiography systems (image formation and signal read-out)
    - Describe how the image is produced, and highlight the differences from CR imaging
    - Understand how the image histogram is employed by the processing algorithms, and identify patient conditions that can cause improper processing
    - List the exposure parameters (user-selected: kVp, mA s, or mAs, SID, etc.) used for the different exam types (skull, chest, abdomen, extremity, etc.)
- Learn how to process digital images
- Learn how to reprocess a study in the event that an incorrect processing method was chosen
- Learn how images are transferred to specific destinations, and how a unit interconnects with RIS and PACS
- Be familiar with the information included in the DICOM metadata.

- Quality Control/Quality Assurance
    - Acceptance testing
        - List of components as included in purchase agreement
        - Tests for meeting regulatory requirements
        - Tests to within manufacturer's specifications
        - Additional tests as recommended by professional guidelines
    - Periodic Testing
        - Review AAPM 74 and relevant portions of the State Regulations
        - Review anatomy, especially the bones and the pulmonary system
        - Review the manufacturer's specifications for the equipment tested
        - Learn how to position the phantoms, use dosimetry equipment, and acquire the appropriate data
        - List applicable tests/frequencies for a general radiographic system
        - Review the outline of applicable tests and an example Triadreport
        - Perform annual compliance testing, analyze and devise report data, then review with the supervising physicist. Verify that, at a minimum, all applicable tests and measurements required by the State are addressed in the annual test document for a general radiographic room (overhead x-ray tube)
        - Assist with Annual QC testing for at least two general radiographic units, at least two portable radiographic units, one tomosynthesis evaluation, semiannual testing of a CR plate reader system, annual CR plate testing
        - Discuss the tests performed (the testing geometry, purpose, method, and expected outcomes) for CR and DR systems and associated equipment
        - Participate in the routine QC performed by the Physics Tech for at leasttwice
        - Assess x-ray field to light field congruence
        - Determine if a backup timer is functioning properly
        - Assess the accuracy of a SID indicator

        - Assess an exposure indicator calibration
        - Assess performance of PBL system
        - Measure and explain the principles of radiation output of a medical X-ray system
        - Measure quantities related to and explain the principles of tomosynthesis
        - Calculate image size from information available from the DICOM header
        - Construct a simple technique chart from available data
    - Perform post-service follow-up tests
    - Assist in troubleshooting image quality or equipment performance issues
- Facility Requirements
    - Shielding
        - Become familiar with shielding guidance document for a general radiographic unit installation.
        - Explain the principles of shielding design as it applies to projection radiography
        - Understand the components of the radiation shielding design report and radiation safety survey
        - Become familiar with determination of workload, occupancy and use factors.
        - Estimate the workload for a busy department. Perform shielding calculations for a current expansion or renovation project. In the absence of active projects, perform the calculations for an existing room
        - Perform shielding calculations and evaluations for general radiography rooms/suites and generate the corresponding reports.
    - Siting and utilities
        - Floor loading, power consumption, air conditioning, water cooling, network ports
    - Layout/Floorplan
        - Unit location and orientation, generator unit, lead protective devices
        - Control booth, tech/nurse station, patient prep/waiting rooms
        - Adjacent equipment
    - Auxiliary equipment
- Dose Calculations
    - Remember to include contributions to dose from all exposures in a particular radiographic exam
    - Utilizing output and HVL data from the annual QC test for a given room, calculate the entrance exposure and entrance skin dose for at least one of the following exams (see technique charts):
        - AP Pelvis
        - LAT Lumbar
        - PA Chest
    - Convert the entrance exposure to entrance dose.
        - Estimate the dose at 8 cm depth. List all assumptions.
        - Assume the patient is female and 10 weeks pregnant. Estimate the fetal dose
    - Patient
        - Measure, calculate, and explain the principles of patient dosimetry
        - Perform patient dose estimates/calculation
        - Calculate and explain the principles of fetal dosimetry
- Safety

- Perform fetal dose estimates/calculations
- Perform risk estimates as follows:

- Adult – risk estimate for development of cancer
- Fetus – risk estimate for mental retardation or other teratogeniceffect

    - Equipment uses
        - Warning lights
        - Emergency buttons
        - Collimation, activation, tube stability, etc.
    - Operator
        - Time, distance and shielding considerations for the operators
        - Qualifications, control area, personnel monitoring, protection devices,etc.
    - Patient
        - Positioning aids
        - Visibility during x-ray exposure
        - Repeat film analysis
        - Protective devices (lead aprons, gonadal shields etc.)
        - Explain the principles of shielding for patient protection inradiography
    - Public
        - Shielding considerations
        - Area radiation surveys
        - Posting requirements, etc.
- Clinical Operations
    - Protocol
        - Become familiar with imaging parameters for different clinical radiographic protocols
        - Become familiar with various types of special procedures
    - Examination
        - Patient positioning (supine, prone, upright, decubitus)
        - Beam direction for each view
        - Number of views
        - Use of contrast
        - Technical factors
            - kVp, mA, mAs, time
            - SID
            - Grid/non-grid
            - Image receptor type
            - Note digital image processing selected for CR or DR images
    - Interpretation
        - Become familiar with anatomy in radiographic images andphysician interpretation of radiographic exams
- Rules and Regulations
    - Standards of practice
        - Become familiar with the policy and procedure manual for general radiography clinical protocols
        - Become familiar with the policy and procedure manual for radiation safety in general radiography
        - Become familiar with the recommendations fromprofessional societies/organizations (AAPM) for general radiography
            - Digital Radiography: ACR–AAPM–SIIM PRACTICE GUIDELINE

FOR DIGITAL RADIOGRAPHY

- Become familiar with regulations/documentation associated with registration of X-ray producing devices at the state and federal levels

- Federal
  - Understand the FDA's role in the field of general radiography

Recommended References:

AAPM Report 74: Quality Control in Diagnostic Radiology. Report of Task Group #12, Diagnostic X-ray Imaging Committee. Jul 2002.

Sprawls P. Digital Imaging Concepts and Applications. In Frey GD and Sprawls P, eds. The Expanding Role of Medical Physics in Diagnostic Imaging. Advanced Medical Publishing: Madison, WI. 1997. 17 – 36.

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§289.203 Notice to Workers
§289.231 Standards for Protection
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AAPM Report 14: Acceptance Testing and Quality Control for X-Ray Generators and AEC Devices. Rossi R, Lin PJ, Strauss K, and Rauch P. Jan 1985

Specification, Acceptance Testing and Quality Control of Diagnostic X-ray Imaging Equipment. Seibert JA, Barnes GT, and Gould RG, eds. Medical Physics Monograph No. 20. American Institute of Physics: Woodbury, NY. 1994. 1129 pp.

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Kitts EL Jr. Recent Advances in Screen-Film Systems. In Frey GD and Sprawls P, eds. The Expanding Role of Medical Physics in Diagnostic Imaging. AAPM. Proceedings of the 1997 Summer School. Advanced Medical Publishing, Madison, WI, 1997. 153-182.

National Academy of Sciences, Health Effects of Exposure to Low levels of Ionizing Radiation (BEIR VII Phase 2), National Academy, Washington, D.C., 2006.

Structural Shielding Design for Medical X-ray Imaging Facilities. NCRP Report No. 147. National Council on Radiation Protection and Measurements: Bethesda, MD, 2004. 194 pp.

Title 10, Code of Federal Regulations, Part 20, Standards for Protection against Radiation, NRC, U. S. Government Printing Office, Washington, D.C.

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United Nations Scientific Committee on the Effects of Atomic Radiation, "Genetic and Somatic Effects of Ionizing Radiation", 1988 Report to the General Assembly, New York, 1988.

Wagner L, Lester R, and Saldana L. Exposure of the Pregnant Patient to Diagnostic Radiations: A guide to medical management. 2nd ed. Medical Physics Publishing; Madison, WI; 1997. 259 pp.

Evaluation Scheme:

IMAGING PHYSICS RESIDENCY PROGRAM FACULTY EVALUATION OF RESIDENT				
Resident name				
Rotation name	**GENERAL RADIOGRAPHY**			
Inclusive dates of rotation				
Faculty name				
Evaluation Criteria	**Not Competent**	**Marginally Competent**	**Fully Competent**	**Explanatory Notes**
Patient care	*(residents should provide information that is appropriate, accurate and relevant to diagnosis of health problems)*			
1. Performs annual compliance testing of a general radiographic unit				
2. Performs acceptance testing of a general radiographic unit.				
3. Performs annual testing of a computed radiography unit.				
4. Determines entrance skin exposure for radiographic examinations.				
5. Estimates patient ionizing radiation dose and risk for radiographic examinations.				
6. Estimates ionizing radiation dose to conceptus and risk for radiographic examinations.				
7. Calculates shielding for a general radiographic room.				
8. Uses information technology to retrieve and store patient demographic, examination, and image information.				
Medical knowledge	*(residents should be knowledgeable, scholarly, and committed to lifelong learning)*			
9. Explains the complete radiographic imaging chain from production of X-rays to image formation.				
10. Explains the origin of radiographic contrast, mechanisms that compromise and enhance contrast.				
11. Explains methods of exposure control in general radiography				

12. Uses information technology to investigate clinical, technical, and regulatory questions.				
Practice-based learning and improvement	*(residents should investigate and evaluate patient care practices, appraise and assimilate scientific evidence and improve patient care practices)*			
13. Analyzes results of testing and recognizes unexpected findings.				
14. Investigates equipment performance and image quality problems.				
15. Recognizes and corrects personal errors.				
Interpersonal and communication skills	*(residents should demonstrate effective information exchange with physicians, technologists, service personnel, and professional associates)*			
16. Works effectively with others as a member or leader of a health care team.				
17. Produces written reports that are accurate, concise, and grammatically correct.				
18. Presents technical information effectively to other residents, technologists, faculty, and other health care professionals.				
19. Listens effectively.				
Professionalism	*(residents should carry out responsibilities, adhere to ethical principles and show sensitivity to a diverse patient population)*			
20. Responsive to the needs of patients that supercedes self-interest.				
21. Respects patient privacy and confidentiality.				
22. Commitment to excellence and ongoing professional development.				
Systems-based practice	*(residents should be aware of the system of health care and effectively call on system resources to provide optimal care)*			
23. Partners with managers and providers to assess, coordinate and improve health care.				
24. Understands how their professional practices affect other health care professionals.				
25. Utilizes system resources effectively to provide care that is of optimal value.				

ANGIOGRAPHY AND FLUOROSCOPY

Rotation Title: Angiography and Fluoroscopy

Supervising Physicists: Frank Dong (Coordinator), Moiz Ahmad, Kyle Jones, Rick Layman, Xinming Liu, Thomas Nishino

Duration: One month full-time for 2-yr residents and 1.5 months at 2/3 time for 3-yr fellows in both of the 2 rounds.

Rotation Objectives:

Round 1 Training Objectives

The resident is to *assist* with the following:

- Annual compliance testing of at least two units having different configurations (e.g, mobile c-arm, general purpose, interventional, cystoscopy)
- Routine quality control
- Shielding calculation for at least one fluoroscopy or interventional room
- Shielding inspection for at least one fluoroscopy or interventional room
- Entrance skin dose calculation for at least two different procedures (one general and one interventional)
- Fetal dose calculation and risk estimate
- Successfully complete required didactic training

The resident is to *observe* the following:

- Troubleshooting image quality or equipment performance issues

Round 2 Training Objectives

The resident is to *perform* the following with minimal supervision:

- Acceptance testing of at least one unit during the residency
- Annual compliance testing
- Shielding calculations
- Patient dose calculation
- Fetal dose calculation and risk estimate

The resident is to *assist* with the following:

- Troubleshooting image quality or equipment performance issues
- Assist with teaching of labs during diagnostic imaging rotations for graduate medical physics students
- Routine quality control

List of Competencies:
By the end of the year 1 and year 2 clinical rotations, the resident is expected to master the following

topics which are components of clinical competencies that will be evaluated by rotation faculty.

- Equipment and image formation
  - Definition of requirements for an RFP
  - Specifications
    - Equipment manufacturer and model differences
  - System components and function
    - Define the different system components
    - Understand the function of these components
  - Imaging chain
    - Understand and be able to explain the underlying physical principles of angiographic and fluoroscopic image formation
    - Explain the fundamentals of image guidance for fluoroscopic/angiographic procedures
    - Understand image intensified fluoroscopic systems and explain the principles that govern their operation
    - Understand flat panel fluoroscopic systems and explain the principles that govern their operation
    - Discuss the interactions of the variable imaging parameters associated with the fluoroscopic configurations and their impact on patient dose and image quality
    - Understand the imaging and patient dose concerns with special procedures, including last-image hold, road-mapping, serial (radiographic) imaging, digital subtraction imaging, rotational fluoro acquisitions, etc.
    - Explain and assess image quality in fluoroscopy and angiography
    - Measure HVL for a portable C-arm fluoroscope or an angiographic system
    - Explain the principles of Digital Subtraction Angiography and Roadmapping
    - Interpret, construct, and measure dose curves
    - Identify and understand dose-saving features on fluoroscopic and angiographic systems
    - Calculate storage requirements for angiographic procedures
    - Learn how images are transferred to specific destinations, and how scanners interconnect with RIS and PACS
    - Be familiar with the information included in the DICOM metadata.
- Quality Control/Quality Assurance
  - Acceptance testing
    - List of components as included in purchase agreement
    - Tests for meeting regulatory requirements
    - Tests to within manufacturer's specifications
    - Additional tests as recommended by professional guidelines
  - Periodic Testing
    - Review applicable regulations and professional recommendations for performance criteria
    - Learn how to position the phantoms, use dosimetry equipment, and acquire the appropriate data
    - Review the appropriate regulations and an example annual report
    - Assist the Faculty Physicist with annual and semiannual testing of at least one of each type of fluoroscopic unit:

        - general fluoroscopy
        - portable c-arm
        - cystoscopy
        - interventional
    - Perform annual compliance testing, analyze, document, and report data, then review with the supervising Faculty Physicist
    - Become familiar with QC phantoms and procedures for weekly and monthly QC
    - Perform and understand weekly and monthly QC
  - Perform post-service follow-up tests
  - Assist in troubleshooting image quality or equipment performance issues
- Facility Requirements
  - Shielding
    - Become familiar with shielding guidance document for an installationof angio/fluoro unit.
    - Become familiar with determination of workload, occupancy and use factors
    - Understand the components of the radiation shielding design report and radiation safety survey
    - Estimate the workload for a busy department
    - Perform shielding calculations and evaluations for a current expansion or renovation project and generate the corresponding reports. In the absence of projects, perform the calculations for an existing room.
  - Siting and utilities
    - Floor loading, power consumption, air conditioning, water cooling, networkports
  - Layout/Floorplan
    - Equipment location and orientation, generator unit, lead protective devices, contrast injector
    - Control booth, tech/nurse station, patient prep/waiting rooms
    - Adjacent equipment
  - Auxiliary equipment
- Dose Calculations
  - Understand stochastic and deterministic effects of radiation, paying particular attention to the skin effects and cataract formation for single and fractionated doses ofx-rays
  - Learn the different quantities that can be used to describe dose and how they can be used in a patient safety program
  - Review documentation and the use of dose measurement equipment in fluoroscopy
  - Measure Entrance Exposure Rate on any type of fluoroscopic/angiographic system
  - Perform a dose reconstruction for an angiographic study
  - Explain the accumulation of dose in fluoroscopic and angiographic procedures
  - Utilize measured data and knowledge gained during patient procedure observations to estimate the skin dose for several fluoroscopically guided procedures
  - Perform a fetal dose estimate
  - Perform risk estimates for the following:
    - Adult – risk of cancer
    - Fetus – risk for mental retardation or other teratogenic effect
- Safety
  - Equipment uses

        - Warning lights
        - Emergency buttons
        - Collimation, activation, tube stability, etc
    - Operator
        - Explain the fundamentals of radiation protection in fluoroscopy/angiography
        - Time, distance and shielding considerations for the operators
        - Lead protective devices in room
        - Qualifications, control area, personnel monitoring, etc
        - Evaluate lead protection devices
        - Assess the protective measures taken by personnel in portable fluoroscopy
        - Develop a proposal to reduce the occupational exposure to an interventional radiologist
        - Interpret a personnel dosimetry report
    - Patient
        - Demonstrate understanding of patient dose monitoring in fluoroscopy/angiography
        - Monitor dose to the conceptus of a pregnant radiation worker
        - Positioning aids, additional shielding, visibility during x-ray exposure, repeat film analysis, etc.
        - Lead protective devices room
    - Public
        - Shielding considerations, area radiation surveys, posting requirements, etc.
- Clinical Operations
    - Protocol
        - Become familiar with the types of fluoroscopic and angio/interventional exams performed in the Division of Diagnostic Imaging
    - Examination
        - Become familiar with patient positioning, technical factors geometry, use of contrast, adjunct imaging modes, dose descriptors, shields
    - Interpretation
        - Become familiar with the relevant anatomy, especially the gastro-intestinal (GI) and circulatory systems in images
        - Become familiar with characteristics making images suitable/unsuitable for diagnosis: patient positioning and compliance with instructions, contrast agents, subject/image contrast, spatial resolution, artifacts, motion, etc.
- Rules and Regulations
    - Standards of practice
        - Become familiar with the policy and procedure manual for clinical protocols
        - Become familiar with the policy and procedure manual for radiation safety
        - Become familiar with the recommendations from professional societies/organizations
        - Become familiar with regulations/documentation associated with registration of X-ray producing devices at the state and federal levels
    - Federal
        - Understand the FDA's role in the field of angiographic and fluoroscopic imaging

Recommended References:

AAPM Report 74: Quality Control in Diagnostic Radiology. Report of Task Group #12, Diagnostic X-ray Imaging Committee. Jul 2002.

Sprawls P. Digital Imaging Concepts and Applications. In Frey GD and Sprawls P, eds. The Expanding Role of Medical Physics in Diagnostic Imaging. Advanced Medical Publishing: Madison, WI. 1997. 17 – 36.

National Council on Radiation Protection and Measurements: Limitations of Exposure to Ionizing Radiations. Bethesda, MD, NCRP Report No. 116, 1993.

Texas Regulations for Control of Radiation
§289.227 Use of Radiation Machines in the Healing Arts and Veterinary Medicine
§289.203 Notice to Workers
§289.231 Standards for Protection
http://www.dshs.state.tx.us/radiation/rules.shtm

FDA recommendations Sept 94, Sept 95

AAPM Report No. 70: Cardiac Catheterization Equipment Performance, Task Group 17 of Diagnostic X-ray Imaging Committee. Feb 2001.

Advanced Training Program: A Comprehensive Course in the Safe Use of Fluoroscopy. Fluoroscopic Safety, LLC, 2011.

Wagner LK and Archer BJ. Minimizing Risks from Fluoroscopic X-rays, 2nd ed. 1998.

Radiation Dose Management for Fluoroscopically-Guided Interventional Medical Procedures. . NCRP Report No. 168. National Council on Radiation Protection and Measurements: Bethesda, MD 2011.

National Council on Radiation Protection and Measurements: Limitations of Exposure to Ionizing Radiations. Bethesda, MD, NCRP Report No. 116, 1993.

AAPM Report 14: Acceptance Testing and Quality Control for X-Ray Generators and AEC Devices. Rossi R, Lin PJ, Strauss K, and Rauch P. Jan 1985

Specification, Acceptance Testing and Quality Control of Diagnostic X-ray Imaging Equipment. Seibert JA, Barnes GT, and Gould RG, eds. Medical Physics Monograph No. 20. American Institute of Physics: Woodbury, NY. 1994. 1129 pp.

AAPM Report 31: Standardized Methods for Measuring Diagnostic X-ray Exposures (1990). Diagnostic X-ray Imaging Committee Task Group #8.

Kitts EL Jr. Recent Advances in Screen-Film Systems. In Frey GD and Sprawls P, eds. The Expanding Role of Medical Physics in Diagnostic Imaging. AAPM. Proceedings of the 1997 Summer School. Advanced Medical Publishing, Madison, WI, 1997. 153-182.

National Academy of Sciences, Health Effects of Exposure to Low levels of Ionizing Radiation (BEIR VII Phase 2), National Academy, Washington, D.C., 2006.

Structural Shielding Design for Medical X-ray Imaging Facilities. NCRP Report No. 147. National Council on Radiation Protection and Measurements: Bethesda, MD, 2004. 194 pp.

Title 10, Code of Federal Regulations, Part 20, Standards for Protection against Radiation, NRC, U. S. Government Printing Office, Washington, D.C.

Title 21, Code of Federal Regulations, Part 1020, FDA, U. S. Government Printing Office, Washington, D.C.
http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfCFR/CFRSearch.cfm

United Nations Scientific Committee on the Effects of Atomic Radiation, "Genetic and Somatic Effects of Ionizing Radiation", 1988 Report to the General Assembly, New York, 1988.

Wagner L, Lester R, and Saldana L. Exposure of the Pregnant Patient to Diagnostic Radiations: A guide to medical management. 2nd ed. Medical Physics Publishing; Madison, WI; 1997. 259 pp.

AAPM Report #58: Managing the Use of fluoroscopy in Medical Institutions (1998). Radiation Protection Committee Task Group #6.

Balter S and Shope T (eds.). Syllabus: A Categorical Course in Physics. Physical and Technical Aspects of Angiography and Interventional Radiology. Presented at 81st RSNA, 26 Nov – 1 Dec 1995.

Evaluation Scheme:

IMAGING PHYSICS RESIDENCY PROGRAM FACULTY EVALUATION OF RESIDENT				
Resident name				
Rotation name	**ANGIOGRAPHY AND FLUOROGRAPHY**			
Inclusive dates of rotation				
Faculty name				
Evaluation Criteria	**Not Competent**	**Marginally Competent**	**Fully Competent**	**Explanatory Notes**
Patient care	*(residents should provide information that is appropriate, accurate and relevant to diagnosis of health problems)*			
1. Performs annual compliance testing of a fluoroscopic or angiographic system.				
2. Performs acceptance testing of a fluoroscopic or angiographic system.				
3. Configures and operates fluoroscopic systems with appropriate regard for radiation safety.				
4. Determines entrance exposure rate for fluoroscopic examinations.				
5. Estimates patient ionizing radiation dose and risk for fluoroscopic examinations.				
6. Estimates ionizing radiation dose to conceptus and risk for fluoroscopic examinations.				
7. Calculates shielding for a fluoroscopic or angiographic room.				
8. Uses information technology to				
retrieve and store patient demographic, examination, and image information.				
Medical knowledge	*(residents should be knowledgeable, scholarly, and committed to lifelong learning)*			
9. Explains the complete fluoroscopic imaging chain from production of X-rays to image formation.				

10. Explains how operator choices affect patient dose and image quality.				
11. Explains methods of exposure control in fluoroscopic systems that use image intensifiers and digital receptors.				
12. Uses information technology to investigate clinical, technical, and regulatory questions.				
Practice-based learning and improvement	*(residents should investigate and evaluate patient care practices, appraise and assimilate scientific evidence and improve patient care practices)*			
13. Analyzes results of testing and recognizes unexpected findings.				
14. Investigates equipment performance and image quality problems.				
15. Recognizes and corrects personal errors.				
Interpersonal and communication skills	*(residents should demonstrate effective information exchange with physicians, technologists, service personnel, and professional associates)*			
16. Works effectively with others as a member or leader of a health care team.				
17. Produces written reports that are accurate, concise, and grammatically correct.				
18. Presents technical information effectively to other residents, technologists, faculty, and other health care professionals.				
19. Listens effectively.				
Professionalism	*(residents should carry out responsibilities, adhere to ethical principles and show sensitivity to a diverse patient population)*			
20. Responsive to the needs of patients that supercedes self-interest.				
21. Respects patient privacy and confidentiality.				
22. Commitment to excellence and ongoing professional development.				
Systems-based practice	*(residents should be aware of the system of health care and effectively call on system resources to provide optimal care)*			
23. Partners with managers and providers to assess, coordinate and improve health care.				
24. Understands how their professional practices affect other health care professionals.				
25. Utilizes system resources effectively to provide care that is of optimal value.				

COMPUTED TOMOGRAPHY

Rotation Title: Computed Tomography

Supervising Physicists: Frank Dong (Coordinator), Moiz Ahmad, Xinming Liu, Rick Layman, Jonh Rong

Duration: One month full-time for 2-yr residents and 1.5 months at 2/3 time for 3-yr fellows in both of the 2 rounds.

Rotation Objectives:

Round 1 Training Objectives

The resident is to *assist* with the following:

- Acceptance test of at least one CT Scanner. If a new unit is not available, the acceptance test may be performed on an existing unit.
- Annual compliance testing of at least one and preferably two CT scanners.
- Daily and weekly phantom QC
- Shielding calculation for at least one and preferably two scanners
- Shielding inspection when available
- Patient dose calculation at least once, preferably twice
- Fetal dose calculation and risk estimate

The resident is to *observe* the following:

- Troubleshooting image quality or equipment performance issues
- CT protocol development and management

Round 2 Training Objectives

The resident is to *perform* the following with minimal supervision:

- Annual compliance testing of one CT scanner (participated in annual testing of at least three scanners by the end of residency)
- Daily and weekly phantom QC
- Shielding calculation
- Patient dose calculation
- Fetal dose calculation and risk estimate

The resident is to *assist* with the following:

- Troubleshooting image quality or equipment performance issues
- CT protocol development and management

List of Competencies:
By the end of the year 1 and year 2 clinical rotations, the resident is expected to master the following topics which are components of clinical competencies that will be evaluated by rotation faculty.

- Equipment and image formation
  - Definition of requirements for an RFP
  - Specifications
    - CT scanner manufacturer and model differences
  - System components and function
    - Define the different system components ofCT scanners
    - Understand the function of these components on CTscanners
    - Understand system configuration, advantages and disadvantages of dualenergy CT from major manufacturers.
  - Imaging chain
    - Understand and be able to explain the underlying physical principles of CT image formation
    - Understand the scan parameters including kV, mA, rotation time,detector/data channel configurations, thickness, pitch, FOV and explain how each of these parameters affects image quality and patient radiation dose
    - Learn dose modulation, explain how it works, and understand the advantages and disadvantages of utilizing this feature
    - Learn how to acquire images on CT scanners
    - Understand how scout/topogram images are generated
    - Learn where to find the displayed dose information prior to a scan and after an exam is completed
    - Learn how to reconstruct images on CT scanners
    - Understand reconstruction algorithms and explain how an algorithm affects image quality and patient radiation dose
    - Learn how secondary derived images (e.g., MIP, reformats) are generated
    - Learn advanced features such as iterative image reconstruction and dual-energy imaging
    - Learn how images are transferred to specific destinations, and howscanners interconnect with RIS and PACS
    - Be familiar with the information included in the CT DICOMmetadata.
- Quality Control/Quality Assurance
  - Acceptance testing
    - List of components as included in purchase agreement
    - Tests for meeting regulatory requirements
    - Tests to within manufacturer's specifications
    - Additional tests as recommended by professional guidelines
  - Periodic Testing
    - Review applicable regulations and professional recommendations for performance criteria
    - Learn how to position the phantoms, use dosimetry equipment, and acquire the appropriate data
    - Perform annual compliance testing, analyze and devise report data, then review with the supervising CT physicist
    - Become familiar with QC phantoms and procedures for daily and weekly CT QC
    - Perform and understand daily and weekly CT QC
  - Perform post-service follow-up tests
  - Assist in troubleshooting image quality or equipment performance issues

- Facility Requirements
  - Shielding
    - Become familiar with shielding guidance document for CT scanner installation.Understand the components of the radiation shielding design report and radiation safety survey
    - Perform shielding calculations and evaluations for CT scanners/suites and generate the corresponding reports.
    - Perform shielding evaluations for CT scanner room repairs andgenerate the corresponding reports.
  - Siting and utilities
    - Floor loading, power consumption, air conditioning, water cooling, networkports
  - Layout/Floorplan
    - Scanner location and orientation, generator unit, lead protective devices, contrast injector
    - Control booth, tech/nurse station, patient prep/waiting rooms
    - Adjacent equipment
  - Auxiliary equipment
- Dose Calculations
  - Perform exposure measurements using head and body CTDI phantoms and a CT pencil ion chamber
  - Perform calculations of CTDI100, CTDIw, CTDIvol
  - Understand the dosimetry for wide beam (beam width >100mm) conditions
  - Understand Dose Report and Dose Record
  - Perform calculations of DLP and effective dose
  - Perform exposure measurements using a Farmer Chamber
  - Patient
    - Perform patient dose estimates/calculation
    - Perform fetal dose estimates/calculations
    - Perform risk estimates for development ofcancer
- Safety
  - Equipment use
    - Warning lights
    - Emergency buttons
    - Understand Dose Check (Notification Value and Alert Value)terminology
  - Operator
    - Time, distance and shielding considerations for the operators
    - Lead protective devices in scanner room
  - Patient
    - Learn Image Gently and Image Wisely
    - Visual contact and voice communication
    - Lead protective devices in scannerroom
- Clinical Operations
  - Protocol
    - Become familiar with imaging parameters for different clinical CT scanning protocols including body, MSK, neuro, and pediatric imaging
    - Become familiar with various types of special procedures performed such as CT Perfusion
  - Examination

        - Patient positioning, imaging techniques, use of contrast agents, shields
    - Interpretation
        - Become familiar with anatomy in CT images and physician interpretation of CT exams
- Rules and Regulations
    - Standards of practice
        - Become familiar with the policy and procedure manual for CT clinical protocols
        - Become familiar with the policy and procedure manual for radiation safety in CT
        - Become familiar with the recommendations from professional societies/organizations (AAPM, ACR) for CT
        - Become familiar with regulations/documentation associated with registration of X-ray producing devices at the state and federal levels
    - Accreditation
        - Become familiar with the CT accreditation organizations approved by the Centers for Medicare and Medicaid Services (CMS)
        - Become familiar with requirements for ACR accreditation in CT
    - Federal
        - Understand the FDA's role in the field of CT
        - Become familiar with requirements for CT in the Medicare Improvements for Patients and Providers Act of 2008 (MIPPA)

Recommended References:

AAPM Report No. 39: Specification and Acceptance Testing of computed Tomography Scanners. Task Group 2 of the Diagnostic X-ray Imaging Committee. May 1993.

AAPM Report No. 96: The Measurement, Reporting, and Management of Radiation Dose in CT. Diagnostic Imaging Council CT Committee Task Group #23. 2008.

AAPM Report No. 111: Comprehensive Methodology for the Evaluation of Radiation Dose in X-Ray Computed Tomography: Report of AAPM Task Group 111: The Future of CT Dosimetry. Computer Tomography Subcommittee Task Group #111. 2010.

AAPM Report No. 204: Size-Specific Dose Estimates (SSDE) in Pediatric and Adult Body CT Examinations. Computer Tomography Subcommittee Task Group #204. 2011.

Bushberg JT, Seibert JA, Leidholdt EM Jr, Boone, JM. The Essential Physics of Medical Imaging. 3rd ed. Lippincott Williams and Wilkins, Philadelphia, PA. 2012. 1030 pp.

Texas Regulations for Control of Radiation §289.227 Use of Radiation Machines in the Healing Arts and Veterinary Medicine (Effective September 1, 2004)
http://www.dshs.state.tx.us/radiation/rules.shtm

Specification, Acceptance Testing and Quality control of Diagnostic X-ray Imaging Equipment. Seibert JA, Barnes GT, and Gould RG, eds. Medical Physics Monograph No. 20. American Institute of Physics: Woodbury, NY. 1994.

Gould R. CT Overview and Basics. pp. 801-832
Mattson R. CT Design Considerations and Specifications. pp. 833-862.
Leh-Nien DL. CT Acceptance Testing. pp. 863-898.
Rothenberg L. CT Dose Assessment. pp. 899-936.

Medical CT and Ultrasound: Current Technology and Applications. Goldman LW and Fowlkes JB eds. Proceedings of the 1995 AAPM Summer School. Advanced Medical Publishing, Inc: Madison, WI. 1995. 640 pp.

Hsieh J. Computed Tomography: Principles, Design, Artifacts, and Recent Advances. SPIE Press: Bellingham, WA. 2003. 388 pp.

Kalender WA, Computed Tomography: Fundamentals, System Technology, Image Quality, Applications. 2nd ed. Wiley-VCH Verlag GmbH & Co, Weinheim, Germany. 2006. 304 pp.

ImPACT: Imaging Performance Assessment of CT Scanners at http://www.impactscan.org/

CT dose index and patient dose: They are not the same thing. McCollogh CH et al. Radiology 259(2):311-6, 5/2011.

Evaluation Scheme:

IMAGING PHYSICS RESIDENCY PROGRAM FACULTY EVALUATION OF RESIDENT				
Resident name				
Rotation name	**COMPUTED TOMOGRAPHY**			
Inclusive dates of rotation				
Faculty name				
Evaluation Criteria	**Not Competent**	**Marginally Competent**	**Fully Competent**	**Explanatory Notes**
Patient care	*(residents should provide information that is appropriate, accurate and relevant to diagnosis of health problems)*			
1. Performs annual compliance testing of a computed tomography scanner.				
2. Performs acceptance testing of a computed tomography scanner.				
3. Performs daily quality control tests of a computed tomography scanner.				
4. Determines CTDI for computed tomographic examinations.				
5. Estimates patient ionizing radiation dose and risk for computed tomographic examinations.				
6. Estimates ionizing radiation dose to conceptus and risk for computed tomographic examinations.				
7. Calculates and evaluates shielding for a computed tomography scanner room.				
8. Uses information technology to retrieve and store patient demographic, examination, and image information.				
Medical knowledge	*(residents should be knowledgeable, scholarly, and committed to lifelong learning)*			
9. Explains the complete computed tomographic imaging chain from production of X-rays to image reconstruction.				
10. Explains the physical meaning of Hounsfield Units.				
11. Explains how specifics of imaging protocol affect patient dose and				

diagnostic benefits of examination.				
12. Uses information technology to investigate clinical, technical, and regulatory questions.				
Practice-based learning and improvement	*(residents should investigate and evaluate patient care practices, appraise and assimilate scientific evidence and improve patient care practices)*			
13. Analyzes results of testing and recognizes unexpected findings including image artifacts.				
14. Investigates equipment performance and image quality problems.				
15. Recognizes and corrects personal errors.				
Interpersonal and communication skills	*(residents should demonstrate effective information exchange with physicians, technologists, service personnel, and professional associates)*			
16. Works effectively with others as a member or leader of a health care team.				
17. Produces written reports that are accurate, concise, and grammatically correct.				
18. Presents technical information effectively to other residents, technologists, faculty, and other health care professionals.				
19. Listens effectively.				
Professionalism	*(residents should carry out responsibilities, adhere to ethical principles and show sensitivity to a diverse patient population)*			
20. Responsive to the needs of patients that supercedes self-interest.				
21. Respects patient privacy and confidentiality.				
22. Commitment to excellence and ongoing professional development.				
Systems-based practice	*(residents should be aware of the system of health care and effectively call on system resources to provide optimal care)*			
23. Partners with managers and providers to assess, coordinate and improve health care.				
24. Understands how their professional practices affect other health care professionals.				
25. Utilizes system resources effectively to provide care that is of optimal value.				

NUCLEAR MEDICINE AND POSITRON EMISSION TOMOGRAPHY (Diagnostic MP Residents)

Rotation Title: NM and PET (Diagnostic MP Residents)

Supervising Physicists: Bill Erwin (Coordinator), Rachel Barbee, Cheenu Kappadath, Osama Mawlawi, Tinsu Pan, Bud Wendt

Duration: Two months full-time for 2-yr residents and 3 months 2/3 time for 3-yr fellows in both of the 2 rounds

Rotation Objectives:

Round 1 Training Objectives

The resident is to *assist* with the following:

Acceptance or annual compliance testing of at least two nuclear medicine gamma cameras (at least one of which will include SPECT testing on a SPECT/CT scanner).
Quarterly ACR SPECT phantom test on at least two SPECT scanners.
Gamma camera (including SPECT and hybrid SPECT/CT) calibrations
Acceptance or annual compliance testing of at least one PET/CT scanner.

Quarterly ACR PET phantom test of at least one PET/CT scanner.
PET scanner (including hybrid PET/CT) calibrations

Quarterly and annual compliance testing of non-imaging instrumentation (uptake probes, counting systems and dose calibrators)

Dose calculation and risk estimate for adults and fetus The resident is to *observe* the following:

Troubleshooting image quality or equipment performance issues.

Round 2 Training Objectives

The resident is to *perform* the following with minimal supervision:
Annual compliance testing of both a SPECT/CT and a PET/CT scanner
Annual compliance testing of an uptake probe or counting system
Quarterly linearity and annual accuracy testing of a dose calibrator
Selected gamma camera and PET scanner calibrations NM/PET procedure patient dose calculation, fetal dose calculation and risk estimate (including CT if the procedure is a hybrid SPECT/CT or PET/CT)

Patient release calculations (basic)

The resident is to *assist* with the following:

Troubleshooting image quality or equipment performance issues.

List of Competencies:
By the end of the year 2 clinical rotation, the resident is expected to master the following topics which are components of clinical competencies that will be evaluated by rotation faculty.

1. Equipment and image formation
    - Specifications
        - § Gamma camera, SPECT/CT and PET/CT scanner model differences

- System components and function
    - Define the different system components of gamma cameras and PET scanners
    - Understand the function of these components on gamma cameras and PET scanners.
- Imaging chain
    - Understand and be able to explain the underlying physical principles of gamma camera (including SPECT) and PET image formation
    - Learn how to acquire images on gamma cameras and PET/CT scanners
    - Learn how to reconstruct images on gamma cameras and PET/CT scanners
    - Learn how secondary derived images (e.g., MIP, fusion) are generated
    - Learn the various ways gamma camera and PET images are analyzed quantitatively
    - Be familiar with the information included in the NM/PET DICOM metadata.

2. Quality Control/Quality Assurance
    - Acceptance/Annual testing
        - Understand and be able to explain the various NEMA and non-NEMA tests for gamma cameras and PET/CT scanners
        - Learn how to perform various NEMA and non-NEMA acceptance or annual tests on gamma cameras and PET scanners
    - Periodic Testing
        - Perform and understand daily uniformity QC on gamma cameras.
        - Perform and understand weekly bars resolution QC on gamma cameras.
        - Perform and understand quarterly ACR SPECT testing on SPECT scanners.
        - Perform and understand daily QC on PET scanners.
        - Perform and understand quarterly PET scanner calibration and normalization.
        - Perform and understand quarterly ACR testing on PET/CT scanners.
        - Perform and understand dose calibrator calibration, quality control and performance testing.
        - Perform and understand uptake probe and well counter quality control, calibration and performance testing.
        - Review (in the appropriate reference) the procedure for Mo-99-breakthrough assays of Mo-99-Tc-99m pertechnetate generators.
    - Assist in troubleshooting artifacts on gamma cameras and PET/CT scanners
3. Facility Requirements
    - Shielding
        - Become familiar with shielding guidance documents for NM and PET.
        - Understand the components of the radiation shielding design report.
    - Auxiliary equipment
        - Be cognizant of auxiliary equipment needed for gamma camera and PET/CT scanners
4. Dose Calculations
    - Patient
        - Perform adult and fetal dose estimate calculations for a NM/PET procedure (including the CT component of a hybrid SPECT/CT or PET/CT)
        - Perform risk estimates for development of cancer in the adult from a NM/PET procedure (including from the CT component of a hybrid SPECT/CT or PET/CT)
        - Determine whether or not a medical event is reportable
5. Safety
    - Hot lab operations
    - Operator
        - Time, distance and shielding considerations for the operators
        - Operator (external and internal exposure, including those for pregnant workers)
    - Patient

        - § Prevention of collision of equipment with patient
    - Radiation survey meters
        - § Underlying physical principles, operation and use of radiation survey meters
            1. End-window and pancake G-M, NaI, ion chamber
6. Clinical Operations
    - Understand the use and characteristics of radionuclides and radiopharmaceuticals for NM and PET
    - Protocol
        - § Become familiar with imaging parameters for different clinical NM and PET scanning protocols (including hybrid SPECT/CT and PET/CT)
    - Examination
        - § Patient positioning, dietary needs, imaging techniques, radiopharmaceutical, quantitative studies for both NM and PET
    - Interpretation
        - § Become familiar with physician interpretation of NM/PET procedures (including hybrid SPECT/CT and PET/CT).
7. Rules and Regulations
    - Standards of practice
        - § Become familiar with the policy and procedure manual for NM/PET clinical protocols.
        - § Become familiar with the policy and procedure manual for radiation safety in NM/PET.
        - § Become familiar with NM/PET recommendations from professional societies/organizations (SNMMI, ACR, ASNC, AAPM).
        - § Become familiar with NM and PET-related publications from advisory bodies (NCRP, ICRP, IAEA).
        - § Become familiar with regulations/documentation associated with registration of X-ray CT scanners at the state and federal levels.
    - Accreditation
        - § Become familiar with requirements for ACR and TJC accreditation in NM and PET
    - Federal (Nuclear Regulatory Commission)
    - Agreement State (e.g., TX Dept. of State Health Services Radiation Control Program)

Recommended References:

Cherry, et al. Physics in Nuclear Medicine, 3rd Edition, Philadelphia: Saunders, 2003

Bushberg, et al. The Essential Physics of Medical Imaging, 4th Edition, Philadelphia: Lippincott, Williams & Wilkins, 2021 (Nuclear Medicine and Radiation Protection sections and appendices)
Bailey, et al, Eds. Positron Emission Tomography: Basic Sciences, London: Springer, 2005 AAPM Report No.: 052: Quantitation of SPECT Performance (1995)

071: A Primer for Radioimmunotherapy and Radionuclide Therapy (2001) 096: The Measurement, Reporting, and

Management of Radiation Dose in CT (2008)

108: PET and PET/CT Shielding Requirements (2006)

126: PET/CT Acceptance Testing and Quality Assurance (2019)

177: Acceptance Testing and Annual Physics Survey Recommendations for Gamma Camera, SPECT, and SPECT/CT Systems (2019)

181: The Selection, Use, Calibration, and Quality Assurance of Radionuclide Calibrators Used in Nuclear Medicine (2012)

204: Size-Specific Dose Estimates (SSDE) in Pediatric and Adult Body CT Examinations (2011)

220: Use of Water Equivalent Diameter for Calculating Patient Size and Size-Specific Dose Estimates (SSDE) in CT (2014)

293: Size-Specific Dose Estimate (SSDE) for Head CT (2019)

NEMA:
NU 1-20yy: Performance Measurements of Gamma Cameras
NU 2-20yy: Performance Measurements of Positron Emission Tomographs (PET) (yy = 07, 12, 15, 18, …)
SNMMI, ACR, NCRP, ICRP, IAEA NM/PET-related publications
Nuclear Regulatory Commission:
10 CFR 20 – Standards for Protection Against Radiation
10 CFR 35 – Medical Use of Byproduct Material NUREG 1556, Volume 9, Revision 3

- Appendix G - Model Procedures for Dose Calibrator Calibration
- Appendix K – General Radiation Monitoring Instrument Specifications and Survey Instrument Calibration Program
- Appendix U - Model Procedure for Release of Patients or Human Research Subjects Administered Radioactive Materials

Regulatory Guide 8.39 Rev. 1 – Release of Patients Administered Radioactive Materials

TX DSHS Radiation Control (TAC 25):
§289.201 General Provisions for Radioactive Material
§289.202 Standards for Protection Against Radiation from Radioactive Material
§289.226 Registration of Radiation Machine Use and Services
§289.227 Use of Radiation Machines in the Healing Arts
§289.231 General Provisions and Standards for Protection Against Machine-Produced Radiation
§289.256 Medical and Veterinary Use of Radioactive Material
Regulatory Guide 3.1:

Evaluation Scheme:

IMAGING PHYSICS RESIDENCY PROGRAM FACULTY EVALUATION OF RESIDENT				
Resident name				
Rotation name	**NUCLEAR MEDICINE AND PET**			
Inclusive dates of rotation				
Faculty name				
Evaluation Criteria	**Not Competent**	**Marginally Competent/ Progressing Toward Full Competency**	**Fully Competent**	**Explanatory Notes**
Patient care	*(residents should provide information that is appropriate, accurate and relevant to diagnosis of health problems)*			
1. Performs annual compliance testing of a nuclear medicine gamma camera.				
2. Performs annual compliance testing of a positron emission tomography scanner.				

3. Performs QC tests and calibrations of nuclear medicine imaging systems, dose calibrators, and counting systems.				
4. Estimates patient and conceptus ionizing radiation doses and risk for nuclear medicine examinations.				
5. Is familiar with hot lab, radiation safety, protection procedures, and associated regulations.				
6. Uses information technology to retrieve and store patient demographic, examination, and image information.				
Medical knowledge	*(residents should be knowledgeable, scholarly, and committed to lifelong learning)*			
7. Explains the complete nuclear medicine imaging chain from the ionizing radiation source to image reconstruction.				
8. Understands the use and characteristics of radionuclides for nuclear medicine and PET imaging.				
9. Uses information technology to investigate clinical, technical, and regulatory questions.				
Practice-based learning and improvement	*(residents should investigate and evaluate patient care practices, appraise and assimilate scientific evidence and improve patient care practices)*			
10. Analyzes results of testing and recognizes unexpected findings.				
11. Investigates equipment performance and image quality problems.				
12. Recognizes and corrects personal errors.				
Interpersonal and communication skills	*(residents should demonstrate effective information exchange with physicians, technologists, service personnel, and professional associates)*			
13. Works effectively with others as a member or leader of a health care team.				
14. Produces written reports that are accurate, concise, and grammatically correct.				
15. Presents technical information effectively to other residents,				
technologists, faculty, and other health care professionals.				
16. Listens effectively.				
Professionalism	*(residents should carry out responsibilities, adher to ethical principles and show sensitivity to a diverse patient population)*			
17. Responsive to the needs of patients that supersedes self-interest.				
18. Respects patient privacy and confidentiality.				
19. Commitment to excellence and ongoing professional development.				
Systems-based practice	*(residents should be aware of the system of health care and effectively call on system resources to provide optimal care)*			
20. Partners with managers and providers to assess, coordinate and improve health care.				

21. Understands how their professional practices affect other health care professionals.				
22. Utilizes system resources effectively to provide care that is of optimal value.				

NUCLEAR MEDICINE AND POSITRON EMISSION TOMOGRAPHY (NM Emphasis Residents)

Rotation Title: NM and PET (NM Emphasis Residents)

Supervising Physicists: Bill Erwin (Coordinator), Rachel Barbee, Cheenu Kappadath, Osama Mawlawi, Tinsu Pan, Bud Wendt

Duration: Two months full-time for 2-yr residents and 3 months 2/3 time for 3-yr fellows in round 1, and 6 months full-time for 2-yr residents and 9 months 2/3 time for 3-yr fellows in round 2

Rotation Objectives:

Round 1 Training Objectives

The resident is to *assist* with the following:

Acceptance or annual compliance testing of at least two nuclear medicine gamma cameras (at least one of which will include SPECT testing on a SPECT/CT scanner).
Quarterly ACR SPECT phantom test on at least two SPECT scanners.
Gamma camera (including SPECT and hybrid SPECT/CT) calibrations
Acceptance or annual compliance testing of at least one PET/CT scanner.

Quarterly ACR PET phantom test of at least one PET/CT scanner.
PET scanner (including hybrid PET/CT) calibrations

Quarterly and annual compliance testing of non-imaging instrumentation (uptake probes, counting systems and dose calibrators)
NM/PET facility shielding calculation
NM/PET facility shielding inspection
Dose calculation and risk estimate for adults and fetus The resident is to *observe* the following:

Troubleshooting image quality or equipment performance issues.

Round 2 Training Objectives

The resident is to *perform* the following with minimal supervision:
Annual compliance testing of both a SPECT/CT and a PET/CT scanner
Annual compliance testing of an uptake probe or counting system
Quarterly linearity, annual accuracy and geometry testing of a dose calibrator
All types of gamma camera, SPECT and PET scanner calibrations

NM/PET facility and NM therapy suite shielding calculations
NM/PET procedure patient dose calculation, fetal dose calculation and risk estimate (including CT if the procedure is a hybrid SPECT/CT or PET/CT)
Internal radionuclide therapy treatment planning dosimetry and patient release calculations

Troubleshooting image quality or equipment performance issues.

List of Competencies:
By the end of the year 2 clinical rotation, the resident is expected to master the following topics which are components of clinical competencies that will be evaluated by rotation faculty.

1. Equipment and image formation
    - Specifications
        - Gamma camera, SPECT/CT and PET/CT scanners
        - Dose calibrators, uptake probes and well counters
    - System components and function
        - Define the different system components of gamma cameras and PET scanners
        - Understand the function of these components on gamma cameras and PET scanners.
        - Define the different system components of dose calibrators, uptake probes and well counters
        - Understand the function of these components on dose calibrators, uptake probes and well counters
    - Imaging chain
        - Understand and be able to explain the underlying physical principles of gamma camera (including SPECT) and PET image formation
        - Learn how to acquire images on gamma cameras and PET/CT scanners
        - Learn how to reconstruct images on gamma cameras and PET/CT scanners
        - Understand how SPECT and PET attenuation correction coefficient maps are derived from CT and MR images
        - Understand how attenuation, scatter, resolution, and time-of-flight (PET) compensations are applied in SPECT and PET reconstruction
        - Learn how secondary derived images (e.g., MIP, fusion) are generated
        - Learn the various ways gamma camera and PET images are analyzed quantitatively
        - Be familiar with the information included in the NM/PET DICOM metadata.
2. Quality Control/Quality Assurance
    - Acceptance/Annual testing
        - Understand and be able to explain the various NEMA and non-NEMA tests for gamma cameras and PET/CT scanners
        - Learn how to perform various NEMA and non-NEMA acceptance or annual tests on gamma cameras and PET scanners
        - Learn how to perform acceptance or annual tests on dose calibrators, uptake probes and well counters
    - Periodic Testing
        - Perform and understand daily uniformity QC on gamma cameras.
        - Perform and understand weekly bars resolution QC on gamma cameras.
        - Perform and understand quarterly ACR SPECT testing on SPECT scanners.
        - Perform and understand daily QC on PET scanners.
        - Perform and understand quarterly PET scanner calibration and normalization.
        - Perform and understand quarterly ACR testing on PET/CT scanners.
        - Perform and understand dose calibrator daily constancy testing.
        - Perform and understand dose calibrator evaluation of accuracy, linearity and geometry, and special-case settings using reference standards (e.g., F-18/Ga-68) and for beta-and alpha-emitter therapeutic radionuclides (e.g., I-131, Y-90, Lu-177, Ra-223)
        - Perform and understand QC, calibration, counting efficiency evaluation, and chi- square testing of uptake probes and counting systems.
        - Review (in the appropriate reference) the procedure for Mo-99-breakthrough assays of Mo-99-Tc-99m pertechnetate generators.
    - Troubleshooting artifacts on gamma cameras and PET/CT scanners
3. Facility Requirements
    - Shielding
        - Become familiar with shielding guidance documents for NM and PET.
        - Understand the components of the radiation shielding design report and how to perform radiation shielding visual and live-source evaluation.

- § Perform shielding design and calculations for a NM/PET facility and generate the corresponding reports.

- Auxiliary equipment
  - § Be cognizant of auxiliary equipment needed for gamma camera and PET/CT scanners

4. Dose Calculations
   - Patient
     - § Perform adult and fetal dose estimate calculations for a NM/PET procedure (including the CT component of a hybrid SPECT/CT or PET/CT)
     - § Perform risk estimates for development of cancer in the adult from a NM/PET procedure (including from the CT component of a hybrid SPECT/CT or PET/CT)
     - § Determine whether or not a medical event is reportable
     - § Demonstrate a thorough understanding of internal radionuclide dose quantities and units, and perform organ dose calculations using the medical internal radiation dose (MIRD) method
5. Safety

   - Hot lab operations and safety
     - § Area wipe testing and radiation surveys
     - § Package labeling for radioactive materials
     - § Procedure for receipt, inspection, and wipe testing of packages containing radioactive materials
     - § Unsealed source management
     - § Radioactive spill containment, decontamination, exposure control
   - Operator
     - § Time, distance and shielding considerations for the operators
     - § Operator (external and internal exposure, including those for pregnant workers)
   - Patient
     - § Prevention of collision of equipment with patient
     - § For nursing mothers, the time necessary to wait between administration of radioactive materials and breastfeeding an infant (Tc-99m, I-131, In-111, etc.)
   - Radiation survey meters
     - § Underlying physical principles, operation and use of radiation survey meters
       1. End-window and pancake G-M, NaI, ion chamber, alpha/beta
6. Radiopharmacy
   The resident should observe and understand:
   - Generator elution procedures and eluate quality control
   - Radioactivity assay
   - Radiopharmaceutical kit preparation
   - Calculations of dosage for administration
   - Unit (gamma- and positron-emitter) and therapeutic (including alpha- and beta-emitter) dosage preparations
   - The physics of radionuclide production using reactors and accelerators and of the operation of an in-house cyclotron
7. Clinical Operations
   - Understand the use and characteristics of radionuclides and radiopharmaceuticals for NM and PET imaging and therapy
   - Protocol
     - § Become familiar with imaging parameters for different clinical NM and PET scanning protocols (including hybrid SPECT/CT and PET/CT)
     - § Develop competency in building scanner protocols
   - Examination

        - § Patient positioning, dietary needs, imaging techniques, radiopharmaceutical, quantitative studies for both NM and PET
        - § Motion management
    - Interpretation
        - § Become familiar with physician interpretation of NM/PET procedures (including hybrid SPECT/CT and PET/CT).
    - Clinical studies
        - § Anatomy and physiology related to pharmaceutical uptake and elimination
        - § Computer analysis (regions of interest, time-activity curve generation, ejection fraction, kinetic modeling)
        - § Become familiar with all the common NM and PET exams (e.g., bone, cardiac, renal, thyroid, oncologic PET)
8. Radionuclide Therapy
    - Quantitative gamma camera planar, SPECT and PET dosimetric imaging
    - Treatment planning organ and tumor dose calculations for radioiodine (I-131 NaI) therapy, Y-90 microspheres therapy, and other radiopharmaceutical therapies (e.g., I-131 mIBG, Lu-177 DOTATATE)
    - Regulatory requirements, including written directive and post-therapy patient release
    - External exposure levels and times post-administration at which a patient undergoing radioiodine (or other radiopharmaceutical) therapy may be released
    - Patient release calculations, including radiation precaution instructions and their durations
    - Duration of radiation isolation of, and radiation safety precautions for personnel caring for, inpatients undergoing radioiodine or other radiopharmaceutical therapy
9. Rules and Regulations
    - Standards of practice
        - § Become familiar with the policy and procedure manual for NM/PET clinical protocols.
        - § Become familiar with the policy and procedure manual for radiation safety in NM/PET.
        - § Become familiar with NM/PET recommendations from professional societies/organizations (SNMMI, ACR, ASNC, AAPM).
        - § Become familiar with NM and PET-related publications from advisory bodies (NCRP, ICRP, IAEA).
        - § Become familiar with regulations/documentation associated with registration of X-ray CT scanners at the state and federal levels.
    - Accreditation
        - § Become familiar with requirements for ACR and TJC accreditation in NM and PET
    - Federal (Nuclear Regulatory Commission)
    - Agreement State (e.g., TX Dept. of State Health Services Radiation Control Program)

Recommended References:

Cherry, et al. Physics in Nuclear Medicine, 3rd Edition, Philadelphia: Saunders, 2003

Bushberg, et al. The Essential Physics of Medical Imaging, 4th Edition, Philadelphia: Lippincott, Williams & Wilkins, 2021 (Nuclear Medicine and Radiation Protection sections and appendices)
Bailey, et al, Eds. Positron Emission Tomography: Basic Sciences, London: Springer, 2005 AAPM Report No.: 052: Quantitation of SPECT Performance (1995)

071: A Primer for Radioimmunotherapy and Radionuclide Therapy (2001) 096: The Measurement, Reporting, and

Management of Radiation Dose in CT (2008)

108: PET and PET/CT Shielding Requirements (2006)

126: PET/CT Acceptance Testing and Quality Assurance (2019)

144: Recommendations of the American Association of Physicists in Medicine on dosimetry, imaging, and quality assurance procedures for ^{90}Y microsphere brachytherapy in the treatment of hepatic malignancies (2011)

177: Acceptance Testing and Annual Physics Survey Recommendations for Gamma Camera, SPECT, and SPECT/CT Systems (2019)

181: The Selection, Use, Calibration, and Quality Assurance of Radionuclide Calibrators Used in Nuclear Medicine (2012)

204: Size-Specific Dose Estimates (SSDE) in Pediatric and Adult Body CT Examinations (2011)

220: Use of Water Equivalent Diameter for Calculating Patient Size and Size-Specific Dose Estimates (SSDE) in CT (2014)

293: Size-Specific Dose Estimate (SSDE) for Head CT (2019)

NEMA:
NU 1-20yy: Performance Measurements of Gamma Cameras
NU 2-20yy: Performance Measurements of Positron Emission Tomographs (PET) (yy = 07, 12, 15, 18, …)
SNMMI, ACR, NCRP, ICRP, IAEA NM/PET-related publications
Nuclear Regulatory Commission:
10 CFR 20 – Standards for Protection Against Radiation
10 CFR 35 – Medical Use of Byproduct Material NUREG 1556, Volume 9, Revision 3

- Appendix G - Model Procedures for Dose Calibrator Calibration
- Appendix K – General Radiation Monitoring Instrument Specifications and Survey Instrument Calibration Program
- Appendix U - Model Procedure for Release of Patients or Human Research Subjects Administered Radioactive Materials

Regulatory Guide 8.39 Rev. 1 – Release of Patients Administered Radioactive Materials

TX DSHS Radiation Control (TAC 25):
§289.201 General Provisions for Radioactive Material
§289.202 Standards for Protection Against Radiation from Radioactive Material
§289.226 Registration of Radiation Machine Use and Services
§289.227 Use of Radiation Machines in the Healing Arts
§289.231 General Provisions and Standards for Protection Against Machine-Produced Radiation
§289.256 Medical and Veterinary Use of Radioactive Material
§289.257 Packaging and Transportation of Radioactive Material
Regulatory Guide 3.1: Medical Use of Radioactive Material
Regulatory Guide 3.2: Broad Medical Use of Radioactive Materials
Regulatory Guide 5.9: Bioassay Requirements for I-125 and I-131

Early and Sodee. Principles and Practice of Nuclear Medicine, 2nd Edition, St. Louis: Mosby, 1995

Henkin, et al., Eds. Nuclear Medicine, 2nd Edition, St. Louis: Mosby, 2006

Wahl, Richard L. and Buchanan, Julia W. Principles and Practice of Positron Emission Tomography, Philadelphia: Lippincott, Williams & Wilkins, 2002

Evaluation Scheme:

IMAGING PHYSICS RESIDENCY PROGRAM FACULTY EVALUATION OF RESIDENT				
Resident name				
Rotation name	**NUCLEAR MEDICINE AND PET**			
Inclusive dates of rotation				
Faculty name				
Evaluation Criteria	**Not Competent**	**Marginally Competent/ Progressing Toward Full Competency**	**Fully Competent**	**Explanatory Notes**
Patient care	*(residents should provide information that is appropriate, accurate and relevant to diagnosis of health problems)*			
1. Performs annual compliance testing of a nuclear medicine gamma camera.				
2. Performs annual compliance testing of a positron emission tomography scanner.				
3. Performs QC tests and calibrations of nuclear medicine imaging systems, dose calibrators, and counting systems.				
4. Estimates patient and conceptus ionizing radiation doses and risk for nuclear medicine examinations and determines whether or not a medical event is reportable.				
5. Demonstrates a thorough understanding of internal radionuclide dose quantities and units, and performs organ dose calculations using the medical internal radiation dose (MIRD) method				
6. Is familiar with hot lab, radiopharmacy, radiation safety, protection procedures, and associated regulations.				
7. Calculates shielding for a nuclear medicine (including PET) facility.				
8. Demonstrates a thorough understanding of radionuclide therapy (dosimetric imaging, treatment planning, written directive, inpatient vs. outpatient, patient release regulations and calculations).				
9. Uses information technology to retrieve and store patient demographic, examination, and image information.				
Medical knowledge	*(residents should be knowledgeable, scholarly, and committed to lifelong learning)*			
10. Explains the complete nuclear medicine imaging chain from the ionizing radiation source to image reconstruction.				
11. Understands the use and characteristics of radionuclides for nuclear medicine and PET imaging, and therapy.				

12. Explains how uptake and clearance of radionuclides affects patient dose and benefits of examination.				
13. Is familiar with all common NM and PET exams				
14. Is familiar with computer analysis and quantification methods associated with NM and PET exams				
15. Uses information technology to investigate clinical, technical, and regulatory questions.				
Practice-based learning and improvement	*(residents should investigate and evaluate patient care practices, appraise and assimilate scientific evidence and improve patient care practices)*			
16. Analyzes results of testing and recognizes unexpected findings.				
17. Investigates equipment performance and image quality problems.				
18. Recognizes and corrects personal errors.				
Interpersonal and communication skills	*(residents should demonstrate effective information exchange with physicians, technologists, service personnel, and professional associates)*			
19. Works effectively with others as a member or leader of a health care team.				
20. Produces written reports that are accurate, concise, and grammatically correct.				
21. Presents technical information effectively to other residents,				
technologists, faculty, and other health care professionals.				
22. Listens effectively.				
Professionalism	*(residents should carry out responsibilities, adher to ethical principles and show sensitivity to a diverse patient population)*			
23. Responsive to the needs of patients that supersedes self-interest.				
24. Respects patient privacy and confidentiality.				
25. Commitment to excellence and ongoing professional development.				
Systems-based practice	*(residents should be aware of the system of health care and effectively call on system resources to provide optimal care)*			
26. Partners with managers and providers to assess, coordinate and improve health care.				
27. Understands how their professional practices affect other health care professionals.				
28. Utilizes system resources effectively to provide care that is of optimal value.				

MAGNETIC RESONANCE IMAGING

Rotation Title: Magnetic Resonance Imaging

Supervising Physicists: Chris Walker (Coordinator), John Hazle, Ping Hou, Ho-Ling Anthony Liu, Jingfei Ma, Thomas Nishino, Jason Stafford, Brian Taylor, Josh Yung

Duration: One month full-time for 2-yr residents and 1.5 months at 2/3 time for 3-yr fellows in both of the 2 rounds.

Rotation Objectives:

Round 1 Training Objectives

1. Have completed MRI Safety training and personnel screening. Approval from Employee Health for the resident to work in high magnetic fields must be received by program director prior to beginning the rotation.
2. Demonstrate understanding of MRI safety principles by working in a safe manner in MRI departments.
3. Demonstrate appropriate handling of MRI phantoms and RF coils to ensure proper operation and to avoid equipment damage or image artifacts.
4. With assistance, perform ACR large MRI phantom scan and data analysis, generate an accurate report and identify issues.
5. With assistance, perform daily MR QC scans and evaluate theresults.
6. Assist an MRI physicist with data collection for an annual system performance evaluation of at least two MRI scanners.
7. Assist an MRI physicist or physics technologist with RF coil testing for several coils of different designs and evaluate the results.
    a. Using vendor's automated coil QC procedure
    b. Using manual coil QC procedure
8. Observe troubleshooting for MR image quality or equipment performance issues.
9. Map the fringe field and assess MRI safety for an MRIdepartment.
10. Observe clinical image acquisition to become more familiar with MRI protocols and applications.

Round 2 Training Objectives

1. Complete an acceptance test report for a new MRI system and coils. If a new system is not installed during this time, compile a report for an annual test as if it was an acceptance test. Ensure that the report meets ACR accreditation requirements.
2. Be able to scan the large ACR MRI phantom independently, analyze the results, generate an accurate report and identify issues.
    a. GE MRI system
    b. Siemens MRI system
3. Be able to independently perform daily MR QC scans and dataanalysis.
4. While under supervision of an MRI physicist, but with minimal direction, acquire data for an annual or acceptance performance evaluation of at least two MRI scanners.
5. Acquire and analyze magnetic field homogeneity data using three different methods.
6. While under supervision of an MRI physicist or physics technologist, but withminimal direction, acquire RF coil QC data and analyze the results.
7. Assist with troubleshooting of MR image quality or equipment performanceissues.
8. Perform an MRI safety evaluation of an MRI department and generate a report.
9. Observe clinical MR image acquisition to become more familiar with advancedMRI applications.

List of Competencies:

By the end of the year 1 and year 2 clinical rotations, the resident is expected to master the following topics which are components of clinical competencies that will be evaluated by rotation faculty:

- Equipment and image formation
    - Requirements for an RFP
    - MRI system specifications
        - Scanner model configurations, advantages and disadvantages
            - Superconductor
            - Permanent magnet
            - Hybrid systems
    - System components and function
        - Describe components of an MRI system
        - Understand the function of each component
        - Be able to explain the advantages and disadvantages of 3T relative to 1.5T
        - Describe RF coils
            - Understand different coil designs
            - Clinical uses
            - Understand parallel imaging
                - Different methods
                - Advantages and disadvantages
                - Clinical applications
    - Imaging chain
        - Describe how 2D and 3D MR images are generated, from signal collection to image formation
        - Understand the role of k-space in MR imaging
        - Understand k-space filling methods, advantages and disadvantages
        - Understand MR image reconstruction
        - Understand MRI scan options
        - Understand methods of fat, silicone and fluid saturation
            - Frequency selective
            - Inversion recovery
            - Dixon
        - Describe methods of MR image post-processing
        - Define scan parameters and their impact on SNR, spatial resolution, contrast, scan time, artifacts and SAR
        - Describe pulse sequences and their variations
        - Be able to identify MR artifacts in clinical and phantom images
            - Describe possible causes
            - Describe methods of elimination or reduction
        - Describe contrast mechanisms
        - Be familiar with the information included in MR image DICOM metadata

- Quality Control/Quality Assurance
    - Acceptance testing
        - Be familiar with tests performed by the physicist and learn how to perform them
            - General system checks
                - Mechanical
                - Emergency systems
                - Auxiliary systems
            - MR Scanner system tests

- Magnetic field homogeneity
- Phase difference method
    1. Spectral peak method
    2. Bandwidth difference method
    - RF subsystem tests
    - Gradient subsystem tests
    - Gradient/RF subsystem tests
    - Global system tests
    - Advanced MR system tests
        1. Spectroscopy
        2. EPI
        3. DWI

- Periodic testing
    - Daily quality control
        - Tests performed
        - Phantoms
        - Data analysis
        - How to establish daily QC performance limits
        - Be able to acquire daily QC images and evaluate the results
    - Annual quality control
        - Tests performed
        - Phantoms
        - Data analysis
        - Understand pass/fail limits
        - Be able to acquire annual QC images and evaluate the results
        - Be able to perform RF coil QC tests, calculate SNR, ghosting, uniformity, assess images for artifacts
            - Volume coils
            - Phased array coils
            - Surface coils
    - Assist with troubleshooting MR image artifacts

- Facility Requirements
    - Siting and utilities
        - Vibration tests, temperature requirements, floor loading, power consumption, air conditioning, water cooling
        - Map the magnetic fringe field using a gaussmeter
        - Cryogens
        - Network connectivity
    - Shielding
        - Faraday cage (RF shielding)
        - Witness RF shield test performed by shield vendor
        - Understand shield performance requirements
    - Magnetic field shielding
        - Understand active and passive shielding
    - Layout/Floorplan
        - Scanner, computer room, operator console, coil storage
        - MRI safety considerations
        - Adjacent equipment
    - Auxiliary equipment
        - Be familiar with the auxiliary equipment needed for MRIscanners

- Safety
  - MRI safety policy
  - Be able to describe the design of an MRI department that meets ACR MRIsafety recommendations
    - MRI safety zone definitions (I through IV)
    - Signage
    - Access control
  - Patient screening
  - Employee screening
  - MRI safety training
    - Level 1
    - Level 2
  - Be familiar with hazards in an MRI department and relationship to field strength, scanner configuration, gradient performance, and protocol parameters
    - Projectile hazards
    - RF burns
      - Potential sources
      - Precautions
    - Specific absorption rate (SAR)
      - FDA limits
      - Calculation of SAR
    - B1+rms
    - Acoustic noise
    - Peripheral nerve stimulation
    - Implanted devices
      - How to determine device safety
      - Terminology (MRI safe, unsafe, conditional)
    - Quench
      - Potential hazards
      - How and when to initiate in an emergency situation
      - How to respond if a quench occurs
    - Contrast agent reactions
      - Nephrogenic systemic fibrosis
  - Gaussmeters
  - Patient screening
    - Underlying physical principles, operation
    - Map the 5 Gauss line for an MRI department
    - Perform an MRI safety evaluation of an MRI department and generate a report.

- Clinical operations
  - Examination
    - Understand the workflow in an MRI department
    - Patient preparation
    - Patient and coil positioning
  - Protocols
    - Be familiar with clinical MR protocols
    - Be familiar with basic protocol development and optimization
    - Understand how to modify protocols to optimize spatial accuracy
    - Contrast agents
      - Types of MRI contrast agents

        - Contrast mechanisms
        - Use in clinical MR imaging
        - Contraindications
    - Interpretation
        - Become familiar with physician interpretation of MR images
        - Develop an understanding of how MR images are used for interventional, surgical, and radiation treatment planning purposes

- Rules and Regulations
    - Standards of practice
        - Become familiar with the institutional policies and procedures for MRI
        - Become familiar with the recommendations from professional societies/organizations (AAPM, ISMRM, ACR) for MRI
    - Accreditation
        - Become familiar with MRI accreditation programs and their requirements
            - ACR MRI Accreditation Program (MRAP)
            - ACR Breast MRI Accreditation Program (BMRAP)
            - ICAMRL
    - Federal
        - Become familiar with FDA guidelines for MRI equipment safety
            - Field strength
            - Operator modes
            - dB/dt
            - Acoustic noise levels

Recommended References:

American College of Radiology (ACR). MRI Accreditation Program and Breast MRI Accreditation Program documents http:/www.acr.org/accreditation

American College of Radiology (ACR). MRI Quality Control Manual 2015. Reston, VA: ACR, 2015.

Bushberg, et al. The Essential Physics of Medical Imaging, 3rd Edition, Philadelphia: Lippincott, Williams & Wilkins, 2012 (Magnetic Resonance chapters and relevant appendices)

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Jackson, et al. AAPM Report no. 100: Acceptance Testing and Quality Assurance Procedures for Magnetic Resonance Imaging Facilities: Report of AAPM MR Subcommittee Task Group 1, 2010.

Kanal et al (2013). ACR guidance document on MR safe practices: 2013. JMRI: 37:501-530.

Bernstein MA, King Kevin F, Xiaohong Joe Zhou. Handbook of MRI Pulse Sequences. Elsevier Academic Press, Burlington, MA, 2004.

Chen HH, Boykin RD, Clarke GD, Gao JH, Roby JW 3rd. (2006). Routine testing of magnetic field homogeneity on clinical MRI systems. Med Phys 33(11):4299–4306.

Cowper SE (2008). Nephrogenic Systemic Fibrosis: An Overview. American College of Radiology, 5(1): 23-28.

Deshmane et al. (2012). Review: MR Physics for Clinicians: Parallel MR imaging. JMRI 36:55-72.

Drost DJ, Riddle WR, Clarke GD. (2002). Proton magnetic resonance spectroscopy in the brain: Report of AAPM MR Task Group #9. Medical Physics 29 (9): 2177-2197.

Le Bihan, et al (2006). Artifacts and pitfalls in diffusion MRI. JMRI 24:478-488.

Haacke EM, Brown RW, Thompson MR, Venkatesan R. Magnetic resonance imaging - physical principles and sequence design. Wiley-Liss, New York, 1999.

Price RP, Allison J, Massoth RJ, Clarke GD, Drost DJ (2002). Practical aspects of functional MRI: Report of AAPM NMR Task Group #8. Medical Physics 29(8):1892-1912.

Runge VM, Nitz WR, Schmeets SH, Schoenbert SO. Clinical 3T magnetic resonance. Thieme, New York, 2007.

Runge VM, Nitz WR, Schmeets SH, Faulkner WH, Desai NK. The physics of clinical MR taught through images. Thieme, New York, 2005.

www.fda.gov/MedicalDevices/Safety/AlertsandNotices/ucm135362.htm

www.fda.gov/MedicalDevices/DeviceRegulationandGuidance/GuidanceDocuments/ucm072686.htm

www.MRIsafety.com

Evaluation Scheme:

IMAGING PHYSICS RESIDENCY PROGRAM FACULTY EVALUATION OF RESIDENT				
Resident name				
Rotation name	**MAGNETIC RESONANCE IMAGING**			
Inclusive dates of rotation				
Faculty name				
Evaluation Criteria	**Not Competent**	**Marginally Competent**	**Fully Competent**	**Explanatory Notes**
Patient care	*(residents should provide information that is appropriate, accurate and relevant to diagnosis of health problems)*			
1. Performs annual testing of a magnetic resonance imaging system.				
2. Performs acceptance testing of a magnetic resonance imaging system.				
3. Performs daily quality control tests of a magnetic resonance imaging system.				
4. Performs quality control tests on RF coils.				
5. Acquires and analyzes phantom images with all other requirements of ACR MR accreditation program.				
6. Practices MR safety.				
7. Plans for siting of a magnetic resonance imaging system.				
8. Uses information technology to retrieve and store patient demographic, examination, and image information.				
Medical knowledge	*(residents should be knowledgeable, scholarly, and committed to lifelong learning)*			
9. Explains the complete magnetic resonance imaging chain from production of signal to image reconstruction.				
10. Explains the role of k-space mapping in MR imaging.				
11. Explains how specific pulse sequences affect contrast in MRI and diagnostic benefits of examination.				
12. Uses information technology to investigate clinical, technical, and regulatory questions.				
Practice-based learning and improvement	*(residents should investigate and evaluate patient care practices, appraise and assimilate scientific evidence and improve patient care practices)*			
13. Analyzes results of testing and recognizes unexpected findings including image artifacts.				
14. Investigates equipment performance and image quality problems.				
15. Recognizes and corrects personal errors.				
Interpersonal and communication skills	*(residents should demonstrate effective information exchange with physicians, technologists, service personnel, and professional associates)*			

16. Works effectively with others as a member or leader of a health care team.				
17. Produces written reports that are accurate, concise, and grammatically correct.				
18. Presents technical information effectively to other residents, technologists, faculty, and other health care professionals.				
19. Listens effectively.				
Professionalism	*(residents should carry out responsibilities, adhere to ethical principles and show sensitivity to a diverse patient population)*			
20. Responsive to the needs of patients that supersedes self-interest.				
21. Respects patient privacy and confidentiality.				
22. Commitment to excellence and ongoing professional development.				
Systems-based practice	*(residents should be aware of the system of health care and effectively call on system resources to provide optimal care)*			
23. Partners with managers and providers to assess, coordinate and improve health care.				
24. Understands how their professional practices affect other health care professionals.				
25. Utilizes system resources effectively to provide care that is of optimal value.				

ULTRASOUND

Rotation Title: Ultrasound

Supervising Physicists: Bill Geiser (Coordinator), Stafford, Geiser, Jones, Nishino, Yung, Walker

Duration: One month full-time for 2-yr residents and 1.5 months at 2/3 time for 3-yr fellows in both of the 2 rounds.

Rotation Objectives:

Round 1 Training Objectives

1. Observe annual or ACR US QC phantom image acquisition and system evaluation of an ultrasound system.
   2. Become familiar with ultrasound equipment operation by reviewing appropriate guidance documents, equipment manuals and references.
3. Handle ultrasound (US) phantoms and transducers in an appropriate manner to ensure proper operation to avoid equipment damage or image artifacts.
4. With assistance, perform annual or ACR US QC phantom image acquisition and system evaluation for at least 2 different vendor platforms.
5. Become familiar with the equipment performance parameters that are monitored as part of an US QC program.
6. Become familiar with the requirements for ACR ultrasound accreditation requirements.
7. Observe troubleshooting for US image quality or equipment performance issues.
8. Observe clinical image acquisition to become more familiar with US protocols and applications.

Round 2 Training Objectives:

1. Complete an acceptance test report for a new ultrasound system and transducers. If a new system is not installed during this time, compile a report for an annual test as if it was an acceptance test. Ensure that the report meets ACR accreditation requirements.
2. While under supervision of an ultrasound physicist or physics technologist, but with minimal guidance, perform an US system performance evaluation, analyze the results, generate an accurate report and identify issues of ultrasound systems and transducers of least 3 different manufacturers.
3. Perform monitor evaluation for an ultrasound system.
4. Assist a physicist or physics technologist with configuration of an ultrasound system for network communications (PACS, RIS).
5. Assist with troubleshooting of US image quality or equipment performance issues.
6. Observe clinical image acquisition to become more familiar with US protocols and applications.

List of Competencies:

By the end of the year 1 and year 2 clinical rotations, the resident is expected to master the following topics which are components of clinical competencies that will be evaluated by rotation faculty:

- Equipment and image formation
    - Requirements for an RFP
        - Ultrasound system and transducer specifications
            - Model configurations
            - Advantages and disadvantages

        - Clinical applications
    - System components and function
        - Describe components of an ultrasound system
        - Understand the function of each component
        - Describe ultrasound transducers
            - Different designs
            - Clinical uses
        - Understand the function of console controls
            - Frequency setting
            - Power
            - Gain
            - TGC
            - Depth
            - Focus/Depth of focus
            - Frame rate
            - FOV
            - Pulse repetition frequency
            - Zoom
    - Imaging chain
        - Describe how ultrasound images are generated, from beam formation tosignal collection and image formation
        - Understand the components of a transducer assembly
        - Understand ultrasound beam properties
            - Near field
            - Far field
        - Understand sound propagation through tissue
            - Transmission
            - Attenuation
            - Absorption
            - Reflection
            - Refraction
            - Scattering
            - Pressure, Intensity
            - Acoustic impedance contrast
            - Reflection coefficient
        - Understand ultrasound modes of operation and scan options
            - B mode
            - M mode
            - Duplex
            - Doppler
                - Continuous wave
                - Pulsed wave
                - Color
                - Power
            - 2D / 3D
            - Beam steering
            - Harmonic imaging
            - Spatial compounding
            - Spectral compounding
            - Coded excitation
            - Speckle reduction

- Fatty imaging
- Elastography

- Be able to identify US artifacts and sources of poor image quality in clinical and phantom images.
  - Drop out
  - Phase aberration
  - Refraction
  - Attenuation effects
  - Reverberation
  - Specular reflection
  - Mirror image artifact
  - Velocity aliasing
  - etc
- Describe contrast mechanisms
- Be familiar with the information included in US image DICOM metadata

- Quality Control/Quality Assurance
  - Acceptance testing
    - Be familiar with tests performed by the physicist and learn how to perform them
      - General system checks
        - Physical inspection
        - Network communication
      - Transducer tests
        - Uniformity
        - Depth of penetration
        - Caliper accuracy
        - Resolution
          1. Axial
          2. Lateral
          3. Azimuthal
        - Dead zone
        - Anechoic object imaging
        - Artifact assessment
      - Functionality/applications
        - Doppler
          - Power Doppler
          - Continuous Doppler
          - Color Doppler
          - Pulsed Doppler
  - Periodic testing
    - Quality control
      - Tests performed
      - Frequency
      - Phantoms
      - Data analysis
      - Understand pass/fail limits
      - Be able to acquire QC images and evaluate the results
      - Be able to perform US transducer QC tests for different types of transducers

        - Linear
        - Curvilinear
        - Phased array
        - Endocavitary
        - 1D, 1.5D, 2D, 3D arrays
    - Troubleshooting US image artifacts

- Facility Requirements
    - Siting and utilities
        - Overhead monitors
        - Network connectivity
    - Layout/Floorplan
        - US system, transducer storage
        - US safety considerations
        - Adjacent equipment
    - Auxiliary equipment
        - Be familiar with the auxiliary equipment needed for US imaging

- Safety
    - Be familiar with hazards in US imaging and relationship to equipment and acquisition parameters
        - Acoustic output
        - Mechanical index
        - Thermal indices
    - Be familiar with potential US imaging hazards to specific patient populations and anatomical regions
        - Obstetric
        - Neonatal
        - Opthalmic

- Clinical operations
    - Examination
        - Understand the workflow in an US department
        - Patient preparation
        - Patient and transducer positioning for various procedures
    - Protocols
        - Be familiar with clinical US protocols
        - Be familiar with basic protocol development and optimization
        - Contrast agents
            - Types of US contrast agents
            - Contrast mechanisms
            - Use in clinical ultrasound imaging
            - Contraindications
            - Restrictions of use in the United States
    - Interpretation
        - Become familiar with physician interpretation of US images
        - Develop an understanding of how US images are used for interventional, surgical, and radiation treatment planning purposes

- Rules and Regulations
    - Standards of practice

        - Become familiar with the institutional policies and procedures for US
        - Become familiar with the recommendations from professional societies/organizations (AAPM, AIUM, ACR, IEC, NEMA) for ultrasound
    - Accreditation
        - Become familiar with ultrasound accreditation programs and their requirements
            - American College of Radiology
                - US Accreditation Program
                - Breast US Accreditation Program
            - AUA/AIUM Ultrasound Accreditation for urology practices
            - Intersocietal Accreditation Commission
                - Vascular
                - Echocardiography
    - Federal
        - Become familiar with FDA guidelines for US equipment safety

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American Association of Physicists in Medicine Medical Physics Monograph No. 27: Accreditation Programs and the Medical Physicist, "Performance Testing of Ultrasound Equipment", 2001

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Feldman MK. US Artifacts. Radiographics 29: 1179-1189, 2009.

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Kremkau FW. Sonography, Principles and Instruments. 8th ed. St. Louis, MO: Elsevier Saunders, 2011.

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Evaluation Scheme:

IMAGING PHYSICS RESIDENCY PROGRAM FACULTY EVALUATION OF RESIDENT				
Resident name				
Rotation name	**ULTRASOUND**			
Inclusive dates of rotation				
Faculty name				
Evaluation Criteria	**Not Competent**	**Marginally Competent**	**Fully Competent**	**Explanatory Notes**
Patient care	*(residents should provide information that is appropriate, accurate and relevant to diagnosis of health problems)*			
1. Performs annual compliance testing of an ultrasound unit.				
2. Performs acceptance testing of an ultrasound unit.				
3. Performs periodic quality control tests of an ultrasound unit.				
4. Performs periodic quality control tests of an ultrasound transducer.				
5. Uses information technology to retrieve and store patient demographic, examination, and image information.				
Medical knowledge	*(residents should be knowledgeable, scholarly, and committed to lifelong learning)*			
6. Explains the complete ultrasound imaging chain from production of vibrations to image reconstruction.				
7. Explains the sources of contrast in ultrasound imaging.				
8. Explains how specifics of imaging protocol affect the diagnostic benefits of examination.				
9. Uses information technology to investigate clinical, technical, and regulatory questions.				
Practice-based learning and improvement	*(residents should investigate and evaluate patient care practices, appraise and assimilate scientific evidence and improve patient care practices)*			
10. Analyzes results of testing and recognizes unexpected findings including image artifacts.				
11. Investigates equipment performance and image quality problems.				
12. Recognizes and corrects personal errors.				
Interpersonal and communication skills	*(residents should demonstrate effective information exchange with physicians, technologists, service personnel, and professional associates)*			
13. Works effectively with others as a member or leader of a health care team.				
14. Produces written reports that are accurate, concise, and grammatically correct.				
15. Presents technical information effectively to other residents, technologists, faculty, and other health care professionals.				

16. Listens effectively.				
Professionalism	*(residents should carry out responsibilities, adhere to ethical principles and show sensitivity to a diverse patient population)*			
17. Responsive to the needs of patients that supersedes self-interest.				
18. Respects patient privacy and confidentiality.				
19. Commitment to excellence and ongoing professional development.				
Systems-based practice	*(residents should be aware of the system of health care and effectively call on system resources to provide optimal care)*			
20. Partners with managers and providers to assess, coordinate and improve health care.				
21. Understands how their professional practices affect other health care professionals.				
22. Utilizes system resources effectively to provide care that is of optimal value.				

BREAST IMAGING

Rotation Title: General Radiography

Supervising Physicists: Bill Geiser (Coordinator), Moiz Ahmad, Frank Dong, Xinming Liu

Duration: One month full-time for 2-yr residents and 1.5 months at 2/3 time for 3-yr fellows in both of the 2 rounds.

Rotation Objectives:

Round 1 Training Objectives

1. Demonstrate understanding of radiation safety principles by working in a safe manner in mammography and stereotactic breast biopsy departments.
2. Demonstrate understanding of MRI safety principles by working in a safe manner in MRI departments.
3. Demonstrate appropriate handling of phantoms, coils, transducers, and test equipment to ensure proper operation and to avoid equipment damage or image artifacts.
4. Under direct supervision of an MQSA-certified physicist, perform an annual system performance evaluation of at least ten mammography systems, evaluate the data, and complete the report.
5. Under direct supervision of an MQSA-certified physicist, perform an annual system performance evaluation of at least one stereotactic breast biopsy system, evaluate the data and complete the report.
6. Under direct supervision of an ultrasound physicist, perform an annual system performance evaluation of at least four breast ultrasound systems, evaluate the data and complete the reports.
7. Assist an MRI physicist with breast RF coil testing for several breast RF coils of different designs.
8. Assist with troubleshooting image quality or equipment performance issues.
9. Observe clinical image acquisition to become more familiar with clinical breast imaging and applications.

List of Competencies:

By the end of the year 1 and year 2 clinical rotations, the resident is expected to master the following topics which are components of clinical competencies that will be evaluated by rotation faculty:

- Equipment and image formation
    - Requirements for an RFP
        - Mammography system
        - Stereotactic breast biopsy system (SBB)
        - Breast ultrasound system
        - Breast MRI system / breast RF coils
    - System specifications
        - Scanner model configurations, advantages and disadvantages
    - System components and function
        - Describe components of a mammography system and the function of each component
            - Digital
            - Tomosynthesis
            - Identify the differences between an x-ray system used for general

radiography
        - Describe components of a stereotactic breast biopsy system and the function of each component
        - Describe components of a breast ultrasound system and the function of each component
            - Identify differences between systems and transducers used for breast ultrasound vs general ultrasound
        - Describe breast RF coils
            - Understand different coil designs

    - Imaging chain – mammography
        - Describe how mammography images are generated, from signal collection to image formation
        - Describe how tomographic images are generated, from signal collectionto image formation
        - Understand the target/filters used in mammography
            - Compare to general radiography/fluoroscopy/angiography
        - Become familiar with mammography detectors
            - Direct digital detectors
            - Indirect digital detectors
        - Describe methods of mammography image post-processing
        - Define acquisition parameters and their impact on SNR, spatial resolution, contrast, time, artifacts and dose
        - Describe acquisition modes available on a mammography system (auto filter, auto kVp, auto time, manual)
        - Be able to identify artifacts in clinical and phantom images
            - Describe possible causes
            - Describe methods of elimination or reduction
        - Describe contrast mechanisms
        - Be familiar with the information included in a mammography image DICOM metadata
    - Imaging chain – stereotactic breast biopsy
        - Describe how stereotactic breast biopsy images are generated, from signal collection to image formation
        - Understand the target/filters used
        - Define acquisition parameters and their impact on SNR, spatial resolution, contrast, time, artifacts and dose
        - Describe the stereotactic acquisition method
        - Be able to identify artifacts in clinical and phantom images
    - Imaging chain – breast ultrasound
        - See ultrasound program of study
    - Imaging chain – breast MRI
        - See MRI program of study

- Quality Control/Quality Assurance
    - Acceptance testing
        - Be familiar with tests performed by the physicist for mammography, stereotactic breast biopsy, breast ultrasound and breast RF coils and learn how to perform them
    - Periodic testing

        - Daily quality control (if applicable)
            - Tests performed, who performs them
            - Phantoms
            - Data analysis
            - How to establish daily QC performance limits
            - Be able to acquire daily QC images and evaluate the results
        - Weekly quality control (if applicable)
            - Tests performed, who performs them
            - Phantoms
            - Data analysis
            - How to establish QC performance limits
            - Be able to acquire weekly QC images and evaluate the results
        - Annual quality control
            - Tests performed
            - Phantoms
            - Data analysis
            - Understand pass/fail limits
            - Be able to acquire annual mammographic and stereotactic QC images and evaluate the results
            - Be able to perform breast US system and transducer tests
            - Be able to perform breast RF coil QC tests, calculate SNR, ghosting, uniformity, assess images for artifacts
        - Assist with troubleshooting image artifacts

- Facility Requirements
    - Siting and utilities
    - Shielding
        - Be able to calculate the shielding requirements for a mammography or stereotactic breast biopsy system
    - Magnetic field shielding (breast MRI)
        - See MRI program of study
    - Layout/Floorplan
        - Equipment location, computer room, storage
        - Safety considerations
        - Adjacent equipment
    - Auxiliary equipment
        - Be familiar with the auxiliary equipment needed

- Dose
    - Be able to measure exposure, HVL and calculate dose for mammographic, tomographic and stereotactic breast biopsy systems.
    - Measure, calculate and explain the principles of mammographic dosimetry.
    - Perform patient dose estimates/calculation

- Safety
    - Become familiar with relevant institutional safety policies
    - Be able to describe the design of a breast imaging department that meets safety requirements
        - Warning lights
        - Operator shield

- Protective devices
- Emergency buttons
- Collimation, activation, mechanical stability,etc
- Breast ultrasound safety – see Ultrasound Program of Study
- Breast MRI safety – see MRI Program ofStudy

- Clinical operations
  - Examination
    - Understand the workflow in a breast imaging department
      - Patient preparation
      - Patient positioning
      - Diagnostic
      - Screening
      - Biopsy guidance
      - "second look" ultrasound
      - When is breast MRI prescribed?
    - Technical factors (mammography,tomosynthesis, stereotactic breast biopsy)
      - kVp, mA, mAs, time
      - target/filter
      - SID
      - Grid
      - Magnification mode
      - Image receptor type
      - Digital image processing
  - Protocols
    - Be familiar with breast imaging protocols and options formammography, stereotactic breast biopsy, breast ultrasound and breast MRI.
    - Be familiar with basic protocol development and optimization.
  - Interpretation
    - Become familiar with identification of anatomy in breast images
    - Be able to identify artifacts on clinical breast images and explain thecause
    - Become familiar with physician interpretation of breast images
    - Understand the procedures for performing breast biopsy using imageguidance
      - Stereotactic breast biopsy
      - Upright stereo
      - Breast ultrasound
      - Breast MRI

- Rules and Regulations
  - Standards of practice
    - Become familiar with the institutional policies and procedures for breast imaging modalities
    - Become familiar with the recommendations from relevant professional societies/organizations
    - Become familiar with regulations/documentation associated with registration of X-ray producing devices at the state and federal levels
  - Accreditation
    - Become familiar with relevant accreditation programs and theirrequirements
      - ACR Mammography Accreditation Program

- ACR Stereotactic Breast Biopsy Accreditation Program
- ACR Breast Ultrasound Accreditation Program
- ACR Breast MRI Accreditation Program

- Federal
  - Become familiar with FDA/MQSA regulations
    - Physicist, technologist, radiologist training, continuing experience and continuing education requirements
    - Equipment performance tests and requirements
      - Frequency
      - Limits
      - Appropriate action if a test fails
    - Timeline for completing reports

Recommended References:

- **Mammography**

American College of Radiology (ACR). Mammography Quality Control Manual, Committee on Quality Assurance in Mammography, 1999.

American College of Radiology (ACR). Mammography Accreditation Program documents http:/www.acr.org/accreditation

Bushberg, et al. The Essential Physics of Medical Imaging, 3rd Edition, Philadelphia: Lippincott, Williams & Wilkins, 2012 (Mammography chapter and relevant appendices)

Butler, P. MQSA and Accreditation for Full-Field Digital Mammography. RSNA, 2007. http://www.acr.org/accreditation/mammography/rsna07presentation.aspx

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Considerations for Digital Mammographic Displays. RadioGraphics 25: 491-501, 2005.

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Sechopoulos, I. A review of breast tomosynthesis. Part II. Image reconstruction, processing and analysis, ad advanced applications. Medical Physics 40, 014302 (2013).

Sechopoulos, I. et al. Radiation dosimetry in digital breast tomosynthesis: Report of AAPM Tomosynthesis Subcommittee Task Group 223, Medical Physics 41(9): 2014.

Texas Department of State Health Services - Radiation Control Web Site for Mammography Rules - 25 TAC 289.230: http://www.dshs.state.tx.us/radiation/rules.shtm

Wu X, Breast dosimetry in screen film mammography: Barnes GT, Frey GD (eds), Screen Film Mammography: Imaging Considerations and Medical Physics Responsibilities, Medical Physics Publishing, Madison WI 1991; 159-175

Stereotactic Breast Biopsy

American College of Radiology (ACR). Stereotactic Breast Biopsy Quality Control Manual, Committee on Quality Assurance in Mammography, 1999.

American College of Radiology (ACR). Stereotactic Breast Biopsy Accreditation Program documents http:/www.acr.org/accreditation

Breast Ultrasound

American College of Radiology (ACR). Breast Ultrasound Accreditation Program documents http:/www.acr.org/accreditation

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Breast MRI

American College of Radiology (ACR). Breast MRI Accreditation Program documents http:/www.acr.org/accreditation

Harvey JA, et al. Breast MR imaging artifacts: how to recognize and fix them, RadioGraphics 27:S131-S145, 2007.

Evaluation Scheme:

IMAGING PHYSICS RESIDENCY PROGRAM FACULTY EVALUATION OF RESIDENT				
Resident name				
Rotation name	**MAMMOGRAPHY**			
Inclusive dates of rotation				
Faculty name				
Evaluation Criteria	**Not Competent**	**Marginally Competent**	**Fully Competent**	**Explanatory Notes**
Patient care	*(residents should provide information that is appropriate, accurate and relevant to diagnosis of health problems)*			
1. Performs annual compliance testing of a screen-film mammography unit.				
2. Performs annual compliance testing of a full-field digital mammography unit.				
3. Performs annual compliance testing of a stereotaxic biopsy mammography unit.				
4. Determines mean glandular dose for mammography examinations.				
5. Reviews technologist quality control records for mammography.				
6. Evaluates viewing conditions for mammography.				
7. Calculates shielding for a mammography room.				
8. Uses information technology to retrieve and store patient demographic, examination, and image information.				
Medical knowledge	*(residents should be knowledgeable, scholarly, and committed to lifelong learning)*			
9. Explains the complete mammographic imaging chain from production of X-rays to image formation.				
10. Explains the origin of radiographic contrast, mechanisms that compromise and enhance contrast.				
11. Explains methods of exposure control in mammography and the purposes of breast compression.				
12. Uses information technology to investigate clinical, technical, and regulatory questions.				
Practice-based learning and improvement	*(residents should investigate and evaluate patient care practices, appraise and assimilate scientific evidence and improve patient care practices)*			
13. Analyzes results of testing and recognizes unexpected findings.				
14. Investigates equipment performance and image quality problems.				
15. Recognizes and corrects personal errors.				

Interpersonal and communication skills	*(residents should demonstrate effective information exchange with physicians, technologists, service personnel, and professional associates)*			
16. Works effectively with others as a member or leader of a health care team.				
17. Produces written reports that are accurate, concise, and grammatically correct.				
18. Presents technical information effectively to other residents, technologists, faculty, and other health care professionals.				
19. Listens effectively.				
Professionalism	*(residents should carry out responsibilities, adhere to ethical principles and show sensitivity to a diverse patient population)*			
20. Responsive to the needs of patients that supersedes self-interest.				
21. Respects patient privacy and confidentiality.				
22. Commitment to excellence and ongoing professional development.				
Systems-based practice	*(residents should be aware of the system of health care and effectively call on system resources to provide optimal care)*			
23. Partners with managers and providers to assess, coordinate and improve health care.				
24. Understands how their professional practices affect other health care professionals.				
25. Utilizes system resources effectively to provide care that is of optimal value.				

IMAGING INFORMATICS

Rotation Title: Imaging Informatics

Supervising Physicists: Chris Walker (Coordinator), Thomas Nishino, Josh Yung

Duration: Duration: One month full-time for 2-yr residents and 1.5 months 2/3 time for 3-yr fellows

Rotation Objectives:

The resident is first introduced to the principles of Imaging Informatics in the Introductory Diagnostic Imaging Rotation course. The following objectives are accomplished during this initial experience:

- Understand the clinical use of PACS for patient image review.
- Understand the role of the Medical Physicist in the Imaging Informatics systems environment.
- Be familiar with the Unix Command Language.
- Be aware of the digital imaging and communications (DICOM) standard.
- Perform some simple DICOM procedures on Windows and Unix platforms.
- Be familiar with reading room design and ergonomics.

The resident builds on the initial experience through hands-on experience with the PACS team working on routine clinical informatics problems, including display monitor acceptance testing and QC, image availability, digital image quality problem reporting and troubleshooting, and repeat/reject analysis. The resident supplements incidental experiences with self-study.

List of Competencies:

By the end of this clinical rotation, the resident is responsible for proficiency in the following topics, which are components of clinical competencies that will be evaluated by rotation faculty.

- Equipment
    - Definitions and standards
        - PACS/RIS
        - DICOM conformance statement
        - IHE compliance and radiology profiles
        - Health Level 7 (HL7)
    - Specifications
        - Functional Specifications
        - Performance Specifications
    - System components and function
        - Identify and describe 4 classical subsystems of PACS
    - Imaging chain
        - Identify specific PACS processes that can compromise image quality, image availability, and patient radiation dose
        - Network architecture

- Open Systems Interconnection (OSI) Standard
- Network components, hub, bridge, router, switch,gateway
- Firewall and VPN
- Wireless connectivity and security

- Draw a process map (flowchart) identifying each task that must be accomplished to add a client to an existing medical imaging informatics system

- Quality Control/Quality Assurance
  - Acceptance testing
  - Periodic testing
    - Display devices for primary interpretation
    - Display devices for secondary interpretation
    - Test equipment
      - Luminance meters
      - Illuminance meters

    - Repeat/reject analysis
  - Troubleshooting
    - Identify and isolate common artifacts from electronic displays
    - Automated reporting of image quality and availability issues
- Facility Requirements
  - Siting and utilities
    - Network
    - HVAC
    - Controlled ambient lighting
    - Uninterruptible power supplies
    - Emergency power
  - Room Layout/Floorplan
    - Ergonomics
    - Auxiliary equipment
- Dose Reporting
  - Patient
    - Identify methods for dose reporting using information from DICOM headers
    - Radiation Dose Structured Reports (RDSR)
- Safety
  - Patient
    - Consequences of delay of diagnosis, loss of images, repeated examinations
    - Integrity and accuracy of displayed information (image and patient demographics)
- Clinical Operations
  - Examination
    - Modality Work List (MWL) management
    - Modality Performed Procedure Step (MPPS)
  - Interpretation
    - Hanging protocols
    - Speech recognition systems
    - VOI LUT
    - Presentation state

        - Image export
        - Image registration, fusion, segmentation, and processing
        - Display template
        - Workstation tools
            - Measurement
            - Annotation
            - Window/level adjustment
            - Pan and zoom
            - Stacked view
            - Image Enhancement
                - CLAHE
                - Median
                - Edge detection and enhancement
            - Cine
        - Computer-aided detection (CAD) and computer-aided diagnosis (CADx) systems
- Rules and Regulations
    - Standards of practice
        - ACR Practice Guidelines and Technical Standards
            - PACS, Teleradiology, and Archiving: ACR TECHNICAL STANDARD FOR ELECTRONIC PRACTICE OF MEDICAL IMAGING
            - Security: ACR–SIIM PRACTICE GUIDELINE FOR ELECTRONIC MEDICAL INFORMATION PRIVACY AND SECURITY
        - Certification mechanisms for PACS personnel
    - Accreditation
    - Federal
        - Health Insurance Portability and Accountability Act of 1996(HIPAA; Pub.L. 104-191, 110 Stat. 1936, enacted August 21, 1996).

Recommended References:

Samei E, Badano A, Chakraborty D, Compton K, Cornelius C, Corrigan K, Flynn MJ, Hemminger B, Hangiandreou N, Johnson J, Moxley M, Pavlicek W, Roehrig H, Rutz L, Shepard J, Uzenoff R, Wang J, Willis C. Assessment of Display Performance for Medical Imaging Systems, Report of the American Association of Physicists in Medicine (AAPM) Task Group 18, Medical Physics Publishing, Madison, WI, AAPM On-Line Report No. 03, April 2005.

Samei E, Badano A, Chakraborty D, Compton K, Cornelius C, Corrigan K, Flynn MJ, Hemminger B, Hangiandreou N, Johnson J, Moxley-Stevens DM, Pavlicek W, Roehrig H, Rutz L, Shepard J, Uzenoff RA, Wang J, Willis CE. Assessment of display performance for medical imaging systems: Executive summary of AAPM TG18 report. Medical Physics 32(4):1205-1225, 2005.

AAPM TG18 Assessment of Display Performance for Medical Imaging Systems
http://deckard.mc.duke.edu/~samei/tg18

DICOM Website http://medical.nema.org/
IHE Website http://www.ihe.net/

IHE General Information http://www.ihe.net/About/

http://www.comptechdoc.org/index.html

SIIM Website http://www.siimweb.org/

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Siegel EL and Kolodner RM eds. Filmless Radiology. Springer, New York, NY, 1999. 434 pp.

Liu Y and Wang J. PACS and Digital Medicine. Taylor and Francis, Boca Raton, FL. 2011. 333 pp.

Kagadis GC and Langer SG. Informatics in Medical Imaging. Taylor and Francis, Boca Raton, FL. 2012. 349 pp.

Seibert JA, Filipow LJ and Andriole KP. Practical Digital Imaging and PACS. AAPM Monograph No. 25. Medical Physics Publishing, Madison, WI. 1999. 577 pp.

Bushberg JT, Seibert JA, Leidholdt EM Jr, Boone, JM. Chapter 5. Medical Imaging Informatics. The Essential Physics of Medical Imaging. 3rd ed. Lippincott Williams and Wilkins, Philadelphia, PA. 2012. pp. 101-168.

Bushberg JT, Seibert JA, Leidholdt EM Jr, Boone, JM. Appendix B. Digital Computers. The Essential Physics of Medical Imaging. 3rd ed. Lippincott Williams and Wilkins, Philadelphia, PA. 2012. pp. 929-937.

Andriole KP. Chapter 8. Overview of Medical Imaging Informatics. In Advances in Medical Physics 2006. Vol 1. Walbarst AB, Karellas A, Krupinski EA and Hendee WR eds. Medical Physics Publishing, Madison, WI. 2006. pp. 201-228.

Samei E and Badano A. Chapter 2. Image Display Systems. In Advances in Medical Physics 2008. Vol 2. Walbarst AB, Karellas A, Krupinski EA and Hendee WR eds. Medical Physics Publishing, Madison, WI. 2008. pp. 19-30.

Krupinski EA. Chapter 7. Perceptual Optimization of Image Quality. In Advances in Medical Physics 2010. Vol 3. Walbarst AB, Karellas A, Krupinski EA and Hendee WR eds. Medical Physics Publishing, Madison, WI. 2010. pp. 113-123.

Kagadis GC, Langer SG, Sakellaropolis GC, Alexakos C, Nagy P. Chapter 10. Overview of Medical Imaging Informatics. In Advances in Medical Physics 2010. Vol 3. Walbarst AB, Karellas A, Krupinski EA and Hendee WR eds. Medical Physics Publishing, Madison, WI. 2010. pp. 159-172.

Evaluation Scheme:

IMAGING PHYSICS RESIDENCY PROGRAM FACULTY EVALUATION OF RESIDENT				
Resident name				
Rotation name	**Imaging Informatics**			
Inclusive dates of rotation				
Faculty name				
Evaluation Criteria	**Not Competent**	**Marginally Competent**	**Fully Competent**	**Explanatory Notes**
Patient care	*(residents should provide information that is appropriate, accurate and relevant to diagnosis of health problems)*			
1.Uses the DICOM standard toconfigure modality devices for PACS integration, to obtain information for quality control purposes, and to diagnose problems involving the storage and communication of medical images.				
2. Applies the IHE profiles to address department workflow improvements and to improve modality imaging operations.				
3. Uses open source software resources to address clinical medical physics problems.				
4. Assesses the display quality of imaging workstations used for primary interpretation and for secondary review.				
5. Adds a new diagnostic image acquisition client to an existing clinical imaging informatics system.				
6. Adds a new diagnostic display device to an existing clinical imaging informatics system.				
7. Adds a new diagnostic image acquisition client to an existing clinical imaging informatics system via a wireless connection.				

8. Uses information technology to retrieve and store patient demographic, examination, and image information.				
Medical knowledge	*(residents should be knowledgeable, scholarly, and committed to lifelong learning)*			
9. Understands the functions of Radiology Information Systems (RIS) as they pertain to ordering, tracking, and reporting images.				
10. Understands the human visual system (HVS), visual performance in diagnostic imaging tasks, and the statistical methods used to measure performance.				
11. Understands how image processing is used to create radiographic imagesfor display presentation, to depict 3D structures in CT and MR, and to augment interpretation with computer automated diagnosis (CAD).				
12. Uses information technology to investigate clinical, technical, and regulatory questions.				
Practice-based learning and improvement	*(residents should investigate and evaluate patient care practices, appraise and assimilate scientific evidence and improve patient care practices)*			
13. Analyzes results of testing and recognizes unexpected findings.				
14. Investigates equipment performance and image quality problems.				
15. Recognizes and corrects personal errors.				
Interpersonal and communication skills	*(residents should demonstrate effective information exchange with physicians, technologists, service personnel, and professional associates)*			
16. Works effectively with others as a member or leader of a health care team.				
17. Produces written reports that are accurate, concise, and grammatically correct.				

18. Presents technical information effectively to other residents, technologists, faculty, and other health care professionals.				
19. Listens effectively.				
Professionalism	*(residents should carry out responsibilities, adher to ethical principles and show sensitivity to a diverse patient population)*			
20. Responsive to the needs of patients that supercedes self-interest.				
21. Respects patient privacy and confidentiality.				
22. Commitment to excellence and ongoing professional development.				
Systems-based practice	*(residents should be aware of the system of health care and effectively call on system resources to provide optimal care)*			
23. Partners with managers and providers to assess, coordinate and improve health care.				
24. Understands how their professional practices affect other health care professionals.				
25. Utilizes system resources effectively to provide care that is of optimal value.				

EXTERNAL ROTATIONS

Rotation Title: External Rotations

Supervising Physicists: Frank Dong (Coordinator), Giles (HMH Coordinator), Ozus (HMH), Pahlka (TCH Coordinator), Feng (UTHealth Coordinator)

Duration: Duration: One month half-time per site and a total of three months (i.e., three sites) during the final year of residency.

Rotation Objectives:

The purpose of this program is to provide our imaging physics resident with direct clinical observation and experience with imaging procedures that are not routinely performed within MD Anderson Cancer Center. These procedures may include but are not limited to cardiac imaging, emergency radiology and community medicine, and pediatric radiology. The specific experiences depend on what clinical activities happen to be occurring at the site during the rotation. The rotation occurs at the end of the residency, so the resident can be expected to have already achieved full competency in all the imaging modalities.

Typical experiences obtained in the external rotations may include:

1. Cardiac Imaging: Activities may occur in different hospital settings under the direct supervision of diagnostic medical physicists or the radiation safety officer. Resident experiences may include, but are not limited to the following:
   - Observe a range of catheterization procedures
   - Observe intravascular radiation therapy for prevention of restenosis and assess radiation safety issues
   - Assist medical physicists with performance evaluation of cardiac catheterization labs
   - Review the performance test and quality control procedures for flat panel digital fluoroscopy systems
   - Review preventative maintenance and quality control programs of the catheterization labs by the Biomedical Engineering department
   - Review patient and staff doses in an adult cardiac catheterization laboratory
   - Observe the quality control procedures for cardiac SPECT cameras
   - Observe treadmill and pharmacologic myocardial perfusion stress testing
   - Review SPECT acquisition and processing options on various vendors' systems
   - Attend interpretation session with nuclear medicine physicians and cardiologists
   - Observe echocardiography studies on representative patients
   - Review patient and staff doses in cardiovascular nuclear medicine
   - Observe diagnostic and interventional pediatric cardiology catheterization procedures
   - Review patient and staff doses in a pediatric cardiac catheterization laboratory
   - Observe pediatric gamma camera quality control and representative cardiac nuclear medicine procedures
   - Review pediatric cardiac patient radiopharmaceuticals' dosages and absorbed doses

2. Emergency Radiology and Community Medicine: The resident will receive first-hand experience with medical physics practice in a community medicine environment including emergency room. Resident experiences may include, but are not limited to the following:
   - Observe imaging procedures and protocols in emergency radiology
   - Assist with testing of radiographic and fluoroscopic systems
   - Assist with surveys of imaging equipment including assistance with ACR Accreditation of CT, MRI, and Nuclear Medicine

- Assist with MQSA testing of mammography systems
- Perform calculations of fetal dose for pregnant patients
- Review personnel dosimeter reports and become familiar with Radiation Safety Officer reports
- Assess shielding design
- Observe radiology faculty and staff meetings
- Participate in routine quality control and troubleshooting of digital radiography equipment.
- Participate in board review study sessions with Radiology Residents.

3. Pediatric Radiology: The resident will obtain direct clinical observation and experience with radiologic imaging procedures in a specialized segregated pediatric imaging section. In addition to participating in imaging physics duties under the direct supervision of the medical physicists at the rotation site, the resident may have opportunities to observe the following procedures and discussing their considerations in pediatric radiology:
   - Interventional radiology in pediatric patients and consideration of radiation safety
   - Diagnostic and therapeutic nuclear medicine procedures in pediatric patients
   - Fluoroscopy procedures and technique adjustments for pediatric patients
   - Scoliosis radiography exam and technical considerations
   - General radiography considerations: techniques, immobilization methods
   - Bedside radiography of pediatric patients
   - Image quality and QA considerations in pediatric radiology

List of Competencies:

The resident is expected to broaden her/his knowledge and skills on general topics outlined in the following after the external rotations. The residents should be able to enhance their ability to address these topics for wider varieties in hospital environment, radiology practice, medical physics practice, and vendor/model of each imaging modality.

- Equipment
  - Definition of requirements for an RFP
  - Specifications
  - System components and function
  - Imaging chain
- Quality Control/Quality Assurance
  - Acceptance testing
  - Periodic Testing
  - Routine quality control
  - Troubleshooting
- Facility Requirements
  - Shielding
  - Siting
  - Layout/Floorplan
  - Utilities
  - Auxiliary equipment
- Dosimetry
  - Patient
  - Fetal

    - Operator
    - General public
- Safety (Radiation, MRI, others)
    - Patient
    - Operator
    - General Public
- Clinical Operations
    - Protocol
    - Examination
    - Interpretation
- Rules and Regulations
    - Standards of practice
    - Accreditation
    - Federal
    - State

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http://www.pedrad.org/associations/5364/ig/

Evaluation Scheme:

EVALUATION OF MD ANDERSON IMAGING PHYSICS RESIDENT

Resident Name:
External Rotation Site/Hospital:
Period of Rotation:
Evaluator:
Date of Evaluation:

Instructions: Please evaluate the trainee using these for ratings: Outstanding, Very Good, Satisfactory, Unsatisfactory, "outstanding" represents a relatively strong positive response, while "Unsatisfactory" represents a relatively strong negative response.

	Very Strong	Somewhat Strong	Not Very Strong	Not at all
Technical knowledge and ability to apply it	☐	☐	☐	☐
Analytical skills and systematic reasoning	☐	☐	☐	☐
Technical and manual skills	☐	☐	☐	☐
Intelligence- Ability to integrate information	☐	☐	☐	☐
Intellectual curiosity	☐	☐	☐	☐
Judgment	☐	☐	☐	☐
Productivity	☐	☐	☐	☐
Originality	☐	☐	☐	☐
Clear and organized	☐	☐	☐	☐
Research interest and ability	☐	☐	☐	☐
Accuracy and completeness of duties	☐	☐	☐	☐
Enthusiasm	☐	☐	☐	☐
Initiative and motivation	☐	☐	☐	☐
Integrity and reliability	☐	☐	☐	☐
Cooperation	☐	☐	☐	☐
Poise, tactfulness and courtesy	☐	☐	☐	☐
Professional character, ethical attitude toward physicians and other health professionals	☐	☐	☐	☐
Emotional stability, self-control	☐	☐	☐	☐
Communication skills:				
Oral	☐	☐	☐	☐
Written	☐	☐	☐	☐
Leadership potential	☐	☐	☐	☐

Evaluation of Imaging Physics Resident **Resident Name:** _____

	Very Strong	Somewhat Strong	Not Very Strong	Not at all
How strongly would you recommend that:				
His/her training be continued?	☐	☐	☐	☐
The trainee be granted a certificate?	☐	☐	☐	☐
This trainee be considered for employment in this department?	☐	☐	☐	☐
This trainee be considered for employment elsewhere?	☐	☐	☐	☐

Comments:

_____

_____

_____

Any further didactic coursework required to enhance his/her clinical training?	☐	☐	☐	☐

Comments:

_____

_____

_____

Overall Comments:

_____

_____

_____

Signature: _____ **Date:** _____

Site Coordinator