

Resident Core Curriculum Body MRI

General Goals: The goals include objectives required for every level of training with graduated levels of supervision and responsibility. All aspects of abdominal and pelvic imaging are incorporated into the residency with a focus on MR imaging and diagnosis of the liver, pancreas, kidneys, adrenal glands, biliary system, female and male pelvis, mediastinum and brachial plexus (the last 2 covered in thoracic rotations). During every training rotation, the resident will read the required literature and study the teaching file in Body Imaging. Over time, the resident will become progressively more knowledgeable about normal MR imaging anatomy, physiology of abdominal and pelvic organs, and the MR appearances of abdominal diseases. In addition, the resident will demonstrate a progressively increasingly understanding of disease entities, their clinical presentations, and current modes of treatment.

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

1. Residents assigned to body imaging will be available for consultations by MRI technologists, clinicians, and other health care providers, except during conference times, when a fellow or faculty member will cover.
2. Resident questions will be referred to the supervising faculty covering body imaging.
3. Resident review of cases with the supervising faculty will be conducted as many times in the day as necessary to keep an efficient workflow.
4. All resident examinations will be dictated by the end of every working day.
5. Residents will check and sign his/her reports prior to final verification by supervising faculty.
6. Residents must be familiar with the operation of all MRI equipment.
7. Residents will learn the MRI techniques for performing high quality, state-of-the art diagnostic examinations throughout the body, but especially liver, pancreas, kidneys, adrenal glands, biliary system, female and male pelvis, mediastinum and brachial plexus. Examinations will be checked before the patient leaves the department if requested to do so by the supervising faculty.
9. Residents must become proficient at detecting abnormalities demonstrated by the MRI and able to generate meaningful differential diagnosis.
10. Residents will become knowledgeable about the use of different MRI contrast agents (including their indications, contraindications, dosages and side effects).
11. Residents will acquire an understanding of the proper preparation of patients for examinations and appropriate follow-up afterward. At the start of every working day, the resident will be familiar with the patient schedule. The resident will assist the fellow in protocoling studies off the respective EPIC list. Absent clinical indication or seemingly inappropriate requests will be clarified and discussed with the referring physician. The goal is to clear both in- and outpatient lists at the end of each day. Primary responsibility for this however, remains with the fellow.

12. Residents will do in-depth reading and study, along with a review of teaching file cases, to become knowledgeable about the normal anatomy and physiology of abdominal organs and the MRI appearances of diseases, and gain a general understanding of the disease entities, their clinical presentations, and certain modes of treatment.
13. Residents will serve as a secondary consultant to referring physicians. This will strengthen the confidence of the resident in the very important role every radiologist must perform throughout his/her career as a consultant to clinicians.
14. Residents will become prepared to pass the core examinations of the American Board of Radiology.
15. Residents will teach and share knowledge with medical students, radiologic technologist students, and junior residents.
16. Residents will participate in the preparation and presentation of imaging studies at the weekly Body Imaging Conference.

Supervising Faculty Responsibilities:

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

Educational Goals and Objectives (Second Year Residents):

Patient Care and Technical Skills:

PCTS1: Consultant

- Familiarity with available medical records and how to access them for the purposes of patient care
- Demonstrate knowledge of ACR practice guidelines and technical standards for body MRI

PCTS2: Competence in Procedures

- Familiarity with the operation of MRI equipment
- Develop knowledge of the preparation for the imaging study
- Understand the MRI physics and how this relates to the various pulse sequence techniques
- Learn the basic physics of MR as well as various MRI pulse sequence techniques and (surface) coils so that differences in tissue contrast related to the various pulse sequence techniques is understood
- Obtain consent when needed for the study and answer all questions the patient may have
- Improve skills for performing MR imaging studies and tailor examinations to answer all questions being asked by the clinician; anticipate those questions that should have been asked but were not
- Observe and learn the techniques to achieve high-quality diagnostic examinations

Medical Knowledge:

MK1: Protocol Selection and Optimization of Images

- Recommend the appropriate study based on the clinical scenario
- Understand the specific problems associated with MR body imaging such as cardiac and respiratory motion, and flow artifacts
- Protocol cases, in consultation with the attending, to assure that MR imaging study is appropriate and of sufficient quality to address the clinical concerns of the patient and referring physician
- Demonstrate knowledge of indications for the examinations requested (when the reason for the examination is not clear, the resident will effectively communicate with the patient and referring physician until clarified)
- Demonstrate the ability to recommend additional imaging studies as appropriate to better assess findings on MR imaging studies
- Explain the impact of the radiology findings on patient care, including what imaging studies may/may not be appropriate

MK2: Interpretation of Examinations

- Familiarity with the anatomy of the organs examined in every case
- Familiarity with imaging findings of common acute and chronic diseases evaluated with MRI
- Identify pathology in order to interpret routine MR imaging studies with accuracy appropriate to the level of training when presenting to the attending
- Distinguish between normal and abnormal body anatomy as demonstrated on MR studies to level of training when presenting to the attending
- Detect abnormalities while the MR imaging studies are in progress, such as 1) disease recognition skills will continue to increase, and 2) begin to develop meaningful differential diagnoses for the pathology that is found
- Recognize the more common abnormalities encountered
- Develop knowledge of the differential diagnoses of the more commonly encountered abnormalities
- Demonstrate the ability to recognize and describe common medical conditions depicted on MR imaging studies
- Review all studies with the supervising faculty attending

Systems-Based Practice:

SBP1: Quality Improvement (QI)

- Familiarity with departmental procedures, contrast safety, and sedation required in the performance of examinations
- Make suggestions to improve methods and systems utilized in radiology whenever appropriate

SBP2: Health Care Economics

- Demonstrate knowledge of ACR appropriateness criteria and cost-effective imaging evaluations
- Show ability to interact with clinicians regarding cost effective and streamlined evaluation for differing clinical entities

Practice-Based Learning and Improvement:

PBLI1: Patient Safety; Contrast Agents; Radiation Safety; MR Safety; Sedation

- Become knowledgeable about the different contrast agents available and begin to recognize abnormalities that are demonstrated by MRI
- List the risk factors for allergic reaction to intravenous contrast media
- State the proper assessment and treatment for allergic reactions to contrast media
- Understand the indications for and contraindications to use of intravenous radiographic contrast material, and be able to monitor its administration
- Recognize and treat reactions to intravenous contrast material
- Understand the indications and contraindications to the different types of contrast material, dosages, side effects, and the differences and relative merits of contrast studies

PBLI2: Self-Directed Learning

- Identify, rectify and learn from personal errors
- Incorporate feedback into improved performance
- Demonstrate evidence of independent reading and learning through use of printed and electronic resources
- Research interesting cases as directed by faculty
- Demonstrate appropriate follow up of interesting cases
- Follow up on abnormal or interesting cases through personal communication with the referring physician or patient medical records
- Able and willing to participate in clinical conferences in which imaging studies are used to guide patient care/evaluations and be able to demonstrate understanding of how imaging relates to the clinical care of the patient

Professionalism:

PROF1: Professional Values and Ethics

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

Interpersonal and Communication Skills:

ICS1: Effective Communication with Patients, Families, and Caregivers

- Appropriately obtain informed consent
- Communicate with the patient at all times during the examination to ensure that patient remains comfortable
- Explain the nature of the examination or findings in an examination to patients and their families when needed
- Adequately explain each examination to the patient in order to ensure that the patient feels comfortable and to provide patient care that is compassionate, appropriate, and effective

ICS2: Effective Communication with Members of the Health Care Team

- Communicate effectively with all members of the healthcare team (technologists, medical students, fellows, residents, allied health providers, support staff, and attending physicians/radiologists)
- Communicate effectively the results of studies to referring clinicians whenever needed (for emergent studies, this will be accomplished in a timely manner)
- Effectively convey the findings of examinations through accurate dictation of reports
- Interact with clinicians when reviewing cases involving MR imaging studies and show ability to provide preliminary readings, follow up with attending radiologists, formulate a plan of complex cases, and communicate any changes to referring clinicians
- Produce concise reports that include all relevant information
- Thorough dictations will be made with indications, techniques, findings, and conclusions
- Provide preliminary reports to all referring clinicians if needed before the final review of cases (when there is a significant discrepancy between the preliminary reading and final reading, the resident will notify the referring clinician immediately)
- Use appropriate language in communicating to clinicians through reports or consultations so proper management decisions can be made
- Dictate and correct reports in a timely fashion to avoid delay in patient disposition
- Competent in using PACS, voice recognition systems, and hospital and patient information systems in the daily accomplishment of the workload and instruct others in their use. Become proficient in dictating reports of significant findings in a concise and clear manner

Monitoring and Assessment of Resident Performance

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

Educational Goals and Objectives (Third & Fourth Year Residents):

The above 2nd Year objectives as well as the following:

Patient Care and Technical Skills:

PCTS1: Consultant

- Demonstrate knowledge of ACR practice guidelines and technical standards for MR imaging studies
- Familiarity with available medical records and how to access them for the purposes of patient care
- Act as a consultant to the clinical services

PCTS2: Competence in Procedures

- Refine diagnostic examination techniques and be very skilled and efficient in performing and interpreting all diagnostic and interventional procedures performed
- Know the proper preparation of patients for diagnostic procedures and the appropriate follow-up afterwards

Medical Knowledge:

MK1: Protocol Selection and Optimization of Images

- Understand the clinical management of the conditions encountered
- Obtain a broad understanding of diseases, their clinical features, MRI manifestations, and current modes of treatment
- Demonstrate knowledge of indications for the examinations requested (when the reason for the examination is not clear, the resident will effectively communicate with the patient or referring physician until clarified)
- Protocol cases, in consultation with the attending, to assure that the MRI examination is appropriate and of sufficient quality to address the clinical concerns of the patient and referring physician

MK2: Interpretation of Examinations

- Develop a thorough knowledge of the differential diagnosis of abnormalities encountered on body MRI studies
- Develop a thorough knowledge of the differential diagnosis of body MRI abnormalities
- Relate the imaging findings to the clinical condition and its pathology
- Familiarity with the anatomy of the organs examined in every case
- Familiarity with imaging findings of common acute and chronic diseases evaluated with MRI
- Identify pathology in order to interpret MR imaging studies with accuracy appropriate to the level of training when presenting to the attending
- Distinguish between normal and abnormal body anatomy with excellent accuracy according to the level of training when presenting to the attending and demonstrate improvement compared to the prior rotation
- Proficient in detecting abnormalities on MR imaging studies while in progress
- Development of appropriate differential diagnostic lists will be well advanced
- Thorough knowledge of studies related the chest, abdomen, liver, kidneys, and pelvis

- Review all studies with the supervising faculty attending

Systems-Based Practice:

SBP1: Quality Improvement (QI)

- Familiarity with departmental procedures, contrast material safety, and sedation required in the performance of examinations
- Make suggestions to improve methods and systems utilized in radiology whenever appropriate

SBP2: Health Care Economics

- Demonstrate knowledge of ACR appropriateness criteria and cost effective imaging practices

Practice-Based Learning and Improvement:

PBLI2: Self-Directed Learning

- Recognize the role that body MRI plays in the management of acute and chronic diseases
- Follow up on abnormal or interesting cases through personal communication with the referring physician or patient medical records
- Identify, rectify, and learn from personal errors
- Incorporate feedback into improve performance
- Demonstrate evidence of independent reading and learning through use of printed and electronic resources
- Complete final preparations to pass the certifying examination of the American Board of Radiology

Professionalism:

PROF1: Professional Values and Ethics

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

Interpersonal Skills:

ICS1: Effective Communication with Patients, Families, and Caregivers

- Explain the nature of the examination of findings in an examination to patients and their families when needed
- Appropriately communicate results to patients and clinicians whenever needed (for emergent studies, this will be done in a timely manner)

ICS2: Effective Communication with Members of the Health Care Team

- Produce concise reports that include all relevant information and be able to effectively convey the findings of examinations through accurate dictation of reports
- Communicate effectively with all members of the healthcare team

- Assist with supervision and teaching of medical and radiology technologist students
- Provide preliminary reports to all referring clinicians if needed before the final review of cases (when there is a significant discrepancy between the preliminary reading and final reading, the resident will notify the referring clinician immediately)
- Produce thorough dictations with indications, techniques, findings, and conclusions
- Dictate and correct reports in a timely fashion to avoid delay in patient disposition
- Use appropriate language in communicating to clinicians through reports or consultations so proper management decisions can be made
- Competent in using PACS, voice recognition systems, and the hospital patient information systems in the daily accomplishment of the workload and instruct others in their use

Monitoring and Assessment of Resident Performance

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

Reading List for all Years

1. William E Brant and Eduard E. de Lange. *MRI: Essentials of Body MRI*. Oxford University Press, 2012.
2. Fundamentals of Body MRI (Christopher Roth)
3. e-mri.org (<http://www.imaios.com/en/e-Courses/e-MRI>)

Other Requirements/Expectations

Body MRI Teaching File

An important element in the resident's development of interpretative skills will be the review of multiple cases from the body MR teaching file. It is our goal that the residents on this service actively review these cases during the working day when they are not involved with current examinations. These cases will be made available for independent review. In addition, whenever possible, the attendings will also review as many cases as possible with each resident on the service. The residents are encouraged to discuss the individual cases with the attending. The residents are also required to assist in preparing suitable cases for the MR teaching file.

Supplemental Reading and Lectures

It is well recognized that MR physics is rather difficult to comprehend. However, there is sufficient literature that teaches MR physics effectively, and a list of basic reading is attached. In addition, most of the books regarding clinical MR imaging usually contain chapters on MR physics. Furthermore, UVA clinical and research faculty offer an annual course on MR physics. The physicists have agreed to also be available for additional teaching of the individual resident during his/her rotation in body MRI.

Core Knowledge Presentation Topics

Magnetic fields

Magnets, direction characteristics, field strength, field gradients, magnetic resonance process, resonant (Larmor) frequency, field strength, chemical shift.

Tissue brightness and contrast

Determination by RF signal intensity, relation to tissue characteristics, photon density, magnetic relaxation rates (T1 and T2), flow, imaging methods.

The acquisition process

The imaging cycle, cycle duration (TR), number of cycles, averaging, acquisition time.

Tissue magnetization and image contrast

Vector representation, nuclear (proton) concentration, proton density image contrast, longitudinal magnetization, growth characteristics (relaxation/recovery), relaxation time (T1), T1 contrast, transverse magnetization, decay characteristics (relaxation), relaxation time (T2), T2 image contrast.

Radiofrequency pulses and signals

Pulse characteristics, flip angle, spin echo, gradient-echo dephasing and rephasing, echo time (TE), multi-echo imaging, inversion recovery, fast imaging.

Image types

Proton density weighted, T1-weighted, T2-weighted, flow imaging, flow related enhancement, flow related intensity reduction.

Image detail and noise

Voxel size, slice thickness, matrix size, field-of-view (FOV) noise.

Spatial characteristics of magnetic resonance imaging

Gradients, coils, slice selection, slice orientation, slice profile, selected excitation, slice thickness, phase encoding, frequency encoding, image reconstruction, 3D imaging.

Motion reduction techniques

Cardiac triggering, pulse triggering, respiratory triggering, gradient moment nulling rephasing/dephasing, multi-averaging, presaturation pulses.

MRI of the body

Bile ducts, liver, pancreas, pancreatic duct, spleen, retroperitoneum, adrenal glands, kidneys, female pelvis, obstetrics, male pelvis and bladder, rectum, scrotum and testes,, MRCP, MRA, mediastinum and lung.