The High Yield Guide to Radiology Rotations for Medical Students

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High Yield General Rotation Advice

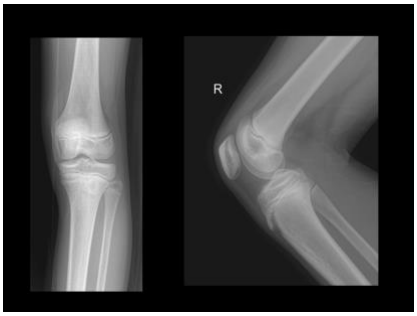
Beginning your rotation can be tough as the radiology sphere is quite different from your core clinical rotations. As a medical student your role is to observe as you watch the radiologist or radiology resident read through imaging studies. The goal of this guide is to provide clear, concise, and valuable (aka High Yield) advice on how to succeed on your radiology rotation.

There are various sections throughout this guide that provide specific information dependent on the body region you are rotating through (i.e. neuroradiology, breast, cardiothoracic, etc.). The beginning of this guide serves as a general overview of how to conduct yourself in the reading room to find the balance between intrigue and interruption. Radiology is incredibly mentally taxing so finding the balance as an observer in the reading room is pertinent to make a good impression and not impede the work of the radiologist.

"One View is No View"

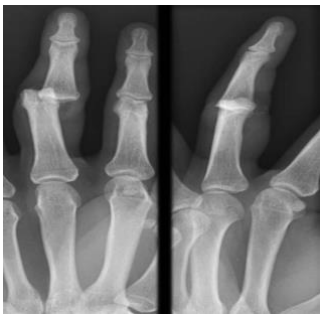
One view may seem sufficient for obvious diagnoses, however there are many circumstances where it is crucial to have multiple views. For instance, some pathologies may only be detectable in one plane and not the other (A and B). Furthermore, multiple views are utilized for taking measurements in three-dimensions for diagnosis, monitoring disease progression or regression, and treatment planning (C). Don't forget to also consider the provided patient presentation and history when reading through cases on your rotations!

(A) Osgood-Schlatter disease



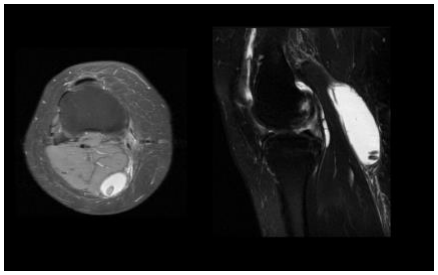
Case courtesy of Mostafa Elfeky
Radiopaedia.org, rID: 178714

(B) Finger subluxation



Case courtesy of Frank Gaillard
Radiopaedia.org, rID: 9154

(C) Baker cyst measurement



Case courtesy of RobertoSchubert
Radiopaedia.org, rID: 18675

Read Outs and Didactics

Generally, your radiology rotation will follow a similar hierarchy to other rotations. You will be paired with a junior radiology resident (PGY-2 or 3) with whom you will spend most of your time. This time with the resident is supplemented with daily didactic training about specific imaging considerations, medical physics, and subspecialty-specific topics. Depending on the attending or the institution, there will be a "*Read Out*" at different times throughout the day. A *Read Out* typically involves you and the resident going to the attending radiologist's workstation to review studies that the resident has read independently to create a preliminary report. Depending on the experience level of the resident or the attending's preference, the attending will then correct the preliminary read on their station or request the resident to edit the report themselves at the resident's workstation. This is often paired with targeted teaching points surrounding relevant pathology, modality, or findings pertinent to reading such exams. Always let the resident answer first and only answer a question if asked. Often, the more senior the resident, the less frequent formal *Read Outs* occur.

The Search Pattern

One thing that will come up frequently throughout your rotation is the integration of a search pattern when approaching radiographic images. Everyone has different search patterns; this is something that you as a student will develop on rotation, and it will take time. Taking time to understand each of your preceptors' search patterns can really help develop your own pattern for each imaging subspecialty. You can observe the same things that your preceptor does at the same time and understand how they evaluate different pieces of information. You can directly ask your resident or attending prior to, or before beginning their search so you can practice implementing the pattern and keep up. Additionally, there are some great videos on YouTube that cover example search patterns for most exams you will encounter throughout your rotation that are worthwhile to watch.

When to Ask Questions

Knowing when to ask questions during rotations is a subjective topic, and there is typically not a "one size fits all" approach. Your rotation in the reading room can be incredibly nuanced in the approach to asking questions. Just as you would not interrupt an attending or resident giving a report during rounds, you do not want to interrupt the attending or resident radiologist performing their clinical duty to read. Knowing how to read a room is imperative in discerning the appropriate times to ask questions. You likely will have to gauge if your preceptor is open to receiving questions. You should typically limit your questions to one per intensive study (CT, MRI, etc.), and one question for every two-to-three less intensive studies (x-ray or fluoroscopy).

Imaging Terminology by Modality

The following is incredibly high yield for medical students as they orient themselves to the basics. This terminology will allow you to communicate questions to radiologists more effectively.

Image Modality	Dark	Bright
X-ray / Fluoro(scopy)	Radiolucent (Lucent)	Radiopaque (Opaque)
Computed Tomography (CT)	Hypodense / Low Attenuation	Hyperdense / High Attenuation
Ultrasound	Hypoechoic / Low Echogenicity / Anechoic (entirely black)	Hyperechoic / High Echogenicity
Magnetic Resonance Imaging (MRI)	Low Signal / Hypointense	High Signal / Hyperintense

Expectations for Outstanding Performance

Not too much is expected during these rotations as they are largely observatorships. However, professionalism goes a long way. As always, show up early, ask informed questions, interact positively with all the staff (technicians, medical students, residents, and attendings), and above all else, do NOT fall asleep! Also, if you are told to go home, go home. Most residents and attendings cannot focus fully with a student present but usually are happy to teach during the designated time. Specific tips for outstanding performance will be outlined based on specific imaging subspecialties in later sections.

Resources

- Learning Radiology: Recognizing the Basics by Dr. William Herring
  - Textbook
    - Fantastic book outlining basics of radiology and interpretation.
  - Website
    - Supplemental cases to the book by the same name.
- YouTube MedEdPage channel by Dr. Omer Awan
  - Phenomenal resources on various aspects of medicine and radiology. “Match and Residency Tips” playlist offers tips for excelling in rotations.
- Search Patterns YouTube Channel
  - Organized by imaging modality and body area.

Basics of Imaging Studies (X-Ray, CT, US, MRI)

X-Ray Basics

X-rays commonly include plain films of the skeletal system. Conventional radiography has five basic densities. From least to most dense: air, fat, soft tissue/fluid, calcium, and metal. X-ray is considered inexpensive, low-risk, and is easily accessible due to portable machines. Limitations of x-ray include diminished range of densities to detect, exposure to ionizing radiation, and variable sensitivity for certain pathologies.

Chest X-ray (CXR)

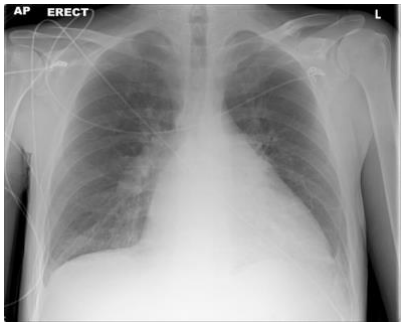
Useful for initial testing as it is cost effective for a variety of possible pathologies suspected on CXR, therefore there is usually a low threshold to order one. Radiographic evaluation is warranted to look for signs of cardiovascular pathologies, including cardiomegaly, right/left atrial or ventricular enlargement, congestive heart failure (CHF). For the respiratory system evaluation of pathologies may include airspace disease, atelectasis, pleural disease, pneumothorax, chronic obstructive pulmonary disease (COPD), pulmonary fibrosis, pulmonary embolism, or cancers/masses.

A chest radiograph is adequate for interpretation if there's appropriate **penetration, inspiration, rotation, magnification, angulation. (PIRMA)**

- **P**enetration:
    - The thoracic spine should be visible through the heart shadow.
- **I**nspiration: Visualizing 10 posterior ribs shows excellent inspiration. 8 to 9 posterior ribs in hospitalized patients is adequate.
    - Can you see 10-11 posterior ribs, 6+ anterior ribs?
- **R**otation: Spinous process should be centered between the medial clavicles.
- **M**agnification: The heart is slightly magnified in anteroposterior (AP) films.
    - AP - Heart/thoracic cage ratio can be up to 0.6.
    - PA - Won't see medial end of scapulae as much in thorax.
        - Less heart magnification.
        - Heart/thoracic cage ratio can be up to 0.5.
- **A**ngulation: Clavicles have an "S" shape.
    - Medial clavicular heads and spinous processes should be midline.
    - In children, check if ribs are symmetrical.
    - Unilaterally-widened sternoclavicular joint corresponds to patient rotation toward that side in the study.

CXR Other Considerations

- Position: Ensure proper patient position and adequate framing of the costophrenic angles
    - Supine CXR:
        - Anterior ribs look less angulated.
    - Lateral CXR:
        - Heart less magnified on left lateral view.
        - Lateral with AP studies provide 3D view of the organs.
        - Five key areas:
            - Retrosternal clear space.
            - Hilar region.
            - Fissures.
            - Thoracic spine.
            - Diaphragm and posterior costophrenic sulci.
- View:
    - AP
        - Heart will appear larger due to magnification.
        - Heart/thoracic cage ratio can be up to 0.6.
    - PA
        - Won't see medial end of scapulae as much in thorax.
        - Less heart magnification.
        - Heart/thoracic cage ratio can be up to 0.5.
- Rotation:
    - Adults
        - Look at medial end of clavicles and spinous processes in middle.
    - Kids
        - See if anterior ribs are symmetrical.
    - Observe the symmetry of the Sternoclavicular joint; widened on one side means patient is rotated to ipsilateral side.
- Coverage
    - Should see costophrenic angles



Case Courtesy of Derek Smith, Radiopaedia rID: 37004

Abdominal X-ray

When reviewing an abdominal radiograph, observe the overall gas pattern with additional attention for the presence of extraluminal air, calcifications, and soft-tissue masses.

- Normal gas patterns
    - Stomach: Almost always contains gas with air/fluid levels.
    - Small bowel: Almost always contains gas in 2 or 3 loops of bowel with air/fluid levels.
    - Large bowel: Almost always contains air in the rectosigmoid region and varying amounts of gas in the remaining areas with **no** air/fluid levels.

Resources

- Useful Books
    - The Unofficial Guide to Radiology: 100 Practice Chest X Rays with Full Colour Annotations and Full X Ray Reports (Unofficial Guides)
        - Highly recommend orienting yourself to the normal anatomy and common pathologies encountered on CXR.
- Podcasts
    - From the Viewbox
        - Educational podcast series that covers diverse topics in radiology for medical students, residents, and fellows.
    - LearningRadiology
    - The Houndsfield Unit
- Anki Deck
    - Radiology in Medical School
- NEOMED Radiology Interest Group learning resources
    - https://www.radiologywhales.com/learn
    - Contains a power lecture on all systems and associated pathologies of each system.
    - Gives a physics background on each imaging modality.

Computed Tomography (CT) Basics

CT scans create images by projecting X-ray beams at an object from a rotating gantry. The resultant images are based on the amount of X-ray that the tissue absorbs/allows to pass through. Dense objects absorb more ionizing radiation resulting in a brighter image, whereas fat or air are less dense and appear darker on CT. Density of a structure on an image is described in Hounsfield units, which range from least dense (-1000 HU) to most dense (1000 HU). Though images are only acquired in the axial plane, the images can be reconstructed based on computer algorithms and software to provide additional views in the sagittal and coronal planes. CT scans offer higher resolution than plain film X-ray and have a shorter study duration and lower cost than MRI. However, CT scans have lower resolution than MRI scans and expose patients to ionizing radiation.

Once the images are processed by the technician and sent to be read by the radiologist, they will often go through different "windows" within a set of CT images. Essentially, the window manipulates the greyscale component of CT images to highlight specific structures. Certain window levels make it easier to see specific structures or pathologies on the image. Many radiologists will use the preset window levels, but others may freehand it (which often looks like clicking and dragging the mouse across the screen to make the image brighter or darker). Additionally, some CT images are acquired in a way that optimizes imaging for a specific window.

CT Scan Types

Chest:

- Lung window: Essential for evaluating lung parenchyma and bronchial anatomy abnormalities.
    - Examples of parenchymal abnormalities in lung: interstitial pneumonia: honeycombing (small cystic spaces with thickened bronchial walls), subpleural reticular opacities and traction bronchiectasis, irregularities of lung nodules in adenocarcinoma, for example, or metastases (mets).
- Mediastinal window: Effective for visualizing mediastinal, hilar, and pleural structures (lung appears black).
- Bone window: bony structures.

Cardiac:

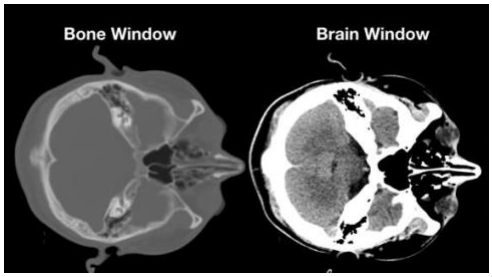
- Utilized for assessing coronary arteries, heart valves, and cardiac masses, often with contrast to enhance vessel and tissue visibility.

Abdomen:

- Primarily used with IV or oral contrast to better delineate organ structure and pathology, including obstructions and masses.

Brain: Case courtesy of Frank Gaillard, Radiopaedia.org, rID: 55748

- Non-Contrast CT: First choice for acute scenarios to differentiate between ischemic and hemorrhagic strokes. Excellent for detecting blood, midline shift, mass effect, and trauma.
- Blood Window-Subdural Window: Specifically used for identifying hard-to-detect subdural hematomas and subarachnoid hemorrhages.
- Bone Window: bony structures, detects fractures or bony lesions.



Common Indications for Non-Contrast CT Modality:

- Stroke: Non-Contrast CT is the first-line imaging modality in the acute setting to differentiate ischemic from hemorrhagic stroke. Ischemic strokes may appear as areas of subtle hypodensity, while hemorrhagic strokes are characterized by hyperdense blood collections.
    - Diffusion Weighted Images (DWI): Recommended to evaluate ischemic stroke more precisely. DWI can highlight areas of restricted diffusion consistent with acute ischemia.
- Subarachnoid Hemorrhage: Blood within the subarachnoid space appears hyperdense, easily discernible on non-contrast CT.
- Head Trauma: Useful for assessing skull fractures, brain contusions and intracranial hematomas.
- Hydrocephalus: Characterized by dilation of the ventricular system.
- Alzheimer's Disease: May show generalized cerebral atrophy in later stages.
- Neoplasm: Primary brain tumors may appear as hypodense or isodense masses on non-contrast CT, but often enhance with contrast. Metastases can show variable appearance but commonly present as ring-enhancing lesions after contrast administration.

Ultrasound (US) Basics

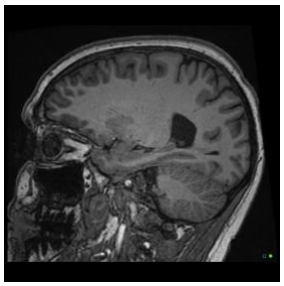
- Sonographic image depends on three components:
  - High-frequency sound waves produced by the probe/transducer.
  - Reflected wave/echo produced from tissue.
  - Conversion of echo into an image.
- Echogenicity: The bright or dark appearance of tissue on the ultrasound monitor is determined by the amount of sound waves the tissue transmits or reflects:
  - Hyperechoic: Tissue reflects more echoes → appears bright.
    - Bones, soft tissue calcifications, renal stones.
    - Portal venous gas, gas-forming infections, pneumobilia.
  - Hypoechoic: Tissue transmits more echoes → appears dark.
    - Fluids: May appear hypoechoic or anechoic if the fluid is simple or complex (i.e. contains pus, blood, debris, etc.).
  - Anechoic: Tissue transmits all echoes → appears black.
    - Fluids: May appear hypoechoic or anechoic if the fluid is simple or complex (i.e. contains pus, blood, debris, etc.).
- Pros: No ionizing radiation, small, portable, inexpensive, little or no patient discomfort.
- Cons: Artifacts are common, quality of image and visualization of true tissue is operator-dependent and may vary.

MRI Basics

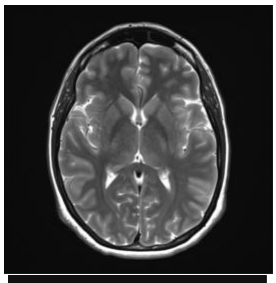
- The generation of a strong electromagnetic field forces the protons in our body to align with that field. Radiofrequency pulses stimulate the protons to spin out of alignment. Once radiofrequency current is turned off, the protons emit radiofrequency energy as they realign with the magnetic field. This energy, sensed by detectors, is used to generate an image.
- Useful for detailed imaging of soft and nervous tissues
  - Example: Tumors, vascular (stroke, aneurysm, thrombosis), infection (abscess, encephalitis), demyelinating/inflammatory lesions (MS/sarcoidosis), hematomas, and cartilaginous structures
- Pros: Unlike CT/X-ray modalities, MRI does not employ ionizing radiation
- Cons: Time/cost intensive and difficult to use for patients with non-removable ferromagnetic metal implants (pacemakers/cochlear implants). Less spatial resolution in some tissues, poor sensitivity for hemorrhage, and poorer visualization of calcific objects (bones, calcifications, etc.) than CT.

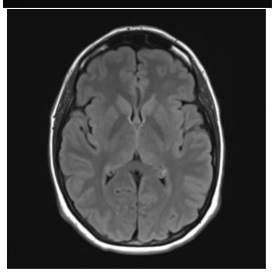
Types of MRI Sequences

- T1-weighted: Uses short time to echo (TE) and repetition time (TR) pulse sequences.
    - Hyperintense: fat, contrast, white matter (WM).
        - T1 MRI with contrast:
            - The contrast used is usually Gadolinium.
            - Used to look at vascular structures, inflammation, tumors, abscess.
            - Possible complication: nephrogenic systemic fibrosis.
            - Contraindication: patients with renal failure, esp. those on dialysis.



    - Hypointense: water (CSF, edema), bone, ligaments, tendons, air (no signal), inflammation (infection, demyelination).
    - Case courtesy of Craig Hacking, Radiopaedia.org, rID: 94347
- T2-weighted: Uses long TE and TR pulse sequences.
    - Hyperintense: water (CSF, edema), fat (but less compared to T1), inflammation (infection, demyelination).
    - Hypointense: bone, WM, ligaments, tendons, air (no signal).
    - Case courtesy of Craig Hacking, Radiopaedia.org, rID: 94347
- FLAIR: Similar to T2 but uses *very* long TE and TR.
    - Abnormalities that appear bright on T2 will be bright but with dark CSF.
    - Case courtesy of Craig Hacking, Radiopaedia.org, rID: 94347





Resources

- Learning Radiology
    - This contains all you need to do well in a radiology clerkship: explanations of different modalities, how to identify abnormalities, and practice problems to test your skills.
    - Recognizing the Basics by William Herring
- AMBOSS
    - Search “ultrasound,” “radiography,” “computed tomography,” and “magnetic resonance imaging.”
    - You’ll find a basic explanation of how each procedure is completed and some examples of common findings with overlays to help you identify the abnormalities.

Cardiothoracic Imaging

Synopsis of Imaging Purpose

Cardiothoracic imaging consists of the interpretation of examinations of the lungs, pleura, mediastinum, chest wall, heart, pericardium and the thoracic vascular system as well as the performance of interventional procedures within the lungs, pleura and mediastinum.

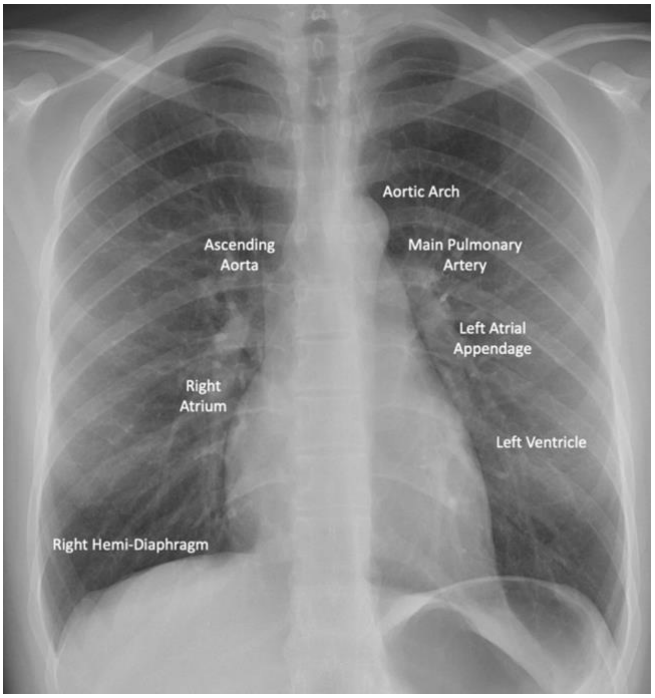
The imaging modalities and procedures include radiography, fluoroscopy, computed tomography (CT), magnetic resonance (MR) imaging, ultrasound (US) and interventional techniques (typically CT or US-guided). When interpreting cardiothoracic imaging, the following information is *high-yield anatomy and knowledge* that can help you to stand out during your clerkship.

The next few sections have key concepts for the following modalities:

- Chest X-ray.
- Chest CT (without contrast, Chest CT with contrast, Chest CT Angiogram).
- Cardiac: Coronary CTA, Transcatheter aortic valve replacement (TAVR) CT, Calcium Score CT.
- Thoracic MRI.

Chest X-ray Cardiac Special Considerations

- Cardiothoracic ratio
  - o Ratio of widest transverse diameter of the heart to widest diameter of the rib cage; should be less than 50% on PA image and less than 60% on AP image.
- PA vs AP
  - o PA = heart's true actual size.
  - o AP = results in magnification causing artificial enlargement of the heart.
- Normal cardiac contours
  - o Ascending aorta.
  - o Aortic arch.
  - o Main pulmonary artery.
  - o Normal left atrium – does not contribute to border of heart.
  - o Left ventricle.
  - o Descending aorta –parallels the spine.



Case courtesy of Mikael Häggström (image was annotated by composers of this specific section of the guides, with assistance from physician advisor).

Chest CT

- Useful in the evaluation of urgent pulmonary embolism, rib fractures, aortic dissections.
- Can be used to stage lung cancer, Staging uses the TNM system, *the T*, primary tumor can be measured using CT.
  - o **T1a:** tumor ≤1 cm.
  - o **T1b:** tumor >1 cm but ≤2 cm.
  - o **T1c:** tumor >2 cm but ≤3 cm.
  - o **T2a:** tumor >3 cm but ≤4 cm.
  - o **T2b:** tumor >4 cm but ≤5 cm.
  - o **T3:** tumor >5 cm but ≤7 cm.
  - o **T4:** Tumor >7 cm.

  *Disclaimer: it is not expected of you to know this verbatim during your rotations, this is simply for your reference.
- Annual low-dose CT scan screening for high-risk individuals (ages 50 to 80 years with a 20-pack-year history of smoking and current smoker or quit within the past 15 years) ~ Up-to-date.
- CT angiography with contrast is typically used when evaluating pulmonary embolism.

- CT without contrast is helpful for interstitial lung diseases, pulmonary nodules and pleural effusions.
- Case Stack has an interactive, color-coded, and labeled CT of the chest that is helpful in learning anatomy:

Cardiac CT

Encompasses a variety of scans; of which the most common include non-contrast calcium score CT, coronary CTA, TAVR CT, and pulmonary vein CTA amongst others. Performed with electrocardiographic (ECG)-gating (either retrospective or prospective) to reduce cardiac motion artifact. Cardiac CT can evaluate the coronary arteries for stenosis, cardiac valves for measurements in anticipation of valve replacement procedures, evaluation of cardiac/pericardial masses, and evaluation of abnormalities of the aorta such as aortic dissection, aneurysm, pseudoaneurysm, and intramural hematoma. Cardiac CT scan can be used to establish a **calcium scoring**, which is based on the amount of calcium detectable in coronary arteries as a result of coronary atherosclerosis; quantifying the severity of calcium which can help predict the likelihood of future acute coronary syndrome events.

When performed retrospective ECG-gated, all phases of the cardiac cycle are obtained. When played as a cine loop, it is possible to analyze wall motion and allows for evaluation of ventricular ejection fraction and left ventricular end-diastolic wall thickness (increased wall thickness is seen in diseases such as hypertrophic cardiomyopathy).

The standard planes for viewing CT images of the chest are axial images with sagittal and coronal reformations. From the superior aspect of the chest and progressing inferiorly, major structures are visible at six key levels:

- Level 1: Five-vessel level
    - Lungs.
    - Trachea – appears black because it contains air.
    - Esophagus – lies posterior and either to the left or right of the trachea.
    - Venous structure appears more anterior than the arterial.
    - Brachiocephalic (aka innominate) vein lies just posterior to the sternum.
- Level 2: Aortic Arch Level
    - Aortic arch – form an upside-down U-shaped tube.
    - Superior vena cava.
    - Azygos vein.
- Level 3: Aortopulmonary Window Level
    - Ascending and descending aorta.
    - Superior vena cava.
    - Uppermost aspect of the left pulmonary artery.

- Level 4: Main Pulmonary Artery Level
    - Main, right and left pulmonary arteries.
    - Right and left main bronchi.
    - Bronchus intermedius.
- Level 5: High Cardiac Level
    - Left atrium, right atrium, aortic root, and right ventricular outflow tract.
- Level 6: Low Cardiac Level
    - Right atrium.
    - Right ventricle.
    - Left ventricle.
    - Interventricular septum.
    - Normal pericardium = 2mm thick and outlined by mediastinal fat outside the pericardium and epicardial fat on its inner surface.

Here is a great set of labeled axial cross-sections on CT for self-study.

Coronary CT Angiography (CCTA)

- CCTA is useful in evaluation of coronary artery stenosis.
- CCTA is favorable in accuracy compared to invasive catheter coronary angiography.
    - Its non-invasive, CCTA is typically read by a *radiologist*, then an imaging *cardiologist* reads it for evaluation of stenosis.

Cardiac MRI

MRI can be used to obtain anatomic and functional images of the heart. There are 4 orthogonal axes of the heart that are obtained.

- Horizontal long axis (aka 4-chamber view)
    - Resembles the axis view on CT scan.
    - Used to evaluate the left ventricle's septal and lateral walls and apex, right ventricular free wall and for the size of the cardiac chambers.
- Vertical long axis
    - Resembles the sagittal view on CT scan.
    - Best to visualize anterior and inferior walls as well as apex of the left ventricle.
- Short axis
    - The most important axis, as this is used to calculate ejection fraction, myocardial mass, and end-diastolic wall thickness.
- Three-chamber views
    - Similar to coronal view on CT scan.

- Helpful in assessing the mitral and aortic valves, left martial size, and the walls of the left ventricle.

Important Cardiac MRI Sequences

- Spin echo pulse sequence – blood is black and used for anatomic evaluation.
- Gradient echo pulse sequence – blood is white and used for function evaluation.

Resources

- The Unofficial Guide to Radiology: 100 Practice Chest X Rays with Full Colour Annotations and Full X Ray Reports (Unofficial Guides)
  - Highly recommend orienting yourself to the normal anatomy and common pathologies encountered on CXR.
- Team Rads
  - Amazing interactive source that has tutorials and quizzes.
- Society of Thoracic Radiology (STR)
  - Has a ton of free educational lectures.
- North American Society for Cardiovascular Imaging (NASCI)
- Society of Cardiovascular Computed Tomography (SCCT)
- Society for Cardiovascular Magnetic Resonance (SCMR)
- ANKI DECK: Recognizing the Basics by William Herring
  - This is an AMAZING book that covers high yield radiology seen on rotations. ANKI, the spaced repetition flashcard app has a deck that goes along with the content in the book.
- Radiographics Articles (journal of the RSNA)
  - This is the premier educational journal for radiology; articles are clear, easy to read, and evidence based. Can be useful for case presentations.

Breast

Synopsis of Imaging Purpose

Ultrasound: Used primarily as a diagnostic tool for evaluating palpable masses, especially in younger women with denser breast tissue where mammography might be less effective. It helps in distinguishing solid from cystic lesions and is essential for guiding biopsies. Ultrasound is also utilized to assess abnormalities detected on mammograms or MRI, and to monitor known lesions over time.

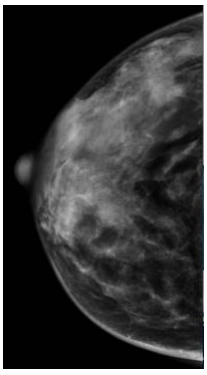
Mammogram: Primary screening tool for breast cancer, recommended annually for women starting at age 40 or earlier for those at increased risk per 2024 United States Preventative Services Task Force (USPSTF) guidelines. It can detect early signs of cancer such as microcalcifications or subtle changes in breast tissue architecture before they are palpable. Diagnostic mammography is used following the detection of suspicious signs or symptoms, such as a lump or nipple discharge, to obtain more detailed images of specific areas of the breast.

MRI: Typically ordered for assessment of clinical symptoms such as breast pain or nipple discharge; for further imaging of known breast cancer to detect occult malignancy in contralateral breast/multifocal cancer; or for screening in high-risk patients (genetic mutations with >20% lifetime risk, history of mantle radiation for Hodgkin's).

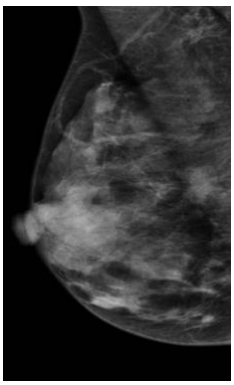
Breast Imaging Specific Considerations

- Mammogram (common views)

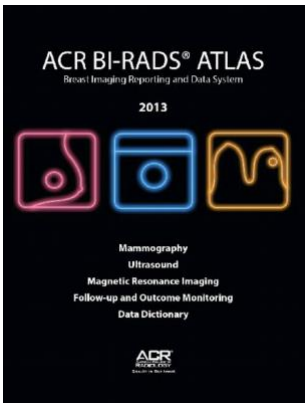
CC view: cranial→caudal



MLO view: medial→lateral oblique[2]



[Case courtesy of Garth Kruger, Radiopaedia rID Number 22386]



- Rolled view or spot compression: sometimes performed to determine if a focal asymmetry "rolls away" or to apply compression to a region for similar purposes.

- How to categorize using ACR BI-RADS®
  - Step 1. Grade the breast density from 1-4:
    1. almost entirely fatty.
    2. scattered areas of fibroglandular density.
    3. heterogeneously dense.
    4. extremely dense.
  - Step 2. Describe the findings (not expected of MS3, or even MS4 to know): roughly be able to spot a focal asymmetry or say whether calcifications are linear or grouped. Linear calcifications in the shape of a duct are more suspicious for intraductal carcinoma.
  - Step 3. Assign a BI-RADS score (not expected of MS4 to know, but you may be asked to try): Know that the score directly guides next steps so the score assigned should be in accordance with your recommendations for follow-up or further testing. *Exact % likelihoods and recommendations may differ from current ACR guidelines; this is a rough guide. *
    - BIRADS 0: Incomplete; imaging quality limits diagnostic ability and further imaging is required → **Recommendation: additional imaging evaluation.**
    - BIRADS 1: Negative, essentially 0% likelihood of cancer → **Recommendation: continue with routine screening.**
    - BIRADS 2: Benign findings, essentially 0% likelihood of cancer → **Recommendation: continue with routine screening.**
    - BIRADS 3: Probably benign, 0-2% likelihood of cancer → **Recommendation: short-interval f/u imaging (MG, US) in 6 months**
      - Follow-up imaging should be able to confirm 3's → 2's or upgrade to 4's, as patients with 3's should not be surveilled in 6 month intervals indefinitely.
    - BIRADS 4: Suspicious (4A: 3-10%, 4B: 11-50%, 4C: 51-94% likelihood of cancer) → **Recommendation: biopsy.**
    - BIRADS 5: Highly suggestive of malignancy, 95% or higher likelihood of cancer → **Recommendation: biopsy.**
    - BIRADS 6: Known biopsy-proven malignancy (confirmed on pathology) → **Recommendation: consult with breast surgeon.**

Expectations for Outstanding Performance

Anatomy knowledge is always important in radiology, and you may be asked about basic normal thoracic/abdominal anatomy or some incidental abnormalities (such as a hiatal hernia), even during a breast radiology rotation. Material tested on Shelf exams and Step 2 regarding pathology, and clinical workup of masses or breast symptoms is sufficient for rotation.

What is expected of med students on the rotation?

This is the most patient-facing subspecialty, and many patients have worries over possible malignancies. As is expected of all rotations, bedside manner is tantamount. It is recommended that you enter a patient's room only after they have consented to having a medical student (given the sensitive nature of breast exams). Most patients are agreeable. Otherwise, advice is consistent with that for other diagnostic radiology subspecialties. Show up on time, reserve meaningful questions for in-between reads (try not to interrupt your preceptor's workflow) and have some basic knowledge of the BI-RADS scale.

What are the hours like?

You will likely report around 8am. Every site varies but attendings may opt to schedule biopsy procedures more in the morning, do readouts intermittently between patients, and then complete the remainder of their reading in the late afternoon/early evening once all patients are seen. On average, the in-clinic commitment time will not exceed 7-8 hours daily. You may be sent home early so that your preceptor can work undisturbed for a period, as having a medical student can greatly slow down their reading pace. You should feel comfortable taking the time to ask your preceptor meaningful questions or getting to know them during downtime, but if offered the opportunity to go home early, realize that it may be for their benefit.

How to stand out / be helpful?

Having a positive attitude and good bedside manner goes a long way. Radiologists do not typically expect much knowledge from an MS3 or even MS4, but it does make a good impression to know the basic BI-RADS scale and common descriptors of findings ahead of time. If your preceptor likes to engage students, they may have you try to grade a mammogram or point out concerning calcifications/masses. The allowed level of student involvement varies between sites and preceptors, ranging from shadowing, or localizing a mass with the US probe to performing a stereotactic-guided biopsy with supervision. The latter may be very unlikely as even junior residents do not always perform the procedure—having the privilege to do one is a huge responsibility for the preceptor and reflects a high level of trust in the student. Smaller sites without residents may be more willing to have an MS4 perform one. Having your own laptop open to chart review is always helpful.

Resources

- Refer to American College of Radiology® (ACR®) and Society of Breast Imaging (SBI) for good resources.
    - ACR/ACR BI-RADS® Atlas Fifth Edition
        - Poster with basic terminology.
    - SBI
- Other:
    - ACR Mammography and Breast Imaging Resources
    - The University of Michigan Division of Breast Imaging (BI)
    - University of Washington Medicine Department of Radiology Breast Imaging Teaching Files
    - Johns Hopkins' Medicine Breast Imaging Procedures
    - I-MED Radiology Breast imaging resources
    - Mammoguide
    - RSNA Breast Radiology Entrustable Activity Supervision Tool

Body

Synopsis of Imaging Purpose

Body imaging refers to imaging of the abdominal and pelvic structures, such as the stomach, pancreas, small bowel, prostate and colon. The evaluation of gynecologic and obstetric pathology is also within the domain of body imaging. X-ray, ultrasound, CT and MRI all play important roles in the context of body imaging.

Abdominal X-Ray

Abdominal X-ray has the advantage of low-cost and can be readily deployed. It can be used to visualize free air, bowel obstruction, ileus, and volvulus, among other applications. When enteric contrast is administered, continuous X-rays (fluoroscopy) may be taken as part of an upper or lower gastrointestinal (GI) series, which is apt in visualizing pathology like strictures, perforations, hernias, and pediatric malrotation.

Recognizing Normal

- The lung bases and diaphragm should compose the top portion of the film, as well as corresponding ribs of this region.
- The lumbar and upper thoracic vertebra should sit at the midline.
- The pelvic bones and femoral heads should comprise the lower portion of the film.
- Black = Air, White = Calcified structures, Gray = Soft tissue structures or fat (slightly darker gray)
- In reading an abdominal film, take note of the bowel gas pattern, solid organ outlines, any abnormal calcifications, extraluminal gas (free air), and nearby skeletal anatomy.
- The small bowel is distinguished by the presence of valvulae conniventes, which give the small bowel a “stacked coin appearance” on radiographs. These valvulae cross the whole width of the bowel.
- The large bowel is distinguished by haustra, which are small patches of the colon that appear as invaginations on radiographs. These invaginations only partially cross the colonic width.

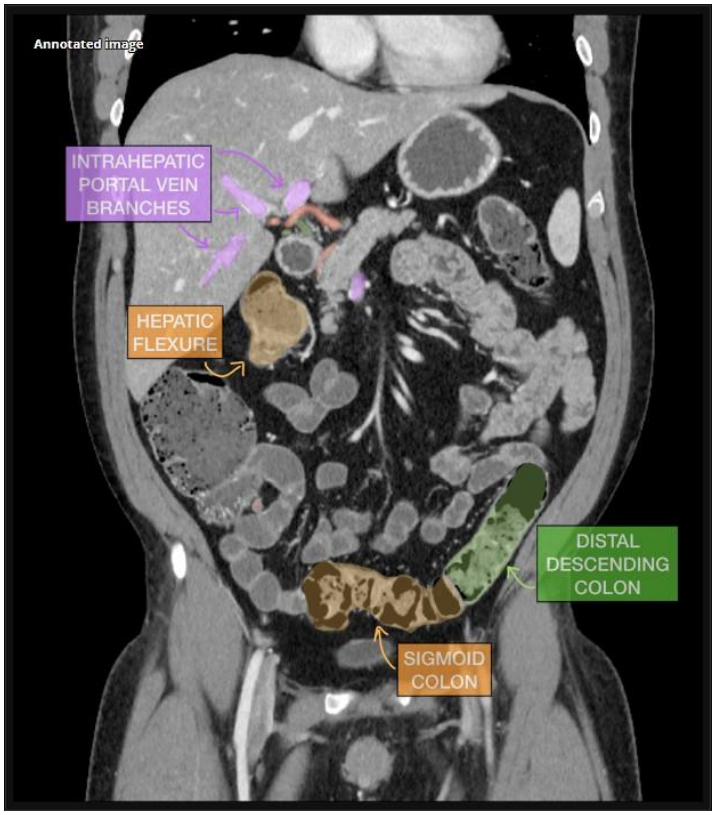
Ultrasound

Ultrasound (US) is a low-cost modality that is highly portable and does not expose the patient to radiation. US is useful for evaluating organs of the abdomen and pelvis. Organs like the liver, spleen, and pancreas have homogenous echogenicity. In contrast, the gallbladder and bladder appear as anechoic structures with hyperechoic rims. Moreover, Doppler can be used to evaluate flow through vasculature. Overall, US is a good first-line choice for evaluation of many pathologies, including cholecystitis, testicular mass, abdominal aortic aneurysm, and

hydronephrosis, among others. US is also crucial for gynecologic evaluation in cases like ovarian torsion, gestational trophoblastic disease, and ectopic pregnancy, among many others. Additionally, US is the preferred modality for obstetric imaging.

Computed Tomography (CT):

CT allows cross-sectional characterization of abdominal and pelvic pathology. It can be used to follow-up on findings made on X-ray or ultrasound, or if findings on those modalities are equivocal. CT can also be used for primary evaluation of pancreatitis and appendicitis, among other conditions. CT is also the initial modality for staging cancers like colorectal carcinoma, and it may be combined with Positron Emission Tomography (PET) for metabolic evaluation. The use of oral and IV contrast can further delineate lesions. For example, CT angiography uses IV contrast for evaluation of mesenteric ischemia and pulmonary embolism.



Annotated Example CT (Enterography Protocol) With Labeled Anatomy[3] (https://radiopaedia.org/cases/66174)

[Case courtesy of Michael P Hartung, Radiopaedia rID 66174]

Magnetic Resonance Imaging (MRI)

MRI is well-suited for evaluating abdominal pathology. In regard to liver pathology, MRI is particularly useful for liver cirrhosis, hepatocellular carcinoma, and hepatobiliary disease using magnetic resonance cholangiopancreatography (MRCP). MRI is also used in post-transplant evaluation (liver, kidney) and for staging abdominal/pelvic cancers. Similarly, prostate MRI allows local staging of prostate cancer and subsequent risk-stratification, as well as planning for MRI-guided biopsy. The prostate imaging reporting and data system (PI-RADS) was developed in 2012 and has helped to standardize the characterization of prostate nodules, in a manner similar to BI-RADS for breast MRI. Regarding sequences, T1-weighted, T2-weighted, diffusion-weighted, and contrast-enhanced sequences all play a role in body imaging. Due to its cost and the time needed to deploy, MRI is often reserved for secondary characterization of lesions following evaluation with other conventional modalities.

Expectations for Outstanding Performance

Medical students rotating on body imaging should try to show an active interest without interrupting workflow. Interest can be shown by asking relevant questions at appropriate times, while being sure not to interrupt during a dictation or asking too many questions at once. Generally, medical students are not expected to fully read or dictate scans themselves. However, students should be familiar with classic imaging findings suitable for their learning level, and which are applicable to USMLE board exams (appearance of pulmonary embolism, small-bowel obstruction on x-ray, "target sign" of intussusception, appearance of volvulus, etc.).

Fellowships

There are a number of body imaging fellowships across the nation. Some are ACGME-accredited and others are not. Often, ACGME-accreditation has little bearing on post-fellowship job prospects. When thinking about fellowship, one should consider factors such as personal fit towards a program, the quality of training provided, and the level of practicing autonomy desired.

Resources

- Online Media
  - PubMed
    - Excellent for searching review articles and topics of research within Body.
  - Radiopaedia
  - "Navigating Radiology" YouTube Channel
  - Learnabdominal.com

    - Radiology Assistant
- Textbooks
    - Abdominal Imaging: Expert Radiology Series 2nd Edition; Dushyant Sahani MD and Anthony E Samir MD, MPH.
    - Fundamentals of Body CT 5th Edition; Richard Webb MD, William E. Brant MD, and Nancy M. Major MD.
    - Fundamentals of Body MRI 2nd Edition; Christopher G. Roth MD and Sandeep Deshmukh MD.
    - Abdominal Imaging Case Review Series 1st Edition; Manjire Dighe, Joseph R. Grajo, and Leslie Lee.

Musculoskeletal (MSK)

Synopsis of Imaging Purpose

Musculoskeletal Radiology is a subspecialty within radiology that focuses on the interpretation of images related to bones, joints, spine and soft tissues. MSK radiologists also perform procedures of these areas that include arthrograms, joint aspirations/injections, and CT-guided biopsies. The most common imaging modalities used are X-ray, MRI, CT, and ultrasonography.

Image Intensity Terminology

Knowing how things will be described is important no matter what type of radiology elective. Here is a small table that demonstrates some of the terminology used across different imaging modalities to describe dark and bright spots. Familiarize yourself with the terminology so that you will be able to understand the radiology report.

Image Modality	Dark	Bright
X-ray / Fluoroscopy	Radiolucent (Lucent)	Radiopaque (Opaque)
Computed Tomography (CT)	Hypodense / Low Attenuation	Hyperdense / High Attenuation
Ultrasound	Hypoechoic/ Low Echogenicity / Anechoic (entirely black)	Hyperechoic / High Echogenicity
Magnetic Resonance Imaging (MRI)	Low Signal / Hypointense	High Signal / Hyperintense

Common Conditions Seen in MSK

Common disorders seen in MSK radiology include but are not limited to bone and soft tissue injuries, arthritis, spine disk and vertebrae issues, tumors, fractures, dislocations, and infections. Familiarize yourself with the common features of some of these types of conditions with regard to imaging. For example, a ligament tear on ultrasound could be described as a hypoechoic area which interrupts ligament fibers. Use some of the other guides to learn the basics of each of the imaging modalities used in MSK radiology and focus study on the joints, spine and soft tissues.

Expectations for Outstanding Performance

The requirements, schedule, and expectations will vary at each institution. If you have classmates who have completed the rotation before, reach out and see if they have tips for the rotation. As a student, you will often be observing a resident or attending. Do your best to not interrupt the workflow. Begin the rotation/day by asking them how to help with the workflow and when it is an appropriate time to ask questions. Ask if there are any procedures that day that you would be able to participate in. Have a notebook and pen to be able to write questions down. Do your best

to avoid being on your cell phone and try not to zone out or fall asleep. Sometimes the resident or attending you are with for the day may not like having students with them. In these cases, take notes of questions you have and try to not be obtrusive. Rotations are a great way to network at programs and you want to do your best to leave a good impression.

At some institutions you may have a short schedule. Ask the residents or attendings if there are projects or research that you can get involved with. These will give you more opportunities to interact with people in the program and give them more opportunities to get to know you. A big part of radiology is networking, so it is important to try and leave a good impression. Always find ways to get involved that you would be interested in participating in.

Resources

- UW Department of Radiology Online MSK Book
- Society of Skeletal Radiology
- Radiopaedia: Musculoskeletal Radiology for Students Curriculum
- Hoop's Radiology Reddit MSK Anki Deck
    - High yield radiology content pertinent to X-ray/CT, MRI and ultrasound.
- YouTube: MSKradiologygenie431
- Learning Radiology

Neuro

Students will be exposed to neuroimaging modalities, such as radiographs, US, MRI, and CT, and procedures, such as fluoroscopy-guided lumbar punctures, and will have the opportunity to learn/review neuroanatomy through radiographic imaging. Note that traditionally, medical student radiology electives involve the shadowing of residents in the reading room, with associated interactive near-to-peer teaching. Didactic conferences allow for additional learning of the fundamentals. Certain programs will incorporate weekly quizzes to incentivize learning and engagement. Diagnostic radiology electives emphasize the experience of observing radiologists in addition to learning and actively contributing to the team, although some institutions have experimented with a hands-on learning approach.

General Schedule/A Day on Neuroradiology

The daily schedule will vary depending on if you are placed with a resident or attending, and if the resident has pre-dictated their studies before your arrival. Generally, you can expect a morning conference before 8 am that may or may not be neuroradiology specific. Following this, you will start with your preceptor. Residents may pre-dictate their studies, in which case you can expect them to be able to provide more teaching. They may allow you to read a few of the studies and practice interpretations or re-run the cases walking you through them. The attending will likely check in periodically to discuss difficult aspects of certain cases with the resident. A formal review of the residents' cases under the supervision of the attending may take place several times in the morning or afternoon. Students are often released for the afternoon to complete required readings, weekly quizzes, and prepare a case presentation for the morning conference. On average, the daily in-hospital time commitment will not exceed 8 hours.

Expectations for Outstanding Performance

The activities, expectations, and other important aspects of your rotation will vary from institution to institution. It may be helpful to reach out to someone who has recently completed a rotation at the institution of interest to get the most up-to-date information. The information provided below is a general overview and was compiled from the perspectives of a variety of programs.

Standing out or knowing what to do on a neuroradiology rotation can be difficult for students. There is a delicate balance of asking too few or too many questions, so aim for somewhere in the middle. Ask your preceptor before starting the readout when it will be acceptable to interject with questions or comments. Faculty tend to notice standout students by their ability to demonstrate evidence of self-directed learning, but this should only be done at appropriate times. One way to do this is by introducing intelligent questions and comments relevant to discussions

in the reading room. Alternatively, this can be done during resident checkout. Ultimately, the "right" way to do this is subject to the workflow and personality of the individual you are working with. In general, be timely, dress professionally (taking the lead of your preceptor) and try to familiarize yourself with the basics of search patterns for the most common modalities and most common pathologies. Review basic protocols regarding which image modalities are most appropriate in common situations (i.e., understand the uses of basic MR sequences).

This rotation is an excellent opportunity to review neuroanatomy and certain preceptors will ask you to identify structures or common pathologies to keep you engaged. You can also be more engaged by having Radiopaedia (or another reference resource) open when paired with a resident to help them review topics as needed. Being able to switch to a patient's chart from your laptop may also be useful to the resident or attending. Most importantly, enthusiasm goes a long way!

If you are eager to obtain even more experience, here are some potential ideas:
(1) You may elect to observe a resident or an attending in the emergency department (where CNS pathology is common). The best time to do this will largely depend on the coverage structure at the institution, so ask first about this option with an attending.
(2) In the reading room, we only see radiology from one perspective. As a student, there is value in understanding what patients must go through when a study is ordered. Consider asking an attending if you can sit with the technologists at the MRI machine at an appropriate time.

Resources

- Online Media:
    - Radiopaedia
    - Understanding The Radiology Report
        - While students are unlikely to create radiology reports, it is helpful to be familiar with the components (*i.e.*, findings, impression, recommendations) to better understand the radiologist's workflow and thought process.
    - Radiology Report Language Primer
    - Radiology Lexicon
    - Multispecialty Core Lecture Series
        - This resource contains lectures pertaining to each radiology subspecialty. Note that they are geared toward residents and becoming knowledgeable in neuroradiology is not a priority for students in this rotation. However, this can be useful if you are interested in learning more about topics discussed in the reading room.
    - Neuroradiology Lecture Series
        - This resource is neuroradiology specific and geared toward the resident-level.

    - Learn Neuroradiology: Medical Students
    - Learning Head and Neck Radiology
    - American Society of Neuroradiology (ASNR) Case of the Week
        - (ASNR Twitter search #ASNRCOTW).
    - (URMC-Teaching Files)
        - Learning Cases
    - X (formerly Twitter) accounts for neuro cases such as the weekly quizzes by:
        - @MohitAgNeurorad
        - @thecortexclub
            - Website
        - @JudyGadde (pediatrics cases)
    - Cortex Club Quizzes:
        - These are quizzes created by Dr. Mohit Agarwal to test neuroradiology knowledge. Following each quiz, a learning slide is released explaining the answers. Medical students can also participate and winners at each level of education can win Cortex Club t-shirts! Quizzes are released at @thecortexclub on X/Twitter.
- Textbooks
    - Recognizing the Basics by William Herring
        - Chapter 21: Magnetic Resonance Imaging: Understanding the Principles and Recognizing the Basics; Chapter 27: Recognizing Some Common Causes of Intracranial Pathology

Pediatrics

General Schedule/A Day on Pediatric Radiology

The hours on a pediatric rotation do not differ significantly from a typical diagnostic radiology core rotation. Typically, there are daily didactics and students arrive between 7-8 am. Following didactics, students will meet with the radiology resident on their pediatrics rotation for the day and review cases. Cases are usually also reviewed with an attending later in the day. The day typically ends around noon, at which point students are free to review cases. Note that the timing of didactics is largely institution dependent. What is unique about the pediatrics rotation is the multidisciplinary nature of the cases, and residents can help you make it to these meetings.

Pediatric radiology departments have modality specific and in some cases organ specific services. For example, there are usually separate Fluoroscopy, Ultrasound, Body and Oncology, General Diagnostic, Nuclear Medicine & PET/CT, Neuro, Cardiac, Fetal, MSK and Interventional Radiology services. Depending on your schedule and your interests you will likely rotate through several of the services throughout your rotation. Common conditions seen include limping, hip click, intussusception of the bowel, vomiting, and intestinal obstruction.

There will likely be a mix of on-site observation and self-directed learning. When you are on-site most programs have you shadow a pediatric radiology attending or resident/fellow or radiology technologist on the service you are assigned to.

When on-site, the goal is to gain exposure to real time cases, with the opportunity to ask questions and learn more about the day-to-day practice of Pediatric Radiology. Additionally, you will have the opportunity to gain exposure to the way diagnostic images are produced by radiology technologists in the x-ray, ultrasound, CT and MRI departments.

Each program will likely assign self-directed learning that usually includes an online learning curriculum geared towards their personal education and interests. Programs may also assign you a list of “Must-See” Diagnoses that medical students should be able to recognize.

Expectations for Outstanding Performance

The rotation coordinator will provide specific information about expectations and requirements. Always arrive on time and enthusiastic to learn. While learning radiology is not a focus of diagnostic radiology rotations for medical students, this can be an excellent opportunity to review the relevant anatomy and common pathologies (e.g. pyloric stenosis, intussusception, etc.). Try to review what may be different in a pediatric patient at a specific age of development compared to an adult patient.

Resources

- Online Resources:
  - Radiology Education
    - Multiple links for teaching files are provided.
  - Pediatric Radiology Digital Library
    - Includes numerous learning resources including teaching files.
  - Cleveland Clinic digital teaching file
- Textbooks:
  - Fundamentals of Pediatric Radiology by Lane Donnelly
  - Practical Pediatric Radiology by David Hilton and Saskia von Waldenburg Edwards
    - RSNA members get free
  - Pediatric Radiology: The Requisites by Hans Blickman
  - Felson's Principles of Chest Roentgenology: A Programmed Text by Lawrence Goodman
  - Recognizing the Basics by William Herring

Imaging in the Emergency Department (ED) Setting

Synopsis of Imaging Purpose

Emergency Radiology aids in the diagnosis and treatment of acutely ill or injured patients. Common imaging modalities like ultrasound, CT, MRI, and X-ray are used to diagnose.

- Trauma
    - Abdominal pelvic trauma.
    - Heart and lung (thoracic) trauma and associated conditions.
    - Trauma to the spine and upper and lower limbs.
    - Blunt trauma and penetrating injuries.

- Non-trauma emergencies
    - Injuries and diseases of the central nervous system (ischemia, hemorrhage, herniations, spinal cord emergencies).
    - Abdominal pathology (obstruction, volvulus, ischemia, gallbladder and biliary, liver, pancreatitis).
    - Emergency obstetrics and gynecology.
    - MSK (bone/joint infections, fractures, cellulitis, abscess).
    - Aortic, large artery, and venous emergencies (Acute Aortic Pathology).

Classic ED Imaging to Review

ED imaging overlaps with the other sections in this guide. This is not a comprehensive list and may vary depending on whether the facility is a trauma center, their specialties, etc.

- Common extremity injuries (upper and lower extremities)
    - Long bone fractures, glenohumeral dislocation, distal radius fracture, femoral neck fracture, tibial plateau fracture, and ankle fracture.
- Pelvic injuries and indications for pelvic binder.
- CTA for pulmonary embolism.
- US for gallstone related diseases.
- US for obstetric emergencies.
- MRI for acute ischemic stroke.
- CT head without contrast for intracranial hemorrhage.
- CT for acute appendicitis.
- CXR for pneumothorax, tension pneumothorax, pneumomediastinum, pneumoperitoneum.

Expectations for Outstanding Performance

Standing out on this rotation entails active participation in didactic sessions, resident lectures,

and case readouts. This includes reviewing cases comprehensively, engaging in discussion about protocols, procedural planning, and selecting appropriate imaging modalities and techniques. A proficient medical student should demonstrate the ability to generate a thorough differential diagnosis and discuss management options while maintaining a strong grasp of relevant anatomy. It's essential to strike a balance between demonstrating interest, asking pertinent questions, and not hindering the radiologist's workflow.

Resources

- Xray Comix 22 Don't Miss Lesions
- Radiopaedia cases
- American Society of Emergency Radiology
    - ASER Core Curriculum
- RSNA Emergency Cases for Residents and Fellows
- Intro to Imaging Modalities used in Emergency Imaging
- General Introduction to Radiology Resource
- A-Z of Emergency Radiology
- Society of Thoracic Radiology Curriculum for Medical Students
- A night in the ED radiology teaching cases

Interventional Radiology (IR)

General Schedule/A Day on IR

Depending on the institution, most programs will require students to arrive around 7am and depart anywhere between 4-9 pm (the reason departure time varies so much is that you leave once the cases for the day are over); weekends and call shifts are usually not required at most institutions for rotating medical students.

Expectations for Outstanding Performance

IR rotations should be approached similarly to a 3rd year surgery clerkship. Plan on arriving early and staying late.

Make it a point to introduce yourself to the nursing staff and scrub techs every day. Residencies are looking to see if you fit in with their program and that means the ENTIRE program. If they see you getting along with techs/nurses, that means you're fitting in well and it will greatly enhance your chances of matching there.

Expectations of medical students on IR rotations will vary from institute to institute, but there are many commonalities amongst them all. We recommend reaching out to an upper-level resident or attending (PGY- 5/6) at the respective programs to gain a more detailed idea of what is expected at each. Unlike many diagnostic rotations, active participation in patient care is highly encouraged throughout the course of the day. Students should participate in morning rounds, pre-op case workup, procedure consenting, the actual procedure itself, and post-op follow-up.

When there is a patient coming into the procedure room, help the nurses/techs get the patient on the operating bed and grab any materials they may need. "Birdwatch" the rooms in order to notify the residents/attending whenever the procedures are about to begin; a decent time is usually when the scrub tech is almost done prepping/draping the patient. Be leaded up and scrubbed in BEFORE the residents and attendings are so that you're not in anyone's way and ready to go when the procedure starts. You should grab your own gloves and gown before the procedure, do not expect/assume the scrub techs will get them for you!!

Assist in the procedure in any way possible (which sometimes means staying out of the way and observing from the side). Read the room, if there are opportunities for you to be of assistance or to get your hands dirty then do it, but don't be an annoyance.

When the procedures are done, ask the residents/attendings if they'd be okay with you sewing in drains/closing incisions/holding pressure. Clean up the sharps, back table, and drapes so that the resident can go begin writing their procedure notes. Assist the procedure staff in moving the patient back to their patient bed.

Most importantly, ASK QUESTIONS!! It is always assumed you won't know what you're doing, so the staff is usually very willing to be of assistance. It will also show the faculty that you're engaged and willing to learn, which goes a huge way when it comes to evaluations and considering applicants for residency.

The majority of rotating students are not expected to write notes on IR services, but it may not be a terrible idea to write practice notes (H&Ps, pre-procedure, procedure, and clinic notes) in order to get some note writing experience. If you do this, it would be smart to get either a resident or an attending to proofread your notes.

The majority of programs will expect a student to present at least one interesting case at the end of their rotation that they participated in during their time. Any of several introductory interventional radiology textbooks and JVIR is a good resource to find pertinent literature that can be included in your presentation.

Resources

- SIR RFS website
    - Has phenomenal resources that can aid rotating students in IR. There are plenty of easy-to-read breakdowns of various procedures that will walk you through the procedure's steps, indications, and high teaching points.
    - If you know you will be scrubbing into a certain procedure the next day, it is highly recommended to read up on the procedure's steps, relevant anatomy, indications/contraindications, and patient's pre-op imaging.
- Useful apps
    - There is a smartphone app called "*SIR Guidelines*" that provides pre-op medication recommendations for varying procedures.
        - App Store
        - Google Play
    - For those interested in podcasts, check out "*BackTable* +" which is an IR-founded podcast that covers dozens of topics in IR and has notable interventionalists from across the world as guest speakers.
        - App Store
        - Google Play

Nuclear Medicine

Synopsis of Imaging Purpose

Nuclear Medicine will expose you to multiple body systems and incorporate therapeutic interventions. For example, you may be exposed to patients being evaluated for conditions such as chest pain, fever, osteomyelitis, cancer, endocrine disorders, neurologic disorders, cardiovascular disease, and pulmonary disease. Interventions can treat conditions such as hyperthyroidism, cancers, bone pain. Generally, exposure to this subspecialty is limited in the general radiology rotation. Students electing to rotate in Nuclear Medicine tend to have ample opportunities to engage with residents and attendings in the department.

General Schedule/A Day on Nuclear Medicine

Students attend readouts with residents, nuclear medicine fellows, and attendings. Students may have the opportunity to present their own interpretations of studies to residents and/or attendings. Didactic conferences are usually once per week. Most of the day will be spent in the reading room. Some institutions allow students to interview and examine patients in the therapy clinic, as is routine in most clinical rotations. Some time will be spent observing the work of nuclear medicine technologists (i.e., positioning patients and operating equipment). Students may experience multidisciplinary discussions (i.e., presenting to radiologists and cardiologists). Common studies that may be encountered on this rotation include planar scintigraphy, SPECT/CT imaging, 18F-FDG PET-CT, multigated acquisition scan (MUGA), myocardial perfusion, gallium, iodine-131, bone scans, hepatobiliary iminodiacetic acid (HIDA) scans, and contrast-enhanced CT imaging for cancer evaluation.

Expectations for Outstanding Performance

Medical students are not expected to become proficient in Nuclear Medicine on this rotation. Don’t be intimidated by how broad this field is, with diagnostic and interventional aspects spanning multiple body systems. Expectations will be tailored to the student-level. Priorities for learning will be familiarizing yourself with the diagnostic and therapeutic scope of this field, the value nuclear medicine studies add to patient care, and indications for the modalities used. Arrive on time, actively participate when appropriate, be enthusiastic, and be respectful to other staff members including nuclear medicine technologists. Generally, days begin at 7:00 or 8:00am, depending on the institution, and students are expected to be present 5 days per week. Students are typically dismissed in the afternoon.

Resources

- Online media
  - Nuclear Medicine teaching cases by study type and diagnosis
  - Nuclear Medicine Information
    - Imaging modality guidelines and indications.
  - PET/CT basics
- Textbooks
  - Mettler's "Essentials of Nuclear Medicine Imaging" book:
    - Broad overview of the field, including the foundational science behind it.