

AMSER

National Medical Student Curriculum
in Radiology

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AMSER Curriculum Update

Key Concepts

This document is not intended to serve as a definitive list of all material that should be included in every radiology clerkship. Because of the wide range of variation between schools in the way radiology is taught, each individual school will likely have unique needs in terms of material to be covered. This document was written to be as inclusive as possible, and should serve as a starting point for a clerkship director looking for opportunities of expanding their course. The material listed in each area is more than could realistically be covered in a 4 weeks or less. It is hoped that most of the core or essential material in each section will be covered at some point in the four years of medical school, but not necessarily during a dedicated radiology clerkship. In particular, the section on core topics and curricular resources is intended to expand the horizons of educators and to offer new methods or sources of information that they may want to add to existing clerkships. This document is thus intended as an overarching compendium of possible topics and resources from which educators can pick and choose those portions that best suit their needs.

Aim

These can be used as guidelines for those programs that wish to develop their own curriculum.

General concepts about the medical student curriculum in radiology (all areas):

- A realistic medical student curriculum – most students spend no more than 4 weeks in radiology.
- Include radiological topics that will be covered while on clinical services, as well as on dedicated radiology rotations.
- Aim at those skills that are required by students entering general medicine or surgery rather than students entering radiology.
- Be flexible enough to be incorporated into a variety of different program formats.
- Identify critical areas for students to focus on during their rotations.

It should include the following general areas:

- Exposure to the scope of radiology
- Imaging management skills – appropriate image requisitions – cost effective, evidence based medicine, tailoring studies to patient and case specifics
- Management of negative or equivocal imaging
- Concepts of positive and negative predictive values of imaging methods
- Knowledge of how procedures and imaging are performed (i.e. see imaging performed not just images)
- Image interpretation - focus on radiographs and to a lesser extent CT, as well as emergency radiology and common conditions
- Use of PACS (Picture Archiving and Communication System)
- Utility of image guided procedures
- Risks of medical imaging (e.g. radiation induced cancer, incidental findings requiring additional evaluation)
- Clinician-radiology interactions during consultations
- Importance of provided clinical information/history

Curricular Framework

Core Radiology Topics

Aim: This curriculum covers topics common to several imaging modalities and organ systems to avoid repetition. Topics could be covered separately or integrated into specialist areas.

Outline:

Physics concepts important to requesting providers

Densities, silhouette signs

Terminology used in radiology

Key modality comparisons, advantages, and limitations (modality and patient specific)

Use of contrast media, types, advantages

Orientation to radiology department

Requesting urgent/routine studies

Obtaining preliminary readings, accessing reports

Use of PACS system

Radiation safety:

 Risks associated with radiation exposure

 Chest radiograph (CXR) equivalents of common examinations

Pediatric exposure
Imaging in pregnancy
Other complications of radiology:
 Contrast media (complications, high risk groups, prophylaxis)
 Interventional procedures
 MRI
Societal and emotional impact
Comparative modality costs

Detailed Organ-based Curriculae

Aim:

To provide more details of the topics that ideally should be covered during a 4-week elective, or incorporated into an integrated radiology curriculum. These utilize a common structured format and will be outlines rather than text-book replacements. Please see the link to an example elective at the end of the document for more recommendations on topics to cover during a dedicated radiology elective.

Outline:

Curriculae developed:

Abdominal & Female Pelvis
Breast
Chest
Interventional Radiology
Musculoskeletal
Neuroimaging
Nuclear Medicine
Pediatrics

Curricular topics:

Technical aspects

Techniques used to image this anatomical/physiological area
Patient preparation and education
Studies that should be visualized during elective

Normal anatomy

Structures that should be identified on common modalities
Emphasis on cross-modality correlation

Pathological conditions

Common pathological conditions/findings that the student should recognize
Iatrogenic pathology
Emergency “don’t miss” findings

Imaging algorithms (ACR Appropriateness Criteria®)

Appropriate imaging management algorithms for common diagnostic situation
Cost-effective imaging
Incorporating pre-test probabilities

Curriculum Resources

Aim:

To provide guidance on how the curriculum may be incorporated into various program formats, with suggestions for teaching methods and educational resources.

Outline:

Teaching methods:

Group based conferences
Student presentations
One-on-one teaching
Informal quizzes
Formal exams
Games
Self-learning exercises
Practical experience

Websites:

Casefiles
Tutorials
General information and portals

Social Media

Textbooks

Diagnostic short-list

Aim:

To provide a limited list of diagnoses that all students must be able to recognize. This should be covered during the radiology course, but could be used as a basis for a quiz, game or other format.

Outline:

30-40 common diagnoses with an emphasis on 'don't miss' or emergency findings covering all organ systems. Mostly radiographs, some CT. These images are all available at AMSER-ID as a shared resource.

Goals and Objectives

Aim:

To provide an example of goals and objectives that can be modified for specific programs.

Outline:

Modality-specific goals and objectives, specific recommendations for students while on clinical rotations and suggestions for further study with hyperlinked web-resources. These guidelines come from Dartmouth-Hitchcock Medical Center.

AMSER Shared Resources

Are found at:

<http://www.dartmouth.edu/~amserimages/>

Login: amserid

Password: roentgen

These include a 4000+ image dataset of commonly found conditions, lectures, curricula and other shared resources donated by AMSER members.

STARS (Standardized Tool for Assessing Radiology Students)

Is found at:

<https://www.acr.org/Lifelong-Learning-and-CME/Learning-Activities/Medical-Student-Activities/Radiology-Student-Assessment-Tool>

- Collaboration between AMSER and the ACR
- National, web-based question item database, over 2,800 questions
- Formerly known as Radiology ExamWeb
- For any issues with faculty or student registration, as well as lost username/password, please contact cortexsupport@acr.org.
- For any questions regarding individual items in the question database, exams, or STARS in general, please contact Mahan Mathur (mahan.mathur@gmail.com) or Judith Gadde (judygadde@gmail.com).

Core Topics

Fundamentals of radiology for the requesting provider

Basic principles of image creation in each modality and implications for image interpretation, understanding terminology in written reports, limitations of modalities, effective interactions with the radiology department, risks of imaging, and best uses for each modality.

1. Imaging physics for the requesting provider

What produces density differences on radiographs

Terminology used in radiology (reports)

Radiographs/fluoroscopy:

Lucency, opacity

CT:

Attenuation, enhancement, density, Hounsfield units, artifact

Ultrasound:

Echogenicity (hyper- and hypo-), attenuation

MRI:

Signal intensity (hyper- and hypo-), enhancement, diffusion restriction, artifact

Nuclear medicine:

Uptake, avidity, increased and decreased radioactivity, radiotracer, radioisotope

Silhouette signs on CXR/KUB

Key modality differences

Anatomical resolution versus soft tissue contrast

Fluoroscopy: Concept of dynamic imaging with radiographs and contrast

CT : Concept of tomography, high resolution, fast, best anatomic resolution, CTA, multiplanar and 3D through reconstruction of data

Ultrasound: Concepts of sound reflection as imaging agent, portable scanner, multiplanar

MRI: Concepts of magnetic resonance, multiplanar imaging, best soft tissue resolution, MRA, limited access to patient in scanner, details of physics beyond student level

Nuclear medicine: Concept of anatomical versus physiological imaging, internal administration of radioisotopes with emission of photons captured by detectors

2. Limitations of modalities

Obese patients (weight limits, x-ray penetration, ultrasound)

Acoustic windows in ultrasound (lung, bowel gas)

Claustrophobia (MRI>CT and PET)

Immobile/elderly/sick patients (MRI, fluoro)

CT, MRI and invasive imaging may require sedation esp. in children

3. Contrast media

Types of contrast media

Intracavitary/Intraluminal:

Bowel - Rationale, types of contrast and best uses in bowel imaging

Bladder - Cystography

Intrathecal - Myelography and CSF leak studies

Intra-articular - Indications

Intravascular:

- Iodine based

- Gadolinium based

- Safe use - allergies, renal function screening

- Uses:

 - Improving soft tissue contrast

 - Solid organs

 - Vascular structures

 - Inflammation

 - Renal collecting systems

 - Bladder

 - Characterizing lesions

4. Orientation to radiology department (specific to individual programs)

Requesting urgent/routine studies

- Institutional methods of requesting routine studies

- Institutional methods of requesting urgent studies

- Importance of clinical information (protocoling, interpretation, billing)

- Contact information for responsible physician

- Role of American College of Radiology (ACR) Appropriateness Criteria (AC) ®

Preliminary interpretations (“wet reads”)

- Office hours/on call

Accessing reports

- Preliminary versus final reports

- Findings versus impression

Use of PACS (specific to individual programs)

- Accessing images

- Manipulating images

- Downloading images for presentations (including confidentiality/HIPAA)

Basics of composing a radiology report

- Patient name and medical record number

- Date of the examination
- Indication for the examination
- Technique
- Type and amount of contrast used and route of contrast administration
- Comparison examination(s)
- Radiation dose and fluoroscopy time, if applicable
- Findings
- Impression
- Documentation of communication of urgent or emergent findings

Consultation with a radiologist

- Selecting an appropriate imaging study or no imaging at all
- Understanding or clarifying the report
- Follow up recommendations
- Consultation on outside studies

Role of radiology technologists and nurses

- Patient safety
- Scheduling and workflow in the department
- Special expertise and training in their field

Patient safety and experience in the radiology department

- Discomfort, claustrophobia, length of exam, medical instability
- MRI safety, esp. implanted medical devices and metallic foreign bodies
- Radiation safety

Performing the best test:

- Defining the clinical question that needs to be answered and performing the exam with the highest likely yield while minimizing risk
- Review medical records and prior imaging exams

Patient and care-provider safety:

- Hand hygiene
- Fluid shield
- Radiation safety for all in the room
- MRI safety for all in the room

Creating a good examination environment:

- Educating the parents and child regarding what to expect during the exam
- Coaching parental participation
- Patient positioning devices explained and gently used as needed

Explaining exam results

Toys, soothing or entertaining music, stickers, videos (most common in pediatrics)

Teamwork and planning:

Working with radiology technologists, physician assistants, nurses, and the patient's clinical care team (physicians, RNs, NPs, PAs, nurses aids, respiratory therapists)

Aid from Child-life specialist prn

Pediatric sedation services prn

Special considerations for healthcare workers in the medical imaging environment

Basic MRI safety for healthcare workers

Basic radiation safety for healthcare workers

5. Radiation safety and risks

Risks associated with radiation exposure

Hematological malignancies

Solid organ malignancies

Local skin effects

Teratogenic effects

ALARA principle (As Low As Reasonably Achievable)

CXR approximate equivalents of common examinations (or use period natural exposure)

Lumbar spine radiographs	20
KUB	75
VQ scan	80
Bone scan	180
Myocardial perfusion	250
Chest CT	400 (approx. 20 yrs of 2 view mammograms)
Abdo/Pelvic CT	750

Methods to reduce radiation exposure

Reduction in unnecessary examinations (e.g. daily ICU radiographs)

Dose reduction (CT)

Exposure time reduction (fluoroscopy)

Promote use of US and MRI

Age dependence of radiation sensitivity

Cancer incidence with age exposure

Importance of reducing pediatric radiation exposure

6. Imaging in pregnancy and while breastfeeding

Risk to fetus from radiation, MRI, contrast

No proven risk to fetus from US

Breastfeeding and contrast considerations

Risk of NOT imaging the pregnant woman - trauma, life-threatening condition

Alternate imaging modalities in pregnancy - ultrasound and MRI

7. Other 'risks' of radiology

Contrast media

Complications

Extravasations with tissue necrosis

Allergic reactions

Physiologic reactions

Renal failure

Gadolinium deposition - brain, bone, skin

High risk groups

Allergy (asthma, previous reaction, not shellfish or iodine allergy)

Acute kidney injury and chronic kidney disease

Elderly and infants

Methods to reduce/manage contrast complications

Steroid and antihistamine protocols

e.g. prednisone 50mg po 13 hours, 7 hours, and 1 hour prior to the exam +/- benadryl

50mg po one hour prior.

Pre and post hydration

Risks of percutaneous biopsies and drainage procedures

Bleeding, infection, organ damage, pneumothorax, nondiagnostic sample

Claustrophobia

MRI>CT>nucs or fluoro

Complications specific to fluoroscopy

Bowel perforation

Barium impaction

Barium mediastinitis and peritonitis

Aspiration of contrast media (barium vs. ionic vs. non-ionic contrast media)

Complications specific to MRI

Ferromagnetic displacement (eye debris, aneurysm clips, objects)

Implanted electrical devices (pacemakers, defibrillators, neuro-stimulators)

Artifacts from metallic prostheses and debris

Burns

False positive and negative studies

Additional physical and financial risks of further imaging or biopsy

Emotional risks (e.g. screening mammography)

Risks of non-treatment in false negative cases

8. Financial costs

Patient and society

Comparative charges for common examinations at student's institution

Example:

Examination	\$ Charged as Multiples of X (Global Fee)
Chest radiograph	1
Abdominal series	1
Abdominal US	2
UGI with SBFT	2
Bone scan	3
VQ scan	4
CT colonography	5
MRI lumbar spine without contrast	6
CT chest with contrast	6
US guided thyroid biopsy	6
MRI abdomen with contrast	10
MRI brain with and without contrast	11

PET scan	13
CT chest, abdomen, pelvis	15
CT guided lung biopsy	19
IVC filter placement	38

Abdominal (and Female Pelvis) Imaging

1. Technical aspects (Foundation)

Techniques used to image this anatomical/physiological area

Radiography:

- Acute abdominal series
- KUB
- Decubitus views

Fluoroscopy:

- Gastrointestinal (single vs. double contrast; barium vs. water soluble):
 - Modified barium swallow
 - Esophagram (barium swallow)
 - Upper GI (UGI)
 - Small bowel follow through (SBFT)
 - Enema
- Genitourinary:
 - Cystogram
 - Voiding cystourethrogram (VCUG)
 - Retrograde urethrogram (RUG)

Ultrasound:

- RUQ ultrasound
- “Abdominal” ultrasound
- Pelvic ultrasound (transabominal vs. transvaginal)
- Scrotal ultrasound
- Ultrasound for intraperitoneal fluid

CT abdomen and pelvis

MRI abdomen and pelvis

Patient preparation and education (Clinical)

- Intravenous contrast: screening for contrast allergy and renal failure
- Claustrophobia (MR): possible need for sedation
- Foreign body/medical device screening (MRI)
- Rationale for bladder filling for pelvic ultrasound
- Use of transvaginal probes for pelvic ultrasound
- Hydration pre and post IV contrast

Studies that ideally should be observed during clinical rotation

- Esophagram or upper GI or enema
- CT scan (including "trauma study")
- Abdominal or RUQ or renal ultrasound
- Pelvic ultrasound (transabdominal and/or transvaginal)
- Abdominal MRI

2. Normal anatomy (Foundation)

Structures that should be identified on each modality (where visible) with emphasis on cross-modality correlation especially CT-Ultrasound-Fluoro-KUB

- Esophagus
- Stomach
- Duodenum
- Small bowel
- Colon
- Liver
- Gallbladder
- Spleen
- Pancreas
- Aorta
- IVC
- Kidneys
- Ureters
- Bladder
- Uterus/cervix
- Ovaries
- Cul-de-sac
- Prostate

Testis

3. Pathological conditions (Clinical)

Common pathological conditions/findings that the student should recognize or at least see examples of:

KUB:

- Pneumoperitoneum (see below)
- Illeus
- Bowel obstruction: small and/or large bowel obstruction
- Sigmoid volvulus
- Renal and ureteric calculi
- Gallstones
- Calcified aortic aneurysm
- Benign calcifications (phleboliths, vascular etc)
- Misplaced naso/orogastric tubes

Fluoroscopic studies:

- Evaluation for leak or obstruction

Ultrasound:

- Hydronephrosis
- Renal stones
- Gallstones
- Acute cholecystitis
- Biliary obstruction
- Ascites
- Testicular torsion
- Uterine pathology
- Ovarian cyst/solid mass
- Early intrauterine and/or ectopic pregnancy

CT:

- Pneumoperitoneum
- Hemoperitoneum/retroperitoneal hematoma
- Solid organ injury (laceration/hematoma)
- Active vascular contrast extravasation
- Organ mass

- Hydronephrosis
- Urinary tract calculus
- Abdominal aortic aneurysm (AAA) (with and without rupture)
- Bowel obstruction
- Inflammation (e.g., appendicitis, diverticulitis, pancreatitis)
- Ascites
- Bladder perforation (indications for cystography)

Emergency “don’t miss” findings

- Pneumoperitoneum – upright chest, supine, decubitus and upright AXR, CT
- Hemoperitoneum/retroperitoneal hematoma
- Bowel obstruction
- Aortic rupture/dissection
- Testicular torsion

4. Imaging algorithms (appropriateness criteria) (Clinical)

Appropriate imaging algorithms for common diagnostic situations including cost-effective imaging

- Criteria for performing CT in trauma patient
- Criteria for performing limited ultrasound for abdominal fluid in trauma patient
- Double versus single contrast fluoroscopic studies – discuss with radiologist
- When to request the modified barium swallow vs. esophagram vs. upper GI
- When to request the small bowel follow through

- Acute onset flank pain (suspected renal calculi)
- Painless hematuria
- Scrotal pain
- Pyelonephritis
- Renal failure

- Acute onset right upper quadrant pain (suspected acute cholecystitis)
- Acute pancreatitis (US vs CT, unhelpful in early disease)
- Acute right lower quadrant pain (suspected appendicitis)
- Acute left lower quadrant pain (suspected diverticulitis)
- Small bowel obstruction (SBO)
- Colonic obstruction/ileus
- Rectal bleeding (acute vs chronic, barium enema vs colonoscopy)
- Upper GI bleeding (acute vs chronic, UGI vs endoscopy)

Suspected ruptured AAA

Female pelvic pain (pregnant versus non-pregnant)

Ectopic pregnancy (importance of bHCG level)

Pelvic masses (US vs MR vs CT)

Pelvic inflammatory disease (PID)

Staging for malignant disease (CT vs MRI)

Indications for scanning in the first trimester:

Bleeding and or pelvic pain: (implantation bleed, subchorionic hematoma, molar pregnancy, incomplete abortion, ectopic pregnancy)

Uncertainty of dates - LMP or size larger/smaller than dates (importance of early scans)

Prior history of ectopic pregnancy

Incorporating imaging findings into patient management including impact of pre-test probabilities

Image negative, high pretest probability suspected acute cholecystitis patient

Suspected ectopic pregnancy when no gestational sac seen

Importance of knowledge of serum bHCG result when interpreting early OB scan results in patients with pelvic pain or bleeding

Image negative patient with suspected ectopic pregnancy

Breast Imaging

1. Technical aspects (Foundation)

Techniques used to image this anatomical/physiological area

Mammogram:

Digital X-ray, principles of compression, high resolution

Tomosynthesis (3D-mammography)

Sensitivity/Specificity

Screening- MLO/CC views

Diagnostic- Problem solving indications/views

Ductogram/Galactogram

Ultrasound:

Screening- handheld vs. automated
Diagnostic- problem solving indications
No radiation
Operator dependent

MRI:

Principle of contrast
Screening - ACS criteria
Diagnostic - indications
Silicone Implants

Patient Education:

ACR/SBI/ASBrS screening guidelines vs. USPTF
Benefits and risks of screening mammography
Increasing patient compliance with screening protocols
Understanding the screening call-back system
Radiation risk and cumulative exposure from screening mammography

Studies that ideally should be observed during clinical rotation

Screening mammogram
Diagnostic mammogram
Diagnostic ultrasound

2. Normal anatomy (Foundation)

Structures that should be identified on each modality:

Fat versus glandular tissue
Four quadrants of the breast on mammography

3. Pathological conditions (Clinical)*

Common pathological conditions/findings that the student should recognize or at least see examples of:

Mammography (to include malignant versus benign features):

Breast Density
Masses

Calcifications

Ultrasound (to include malignant versus benign features):

Cystic Mass
Solid Mass

MRI (to include malignant versus benign features):

Masses
Non-Mass Enhancement

Emergency “don’t miss” findings

There are no acute findings in breast imaging required at the medical student level.

****In addition, the student should have a basic understanding of the role of the BI-RADS Lexicon in describing and reporting breast findings****

4. Imaging algorithms (appropriateness criteria) (Clinical)

Appropriate imaging management algorithms for common diagnostic situations

Screening Mammography- when to begin, frequency, when to stop
Dense breasts and supplemental screening
High risk and supplemental screening
Palpable Abnormality
 Woman 40 years or older

Breast Pain
Nipple Discharge
Symptomatic Male Breast
Skin thickening and erythema
Implant rupture
Principles of percutaneous core biopsy- mammo, ultrasound, MRI
Principles of localization techniques for breast conservation

Cost-effective imaging

Mammography as the gold standard for screening

Screening MRI vs. screening ultrasound

Incorporating imaging findings into patient management

Management of callback findings on screening mammography

BI-RADS categories and PPV

Breast Density and supplemental screening

Lifetime risk and supplemental screening

Rad-path correlation

Benign

Malignant

Chest Imaging

1. Technical aspects (Foundation)

Techniques used to image this anatomical/physiological area

CXR:

PA, lat, AP, decubitus views, lordotic view, expiratory view, supine (limitations)

CT:

When contrast helps and when it is contraindicated, definition and use of: high resolution CT, CT pulmonary, aortic, and coronary angiography

MRI:

Basic principles of imaging the heart and mediastinum

Pulmonary angiography:

Basic principles, contraindications, risks

Nuclear medicine:

(FDG lung cancer) – covered under nucs curriculum

VQ scans- covered under nucs curriculum

Patient preparation and education

Fasting 6hr for PET FDG scan

Need to hold breath for CT, respiratory gating MR, cardiac gating for cardiac CT

Studies that ideally should be observed during clinical rotation

Chest radiographs (CXR) - PA and lateral

Portable chest radiograph

CT chest

Cardiac MRI

Chest tube insertion and/or thoracentesis

2. Normal anatomy (Foundation)

Structures that should be identified on each modality (Emphasis on cross-modality correlation)

CXR (PA and lateral) and CT

Lungs:

RUL, RLL, RML, LLL, LUL

Costophrenic and cardiophrenic angles

Minor and major fissures

Trachea and carina

Right and left main bronchi

Retrosternal clear space

Heart:

RV, RA, LV, LA

Aorta, pulmonary outflow tract

Pericardium

Pulmonary veins

Position of heart valves

Mediastinum:

SVC

Carotid and subclavian vessels
Aortic knob, AP window
Right paratracheal line
Azygos vein
Carina
Right and left main pulmonary arteries
Azygo-esophageal line
Right paraspinal line
Left paraaortic line

Bone and soft tissues:

Humeral head, cervical spine, thoracic spine
Scapulae
Clavicles
Sternum
Diaphragms
Liver
Stomach
Colon

Common normal variants:

Azygos lobe
Cervical ribs
Mediastinal lipomatosis
Pericardial fat pads
Left superior vena cava

Pulmonary angiogram (CT and conventional) and MRI

Right and left main pulmonary arteries
Ascending and descending aorta
Origin of great vessels

3. Pathological conditions (Clinical)

The student should be taught a system (chosen by the tutor) of surveying every CXR for abnormalities to ensure that they do not 'gestalt' films.

Common pathological conditions/findings that the student should recognize or at least see examples of:

Atelectasis:

Linear

Lobar: LLL, LUL, RLL, RML, RUL

Indirect signs (mediastinal, hilar, diaphragmatic and fissure shift)

Total lung atelectasis

Pneumonia:

Appearance of and DDX of consolidation (fluid, blood, malignancy, pus)

Silhouette and spine signs

Air bronchograms

Lobar patterns: LLL, LUL, RLL, RML, RUL

Viral/atypical patterns: mycoplasma, PCP

Vascular abnormalities:

Recognition and differential of dilated aorta

Appearance of great vessel ectasia

Thoracic aortic aneurysm

Traumatic aortic injury

Ruptured aorta

Aortic dissection

Pulmonary hypertension

PE (CXR, CT)

Pleural abnormalities:

Pleural effusion (small, large, subpulmonic, decubitus films, supine and upright)

Pneumothorax (small, large, supine and upright, decubitus and expiratory films, tension)

Pneumomediastinum

Pleural thickening and calcifications (asbestos exposure)

Pseudotumor

Empyema

Cardiac abnormalities:

Cardiomegaly (individual chamber enlargement, generalized cardiomegaly)

Cardiac failure (pulmonary venous hypertension, interstitial edema, alveolar edema)

Masses:

- 'Danger zones' for missing tumors
- Non-small cell lung cancer (hilar mass, parenchymal tumor)
- Anterior mediastinal mass (Hodgkins, goiter, thymoma etc)
- Cavitating mass
- Goiter
- Granuloma

Adenopathy:

- Lymphoma
- Sarcoidosis
- Metastases

Interstitial abnormalities:

- Interstitial edema
- Emphysema
- Extensive fibrosis (honeycombing, cystic fibrosis)

Other:

- Distinguishing causes of hemithorax opacification (effusion, vs atelectasis vs pneumonia vs pneumonectomy)
- Meaning of 'groundglass opacity' on CXR/CT

Iatrogenic pathology

- Malplaced Dobhoff/NG tube (eg. esophagus, trachea, bronchus)
- Malplaced central venous catheters (jugular, subclavian, right atrium)
- Malplaced endotracheal tube (too high, low, esophageal)
- Other misplaced wires, catheters

Emergency "don't miss" findings (CXR)

- Tension pneumothorax
- Supine pneumothorax (deep sulcus sign)
- LUL collapse
- Pulmonary edema (interstitial and alveolar)
- Sub-diaphragmatic air

Pneumomediastinum
Signs of aortic dissection
Aortic rupture (supine CXR, CT)
Dobhoff in trachea/bronchus

4. Imaging algorithms (appropriateness criteria) (Clinical)

Appropriate imaging management algorithms for common diagnostic situations

Screening for metastases (CXR vs CT)
Lung cancer screening
Staging for lung cancer (CXR vs CT vs PET)
Suspected pulmonary embolus (CT pulmonary angiography vs VQ vs angio vs leg venous doppler)
Trauma (when to request C/A/P CT scan)
Aortic trauma (when to request CT angiogram, alternatives)
Aortic dissection (CT vs MRI vs TEE)
Small pneumothorax (use of expiratory/decubitus views)
Foreign body aspiration (kids, decub, expiratory views, fluoro)
Solitary pulmonary nodule (SPN) seen on CXR (old radiographs, follow up, CT, PET, biopsy)
Pneumonia (importance of follow up radiographs, when to consider neoplasm workup)
Pneumomediastinum (when is additional imaging required)
Dyspnea in immunocompetent patient
Dyspnea in immunocompromised patient (CXR vs CT)
Interstitial lung disease (CXR vs regular CT vs high res CT)
Total hemithorax opacification (not decubitus)

Cost-effective imaging (Clinical)

Value of obtaining older studies
Daily ICU radiographs indications
PET for lung cancer diagnosis and staging

Incorporating imaging findings into patient management

Interventional Radiology

1. Technical aspects (Foundation)

Techniques used in IR

Imaging guidance for procedures

Fluoroscopy - real time visualization; risk of significant radiation dose (patient and operator)

Digital subtraction angiography - subtraction of non-vascular structures; patient motion artifacts

CT - better visualization of small internal structures than fluoroscopy; risk of significant radiation dose (patient)

US - real time visualization, limited depth, no ionizing radiation, limited by air and bone

Contrast Agents

Non-ionic contrast – intravenous and intra-arterial injections; injections into tubes/drains

Image guided procedures and therapy

Biopsy

Aspiration

Drainage tube placement

Central venous access

GI tube placement

Angiography

IVC filter placement

Fluoroscopic guided lumbar puncture/myelogram

Devices/equipment (Clinical) – basic awareness of tools of the trade

Needles

Catheters (angiographic vs drainage)

IVC Filters (retrievable vs. non-retrievable)

Patient preparation and education

Pre-procedure review of patient imaging

- NPO
- Informed consent
- Pre-procedure labs required (CBC, coagulation, renal function)
- Correction of Coagulopathy
- Pretreatment of contrast allergy
- Hydration pre and post IV contrast
- Timeout (identification of correct side/site for procedure—right/left if applicable)
- Tube and catheter care/management (in hospital and post discharge)

Studies that should ideally be observed during clinical rotation

- Percutaneous biopsy
- Angiographic study
- Central venous access line placement
- Drainage catheter placement
- Thoracentesis
- Paracentesis
- Percutaneous feeding tube (gastrostomy, gastrojejunostomy) placement
- IVC filter placement/retrieval

2. Normal anatomy (Foundation)

Structures that should be identified on each modality (Emphasis on cross-modality correlation)

- Angiographic anatomy
- Recognition of arterial vs venous structures
- Major arteries (aorta-abdominal and thoracic, origins of great vessels, iliac, celiac, hepatic, splenic, SMA, IMA, carotid)
- Major veins (SVC, IVC, IVJ, subclavian, iliac)
- Refer to organ specific curriculae for radiographs, fluoroscopy, CT, US, MRI, Nuclear medicine

3. Pathological conditions (Clinical)

Common pathological conditions/findings that the student should recognize or at least see examples of on diagnostic/therapeutic IR studies during radiology or clinical rotations

Vascular:

- Peripheral vascular disease (stenosis, occlusion)
- AAA
- GI bleed or other site of hemorrhage
- Renal artery stenosis
- Carotid stenosis
- Bowel ischemia
- DVT

Non-vascular:

- Ureteric/UPJ obstruction
- Biliary obstruction
- Pleural effusion
- Empyema
- Ascites
- Abscess
- Tumor (solid organ: lung, liver, thyroid, etc.)

Emergency “don’t miss” findings

IR is generally not used to make initial imaging diagnoses, but to obtain tissue or treat known conditions. Interpretation is beyond the scope of medical student curriculum.

4. Invasive procedures (Clinical)

Identify clinical scenarios where image-guided procedures may be beneficial

Diagnostic studies:

- Peripheral limb ischemia
- Bowel ischemia
- Vascular aneurysms (traumatic and non-traumatic)

Biopsy procedures:

- Mass: lung, liver, thyroid
- Lymph node

Drainage procedures:

- Abscesses – lung, abdomen, pelvic
- Thoracentesis for pleural effusions
- Paracentesis for ascites
- Ureteric obstruction (nephrostomy tube, internal/external drainage)
- Biliary obstruction

Angioplasty, direct intravascular thrombolysis and stent placements:

- Peripheral limb ischemia
- Bowel ischemia
- Biliary strictures

Embolization procedures:

- Intracranial and extracranial aneurysm/pseudoaneurysm
- GI hemorrhage
- Post-traumatic hemorrhage – aortic, spleen, liver, pelvic, limb

Access procedures:

Chemo/pharmacotherapy:

- Central venous access – PICC, Dialysis catheters, central lines, subcutaneous ports

Feeding:

- Gastrostomy tubes

Jejunostomy tubes (reflux rationale)

Others:

Portal hypertension – TIPS
Pulmonary emboli/DVT – IVC filter placement
Osteopenic vertebral body collapse – vertebroplasty/kyphoplasty
Meningitis - fluoroscopic-guided lumbar puncture

5. Imaging algorithms (appropriateness criteria) (Clinical)

Appropriate imaging management algorithms for common diagnostic/therapeutic situations including cost-effective imaging

Indications for placement of an IVC filter in DVT/PE
Management of lung/liver/kidney mass (surgical/bronchoscopic/endoscopic/laparoscopic vs percutaneous approach for biopsy/therapy)
Abscesses (surgical vs IR)
Selection of type of venous access (non-tunneled vs tunneled central line vs port vs PICC)
Dialysis access (AV fistula vs AV graph, dialysis catheter, central vs peripheral stenosis)
Pneumothorax
Pleural effusions (taps vs tubes vs pleurodesis)
Feeding tubes (gastrostomy vs gastrojejunostomy vs surgical placement or endoscopic placement)
GI bleeding (surgery vs endoscopy vs IR)
Post-traumatic hemorrhage (solid organ laceration or pelvic fracture)

Musculoskeletal Radiology

1. Technical aspects (Foundations)

Techniques used to image this anatomical/physiological area

Radiography:

- Importance of focused/goal-directed study ie 'cone and center' (less is more)
- Importance of different projections ("One view is NO view")
- Importance of 4th dimension (Time: changed, unchanged)
- Initially occult fractures often seen at 10-14 days, advise F/U
- Useful additional views including scaphoid view, radial head view
- Normal Variant book
- Importance of older studies/comparisons ("Worry/Don't Worry")

CT:

- Rapid, can create reformats in various planes. Good for bone detail, calcifications
- Use of intravenous and intra-articular contrast
- Radiation dose considerations
- Different soft tissue and bone windows

MR:

- Good for soft tissues, marrow, ligaments, marrow edema for occult fractures
- Multiplanar
- Use of intravenous and intra-articular contrast
- Clinician requests/informs, radiologist protocols
- Getting faster but still relatively slow

Fluoroscopy:

- Guidance for biopsy, analysis of motion in real-time
- Low-dose alternative

Ultrasound:

- Superficial tendons, ligaments, foreign bodies, superficial infections, joint effusions

Nuclear Medicine:

- DEXA for bone mineral density
- PET CT
- Scintigraphy

Patient preparation and education

- Clear expectations: what may hurt, how long it takes, after-effects or absence of same
- No driving after shoulder arthrogram
- Post-procedure pain management
- Importance of holding still during CT/MR

Importance of older studies/exams done elsewhere

Studies that should ideally be observed during clinical rotation

Extremity radiography
Joint Injection- under fluoro and/or US
Shoulder/hip/knee MR

2. Normal anatomy (Foundations)

Structures that should be identified on each modality (Emphasis on cross-modality correlation)

Identification of major parts of:

Name carpal bones (common on shelf and Step exams)
Cardinal directions—medial/lateral, anterior-volar-ventral/posterior-dorsal, cephalo/caudal, AP vs PA

Growth, repair, remodelling (Wolffe's Law)

Structure of long bones:

Diaphysis, metaphysis, epiphysis; apophysis; cancellous/cortical difference; periosteum; articular cartilage; synovium, sesamoids

Common normal variants:

Cervical ribs, extra lumbar vertebra, bipartite patella

Soft tissues:

Identification of and significance of normal soft-tissue fat interface, fascial planes, fat pads

3. Pathological conditions (Clinical)

Common pathological conditions/findings that the student should recognize or at least see examples of:

Trauma:

Joint effusions:

Knee or elbow

Appendicular fractures:

Descriptive conventions for fracture orientation, displacement and angulation
Significance of intra-articular involvement
Significance of physeal plate involvement
Fracture 'evolution' on delayed radiographs
Most common fractures by age (toddler, buckle, supracondylar, jumper's knee, SCFE, proximal femoral neck)
Sports/overuse/stress injuries
Disuse osteopenia
Femoral neck: implications of blood supply; ubiquity/morbidity in elderly
Scaphoid fracture: caveats, physical exam, delayed healing; views
Medial and lateral malleolar fractures, mortise
Base of 5th metatarsal fracture (NOT "Jones"!!)
Tarsal-metatarsal (Lisfranc) fracture/dislocation
Metacarpal/phalangeal fractures
Wrist: Fall On Outstretched Hand
Radial head (signs elbow effusion)
Distal humeral fracture in a child (signs elbow effusion)
Proximal humerus fracture
Clavicle fracture
Metaphyseal corner fractures (bucket handle) in child abuse/nonaccidental trauma
Tibial plateau fracture
Toddler fracture tibia (get BOTH views!)

Common spine fractures:

Compression fractures thoracic and lumbar vertebrae
Burst fractures (mechanism of injury; significance of canal narrowing)
Importance of identifying cervical lines and soft tissues on lateral radiograph
C1 burst (Jefferson) fracture
C2 fractures, dens type I-II-III
Anterior subluxation flexion injury
Posterior ligamentous injury (subtle signs of)

Spinous process fracture
Bilateral jumped facets

Dislocations:

Subluxation vs Dislocation
Biomechanics/mechanisms of injury: history guides search
Anterior gleno-humeral dislocation and Hill Sachs fracture
Common sites

Soft tissue injuries:

Importance of soft tissue planes/exposure/positioning
Appropriate triaging of imaging modalities
Rotator cuff injury
Knee ligament and meniscal injury
Effusion vs contusion

Arthritis:

Osteoarthritis
Inflammatory arthritis
Septic arthritis
Spondylosis/degenerative change vs. arthritis in spinal column

Tumors:

Describe location, margins, matrix, periosteal reaction
Clues to "Worry/Don't Worry"
Importance of older studies; chronic vs changing
Enchondroma
Aggressive vs indolent features
Bone metastasis - blastic vs lytic; appropriate imaging study to assess
Myeloma- imaging caveats

Metabolic bone disease:

Osteoporosis

Infections:

Osteomyelitis
Diskitis
Cellulitis

Emergency “don’t miss” findings

- Septic joint
- Fracture with extension into joint
- Elbow joint effusion, radial head fracture
- Shoulder dislocation
- Abnormalities of spinal-laminar lines/alignment of the c-spine e.g. posterior ligamentous injury
- (Child abuse see pediatric section)
- Replace “Normal” with “Unremarkable”—be suspicious, advise/get F/U
- When in doubt get follow-up and/or additional imaging

4. Imaging algorithms (appropriateness criteria) (Clinical)

Appropriate imaging management algorithms for common diagnostic situations including cost-effective imaging

- Importance of appropriate clinical information
- Importance of CONSULTING radiologist, NOT just ‘ordering’ a study
- Assess adequacy of positioning and exposure FIRST
- Utilizing the ACR AC
- Chronic back pain in an adult (no imaging vs radiographs vs CT vs MR vs myelography)
- Chronic back pain in a child (as above, plus bone scan)

Appropriate imaging for:

- Acute back pain
- Metastatic disease
- Shoulder pain
- Suspected occult femoral neck fracture (CT vs MRI)
- Diabetic foot infection vs neuropathy
(radiography vs MR vs bone scintigraphy vs white cell scan)
- Suspected osteomyelitis in non-diabetic (radiographs vs MR vs bone scan vs white cell scan)
- Suspected osteoporosis
- Total joint replacement (arthroplasty)
- Primary and metastatic bone disease
- Suspected avascular necrosis femoral head

Use of:

- ‘Trauma series’; indications for further imaging

Radiography of the neck in trauma
Defining adequate images- lateral to T1, odontoid view
CT of the cervical spine in trauma
MR of the cervical spine in trauma

Incorporating imaging findings into patient management including effects of pre-test probabilities

Management of:

High suspicion for proximal femoral neck, negative radiographs
Low suspicion c-spine injuries, unremarkable radiographs
(esp. whiplash injuries) --Canadian Cervical Spine Rules and NEXUS
criteria
Persistent pain following injury, imaging negative (use of delayed radiographs,
bone scans, MR)
Suspected avascular necrosis of the hip
Traumatic knee and ankle pain including the Ottawa and Pittsburgh knee rules
and Ottawa Ankle Rules

Neuroimaging

1. Technical aspects (Foundation)

Techniques used to image this anatomical/physiological area

CT - head, neck, face, temporal bones, sinuses, spine
MR - brain, neck, face, temporal bones, sinuses, spine
CTA/MRA - head, neck
Cerebral angiography
Myelography

Studies that should ideally be observed during clinical rotation

- CT - head, spine
- MR - head, spine
- Myelography
- Cerebral angiogram

2. Normal anatomy (Foundation)

Structures that should be identified on each modality (Emphasis on cross-modality correlation CT vs MR)

- Lobes of brain
- Midbrain
- Brainstem
- Spinal cord
- Ventricles
- Optic nerves
- Epidural vs subdural vs subarachnoid spaces
- Circle of Willis
- Venous sinuses
- Vertebral column and discs and nerve roots
- Paranasal sinuses
- Pharynx
- Larynx

3. Pathological conditions (Clinical)

Common pathological conditions/findings that the student should recognize or at least see examples of:

Tumors:

- Intraaxial tumors
- Metastases
- Extraaxial tumors
- Head and neck tumors

Infection:

- Cerebral abscess
- Meningitis
- Discitis/Osteomyelitis
- Paraspinal abscess
- Sinusitis

Trauma:

- Subdural hematoma
- Epidural hematoma
- Subarachnoid hemorrhage
- Intracerebral hemorrhage (appearance of blood on MR vs CT, time dependency)
- Diffuse axonal injury
- Cerebral herniation
- Cervical spine trauma
- Facial trauma

Vascular disease:

- Cerebral aneurysm
- Stroke: early vs late (atherosclerotic, thrombotic/embolic)

Miscellaneous:

- Demyelinating diseases
- Dementia (atrophy)
- Normal age related changes

Emergency “don’t miss” findings

- Hemorrhagic stroke
- Traumatic hemorrhage (subdural, epidural, subarachnoid, intraparenchymal)
- Signs of increased intracranial pressure, midline shift
- Cerebral herniation
- Hydrocephalus
- Space occupying lesions
- Isodense subdurals
- Bilateral hematomas of different ages in nonaccidental trauma (NAT)

Cord compression

4. Imaging algorithms (appropriateness criteria) (Clinical)

Appropriate imaging algorithms for common diagnostic situations including cost-effective imaging

- Suspected stroke patient (CT vs MRI)
- Suspected SAH (CT vs MRI vs angio)
- Proven non-traumatic intracerebral hemorrhage (CTA vs MRA vs angio)
- When to request spine CT vs MR vs radiographs
- Spinal trauma
- Facial trauma (radiographs vs CT)
- Metastatic disease to CNS (CT vs MRI, contrast)
- Headache (CT vs MR vs none)
- Dizziness
- Seizures
- Dementia
- Meningitis
- AIDS in the CNS (MR vs PET vs thallium)
- CNS tumor recurrence vs radiation necrosis (MR vs PET vs thallium)
- Paranasal sinus disease (radiographs vs CT vs MR vs none)
- When myelography is indicated vs MR
- When conventional neuroangiography is indicated
- Stroke – early and late (CT vs MR vs angio)
- TIA's
- Criteria for performing CT prior to lumbar puncture
- Encephalitis
- Multiple sclerosis

Incorporating imaging findings into patient management including effects of pre-test probabilities

- MRA negative patient with subarachnoid hemorrhage
- Stroke patient with evidence of hemorrhage
- Stroke patient without evidence of hemorrhage (timing) with or without CT evidence of

infarct

Nuclear Medicine

1. Technical aspects (Foundation)

Techniques used to image this anatomical/physiological area

Outline of gamma camera operation including to create static images, images over time, and 3D images using SPECT

Concept of radiopharmaceuticals, in general

^{99m}Tc as most commonly used isotope

Concept of ^{18}F -FDG PET scanning and PET-CT

Concept of physiological versus anatomical imaging

Patient preparation and education

Patient preparation for myocardial perfusion imaging (e.g. Caffeine withholding for cardiac pharmacologic stress testing, physically able to do exercise stress, etc)

Fasting for PET scans

Iodine containing products preceding thyroid imaging or treatment

Requirement for keeping still for 20-50 minutes for many nuclear medicine exams

Studies that should ideally be observed during clinical rotation

Bone scan or other routine planar study

SPECT scan of some type

Cardiac stress test and perfusion scan

2. Normal anatomy (Foundation)

Structures that should be identified on each modality with emphasis on cross-modality correlation

Recognize a bone scan

Recognize a myocardial perfusion scan (left ventricular walls, right ventricle)

Recognize a VQ scan

Recognize a PET scan

3. Pathological conditions (Clinical)

Common pathological conditions/findings that the student should see examples of

Interpretation of nuclear medicine studies is beyond the scope of student curriculum; however, they should be shown examples of obvious common clinical entities to demonstrate the role of the modality. The challenge of interpreting the full spectrum of cases should be emphasized:

High probability VQ scan

Extensive bone metastases on bone scan

Myocardial ischemia on myocardial perfusion study

Acute cholecystitis on hepatobiliary scan

Graves' disease on radiotracer thyroid imaging

Metastatic tumor on FDG PET

Emergency “don’t miss” findings

Emergency interpretation of nuclear medicine studies is not appropriate for students or non-radiology interns/residents

4. Imaging algorithms (appropriateness criteria) (Clinical)

Appropriate imaging algorithms for common diagnostic situations

Indications for common nuclear medicine exams: (Tracers used for these exams)

Bone scan (^{99m}Tc methylene diphosphonate (MDP))

- Metastases
- Osteomyelitis

Thyroid scan (^{99m}Tc pertechnetate, ^{123}I NaI, ^{131}I NaI)

- Thyrotoxicosis
- Thyroid nodules

Ventilation perfusion [VQ] scan (^{99m}Tc macro-aggregated albumin, ^{133}Xe , ^{99m}Tc DPTA aerosol)

- Acute pulmonary embolism
- Chronic pulmonary embolism
- Differential lung perfusion

Myocardial perfusion imaging (^{99m}Tc Sestamibi)

- Suspected ischemia
- Evaluation of infarct size
- Pre-operative evaluation of high risk patients e.g AAA
- Viability (FDG)

MUGA (^{99m}Tc labeled RBC)

- Ejection fraction prior to chemotherapy

Hepatobiliary scan (^{99m}Tc DISIDA/mebrofenin)

- Suspected acute cholecystitis
- Suspected chronic cholecystitis/biliary dyskinesia (CCK)

Renal scan (^{99m}Tc DPTA or MAG3 or DMSA)

- Obstruction
- Renovascular hypertension

Renal infarction/function

Gastrointestinal bleeding scan (^{99m}Tc labeled red blood cells)

GI bleed with negative endoscopy

Gastric emptying study (^{99m}Tc sulfur colloid labeled egg sandwich)

Suspected gastroparesis

White blood cell [WBC] scan (^{99m}Tc HMPAO or ^{111}In oxine labeled white blood cells)

Osteomyelitis

PET scan (^{18}F Fluorodeoxyglucose – FDG)

Cancer diagnosis, staging and restaging

Myocardial viability (also listed above)

Seizure focus localization

Acute cholecystitis (hepatobiliary scan vs US vs CT)

Pulmonary embolism (VQ vs CT angiogram)

GI bleeds (bleeding scan vs CT vs angiogram vs endoscopy)

Osteomyelitis (radiographs vs bone scan vs MRI vs WBC scan)

Incorporating imaging findings into patient management including the effects of pre-test probabilities

Understanding the concept of PLOPED criteria

Tumors that may produce false negative bone or FDG PET scans (on bone scans, examples include renal, myeloma, lung, thyroid)

Cardiac stress test data effects interpretation of myocardial perfusion studies

Pediatrics

1. Technical aspects (Foundation)

Techniques used to image this anatomical/physiological area

Fluoroscopy with low dose pulsed fluoroscopy, and other dose reduction techniques

Radiographs -with positioning aids if necessary

CT- may need to swaddle, rarely need sedation, typically do not need precontrast series

MR-with sedation if needed

Ultrasound-no sedation, no radiation, including brain and spine prior to closure of fontanelles and extensive spine ossification

Nuclear medicine – may or may not need sedation

Contrast agents – types, uses, indications and contraindications

Studies that should ideally be observed during clinical rotation

Chest radiograph

Abdominal radiograph

Barium swallow

Fluoroscopic Upper GI

Contrast enema

VCUG

Cranial ultrasound

Abdominal ultrasound

CT angiogram

MR

2. Normal anatomy (Foundation)

Structures that should be identified on each modality or at least seen during elective (Emphasis on cross-modality correlation)

Chest:

- Assessment of CXR rotation in baby
- Normal pulmonary vascularity
- Normal lung volumes
- Expected equal elevation of hemidiaphragms in infants
- Heart size (noting larger ratio heart:thorax in neonate)
- Thymus
- Bones
- Soft tissues
- Pleura
- Tubes and Lines
- Upper abdomen

Abdomen:

- Liver
- Spleen
- Kidneys
- Normal bowel gas pattern in an infant versus older child or adult
- Small bowel versus colon in older children
- Stomach and rectum
- Full bladder
- Lung bases

Skeletal radiographs:

- Normal appearance of growth plates, identification of metaphysis, physis and epiphysis
- CRITOE mnemonic for elbow ossification centers
- Bone age determination

Brain:

- Normal term versus premature neonatal brain appearance (US, CT)

3. Pathological conditions (Clinical)

Common pathological conditions/findings that the student should recognize or at least see examples of:

Trauma:

- Fractures with possible Growth plate injuries (Salter-Harris classification)
- Elbow effusion (significance of)
- Greenstick fractures, esp distal radial torus fracture, toddler fracture
- Fractures highly specific for child abuse: posterior rib fractures and metaphyseal corner fractures
- Avulsion injuries

Infections:

- Pneumonia and round pneumonia
- Bronchiolitis (hyperinflation)
- Necrotizing enterocolitis
- Osteomyelitis vs. septic arthritis
- Febrile UTI: pyelonephritis

Tumors:

- Wilm's tumor
- Neuroblastoma
- Osteosarcoma/Ewings
- Hepatoblastoma

Foreign Bodies:

- Ingested
- Aspirated
- Subcutaneous (radiopaque vs. US for non-radiopaque)

Enteric Pathology:

- Hypertrophic pyloric stenosis
- Malrotation and malfixation of the bowel
- Appendicitis
- Intussusception
- Gastroschisis
- Omphalocele
- Newborn bowel obstruction
- Chronic constipation

Urologic pathology:

Vesicoureteric reflux (VCUG)
Pyelonephritis (US or CT)
Hydronephrosis (prenatal and optimal timing of postnatal US)

Congenital Cardiopulmonary Anomalies

Left to right shunts: ASD, VSD, PDA

Lines and Tubes:

Umbilical artery catheter
Umbilical venous catheter
PICC lines
Endotracheal tube position

Hemorrhage:

Germinal matrix hemorrhage diagnosed by ultrasound

Bone pathology:

Slipped Capital Femoral Epiphysis
Eosinophilic Granuloma
Scoliosis

Emergency “don’t miss” findings

Malpositioned tubes and lines
Non-accidental trauma – posterior rib fractures, metaphyseal corner fractures, multiple fractures of different ages, subdural hematomas of different ages

4. Invasive procedures unique to pediatrics (Clinical)

Identify clinical scenarios where image-guided procedures may be beneficial

Intussusception reduction

5. Imaging algorithms (appropriateness criteria) (Clinical)

Appropriate imaging algorithms for common diagnostic situations including cost-effective imaging

Suspected appendicitis (US vs CT with oral and IV contrast vs MR vs abdominal radiograph)
Cervical spine injury, radiographs and when to do CT/MR
Developmental dysplasia of the hip (US vs radiographs), child with a limp (radiographs vs US vs MRI)
Suspected non-accidental trauma
Suspected intussusception (US vs. abdominal radiograph)
Neonate or young infant with bilious vs non-bilious vomiting (UGI vs US vs enema)
Febrile UTIs (US and or VCUG)
Indications for VCUG
Assessment of possible air-trapping (airway fluoroscopy, inspiration/expiratory radiographs, bilateral decubitus images)
Acute and chronic back pain in children (radiographs vs CT vs bone scan with SPECT)

Contraindicated studies

Intussusception reduction attempt in child with surgical abdomen or hemodynamically unstable

Curriculum Resources

The following are lists of potential teaching resources and methods for a student elective or required course in Radiology. These are collated from multiple programs with different resources, program formats and needs, and obviously not all could be applied in any one program.

1. Teaching Methods

Group based conferences

- Didactic Powerpoint
- "Hot seat" case conference

- Digital interactive teaching using graphical pad and image manipulation software (e.g. Photoshop or Paintshop Pro)
- Case conferences with preview of cases
- Case-based image management conferences with or without preview of clinical scenarios

Student presentations

- Case based or topic based
- To department or just to other students
- Posting past presentations as teaching files or examples on websites
- Examples of good and bad presentations
- Practicing clear guidelines for effective presentation
- Assigning staff or residents to assist in case presentation, preview, and critique
- Recording presentations for feedback and critique
- Development into published case reports
- Evaluation by staff/residents/students as part of the elective evaluation
- Practical feedback/group discussion following presentations

One-on-one based teaching/shadowing

- Workstation shadowing
- Lists of procedures and exams to observe during rotation
- Observation of patient experiences
- Longitudinal shadowing of specific resident or staff mentor
- On-call with resident
- “Sub-intern” experience – assigned cases for interpretation
- Individual OSCE with structured questions and immediate feedback

Informal Quizzes

- Powerpoint quiz
- Web-based multiple choice quizzes with feedback (with or without cumulative student responses for self-comparison)
- Group or individual effort

Formal Exams

- <http://radiology.examweb.com>

- National database of multiple choice questions for students on radiology rotations.
- Exams developed, shared and taken
- For more information contact: mahan.mathur@gmail.com
- Paper or computer based
- Multiple choice
- Fact based or image based
- Timed or open
- Powerpoint or web-based
- Self-scoring or not
- Oral case discussions
- Provide immediate immediate/delayed/no feedback and explanatory answers
- Multiple or single attempts
- Pre-course and post-course examinations
- Supervised or honor system
- Individual OSCE with structured question

Games

- Team case conference (previewed or not)
- Image Jeopardy (blank downloadable from AMSER website)
- Image “Who wants to be a Millionaire”
- “Radiology Charades” conference (contestant has to describe the findings of a case using the correct radiology terminology and the audience who have their backs to the case have to guess what it is)
- Use of audience response systems (ARS)
- Use of team/individual response buzzers

Self-learning exercises

- Student specific teaching files
- Websites (see below)
- Web-based tutorials
- Imaging algorithms with clinical scenarios
- Anatomy identification on images with or without immediate answers
- Past student presentations

Hands-on-practical experiences

- Supervised ultrasound practice on other students or phantoms (with or without atlas reference)
- PACS access
- “Sub-intern” experience – assigned cases for interpretation from worklist

2. Websites

Casefiles

- [AMSER Shared Resources](http://www.dartmouth.edu/~amserimages/) (<http://www.dartmouth.edu/~amserimages/>)
Login: amserid, Password: roentgen
These include a 4000+ image dataset of commonly found conditions, lectures, curricula and other shared resources donated by AMSER members
- [Pediatricradiology.com](http://www.pediatricradiology.com/) (<http://www.pediatricradiology.com/>)
Extensive links to collections of pediatric cases, and additional links to tutorials on pediatric imaging procedures, congenital heart disease, pediatric measurements and fractures amongst others.
- [Compare Radiology](http://www.evaluation.idr.med.unierlangen.de/Ecomparetitlepage.htm)
(<http://www.evaluation.idr.med.unierlangen.de/Ecomparetitlepage.htm>)
This site was developed by students and staff at Univ. Erlangen, Germany. It is quite a nice if not "glossy" interactive student teaching tool for general radiology.
- [Mallinkrodt teaching files](http://gamma.wustl.edu/home.html) (<http://gamma.wustl.edu/home.html>)
Excellent nuclear medicine teaching cases.

Teaching programs

- [Chest X-ray.com](http://www.chestx-ray.com) (<http://www.chestx-ray.com>)
Site devoted to thoracic imaging with many links. Also has a more public section describing all of the modalities and their protocols. One link is designed for medical students. Nice chest CT anatomy section.

- [University of Virginia Radiology Teaching](http://www.med-ed.virginia.edu/courses/rad)
(<http://www.med-ed.virginia.edu/courses/rad>)
Excellent radiology tutorial series.
- [Breast Cancer Detective](http://www.med.umich.edu/lrc/breastcancerdetective) (<http://www.med.umich.edu/lrc/breastcancerdetective>)
Interactive game teaching basic mammography to medical students from Marilyn Roubidoux at the University of Michigan.
- [Washington University Skeletal Anatomy](http://uwmsk.org/RadAnatomy.html) (<http://uwmsk.org/RadAnatomy.html>) Review of basic skeletal anatomy on radiographs. This site also has more complex MRI-based MSK anatomy tutorials.
- [LUMEN crosssectional anatomy project](http://www.lumen.luc.edu/lumen/meded/grossanatomy/x_sec/mainx_sec.htm)
(http://www.lumen.luc.edu/lumen/meded/grossanatomy/x_sec/mainx_sec.htm)
Using CT and the Visible Human Project from Loyola University.
- [Albert Einstein radiology education site](http://www.learningradiology.com) (www.learningradiology.com)
Albert Einstein Medical Center Radiology teaching resources and tutorials, cases aimed at medical students and radiology residents-in-training with a very good section for students.
- [University of Auckland Anatomy Atlas](http://www.fmhs.auckland.ac.nz/sms/anatomy/atlas/intro.aspx)
(<http://www.fmhs.auckland.ac.nz/sms/anatomy/atlas/intro.aspx>)
Sectional anatomy with CT and MRI correlation of entire body
- [OB Ultrasound.net](http://www.ob-ultrasound.net/) (Joseph Woo) (<http://www.ob-ultrasound.net/>).
Nice introductory site for students interested in learning the rudiments of obstetrical ultrasound.
- [Beth Israel nuclear medicine tutorial](http://mycourses.med.harvard.edu/vp_view.asp?frame=Y&case_id=%7BA05B20FA-F648-468F-BB4C-F6FE9ED09438%7D)
(http://mycourses.med.harvard.edu/vp_view.asp?frame=Y&case_id=%7BA05B20FA-F648-468F-BB4C-F6FE9ED09438%7D)
Course designed for primary care physicians covering the indications and descriptions of the common nuclear medicine studies. Nice review for students.
- [Learning Radiology](http://www.learningradiology.com/medstudents/medstudtoc.htm) (<http://www.learningradiology.com/medstudents/medstudtoc.htm>)
A resource for all radiology trainees with a dedicated section for medical students, including modules, quizzes, and lectures.
- [Radiology Masterclass](https://www.radiologymasterclass.co.uk/) (<https://www.radiologymasterclass.co.uk/>)

Radiology courses, tutorials, galleries, and quizzes for medical students, junior physicians, and allied healthcare professionals.

- [HeadNeckBrainSpine \(https://headneckbrainspine.com/\)](https://headneckbrainspine.com/)
Neuroradiology anatomy and cases for all levels of trainees.
- [Radiopaedia \(https://radiopaedia.org/?lang=us\)](https://radiopaedia.org/?lang=us)
Open-edit educational radiology resource.
- [Team Rads \(http://teamrads.com/\)](http://teamrads.com/)
John Hopkins University School of Medicine educational website including anatomy modules and information about transition to the wards.
- [Lieberman's eRadiology \(http://www.bidmc.org/MedicalEducation/Departments/Radiology/MedicalStudents.aspx\)](http://www.bidmc.org/MedicalEducation/Departments/Radiology/MedicalStudents.aspx)
This is an extensive series of sites, containing modules for students as well as primary care practitioners. It includes flash and ppt modules, some with voice. Excellent and comprehensive site, especially for chest and abdomen. Some files very large.
- [Dartmouth anatomy \(Nancy McNulty\) \(http://www.dartmouth.edu/~anatomy\)](http://www.dartmouth.edu/~anatomy)
Basic anatomy and radiological anatomy modules, most suitable for first year students or refresher for clinical years.

General information and Portals

- [AMSER \(http://www.aur.org/Affiliated_Societies/amser/index.cfm\)](http://www.aur.org/Affiliated_Societies/amser/index.cfm)
Alliance of Medical Student Educators in Radiology is an affiliate of the Association of University Radiologists and an excellent resource for medical student program directors in radiology.
- [Aunt Minnie.com \(http://www.auntminnie.com\)](http://www.auntminnie.com)
General radiology news, cases, and well used med student discussion board. Good if you hear about some new radiology test/news and want the inside story on it before your patients ask you.
- [Association of Program Directors in Radiology \(http://www.apdr.org/\)](http://www.apdr.org/)
Includes information for medical students, teaching resources and program information
- [RSNA \(http://www.rsna.org/residency.cfm\)](http://www.rsna.org/residency.cfm)
Links for medical students interested in a career in Radiology.

- [Radiology Education](http://www.radiologyeducation.com/) (http://www.radiologyeducation.com/) Multiple links to a huge number of websites, lists textbooks and case files.
- [ACR Appropriateness Criteria](http://www.acr.org/secondarymainmenucategories/quality_safety/app_criteria.aspx) (http://www.acr.org/secondarymainmenucategories/quality_safety/app_criteria.aspx) A must for every medical student to know about. Useful resource for image algorithm sessions.

3. Educational Social Media Accounts

Twitter:

@AURtweet - The Association for University Radiologists
 @ASNR - American Society of Neuroradiology
 @ASHNRSociety - American Society of Head and Neck Radiology
 @ASPNR - American Society of Pediatric Neuroradiology
 @SocPedRad - The Society for Pediatric Radiology
 @SocAbdRadiology - Society of Abdominal Radiology
 @SSRBone - Society of Skeletal Radiology
 @SRUradiology - Society of Radiologists in Ultrasound
 @BreastImaging - Society of Breast Imaging

4. Textbooks

Felson's Principles of Chest Roentgenology, A Programmed Text: **4th Edition** by [Lawrence R. Goodman](#)

Publisher: Harvard University Press
 Pub. Date: November 2014
 ISBN-13: 978-1455774838

Learning Radiology: Recognizing the Basics: 3rd Edition by [William Herring](#)

Publisher: Saunders
 Pub. Date: April 2015
 ISBN-13: 9780323043175

Squire's Fundamentals of Radiology: 7th Edition by [Robert A. Novelline](#)

Publisher: Harvard University Press
 Pub. Date: January 2018
 ISBN-13: 9780674012790

Diagnostic Shortlist : The “Must See” Images

Images all students should see

This is a limited list of diagnoses and their respective imaging modalities that all students should be shown and be able to recognize classic examples of, regardless of their planned speciality. Images that can be used for teaching this list are available at AMSER-ID (see websites above).

Condition	Details	Modalities
Pneumothorax	Upright, supine, signs of tension, adult and child	CXR, CT
Pneumonia	Lobar, sublobar, viral, spine sign	CXT, CT
Pneumomediastinum		CXR, CT
Pneumoperitoneum	Upright, supine, left lateral decubitus	CXR, KUB, CT
Pleural effusion	Upright, supine	CXR, CT
Pulmonary edema	P.venous hypertension, interstitial, alveolar	CXR
Aortic dissection		CXR, CT
Aortic rupture		CXR, CT
Diaphragmatic rupture		KUB, CT
SBO	Upright, supine	KUB

Cecal and sigmoid volvulus		KUB, enema
Distal large bowel obstruction	Upright, supine	
Ascites		US, CT
Misplaced lines/tubes	Dobhoff/NG tubes, central venous catheters, endotracheal tubes	CXR, KUB
Non-accidental trauma	Metaphyseal and posterior rib fractures, subdurals (inc. isodense)	CXR, extremity films, CT/MR
Stroke	Edema, hemorrhage, mass effect	CT
Intracranial traumatic hemorrhage	Epidural, subdural, subarachnoid, intraparenchymal	CT
Increased intracranial pressure	Inc. shift and cerebral herniation, hydrocephalus	CT
Space occupying lesions	Mass effect, +/- contrast	CT, MR
Cervical spine injury	Abnormalities of spinal-laminar lines/alignment of the c-spine e.g. posterior ligamentous injury	Radiographs
Fracture with extension into joint	Knees, ankles, wrist, elbow	Radiographs
Elbow joint effusion	Radial head fracture, distal humeral fracture	Radiographs, child and adult

Shoulder dislocation	Anterior and posterior	Radiographs
Buckle fractures	Extremity, child	Radiographs
Scaphoid fracture		Radiographs
Proximal femoral fracture	Obvious and more subtle	Radiographs

Example of Goals and Objectives for a Student Elective

This is an example of modality specific goals and objectives for 4th year medical students on a 4-week rotation in radiology (from Dartmouth-Hitchcock Medical Center). It includes web resource links for the students.

(current version available at http://docs.google.com/View?id=dc544pq3_2ds3ks2dq)