

DIAGNOSTIC MEDICAL IMAGING

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Table 1. Imaging Modalities

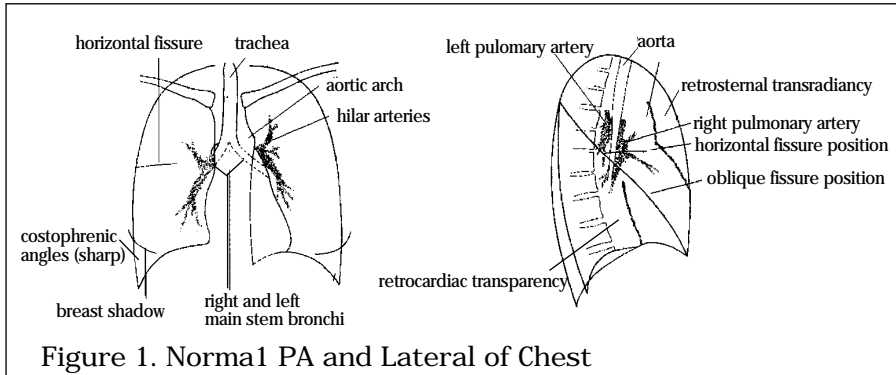
Modality	Theory	Considerations	Advantages
plain film (non-contrast)	<ul style="list-style-type: none"> x-rays, or roentgen rays: form of extremely electromagnetic energy of short wavelength images produced by passing x-rays through subject and recording image onto x-ray film radiation exposure 	<ul style="list-style-type: none"> contraindicated in pregnancy limited densities visible (metal, bone, fat, water, air) portable may not identify soft tissues well 	<ul style="list-style-type: none"> inexpensive noninvasive readily available
contrast studies	<ul style="list-style-type: none"> contrast media necessary to examine structures that do not have inherent contrast differences barium sulphate: most common contrast material in GI exams water-soluble materials; indicated whenever there is a possibility of leakage of contrast material beyond bowel wall or into mediastinum contrast materials may be given alone or in combination with air, water, or CO₂-producing effervescent mixture (air contrast studies) preparations given by mouth (anterograde) or rectum (retrograde) 	<ul style="list-style-type: none"> barium produces a severe desmoplastic reaction in tissues water-soluble contrasts do not produce desmoplastic reaction are absorbed from the rupture site to be excreted through the kidneys may cause severe chemical pneumonia if aspirated cost more radiation exposure due to fluoroscopy contraindications: contrast allergy, renal failure, multiple myeloma, dehydration, diabetes, severe heart failure 	<ul style="list-style-type: none"> delineates intra-luminal anatomy may demonstrate patency, lumen integrity, or large filling defects under fluoroscopy, may also give information on function of an organ
US	<ul style="list-style-type: none"> high frequency sound waves transmitted from a transducer and passed through tissues reflections of the sound waves: picked up by transducer and transformed into images reflection occurs when the sound wave passes through tissue interfaces of varying acoustic density Doppler: specialized mode where velocity of blood that flows past the transducer can be quantified based on Doppler principle Duplex Scan: a procedure or scanner capable of producing visual images as well as Doppler scanning; false colour is often used for further details regarding flow description of findings based on echogenicity hyperechoic lesions: areas where a bright line or area is noted with no through transmission hypoechoic lesions: darker areas; may present with increased transmission of sound waves 	<ul style="list-style-type: none"> tissues with large differences in acoustic density produce return signals approaching 100%, preventing through transmission to deeper structures highly operator-dependant air in bowel or bony structures prevents imaging of abdomen and head coupling fluid (jelly) must be used on skin to improve transmission 	<ul style="list-style-type: none"> relatively low cost little preparation required noninvasive investigation no radiation exposure real time imaging may be used for guided biopsies
CT	<ul style="list-style-type: none"> multiplanar imaging modality fan x-ray beam from an x-ray source rotates around patient with subsequent scatter picked up by detectors on opposite side of patient transmission of radiation at various angles through patient → mathematical equations may be implemented to calculate the signal attenuation within a single point in space (a.k.a. voxel) → information rendered in a 256 grey scale image unit of attenuation: Hounsfield: +1 000 (bone) > 0 (water) > -1 000 (air) window (gate): specific range of Hounsfield optimized for specific tissues (e.g. bone, liver, lung, soft tissue) centre (level): Hounsfield unit around which the 256 grey scale is centred helical/spiral CT: allows for volume data set to be acquired for finer detail and 3D rendering, particularly of vascular anatomy 	<ul style="list-style-type: none"> relatively high radiation exposure IV contrast injection anxiety of patient when going through scanner relatively high cost absolutely contraindicated in pregnancy 	<ul style="list-style-type: none"> spiral CT has fast data acquisition CT angio less invasive than angiography delineates surrounding soft tissues excellent at delineating bones centre and window can be changed after exam excellent at identifying lung nodules/liver metastases may be used to guide biopsies helical CT may allow 3D reconstruction MDCT

Table 1. Imaging Modalities (continued)

Modality	Theory	Considerations	Advantages
MRI	<ul style="list-style-type: none"> • patient placed in magnetic field • measure response of H⁺ protons in tissues to an applied radio frequency • computers process the images in various planes • MR image depends on signal intensity, which depends on several factors such as hydrogen density and two magnetic resonance times (T1 and T2) • the greater the hydrogen intensity, the more intense (bright) the MR signal • tissues that contain very little hydrogen (e.g. cortical bone, flowing blood, air-filled lung) generate little or no MR signal and appear black on images 	<ul style="list-style-type: none"> • relatively high cost • limited facilities • not good for identifying bone lesions • contraindicated if patient has metal prosthetics • high level of anxiety associated with high failure rates • patient must be able to fit into magnet • claustrophobia 	<ul style="list-style-type: none"> • no radiation, noninvasive • can produce images in any plane (e.g. coronal and sagittal) • able to highlight pathologic changes in different tissues through contrast manipulation • bone artifact does not obscure posterior fossae imaging • easy to differentiate white and grey matter • delineation of soft tissues
nuclear imaging	<ul style="list-style-type: none"> • based on selective uptake of various compounds by different organs of the body • radioisotopes may be tagged to these compounds or given alone if isotope has physiologic activity • emitted rays recorded by gamma camera during period of gamma emission --> converted to an image • commonly used labels: technetium-99m (most common), gallium-67, iodine-123, indium-113m, thallium-201 • 5 mechanisms of isotope concentration in body <ol style="list-style-type: none"> 1. blood pool or compartmental localization (e.g. cardiac scan) 2. physiologic incorporation (e.g. thyroid scan, bone scan) 3. capillary blockage (e.g. lung scan) 4. phagocytosis (e.g. liver scan) 5. cell sequestration (e.g. spleen scan) • conventional nuclear scans use isotopes that produce gamma radiation • PET: use cyclotron-produced isotopes of extremely short half-life that emit positrons • SPECT: use a gamma-camera that can do tomography 	<ul style="list-style-type: none"> • radiation exposure/injection is now minimal • relatively long procedures due to uptake times • relatively high cost of procedure • limited facilities for radioactive substances 	<ul style="list-style-type: none"> • offers information regarding functional status of organs • able to evaluate physiological activity of area of interest • able to spatially localize areas of uptake • may assess flow rates and turnover rates of specific tissues • one of the only imaging modalities for inflammation/infection scanning • useful for identifying bone metastasis

GENERAL

- density: defined by the ability of a structure to attenuate the x-ray beam (air < water < fat < calcium)
- contrast: difference between densities
- standard views: erect PA and left lateral (see Figure 1)
- supplemental films may include oblique, lordotic, and decubitus (left or right) views
- structures further away from film are enlarged due to scattering of rays
- differentiate AP from PA, and supine from erect



APPROACH TO THE CHEST X-RAY (CXR)

- Mnemonic: It May Prove Quite Right but Stop And Be Certain How Lungs Appear

Extrinsic

- Identification: date of exam, patient name, sex, age
- Markers: R and L
- Position: medial ends of clavicles should be equidistant from spinous process at midline
- Quality: degree of penetration (e.g. disc spaces just visible through heart but not able to see detailed bony anatomy)
- Respiration: right hemidiaphragm at 6th anterior interspace or 10th rib posteriorly on good inspiration
 - poor inspiration results in poor aeration, vascular crowding, compression and widening of central shadow

Intrinsic

- Soft tissues: neck, axillae, pectoral muscles, breasts/nipples, chest wall
 - nipple markers can help identify nipples
 - look for masses and amount of soft tissue present
 - soft tissues may cast shadows into the lung fields
- Abdomen: liver, stomach and gastric bubble, spleen, gas-filled bowel loops, vertebrae, free air
- Bones: C-spine, T-spine, shoulder girdle, ribs (turn film on its side to help focus on ribs), sternum (best on lateral film)
- Central shadow: trachea, heart borders, great vessels, mediastinum, spine
- Hila: pulmonary vessels, mainstem and segmental bronchi, nodes
- Lungs: pleura, diaphragm, lung parenchyma
- Absent structures: review the above, noting ribs, breasts, lung lobes

COMMON CXR ABNORMALITIES

- abnormal findings are not pathognomonic of a particular diagnosis and only suggest certain types of disease
- always consider the clinical history
- ALWAYS HAVE PREVIOUS FILM FOR COMPARISON (if available)

Bones and Soft Tissues

- obliteration of clavicular companion shadow may represent excess fat or supraclavicular adenopathy (the latter most likely if unilateral)
- lytic or sclerotic lesions may be primary or mets (see Musculoskeletal System below)
- fractures in ribs (discontinuity in bony cortex or sharp line)
- features of osteoporosis (osteopenia, compression #, wedged vertebral bodies) may be seen in the T-spine (see Musculoskeletal System below)

Pleura, Diaphragm, and Viscera

- pleural and extrapleural masses: form obtuse angles at their edges
- pulmonary masses: form acute angles with the pleura
- pleural thickening and effusions
- high diaphragm: abdominal distention, lung collapse, pneumonectomy, pregnancy, pleural effusion
- low diaphragm: asthma, emphysema, large pleural effusion, tumour
- free air underneath diaphragm (pneumoperitoneum)
- calcifications in diaphragm: asbestosis

Blunting of Costophrenic Angles

- indicates pleural effusion or thickening
- features of effusion
 - fluid is higher laterally than medially
 - fluid forms meniscus with pleura, best seen on lateral
 - no air bronchogram
 - where effusion runs into a fissure, both sides of the fissure are visible
 - trachea and mediastinum central or pushed to opposite side
 - lateral decubitus film with effusion in dependent position will show layering
 - may see partial collapse (atelectasis)
- pooling of fluid occurs first in posterior recess, then spreads laterally and anteriorly
- first sign may be a shift of maximal convexity of the hemidiaphragm from the middle 1/3 to the junction of the middle 1/3 and lateral 1/3
- need at least 200 cc of fluid in subpulmonic pleural space for blunting to occur
- never see horizontal fluid level unless associated with pneumothorax (always a meniscus)
- effusions more likely to be malignant when massive (a soft sign)
- blunting may also represent scarring of parietal pleura from old infections, trauma, surgery
- U/S superior over plain film for detection of small effusions (can also aid in thoracentesis)

Pneumothorax (see Colour Atlas K8)

- thin, veil-like pleural margin over the lung edge with no lung markings extending beyond
- air collects superiorly
- more obvious on expiratory or lateral decubitus film
- atelectasis (partial, complete) may be seen
- mediastinal shift if air under tension

Enlargement/Distortion of Cardiovascular Shadow

- cardiothoracic ratio
 - in adults, the ratio of the greatest transverse dimension of the central shadow to the greatest transverse dimension of the thoracic cavity
 - only valid on good quality erect PA chest film
 - > 0.5 abnormal
 - cardiomegaly, poor inspiration, supine position, obesity, pectus excavatum
 - Ddx of ratio > 0.5: cardiomegaly suggests either myocardial hypertrophy or dilatation or pericardial effusion (pure hypertrophy very hard to see)
 - may be < 0.5 and still be enlarged if multiple problems (e.g. cardiomegaly + emphysema)
- pericardial effusion
 - globular heart
 - loss of indentations on left mediastinal border
 - peri- and epicardial fat pad separation on lateral film
- transverse diameter of heart changes by 1 cm between systole and diastole

Isolated Cardiac Chamber Enlargements (see Figure 2)

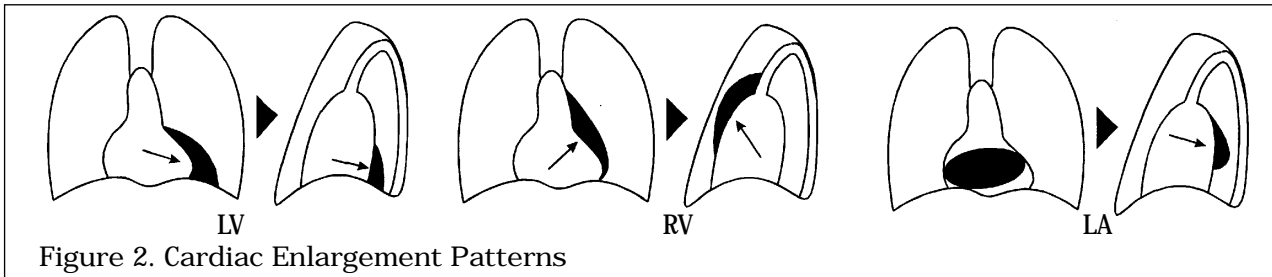


Figure 2. Cardiac Enlargement Patterns

- RA enlargement
 - increase in curvature of right heart border
 - enlargement of SVC
- LA enlargement
 - straightening of left heart border
 - increased radio-opacity of lower right side of cardiovascular shadow (double heart border)
 - elevation of left main bronchus, splayed carina (late)
 - compression of esophagus on GI barium studies
- RV enlargement
 - elevation of cardiac apex off diaphragm
 - anterior enlargement on lateral leading to loss of retrosternal air space
 - increased contact of RV against sternum
- LV enlargement
 - displacement of cardiac apex inferiorly and posteriorly
 - increased outward lower bulging
 - on lateral film, from junction of IVC and heart at level of diaphragm, measure 1.8 cm posteriorly then 1.8 cm superiorly → if cardiac shadow extends beyond this, then LV enlargement (Rigler's Sign)

Calcifications

- valves, coronary arteries, pericardium, aorta, walls of LV (posterior infarct/aneurysm), costochondral junction
- to identify calcified/artificial valves, consider direction of blood flow and location
- on lateral film, draw line from carina to xiphoid → divide heart into thirds → valves should fall at junctions of lines shown in Figure 3

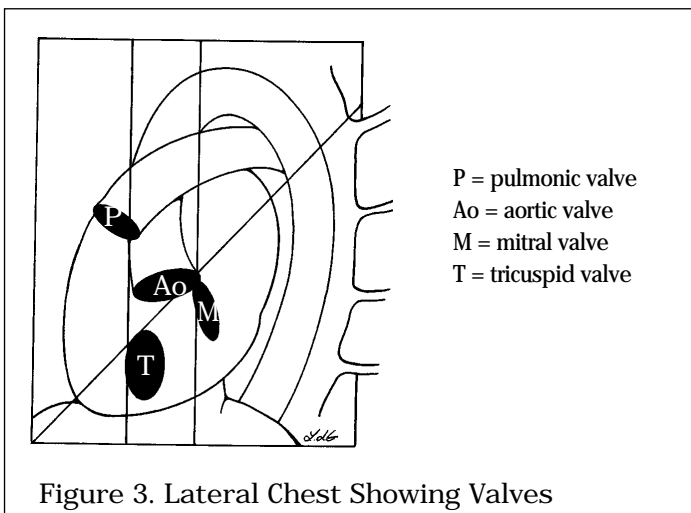


Figure 3. Lateral Chest Showing Valves

Hyperinflation (see Colour Atlas K11 and K12)

- increased radiolucency (increased aeration)
- vasculature spread further apart (attenuation)
- low, flattened diaphragms, often serrated (fibrosis), seen best on lateral

- look for spontaneous pneumothorax secondary to rupture of air bullae
- increased AP chest diameter and retrosternal airspace on lateral
- HRCT is best modality

Silhouette Signs (see Colour Atlas K10)

- in CXR, can see diaphragm and mediastinum because of abrupt change of radiodensities between lung and these structures
- silhouette sign refers to loss of normally appearing profiles or interfaces implying solid change in adjacent lung
 - e.g. loss of R heart border = RML consolidation
 - L heart border = lingula
 - R hemidiaphragm = RLL or pleura
 - L hemidiaphragm = LLL or pleura
 - aortic arch = ant seg LUL
 - superior vena cava = RUL
- signs mostly due to consolidation, but other processes may also produce silhouette sign (atelectasis, masses)

Air Space Disease vs Interstitial Disease (see Colour Atlas K1 and K2)

- air space disease: pathological process primarily in alveoli
 - acinar shadows (small, fluffy, ill-defined densities which tend to coalesce)
 - air bronchogram (air-containing bronchi surrounded by dense, airless lung)
 - the silhouette sign
- DDx: fluid (pulmonary edema), pus (pneumonia), blood (hemorrhage), cells (lung CA/lymphoma), protein (alveolar proteinosis)
- interstitial disease: pathological process primarily in lung interstitium (i.e. scaffolding of lung)
 - reticular pattern: thin, well defined linear densities, often in net-like arrangement; Kerley B lines may be present (see below)
 - nodular pattern: multiple, discrete, nodular densities, < 5 mm diameter
 - reticulonodular: may see both patterns
- DDx: pulmonary edema, miliary TB (see Colour Atlas K6), idiopathic pulmonary fibrosis, sarcoidosis, pneumoconioses
- both air space and interstitial disease may be occurring simultaneously (e.g. pulmonary edema)

Consolidation (see Colour Atlas K2)

- process whereby air in lung acini is replaced by fluid (or tissue) (i.e. air space disease)
- areas vary from 5 mm to entire lung fields
- initially may have multiple foci, ill-defined and irregularly-shaped
- foci may later coalesce into areas of homogeneous radiopacity (i.e. lobar consolidation)
- features
 - shape conforms to that of lobes or segments (see Figure 4)
 - no homogeneous shadow outside the lung edge
 - air bronchogram may be present
 - where the consolidation abuts against a fissure, only one side of the fissure is visible
 - trachea and mediastinum are pulled toward side of shadow (secondary to volume loss)
 - silhouette sign
- DDx: infection (especially bacterial pneumonia), infarction, pulmonary contusion, allergy, tumour

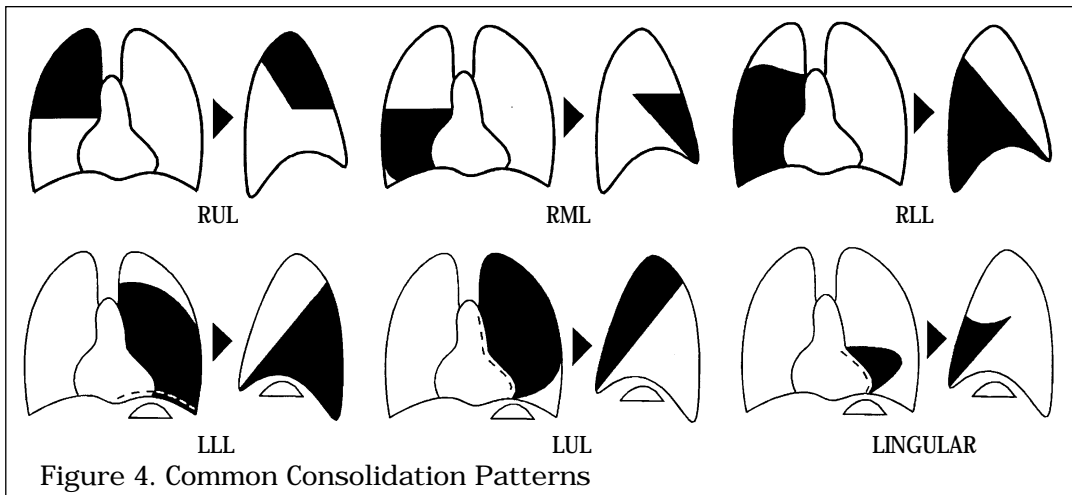


Figure 4. Common Consolidation Patterns

Pulmonary Edema

- ❑ either cardiogenic (CHF, renal failure, volume overload) or non-cardiogenic (ARDS, aspiration, noxious gas inhalation), neurogenic
- ❑ edema fluid initially collects in interstitium → see reticulonodular pattern first → Kerley B lines
- ❑ seen first in hilum, then spread outwards to periphery - "bat wing's appearance"
- ❑ in severe pulmonary edema, fluid begins to collect in alveoli

Septal (Kerley) Lines

- ❑ thickened connective tissue planes
- ❑ occur most commonly in pulmonary edema and lymphangitis carcinomatosa
- ❑ Kerley A lines: radiate towards hila in mid- and upper-lung zones, lines 3-4 cm long, smaller than vascular markings (not useful)
- ❑ Kerley B lines: horizontal, < 2 cm long and 1 mm thick, at periphery of lung, reach lung edge (very useful)
- ❑ DDX of Kerley B Lines
 1. pulmonary edema
 2. lymphangitic carcinomatosis
 3. sarcoid
 4. lymphoma

Sequential Pattern of Findings in CHF Relative to LVEDP

(see Colour Atlas K3 and K4)

- ❑ LVEDP of 15 - pulmonary vascular redistribution to upper lung zones
- ❑ LVEDP of 20 - interstitial edema with Kerley B lines and peribronchial cuffing (edema)
- ❑ LVEDP of 25 - alveolar edema, significant air space pattern

Atelectasis

- ❑ loss of volume pattern (subsegmental pulmonary collapse)
- ❑ may be secondary to bronchial obstruction, fibrosis, pleural disease, PE, bronchiectasis
- ❑ examples of bronchial obstruction include bronchogenic CA and post-op mucus plugging
- ❑ resorption: collapse of alveoli develops within a few hours of airway obstruction because air distal to lesion is resorbed
- ❑ passive: decreased lung volume secondary to a space-occupying lesion
- ❑ cicatrization: increased recoil secondary to fibrosis
- ❑ signs of collapse
 - shift of a fissure (most important)
 - mediastinal shift to the side of collapse
 - shift of hilum
 - diaphragm elevation (less volume in the hemithorax)
 - increased density (shadow of collapsed lobe)
 - compensatory hyperinflation (ventilated areas are blacker)
 - silhouette sign may be seen
 - bronchogenic CA until proven otherwise

Pulmonary Nodules (see Table 2)
(see Colour Atlas K7)

DDx

- primary CA (35%)
- non-specific granuloma (35%)
- TB granuloma (20%)
- hamartoma (5%)
- metastatic CA (5%)

	Malignant	Benign
margin	ill-defined/spiculated (corona radiata)	well-defined
contour	multi-lobular	smooth
calcification	eccentric or stippled	diffuse, central, popcorn, concentric
doubling time	20-460 days	< 20 days, > 460 days
other features	cavitation, collapse, adenopathy, pleural effusion, lytic bony lesions, smoking history	

- doubling time: time to increase diameter by 1.26x - compare old films
- if no change in size over 2 years, 99% chance benign
- CT scan excellent for determining the pattern of calcification and presence of fat (as in hamartoma)
- clinical information and CT appearance determine level of suspicion of CA
 - if high probability, then do an invasive test
 - if low then repeat CXR in one month and repeat every 6 months for 2 years
- needle aspiration - CT or fluoroscopic guidance
 - more sensitive than TBB but increased morbidity
 - diagnostic yield > 90% for malignancy
 - sensitivity for benign lesions less than with TBB
 - iatrogenic pneumothorax in 25%, 1/3 of which need chest tube drainage

Mediastinal Masses

- anterior (anterior to heart and trachea)
 - the "5 Ts": teratoma, thyroid, thymus, thoracic aortic aneurysm, terrible lymphoma
 - pericardial cyst, fat pad, Morgagni hernia if at level of diaphragm
- middle (mediastinal structures; heart and great vessels)
 - bronchial CA, bronchogenic cyst, aortic aneurysm, esophagus/hiatus hernia
- posterior (posterior to heart)
 - GI or spine
 - aortic aneurysm, neurogenic tumours, soft tissue mass of vertebral infection or neoplasm
- lymphoma may be seen in any area

Pulmonary Embolus (PE)

- CXR may be normal (approximately 50%)
- may see decreased lung volume with elevated hemidiaphragm, atelectasis
- underperfused lung distally, dilated hilar artery proximally
- +/- pleural effusion
- Westermark's sign: abrupt cutoff of vasculature distal to embolus
- Hampton's hump: pleural-based wedge representing lung infarct with pleural effusion
- infarct always involves pleural-based lung (against chest wall, diaphragm, mediastinum, or fissures)
- evaluate with V/Q scan ± angiography, or spiral CT

CT SCAN

- for investigation of masses, metastases, staging of CA, some other lung pathologies (e.g. bronchiectasis) when not certain using CXR alone
- best way to image mediastinum and assess adenopathy
- HRCT is good for assessing diffuse infiltrative lung disease (interstitial lung disease)

MODALITIES

- ❑ plain films: mainstay of MSK radiology
 - initial study used in most evaluations of bone
 - not very effective in evaluating soft tissue injury
- ❑ MR: excellent for visualization of marrow and surrounding soft tissues
 - not as good as CT for visualization of bone cortex
 - multiplanar viewing and reconstruction with no radiation exposure to the patient
- ❑ CT: for evaluation of bone cortex and type of cortical expansion
 - IV contrast may be used to determine lesion vascularity
 - specific protocols and windows optimize its ability to delineate bone
- ❑ U/S: for evaluation of surrounding soft tissue (nerves, joints, effusions, impingement)
 - not used for imaging bone
 - used in muscle for determination of cystic structures
 - used to diagnose tendon and ligament injury
- ❑ nuclear medicine: determine the degree of activity (uptake) within the bone
 - localizes areas of increased bone turnover
 - Technetium-99 (Tc99): a triphasic bone scan can establish skeletal vs. soft tissue infection and distinguish septic arthritis vs. osteomyelitis vs. peripheral cellulitis based on uptake
 - Indium-111 WBC: tracks the active migration of the WBC; not a good test for discerning the different types of infections
 - Gallium-67 Citrate: specific to infection but not good at discerning the different types; useful for some tumours (e.g. lymphoma)
- ❑ approach to selected common pathologies (see Table 10)

GENERAL APPROACH TO INTERPRETATION OF BONE X-RAYS

- ❑ identification - name, age of patient, type of study, region of investigation
- ❑ soft tissues
- ❑ joints - alignment, joint space, synovial structures
- ❑ bone - periosteum, cortex, medulla, trabeculae, density

TRAUMA

Fracture/Dislocation

- ❑ approach
 - minimum 2 films at right angles to each other
 - CT for curved bones: skull, spine, acetabulum, calcaneus
 - if in doubt, consider other techniques
- ❑ characteristics of fractures (see Orthopedics Notes)
 - breaks in continuity of cortex
 - radiolucent or radiopaque fracture lines
 - overlap of cortical bone and spongy bone
 - unexplained fragments of bone
 - areas or lines of density representing impaction of bone
 - discontinuity in trabecular patterns or changes in trabecular density
 - soft evaluation of
 - periosteal areas for bone bruises or callus formation
 - surrounding area for swelling, foreign bodies, air (not all foreign bodies are radiopaque)
 - increased lucency of the fat pad may suggest swelling and edema near the bone (e.g. patellar fat pad, anterior "sail" sign, posterior "sail" sign)

C-Spine Injury

- ❑ clearing the C-spine and interpretation of films (see Emergency Medicine Notes)

ARTHRITIS

Approach

- consider
 - clinical history
 - physical exam
 - lab results
 - distribution of arthropathy

Chondropathic/Osteoarthritis

- classic signs
 - narrowed joint space
 - asymmetrical joint involvement
 - subchondral sclerosis appears as increased density surrounding the joint
 - marginal osteophyte with or without spondylolisthesis/spondylolysis
 - vacuum phenomenon: translucent disc space area that is pocket of gas
 - subchondral cysts with sclerotic borders in larger joints

Inflammatory

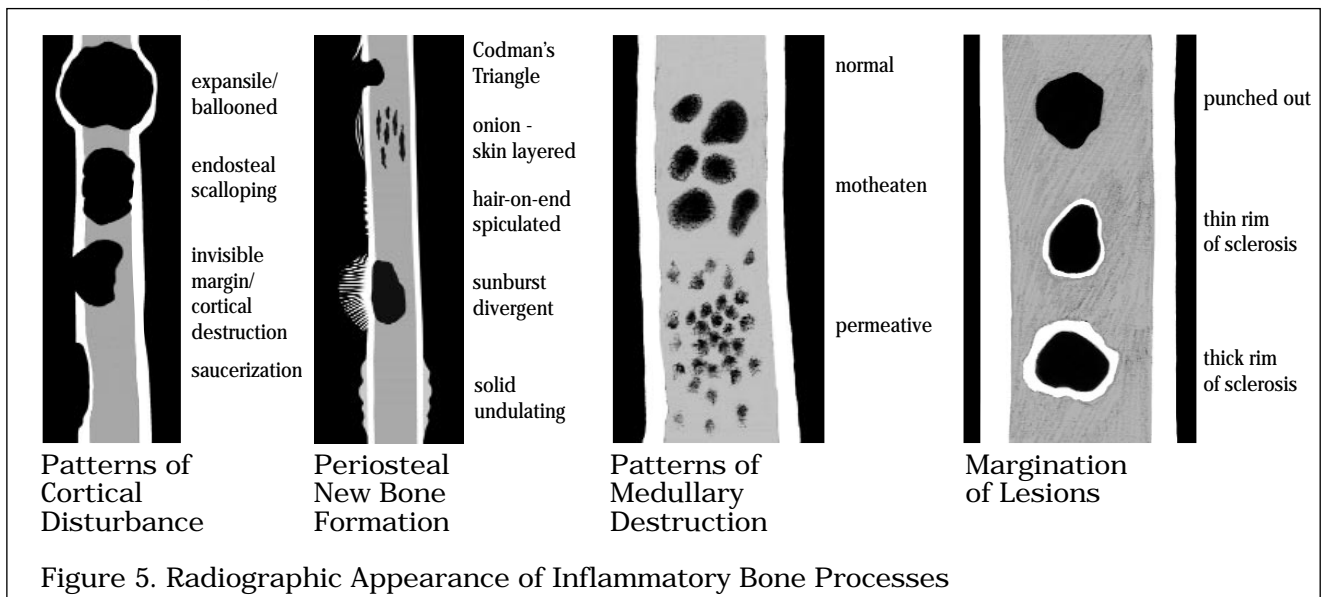


Figure 5. Radiographic Appearance of Inflammatory Bone Processes

Drawings by Myra Rudakewich

□ Infectious Arthritis

- periarticular soft tissue swelling and distention of affected joint with fluid
- +/- joint space narrowing due to proteolytic enzymes destroying the cartilage
- localized osteopenia
- bony destruction characterized by irregularity of the subchondral bone and opposing margins usually presents 8-10 days after onset
- chronic ankylosis and fusion of the joint may result if infection becomes chronic

□ Rheumatoid Arthritis (RA)

- begins in distal joints, symmetrical fashion
- soft tissue swelling with characteristic fusiform pattern
- periarticular osteopenia in subchondral bone
- malalignment first manifested as ulnar deviation
- joint destruction beginning with distal clavicle erosion
- symmetrical narrowing of joints, pannus, inflammatory process around articular surface
- pannus forming initially on the radial sides of the MC, MT, phalanges, radioulnar joints
- spinal involvement in severe cases may lead to atlantoaxial subluxation, restricted cervical spines with odontoid erosion

- ❑ Seronegative Spondyloarthropathies
 - Ankylosing Spondylitis (AS)
 - sacroiliitis radiographically characterized by blurring and irregularity of SI joint margins with sclerosis and obliteration of joint
 - in terminal stages, bone bridges fuse throughout spine, beginning in the lumbar —> classic “bamboo” spine
 - Psoriasis
 - typically restricted to small joints of hands and feet
 - no osteoporosis
 - DIP and PIP: classic “pencil in cup” deformity
 - decrease in the total length of the phalanx
 - Reiter’s
 - asymmetrical joint distribution (mostly in feet)
 - appears similar to psoriasis
 - whisker-like fluffy periosteal inflammation (thickening of periosteum) usually in plantar fascia
 - may present with sacroiliitis
 - Inflammatory Bowel Disease (IBD)
 - symmetrical sacroiliitis but not as extensive as ankylosing spondylitis
 - usually an incidental finding on AXR
 - radiographically worsens with IBD exacerbation
- ❑ Seropositive Spondyloarthropathies
 - Dermatomyositis
 - lack of bone and joint pathology
 - soft tissue calcifications (chondrocalcinosis)
 - Systemic Lupus Erythematosus (SLE)
 - a number of nonspecific inflammatory processes
 - soft tissue atrophy, osteoporosis, poor joint alignment despite lack of articular erosive process
 - swan neck deformities and AVN common
 - Scleroderma
 - radiological findings restricted to the hands with tapered phalanx (atrophy of soft tissues and bone resorption)
 - may also present with calcification of soft tissue
- ❑ Gout
 - radiographic findings do not appear until 8-10 years after the diagnosis
 - begin as periarticular erosion
 - soft tissue masses with no signs of calcification
 - joint space preserved
 - usually no signs of osteoporosis
 - lesions are well demarcated and sharply defined, often with spur bone formation of the periphery
- ❑ Pseudogout (CPPD)
 - chondrocalcinosis
 - calcification of the fibrocartilage
 - swelling of the joint capsule due to synovitis with progression to osteoarthritis (usually appears as broad based osteophytes of the MCP joints)

TUMOUR

Approach

- ❑ metastatic tumours much more common than primary bone tumours
 - diagnosis will usually require a biopsy if primary not located
 - few benign tumours/lesions have potential for malignant transformation
 - plain films: one of the least sensitive tools for evaluation of bone tumours
 - CT: best way to identify the extent of bone lesion in the cortex, medulla, soft tissue
 - MR: good for tissue delineation and preoperative assessment of surrounding soft tissues

Considerations

- ❑ age
- ❑ single or multiple lesions: multiple lesions more suggestive of malignant process or metabolic disease
- ❑ characteristics of lesion (see Table 3)
 - margins: sharply defined with no sclerosis suggestive of multiple myeloma
 - zone of transition: transition area from normal bone to area of lesion, reflective of the aggressiveness of the lesion
 - sclerosed borders, graduated zones: more suggestive of a slow process; it does not identify malignant or benign

- expansile
 - intact, ballooned cortex: more likely benign
 - destruction of cortex: more likely malignant
- ☐ periosteal reaction
 - lamellar: faint and solid, fine periosteal density paralleling cortex, most likely benign process
 - wavy: undulating thickness of the periosteum, most likely PVD or bone infarct
 - sunburst: Ewing's sarcoma (highly suggestive)
 - hair on end: thalassemia or osteosarcoma (highly suggestive)
- ☐ cortical thickening: new bone formation, suggestive of osteomyelitis or malignancy

Table 3. Characteristics of Benign and Malignant Bone Lesions

Benign	Malignant
<ul style="list-style-type: none"> • single lesion • no bone pain • sharp area of delineation • overlying cortex intact • no or well organized periosteal reaction • thick and sharp zone of transition • minimal distortion of normal anatomy • lesion continuous with cortex • centralized calcification 	<ul style="list-style-type: none"> • multiple lesions • bone pain • poor delineation of lesion • loss of overlying cortex/bony destruction • periosteal reaction • thin and wide zone of transition • scattered areas of spotty density • diagnosis of primary cancer

Note: specific bone tumours (see Orthopedic Notes)

Metastatic Bone Tumours

- ☐ all malignancies have potential to metastasize to bone, with some much more likely than others
- ☐ metastases are 20-30x more common than primary bone tumours
- ☐ when a primary malignancy is first detected, a bone scan is part of the initial work-up
- ☐ may present with pathological fractures or pain
- ☐ biopsy or determination of primary is the only way to confirm the diagnosis
- ☐ metastasis can cause a lytic or a sclerotic reaction when seeding to bone

Table 4. Characteristic Bone Metastases of Common Cancers

lytic	sclerotic
lung thyroid kidney breast multiple myeloma	prostate breast

INFECTION

Osteomyelitis

- ☐ Plain Film
 - visible on plain x-ray 8-10 days after osteomyelitis has begun
 - Tc99 radioisotope scan is the best modality to establish the presence of bone infection
 - osteomyelitic changes on plain film
 - soft tissue swelling that is deep and extends from the bone with loss of tissue planes (muscle, fat, skin)
 - local periosteal reaction over the area of bone
 - bone destruction directly over the area of bone infection
 - pockets of air (from anaerobes or *Clostridium*) may be seen in the tissue planes
 - metaphysis over the area of infection may appear mottled and inhomogeneous with a classic moth-eaten appearance

Bone Abscess

- ☐ classical appearance known as Brodie's Abscess
 - overlying cortex has periosteal new bone formation (onion skin pattern)
 - sharp outlined radiolucent area with variable thickness in zone of transition
 - variable thickness periosteal sclerosis

METABOLIC

Approach

- hormonal changes result in diminution of bone maintenance mechanisms
 - thinning of cortex
 - spongy bone becoming more lucent
 - pathological fractures
 - overall diffuse process, affecting all bones

Osteoporosis

- DEXA sensitive to > 12-15% bone loss
 - diagnostic sensitivity highest when BMD measured at lumbar spine and proximal femur
 - T-Score: difference of BMD from young adult mean
 - measure of current fracture risk
 - Z-score: difference of BMD from age-matched mean
- radiographic manifestation
 - increase in bone lucency
 - compression of vertebral bodies
 - biconcave vertebral bodies ("codfishing" vertebrae)
 - long bones have appearance of increased cortex size
 - widening of bone spicules
 - ischemic necrosis of hips leading to "snowcapping"

Osteomalacia

- Looser's Zones (characteristic radiological feature)
 - fissures or clefts extending through cortex of long bones (represent failure of ossification of the fibrous tissue of the bone)
- irregular resorption of bone --> softening and arching of long bones
- initial radiological appearance of both osteoporosis and osteomalacia is osteopenia

Renal Osteodystrophy

- manifestations are a hybrid of hyperparathyroidism and osteomalacia
- slipped epiphysis (bilateral)
- spontaneous separations
- chondrocalcinosis: intra-articular deposits of calcium
- calcifications of the soft tissues (including arteries and around the joints)
- AVN of femoral head must be considered in all cases
- subperiosteal erosion of femoral neck
- osteopenia
- poor definition of trabeculae and cortex
- increased bony density

Paget's Disease

- may involve single or multiple bones
- destruction of bone followed by repair of bone although lysis may occur faster in some areas
 - thickening of cortex or sharp junctions
 - coarsening of the trabeculae
 - enlargement of bone
 - patchy spaces of dense bone (cotton wool)
 - bone softening/bowing
 - bone scan will reveal high activity, especially on bone ends

- approaches to selected common pathologies (see Table 11)

ABDOMINAL PLAIN FILMS

- abdominal series
 - usually includes supine (flat plate/KUB), upright, LLDB ± erect CXR

Pathologies Assessed

- bowel obstruction/ileus
- bowel ischemia
- volvulus
- calcifications (e.g. gallstones, renal stones)
- abnormal gas collections (free air, intramural air, biliary air)
- ascites (used less often)
- bony abnormalities (e.g. metastases)
- foreign bodies (e.g. iatrogenic items from surgery)

Approach to Interpretation

- identifying data
 - name, age of patient, type of study (supine, upright, decubitus)
- suprahrenic structures
 - heart, lung base, costophrenic angles
- skeletal structures
 - thoracic vertebrae: ribs attached
 - lumbar vertebrae: ribs, pelvis, hips
- soft tissues
 - flanks - often trilaminar in appearance
 - superficial - subcutaneous fat
 - intermediate - abdominal wall musculature
 - deep - "flank stripe" of extraperitoneal/preperitoneal fat
 - psoas shadow
 - represents fatty fascia enveloping the muscle
 - right psoas shadow often not seen; normal variant
- solid visceral organs: best seen with other modalities
 - liver: may see depression of hepatic flexure (colon) with hepatomegaly
 - spleen: may see medial displacement of gastric air bubble with splenomegaly
 - kidneys: outlined by perirenal fat, 8-15 cm in adults, left higher than right (renal hilā located at L2 and L1 respectively), long axis parallel to psoas shadow
 - gallbladder and pancreas: not usually visualized
 - aorta
 - bladder and uterus
- hollow viscus: stomach, small bowel, large bowel, rectum
 - gas pattern (amount and distribution)
 - normally some air in stomach and throughout colon but little in small bowel
 - assess for obstruction, intraperitoneal air (free air), intramural air
 - differentiate small and large bowel (see Table 5)
- calcifications
 - RUQ - renal stone, adrenal calcification, gallstone
 - RLQ - stone in ureter, appendicolith, gallstone ileus (rare)
 - LUQ - splenic vessel, renal stone, adrenal calcification, tail of pancreas
 - central - aorta, pancreas, lymph nodes
 - pelvis - phleboliths, fibroids, bladder, prostate

Table 5. Differentiating Small and Large Bowel

	Small Bowel	Large Bowel
mucosal folds	uninterrupted plicae circulares/valvulae conniventes	interrupted haustra
location	central	peripheral
maximum diameter	2.5 - 3 cm	5 cm
other	rarely contains solid fecal material	commonly contains solid fecal material

Abnormal Findings

- ❑ paralytic ileus vs mechanical obstruction (see Table 6)

Table 6. Paralytic Ileus vs. Mechanical Obstruction

	Paralytic Ileus	Mechanical Obstruction (see Colour Atlas C1)
Calibre of bowel loops	<ul style="list-style-type: none"> • normal or dilated in small and/or large bowel 	<ul style="list-style-type: none"> • usually dilated in small and/or large bowel
Air-Fluid levels (only on upright and lateral decubitus films)	<ul style="list-style-type: none"> • same level in a single loop • longer ones in the colon 	<ul style="list-style-type: none"> • “step ladder” appearance • “string of pearls” (row of small gas accumulations collected in the dilated valvulae conniventes)
Other	<ul style="list-style-type: none"> • air throughout the GI tract • may be generalized or localized • in a localized ileus, a dilated loop (“sentinel loop”) remains in the same location on serial films and is usually adjacent to areas of inflammation (e.g. pancreatitis, appendicitis) 	<ul style="list-style-type: none"> • dilated bowel up to the obstructed segment • no air distal to obstructed segment (unless very early obstruction)

- in large bowel obstruction, important to assess the functionality of the ileocecal valve
 - if competent and functional
 - see large bowel distention from site of obstruction to valve
 - marked cecal distention with risk of perforation (if > 9 cm)
 - if incompetent
 - pressure released into small intestine, causing distention of both large and small bowel
 - cecum is relatively protected from perforation in this case
 - may be difficult to differentiate large bowel obstruction with incompetent valve and paralytic ileus
- ❑ free intraperitoneal air (pneumoperitoneum)
 - LLDB: look for free air between liver and right anterolateral abdominal wall
 - erect PA CXR: air under diaphragm (see Colour Atlas C2)
 - supine film poor for showing free abdominal air unless large amount, but may see
 - Rigler's sign - both the inner and outer wall of the bowel seen (outlined by free air)
 - falciform ligament sign - free air collects on both sides of falciform ligament, outlining it
 - “football” sign with a large amount of air
 - DDx: hollow viscus perforation (most common), iatrogenic, introduction per vagina, pneumothorax (due to pleuroperitoneal fistula), peritoneal dialysis catheter
- ❑ intramural air (pneumatosis)
 - lucent air streaks in wall of bowel
 - linear type - ischemia
 - cystoides type - seen in large bowel due to COPD
- ❑ biliary air
 - located centrally over liver
 - causes: sphincterotomy, gallstone ileus
- ❑ portal venous air
 - peripherally located branching air underneath the diaphragm due to bowel ischemia
- ❑ volvulus
 - in descending order of radiographic recognition
 - sigmoid - “coffee bean” sign
 - cecal - single/large bowel loop in LUQ
 - gastric
 - small bowel (most difficult to diagnose)
 - plain film: useful in all except small bowel where CT needed for definitive diagnosis
 - contrast studies: “bird beak” sign typical of volvulus
- ❑ ischemia
 - important acute causes: hypotension, embolic, thrombotic, volvulus
 - plain film: not useful except when thickened folds, pneumatosis, or portal venous air seen

- CT: better yield, especially CT angio (thickened folds, mesenteric changes, embolus)
- U/S: good screening, especially with plain film finding of "gasless abdomen" as cause of ischemia
- angiography used less often
- toxic megacolon
 - seen with UC, Crohn's, infectious/pseudomembranous colitis
 - radiographic findings - thumb printing of colonic mucosa +/- dilatation
 - clinical picture of toxicity
 - dilatation (> 6 cm) and progressive distention with clinical deterioration → impending perforation
- intussusception
 - diagnosed by barium enema or U/S
 - possible to reduce with diagnostic barium enema, air enema

CONTRAST STUDIES (see Table 7) (see Colour Atlas C3-C6)

- barium sulphate serves as contrast medium within lumen of GI tract
- provides fluid "cast" images, mucosal relief images (barium spread over mucosal surface), or double-contrast images (air injected into lumen with barium present)
- esophagus to rectum examined in double contrast (air + barium)
- mucosal detail and mural changes seen as well as intraluminal abnormalities

Contraindications to Barium Study

- unable to withstand or perform the positions required
- cannot undergo bowel preparation
- PO barium contraindicated in suspected colonic obstruction because of risk of dehydration of barium and secondary colonic impaction
 - instead consider colonoscopy or hypaque enema
 - in small bowel obstruction, luminal contents retained are liquid, therefore barium PO is not contraindicated
- suspected or known perforation or if predisposed (e.g. ischemic colitis)
- toxic megacolon

Table 7. Types of Contrast Studies

Study	Description	Area Assessed	Diseases
Cine Esophagogram	<ul style="list-style-type: none"> •contrast agent swallowed •recorded for later playback and analysis 	cervical esophagus	aspiration, webs, Zenkers, cricopharyngeal bar, laryngeal tumours
Barium Swallow	<ul style="list-style-type: none"> •contrast agent swallowed under fluoroscopy •selective images captured 	thoracic esophagus esophagitis, cancer	achalasia, hiatus hernia,
Upper GI Series	<ul style="list-style-type: none"> •barium + effervescent agent swallowed for double contrast •patient NPO after midnight before study 	thoracic esophagus, stomach, duodenum	ulcers, neoplasms, filling defects
Small Bowel Follow Through	<ul style="list-style-type: none"> •images of small bowel obtained following UGI series 	single contrast barium of entire small bowel	neoplasms, IBD, pain, malabsorption, infection
Small Bowel Enema (enteroclysis)	<ul style="list-style-type: none"> •intubation with barium/methyl cellulose •infusion and fluoroscopic evaluation 	small bowel	IBD, anemia, polyposis syndromes, Meckel's, neoplasm
Barium Enema	<ul style="list-style-type: none"> •colon filled retrograde with barium and air/CO₂ insufflation •bowel prep the night before procedure 	large bowel rectum may be obscured by tube - therefore must do sigmoidoscopy (complementary test to exclude rectal lesions)	diverticulosis, neoplasms, IBD
Hypaque Enema	<ul style="list-style-type: none"> •water soluble contrast with or without bowel prep 	large bowel	perforation, obstruction

SOLID VISCERAL ORGAN IMAGING

Liver

- moderate hepatomegaly difficult to determine on plain films
- U/S good for assessment of cysts, abscesses, tumours, biliary tree
- CT with IV contrast best for imaging liver parenchyma
- primary tumours
 - echogenic on U/S (compared to echo-free cysts), but hypoechoic compared to normal liver parenchyma
 - cold spots on radioisotope liver scans (most)
 - most are less dense than the parenchyma on CT but vascular tumours may be more dense (increased contrast uptake)
 - may have ill-defined margins, necrotic centres, calcification
- metastases - more common
 - common primaries are lung, breast, GI (especially colon)
 - often multiple
 - metastases are generally less dense than parenchyma on CT
 - U/S may show large (> 2 cm) ill-defined, hypoechoic masses
- cysts and abscesses
 - both: appear less dense than parenchyma on CT (modality of choice)
 - cysts: sharply-defined round masses; echolucent centres on U/S
 - abscesses: less sharply-defined, tend to have fluid centres, thick walls, may become necrotic
 - vary in appearance on U/S, depending on amount of fluid within abscess cavity
- cirrhosis and portal hypertension
 - CT: altered liver size, contour, density
 - if fatty infiltration, liver appears less dense than spleen (reverse is true if healthy)
 - if advanced cirrhosis, liver is smaller and irregular; splenomegaly and ascites may be present due to portal HTN
 - nuclear medicine study: small shrunken liver with increased background marrow activity

Spleen

- splenomegaly may be suggested by U/S, CT, and/or radionuclide scan
- lymphoma more commonly seen than metastases

Biliary Tree

- U/S imaging modality of choice
- bile ducts normally not seen
- if enlarged, see "double tract" sign and through transmission
- obstruction: intra- and extrahepatic dilatation of bile ducts + source of obstruction (stone, pancreatic mass)
- cholecystitis (see "itis imaging" below)
- CT, ERCP, MRCP, PTC for further work-up
- on CT, dilated intrahepatic ductules are branching and tubular following pathway of portal venous system

Pancreas

- plain film: not seen unless calcifications are present (see Colour Atlas C7)
- U/S: seen in most patients
- CT: gives better detail with IV +/- PO contrast material
- look for masses, pseudocysts, biliary obstruction, evidence of pancreatitis
- ERCP: used when U/S and CT inconclusive
- pancreatitis (see "itis" Imaging below)
- tumours
 - U/S: useful, the mass being more echogenic than normal pancreatic tissue
 - CT: preferred when tumour suspected; density often normal

“ITIS” IMAGING

- acute cholecystitis, appendicitis, diverticulitis, pancreatitis require special imaging

Acute Cholecystitis

- U/S very accurate - thick wall, pericholecystic fluid, gallstones, dilated gallbladder, positive sonographic Murphy's sign
- nuclear medicine (HIDA scan) may be helpful in equivocal cases

Acute Appendicitis

- U/S very useful - thick wall appendix, appendicolith, dilated fluid-filled appendix
- may find other causes of RLQ pain (e.g. ovarian abscess, IBD, ectopic pregnancy)
- CT done when abscess present and to facilitate percutaneous drainage

Acute Diverticulitis

- common site is rectosigmoid
- CT: imaging modality of choice, though U/S is sometimes used as screening
 - oral and rectal contrast given before CT to opacify bowel
 - cardinal signs: thickened wall, mesenteric infiltration, gas-filled diverticula, abscess
 - sometimes difficult to distinguish from perforated CA (therefore, send abscess fluid for cytology)
 - CT: used for percutaneous abscess drainage before definitive surgical intervention

Acute Pancreatitis

- clinical symptoms and lab results (serum amylase and lipase) important
- U/S: good screening (though useless if ileus present because gas obscures pancreas)
 - see hypoechoic enlarged pancreas
- CT: useful in advanced stages of pancreatitis and assessing for complications (e.g. pseudocyst, abscess, phlegmon, necrosis)
 - enlarged pancreas, mesenteric and Gerota's fascial thickening, pseudocyst in lesser sac, abscess (gas or thick walled fluid collection), pancreatic necrosis (low attenuation gas-containing non-enhancing pancreatic tissue)
 - CT-guided needle aspiration and/or drainage done for abscess drainage where clinically indicated
 - pseudocyst may be followed by CT and drained if symptomatic

GENITOURINARY SYSTEM**INTRODUCTION**

- studies commonly used to evaluate the urinary tract
 - IVP/IVU
 - retrograde pyelogram/urogram
 - cystogram (often combined with study of urethra as a VCUG)
 - U/S
 - CT scan
 - MRI
 - renal arteriography
 - isotope studies

MODALITIES**IVP/IVU (see Colour Atlas M1 and M2)**

- a morphologic examination, and also a rough physiological study of renal function
- assessment made by viewing the films temporally
- consists of KUB and series of post-contrast injection films
- the patient should have clear fluids one day prior to the study, cathartics the evening before, and NPO after midnight before the study (liquids are allowed in the morning if the study is booked for the afternoon)
- contraindications to contrast (see Table 1)

- pre-contrast scout film
 - KUB plain film done supine
 - look for abnormal calcifications in the kidneys, calyces, ureters (running over the transverse processes - look for later films to identify their path)
 - beware of phleboliths (calcified venous thrombi in pelvic veins)
 - often smooth, round, may have a central lucency of recanalization
 - likely if the calcification exists inferior to a line drawn between the ischial spines
 - nephrotomograms can also be done to locate stones further
- nephrogram phase
 - 1 minute post-contrast injection
 - contrast material enters the microvasculature and tubules within one minute, opacifying the kidney
 - assess kidney position (T12-L3), size (10-15 cm, difference < 1.5 cm), shape, outline, parenchyma outline
 - DDx of bulges: mass, tumour, cyst
 - DDx of indentations: infarction, scarring
 - DDx of decreased/absent opacification
 - decreased blood flow to the kidney (e.g. renal artery compromised)
 - decreased blood flow from the kidney (e.g. renal vein thrombosis)
 - blocked drainage (i.e. ureteral stone)
 - nephron dysfunction
- subsequent post-contrast injection films
 - usually obtain 2 or more films at 5 minute intervals
 - assess (in order) calyces (cupped = normal; clubbed or enlarged = dilated), pelvices, ureters (normal diameter < 7 mm), bladder
 - after 20-30 minutes, the collecting system is too faint and bladder is opacified
 - pre-void: irregular outline of bladder (superior-fibroids, sigmoid; inferior-prostate)
 - post-void: to assess clearance of bladder

Retrograde pyelogram/urogram

- contrast medium injected into ureters at cystoscopy via ureteral catheterization

Cystogram

- contrast injected retrograde into bladder to visualize bladder
- VCUG enables visualization of urethra

U/S

- useful in evaluating renal size and renal shape
- can differentiate solid vs. cystic masses
- TRUS also useful to evaluate prostate gland and guide biopsies

CT

- useful in evaluating renal mass lesions, extrarenal masses that are distorting or displacing normal urinary tract
- best method to determine extrarenal involvement of tumours (e.g. vascular involvement, nodes), renal trauma, stone disease
- good for assessing renal colic
- use unenhanced imaging for stones
 - spiral CT gold standard for detecting stones
- contrast enhancement may show hypervascularity of mass lesions, areas of necrosis within mass
- CT angiography may also be used to evaluate renal artery stenosis

MRI

- used to evaluate renal masses or effects of pelvic neoplasms on bladder
- useful in evaluating prostate tumours both diagnostically and in planning treatment (i.e. surgical vs. radiation treatment)
 - very useful in assessing gynecological pathology, especially tumours

Renal Scan

- 2 radionuclide tests for kidney: renogram and morphological scan
- in renogram, passage of radionuclide (Tc99m DTPA or iodine-labeled hippurate) quantitated to assess function
- useful in evaluation of renal failure, workup of urinary tract obstruction and HTN, investigation of renal transplant
- morphological study done with Tc99m DMSA and Tc99m glucoheptonate to look at renal anatomy
- useful in investigation of renal mass and cortical scars

SELECTED PATHOLOGY

Obstruction

- see Urology Notes
- IVP findings
 - may see radiopaque stone on plain film (~90% are calcified) (see Colour Atlas M1)
 - delayed visualization on the abnormal side - the "late white kidney" of acute renal obstruction
 - appearance of calyces: blunting of ends of minor calyces
 - degree of dilatation of collecting system (hydronephrosis vs pelvicalyurectasis) depends on whether obstruction is partial or complete and also duration of obstruction (see Colour Atlas M2)
 - usually entire length of ureters not seen due to clearing by peristalsis (if seen consider UPJ obstruction)
- U/S will be positive if significant hydronephrosis

Mass Lesions

- DDx of mass lesions in kidneys: cysts, tumours, or inflammatory lesions
- lesions elsewhere in urinary tract: most likely tumours
- initial investigation should be U/S
 - cysts: uniformly hypoechoic, good through transmission, imperceptible wall
 - tumours: solid, contour deforming
- to further determine nature of mass, CT with contrast evaluates vascularity, necrosis, local invasion
- arteriography (rarely done) will show vascularity and renal vein/IVC invasion

Other

- other GU pathology (see Nephrology and Urology Notes)
- approaches to selected common GU and Reproductive pathology (see Tables 12 and 13)

INTRODUCTION

- primary modalities to radiologically investigate brain and spinal cord
 - plain film
 - CT
 - MRI
 - myelography
- diagnostic approaches to selected Neuropathology (see Table 14)

MODALITIES

Vertebral Films

- mainstay for diagnosis of diseases in vertebral column
- should be the initial study
- C-spine views (see Emergency Medicine Notes)
 - lateral
 - AP of lower column and cranioatlantoaxial region
 - oblique
 - +/- flexion/extension views
- thoracic and lumbar views
 - frontal and lateral
 - oblique lumbar views in non-traumatic cases

Skull Films

- a highly overused, low-yield examination
- generally, not indicated for head trauma!
- indications
 - penetrating trauma
 - destructive lesions
 - metabolic disease
 - skull anomalies
 - post-op changes
- standard views (each designed to demonstrate a particular area of the skull)
 - PA - frontal bones, frontal and ethmoid sinuses, nasal cavity, superior orbital rims, mandible
 - lateral - frontal, parietal, temporal, and occipital bones, mastoid region, sella turcica, roofs of the orbits, lateral aspects of facial bones
 - Townes view (occipital) - occipital bone, mastoid and middle ear regions, foramen magnum, zygomatic arches
 - base view - basal structures of skull, including major foramina
 - Waters view (occipitomeatal) - facial bones and sinuses
- approach to interpretation: bony vault, sella turcica, facial bones, basal foramina, sinuses, calcifications, soft tissues

Myelography

- introduce water-soluble, low osmotic contrast media into subarachnoid space using lumbar puncture --> conventional films or CT scan (CT myelography)
- excellent study for disc herniations, traumatic nerve root avulsions
- use has decreased due to MRI

CT Scans (see Colour Atlas G1-G6)

- modality of choice for patients with suspected intracranial abnormalities
- excellent study for evaluation of disc herniations
- usually done without, and then with intravenous contrast, to show vascular structures or anomalies
- attenuation: bone > grey matter > white matter ("fatty" myelin) > CSF > air
- vascular structures and areas of blood-brain barrier impairment: radiopaque (white) with contrast injection
 - when in doubt, look for circle of Willis or confluence of sinuses to determine presence of contrast enhancement
- head CT: inspect soft tissues, bone, cortical parenchyma, ventricular system, mass lesion, symmetry, shift of falx, posterior fossae obscured by bone and Hounsfield phenomenon
- target lesions (associated with contrast ring enhancement): metastases, infections

MRI

- rapidly becoming the primary investigative tool for suspected intracranial abnormalities
- shows brain anatomy in extremely fine detail
- clearly distinguishes white from grey matter
- modality of choice for spinal cord pathology (e.g. disc herniation, infections, tumours, trauma), brain tumours, pituitary tumours, MS
- multiplanar reconstruction helpful in pre-op assessment

Cerebral Angiography

- to evaluate vascular lesions such as arteriosclerotic occlusive disease, aneurysms, vascular malformations
- also helpful in supplementing CT and MRI in patients with tumours
- digital subtraction angiography commonly used

Nuclear Medicine

- SPECT HMPAO imaging assesses cerebral blood flow
- PET imaging assesses metabolic activity

SELECTED PATHOLOGY (see Neurosurgery Notes)

- diagnostic approaches to selected neuropathology (see Table 14)

Head Trauma

- CT: imaging modality of choice following head trauma if any evidence of intracranial damage (e.g. LOC, neurological abnormalities)
- treatment directed at the neurologic abnormality
 - the presence or absence of a skull # may not make any difference in Mx of patient, EXCEPT
 - 1) depressed #
 - 2) penetrating foreign object (e.g. bullet)
- facial fractures: need CT for complete evaluation
- see Neurosurgery and Plastic Surgery Notes

Vertebral Trauma (see Emergency Medicine Notes)

Intracranial Mass Lesions (see Neurosurgery Notes)

- investigate with CT scan, MRI with contrast, angiography (see Colour Atlas G2)

Vascular Disease

- including infarction, intracerebral hemorrhage, AVM, extracerebral hematomas
- carotid Doppler U/S used in evaluating for carotid artery disease
- arteriography if carotid angioplasty considered
- findings in ischemic infarction
 - basal ganglia most common site
 - first few hours: normal
 - 12-24 hours: reduced density (edema/mass effect) with no contrast enhancement
 - 1-4 weeks: patchy enhancement
 - 1 month: density approaches that of CSF
- TIAs - no findings

Multiple Sclerosis (MS)

- MRI shows plaques that form within the white matter of the brain

Degenerative Spinal Abnormalities

- spondylosis
 - mild: slight disc space narrowing and spur formation
 - severe: marked disc space narrowing, facet joint narrowing, spur formation
 - spurs may impinge on spinal cord --> evaluate with CT, MRI, myelography
- herniated disc
 - if symptomatic, evaluate with CT, MRI, and/or myelography

Vertebral Column Metastases

- common area for metastases
- evaluate with plain films, bone scans, MRI, CT
- MRI: most sensitive, can delineate areas of spinal cord compression
- plain film: not sensitive (need ~50% of cancellous bone destruction before visible on plain films)

NUCLEAR MEDICINE

THYROID

Radioactive Iodine Uptake

- radioactive I-131 or I-123 PO in fasting patient
- provides index of thyroid function (trapping and organification of iodine)
 - measured as a percentage of administered iodide taken up by thyroid
- elevated in hyperthyroid states (e.g. Grave's, toxic multinodular goiter, toxic adenoma)
- decreased in hypothyroid states (e.g. subacute thyroiditis, late Hashimoto's disease)
- falsely decreased in patient with recent radiographic contrast studies

Thyroid Imaging (Scintiscan)

- technetium pertechnetate IV, radioactive iodine to determine if nodule functioning
- provides functional anatomic detail
- hot (hyperfunctioning) lesions
 - adenoma, toxic multinodular goiter
 - CA very unlikely
- cold (hypofunctioning) lesions
 - CA must be considered until biopsy negative
- cool lesions
 - CA must be considered as they may represent cold nodules superimposed on normal tissue
 - if cyst suspected, correlate with U/S

CHEST

V/Q Scan

- for suspected PE and qualitative or quantitative evaluation of pulmonary ventilation and perfusion
- look for areas of lung which are ventilated but not perfused or vice versa
- in PE, see areas of lung that are well ventilated but not perfused
- normal perfusion scan makes PE unlikely
- ventilation scan
 - patient breathes radioactive gas (aerosolized technetium-DTPA or xenon-133) through a closed system, thus filling alveoli proportional to ventilation
 - defects seen if airway obstruction, chronic lung disease, bronchospasm, tumour mass obstruction, oxygenation of lung fields
- perfusion scan
 - radiotracer (albumin macroaggregates) injected IV --> trapped in pulmonary capillaries according to blood flow
 - perfusion scan relatively contraindicated in severe pulmonary HTN, right-to-left shunt
 - defects indicate reduced blood flow due to PE, parenchymal lung disease

Myocardial Perfusion Scanning

- thallium-201 is a radioactive analogue of potassium
- active uptake by myocardium proportional to regional blood flow
- thallium injected at peak exercise or after persantine challenge and again at rest to detect ischemia
- persistent defect suggests infarction; reversible defect suggests ischemia or fixed stenosis
- for investigation of angina, atypical chest pain, coronary artery disease, reversible vs. irreversible changes when other investigations are equivocal

Radionuclide Ventriculography

- technetium-99m attached to red blood cells
- first pass through RV --> pulmonary circulation --> LV
- provides information about RV function
- cardiac MUGA scan (Multiple GAted acquisition scan) sums multiple cardiac cycles
 - evaluation of LV function
 - images are obtained by gating the count acquisitions to the ECG signal
 - provides information on ejection fraction, estimates of ventricular volume, wall motion

Pyrophosphate Scintigraphy

- technetium pyrophosphate concentrates in bone and in dying and necrotic tissue
- used to detect infarcted tissue 1-5 days post-MI when ECG and enzyme results are equivocal or unreliable
- sensitivity and specificity about 90% in transmural infarct

BONE

Bone Scan

- technetium with a phosphate or fluoride carrier binds to hydroxyapatite of bone matrix
- increased when increased blood supply to bone and/or high bone turnover
- indications: bone pain of unknown origin; screening of patients with suspected malignancy; staging of CA of breast, prostate, or bronchus; follow up after treatment; detection and follow up of primary bone disease; assessment of skeletal trauma; detection of soft tissue calcification; renal failure
- positive bone scan
 - bone metastases from breast, prostate, lung, thyroid
 - primary bone tumours
 - arthritis
 - fractures
 - infections
- multiple myeloma: typically normal or cold
- kidneys and bones: normally equal in intensity
- low renal uptake: renal failure, metabolic bone disease, diffuse bony metastasis (superscan)

ABDOMEN

Liver/Spleen Scans

- IV injection of radioisotope-labeled sulfur colloid (usually technetium) which is phagocytosed by reticuloendothelial cells of liver and spleen
- "cold spots": lesions displacing the normal reticuloendothelial system (tumour, abscess, cyst)
- diffuse patchy reduction in uptake: diffuse parenchymal disease (e.g. cirrhosis)

HIDA (Hepatobiliary Iminodiacetic Acid) Scan

- IV injection of radiofracer (HIDA) which is bound to protein, taken up, and excreted by hepatocytes into biliary system
- can be performed in non-fasting state but prefer NPO after midnight the day before
- gallbladder visualized when the cystic duct is patent
- if gallbladder is not visualized, suspect obstructed cystic duct
- DDx of obstructed cystic duct: acute cholecystitis, decreased hepatobiliary function (commonly due to alcoholism), bile duct obstruction, parenteral nutrition
- if gallbladder fills, rule out cholecystitis (< 1% probability)

RBC Scan

- IV injection of radiotracer with sequential images of the abdomen

- for GI bleed
 - if bleeding acutely at > 0.5 mL/min, the focus of activity in the images generally indicates the site of the acute bleed
 - more sensitive for lower GI bleed
- for evaluation of liver lesion
 - hemangioma has characteristic appearance

Renal Scan

- see Genitourinary System above

INFLAMMATION AND INFECTION

- use gallium citrate- and indium-labeled WBCs
- gallium accumulates in normal liver, spleen, bone marrow, sites of inflammation, some neoplasms (lymphomas)
- indium-labeled WBCs accumulate in normal spleen, liver, bone marrow, sites of inflammation and infection

BRAIN

- SPECT HMPAO imaging assesses cerebral blood flow
- PET imaging assesses metabolic activity

VASCULAR-INTERVENTIONAL RADIOLOGY

Contraindications to Intravascular Contrast Media (see Table 1)

Vascular Procedures, Indications, Considerations, Complications (see Table 8)

Nonvascular Procedures, Indications, Considerations, Complications (see Table 9)

Table 8. Vascular Procedures

Procedure	Indications	Considerations/Complications
<p>Angiography:</p> <ul style="list-style-type: none"> invasive procedure injection of contrast material directly into artery (or vein) to directly delineate vascular anatomy catheter can be placed into aorta for a "flush", or selectively placed into a branch vessel for a more thorough examination of the smaller vessels and to better examine specific organs initially, procedure was performed using plain films, but replaced by digital subtraction angiography (faster study with less radiation exposure and less contrast) 	<ul style="list-style-type: none"> aneurysm assessment peripheral claudication/ischemia coronary angiography carotid or cerebral disease PE disease vascular road map prior to any reconstructive surgery trauma evaluation of vascularity of tumours 	<ul style="list-style-type: none"> procedure takes approximately 1 hour; however, the patient must be on bed rest for 6-8 hours following the procedure (to allow the puncture site to heal) common complications: puncture site hematoma, pseudoaneurysm, AV fistula other complications: dissection, thrombosis, or embolic occlusion of a distal vessel (overall, significant complications occur in less than 5% of patients) more recently, noninvasive evaluation of vascular structures are being performed (colour Doppler US, CT angiography and MR angiography) small catheter-based US probes may be introduced to obtain detailed images of the vessel wall and lumen access sites: common femoral artery (most common), brachial, axillary, and direct transumbilical
<p>Percutaneous Transluminal Angioplasty:</p> <ul style="list-style-type: none"> introduction and inflation of a balloon into stenosed vessel to restore distal blood supply 	<ul style="list-style-type: none"> any stenosed artery or vein renal, mesenteric, subclavian, and carotid artery stenosis now commonly treated 	<ul style="list-style-type: none"> complications similar to angiography, but also include vessel rupture represents an alternative to surgical bypass grafting five year patency rates are similar to that for surgery the introduction of vascular stents (including covered stents) may help improve long term results, may provide alternate treatment for aneurysms alternate interventional method of treating stenosis involves an atherectomy device which cuts out the atheroma
<p>Thrombolytic Therapy:</p> <ul style="list-style-type: none"> infusion of a fibrinolytic agent (urokinase, streptokinase, TPA) administered by a catheter directly into thrombus (local infusion) or via peripheral intravenous (systemic) for treatment of some diseases 	<ul style="list-style-type: none"> to restore flow in a vessel obstructed with thrombus or embolus treatment of ischemic limb (most common) early treatment of MI or stroke to reduce organ damage treatment of venous thrombosis (DVT of the leg or PE disease) 	<ul style="list-style-type: none"> usually performed in conjunction with an angiogram, and often a follow up angioplasty must be performed infusion may last hours to days contraindicated in cases of central nervous system tumours, or any recent surgery or trauma complications: bleeding, stroke, or distal embolus reperfusion injury with myoglobinuria and renal failure may occur if advanced ischemia is present (these patients should undergo surgery rather than thrombolysis)
<p>Embolization:</p> <ul style="list-style-type: none"> injection of material into the vessels to occlude them variety of permanent agents (coils, balloons, glue) and temporary agents (gel foam, blood clots) 	<ul style="list-style-type: none"> management of actual hemorrhage (epistaxis, trauma, GI bleed) treatment of AVMs pre-operative treatment of vascular tumours (bone metastases, renal cell CA) varicocele embolization for infertility 	<ul style="list-style-type: none"> beware of post embolization syndrome (pain, fever, leukocytosis) if "distal" embolization is performed, there may be an organ necrosis (such as small bowel infarction, or skin or nerve involvement)
<p>Inferior Vena Cava Filter:</p> <ul style="list-style-type: none"> insertion of metallic "umbrellas" to mechanically trap emboli which may result in PE inserted in patients who cannot have first line therapy (anticoagulation) variety of filters available (Greenfield, Simon Nitinol, Bird's Nest, Venatech) filters initially were inserted via surgical cut down, but are now inserted percutaneously in Radiology departments 	<ul style="list-style-type: none"> contraindication to anticoagulation complication of anticoagulation failure of adequate anticoagulation prophylaxis pulmonary HTN 	<ul style="list-style-type: none"> typically inserted via the femoral vein, jugular vein, or antecubital vein should be placed infra-renal to avoid renal vein thrombosis complications include migration and fracture, recurrent PE, IVC thrombosis complications can occur in approximately 5% of patients

Table 9. Nonvascular Interventions

Procedure	Indications	Considerations/Complications
<p>Central Venous Access:</p> <ul style="list-style-type: none"> • variety of devices available for long term venous access • peripherally inserted central catheter (PICC) • external tunneled catheter (Hickmann) • subcutaneous Port (Portacath) <p>Percutaneous Biopsy:</p> <ul style="list-style-type: none"> • replaces an open surgical procedure • any site is amenable to biopsy using U/S, fluoroscopy, or CT guidance • fine needle aspiration (22 g) for cytology • core biopsies (18 g or larger) for histology • indications - lung, liver, kidney, adrenal, breast, bone, prostate, thyroid, pancreas, lymph node <p>Abscess Drainage:</p> <ul style="list-style-type: none"> • placement of a drainage catheter into an infected fluid collection • can be performed for cure • also valuable to stabilize the patient until definitive surgery can be performed 	<ul style="list-style-type: none"> • chemotherapy • TPN • long term antibiotics • fluids and blood products • blood sampling • to obtain tissue for diagnosis of malignant or benign disease • to differentiate recurrent tumour from post therapy fibrosis • suspected lymphoma • appendicitis, diverticulitis, inflammatory bowel disease, postoperative collections • pancreatic pseudocysts, empyemas 	<ul style="list-style-type: none"> • exact type of device required depends upon frequency of access and length of therapy • devices must be flushed with heparin on regular basis • complications include venous thrombosis and infection • beware of false negative biopsies due to sampling error or tissue necrosis • pneumothorax occurs in approximately 50% of lung biopsies, with a chest tube being required in approximately 20% • pancreatic biopsies are potentially the most dangerous with the risk of inducing pancreatitis • transjugular liver biopsies can be performed in order to minimize bleeding complications in patients with uncorrectable coagulopathies • usually a 12 French drainage catheter will suffice • catheter is removed when no fistula is demonstrated, the clinical symptoms have resolved, and the cavity is gone • broad spectrum IV antibiotics should be administered prior to procedure • bacteremia with sepsis due to excessive manipulation • contamination of previously uninfected collection due to introduction of a catheter
<p>Biliary Drainage/Cholecystostomy:</p> <ul style="list-style-type: none"> • placement of drainage catheter into obstructed biliary system or gall bladder for relief of jaundice or infection 	<ul style="list-style-type: none"> • acute cholecystitis • biliary obstruction secondary to stone disease or tumour • oriental cholangiohepatitis 	<ul style="list-style-type: none"> • ERCP should be primary modality for treating distal common bile duct obstructions • percutaneous drainage may be required when ERCP is unsuccessful or if complex hilar lesions such as cholangiocarcinoma • both placement of drainage catheters, and internal metallic stents can be placed • percutaneous access can be used to crush or remove stones • acute procedural-related complications include sepsis when there is underlying infection • long term complications: tumour over-growth and stent occlusion
<p>Percutaneous Nephrostomy:</p> <ul style="list-style-type: none"> • placement of tube into renal collecting system 	<ul style="list-style-type: none"> • hydronephrosis (urinary obstruction) as a result of a stone or tumour 	<ul style="list-style-type: none"> • hematuria common for several days following procedure • pseudoaneurysms or AV fistulas may occur as a complication • long term catheter should be routinely changed every few months to avoid encrustation and tube obstruction • using the percutaneous access, antegrade placement of a stent is often successful even when retrograde placement is not • percutaneous access can also facilitate stone manipulation
<p>Gastrostomy/Gastrojejunostomy:</p> <ul style="list-style-type: none"> • percutaneous placement of tube into either stomach or duodenum and into proximal small bowel 	<ul style="list-style-type: none"> • structural or physiologic inability to maintain oral intake • tubes may also be used to facilitate long term decompression when there is a proximal obstruction 	<ul style="list-style-type: none"> • position of a tube in a stomach may be associated with gastroesophageal reflux and aspiration pneumonia in patients with decreased LOC or impaired neurologic function • tubes may also be inserted surgically or endoscopically

□ Tables 10-14

- Modality of Choice
 - identifies the best available diagnostic tool(s) regardless of cost
 - subjective consensus from references and faculty editors based upon sensitivity and specificity (particularly specificity)
 - in some cases (e.g. angiography for massive lower GI bleed) therapeutics were also considered
- Approach to Imaging
 - provides a framework for the work-up of a suspected diagnosis
 - in general, in order of sensitive screening modalities to more specific studies
- compiled from Eisenberg, RL and Margulis, AR, *Radiology Pocket Reference: What to Order When*, 1996

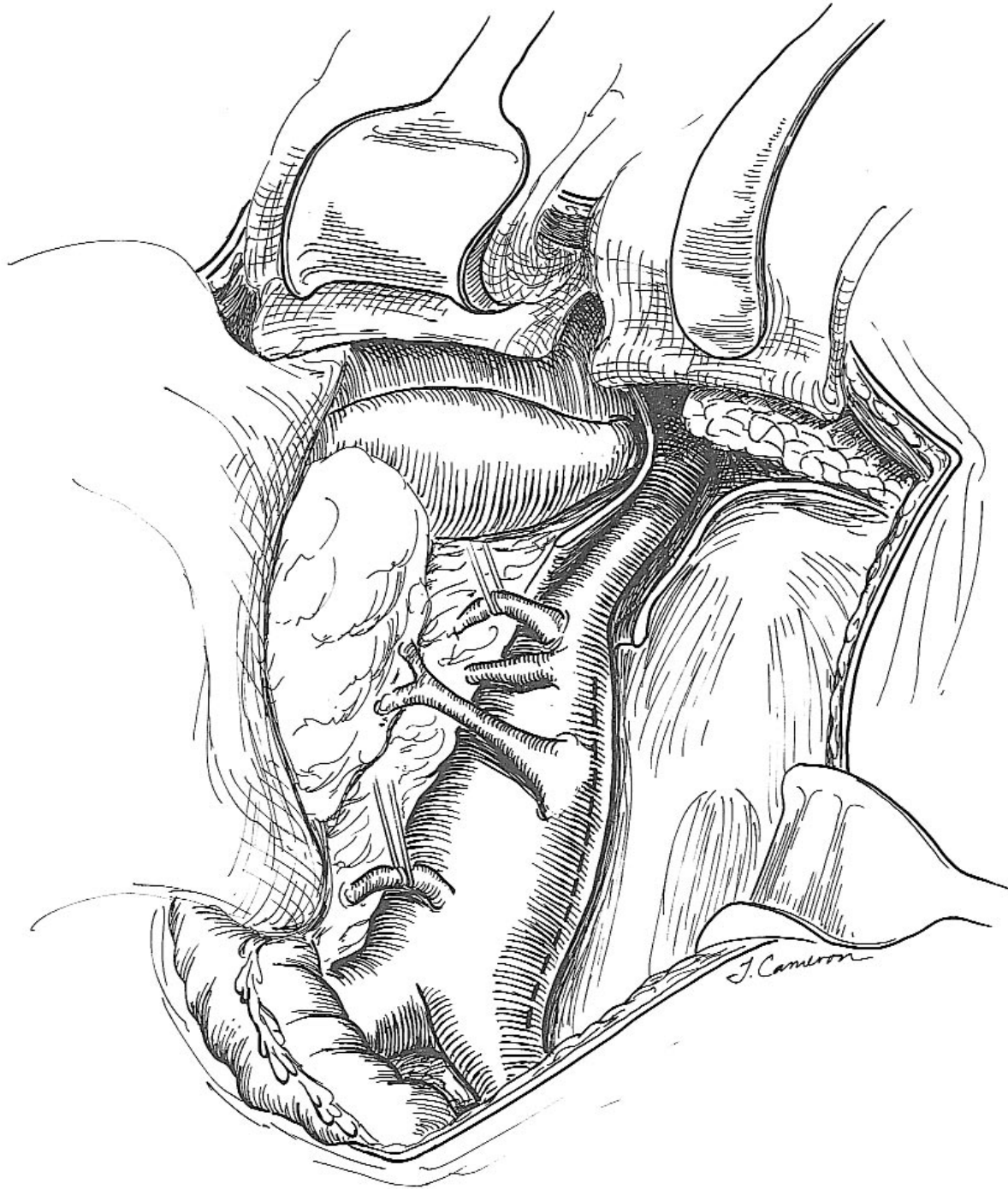
Table 10. Musculoskeletal Pathology *NOTE: Plain Films (PF) are ALWAYS useful		
Pathology	Modality of Choice	Approach to Imaging
Avascular Necrosis	MRI	1. PF: not sensitive but ideal for following progression of disorder 1a. Radionuclide bone scan: may detect abnormality before PF 2. MRI: most sensitive for detecting early changes while PF and scan are normal 2a. +/- SPECT if MRI unavailable
Hematogenous	MRI	1. Radionuclide bone scan: increased activity in early disease; not specific, but sensitive 2. MRI: equally or more sensitive than scintigraphy, not specific
Inflammatory arthropathy	PF	1. PF of affected joints, plus SI joints if seronegative suspected
Meniscal Tear (Knee)	MRI arthroscopy	1. US: becoming more common, but operator-dependent 2. MRI: detects meniscal tears and associated abnormalities of collateral ligaments and cruciates *NOTE: need for MRI is controversial and some studies indicate that arthroscopy alone is sufficient
Multiple Myeloma	PF (skeletal survey)	1. PF: skeletal survey is specific but not sensitive 2. MRI: preferred screening study
Osteoarthritis	PF	1. PF
Osteomyelitis Direct seeding or Contiguous spread	CT MRI	1. PF: no change seen until 8-10 days 2. Gallium Scan: sensitive before 8-10 days 3. CT: to detect sequestra 4. MRI: sensitive but not specific
Osteoporosis	measurements of bone mineral content	1. Bone mineral content: many different methods 1a. Usually DEXA-scan with X-ray source ==> lumbar spine and R hip *NOTE: PF may detect compression fracture; otherwise not indicated since radiolucency not seen until 50-70% bone loss
Primary Malignant Tumours of Bone	MRI	1a. PF: initial screening, but poor sensitivity; however, yields useful info when positive 1b. Bone scan: if suspect metastases then essential to scan (not a PF skeletal survey) 2. MRI: best for determining bony and soft tissue extent, ability to distinguish benign from malignant is controversial
Rotator Cuff Tear	MRI	1. U/S: operator-dependent 2. MRI: detects partial and complete tears 3. Arthrography: if MRI unavailable; only detects complete tears
Septic Arthritis	aspirate and culture	1. Radionuclide bone scan: not specific but may permit early diagnosis *NOTE: must aspirate and culture; plain films not specific/sensitive
Skeletal metastases	radionuclide bone scan	1. Radionuclide bone scan: false negative may occur if there is uniform uptake by diffuse metastases 2. PF: generally not indicated unless scan is equivocal, insensitive (40-80% of bone must be destroyed to be apparent) thus NEVER order a skeletal survey to screen for metastases 3. CT or MRI: to evaluate nonspecific focal abnormalities from scan or PF, should not be used as initial screening
Stress Fracture	radionuclide bone scan	1. Radionuclide bone scan: sensitive for early detection 2. PF: fracture may not be detectable for several weeks
Vertebral	radionuclide bone scan	1. Radionuclide bone scan: detect early activity 2. MRI: sensitive for detecting abnormality but does not accurately distinguish infection from tumour

Table 11. Abdominal Pathology		
Pathology	Modality of Choice	Approach to Imaging
AAA ====> allows digital reconstruction of renal/visceral vasculature	MRI	1. U/S: most cost-effective, serial exams to monitor 2. CT: if suspect leak or acute rupture, more accurate than U/S, especially with MDCT 3. MRI: only if U/S and CT fail to provide info about renal, iliac artery, and visceral involvement
Cholecystitis (acute)	cholescintigraphy U/S	1. cholescintigraphy: 95% specific, 98% sensitive (post-prandial HIDA scan) 2. U/S
Cholecystitis (chronic)	U/S	1. U/S
Colon CA (diagnosis)	double-contrast BE	1. BE 2. colonoscopy/flex sig: slightly more sensitive and specific than BE but cost & complications
Colon CA (staging)	CT transrectal U/S	1. CT: most effective for demonstrating presence and extent of colonic spread 2. transrectal: most accurate for staging local rectal CA (depth of invasion, presence in lymph nodes)
Crohn's	BE CT	1. small bowel follow-through: if level of suspicion for disease is low 1a. enteroclysis (small bowel enema): if clinical suspicion not low 2. small bowel examination required if terminal ileum not visualized in BE 3. CT: best for demonstrating mesenteric and extraintestinal extent of disease and abscess formation
Diverticulitis	CT BE	1. CT 2. BE (HE may be indicated due to threat of sigmoid perforation)
Diverticulosis	BE	1. BE
Fatty Liver	CT	1. CT
Hepatocellular CA	CT MRI	1. CT: preferred screening technique 2. U/S: screen chronic Hep B carriers 3. MRI: may permit specific diagnosis of hepatocellular CA
Irritable Bowel Syndrome	nothing or BE	1. BE: primarily performed to exclude IBD or CA (diagnosis of exclusion)
Large Bowel Obstruction	AXR CT	1. AXR: can differentiate between ileus and mechanical obstruction 2. BE (HE if threat of perforation) 3. CT with dilute contrast
Massive Lower GI Bleed	colonoscopy angiography	1. Colonoscopy: first choice if bleed not obscuring vision 2. RBC scan: as a "scout" to direct further investigation 3. Angiogram: to localize bleed, can be therapeutic; superior to RBC scan
Pancreatitis (acute)	CT	1. CT: superior to U/S for inflammation, edema, gas detection 2. U/S: used for follow-up of specific abnormalities
Pancreatitis (chronic)	CT	1. AXR: often done in practice, but low yield 2. CT: most accurate in demonstrating malignancy 3. ERCP/MRCP
Peritonitis	CT	1. AXR: upright or lateral decubitus for free air; supine look for double wall sign 2. CT: procedure of choice to detect fluid, abscess, strangulation
PUD	endoscopy upper GI series	1. upper GI series (double contrast) 1a. urease breath test: nuclear medicine can be used under certain circumstances 2. endoscopy: may be preferable for suspected GU b/c can biopsy, fails to detect 5-10% of peptic ulcers *NOTE - Once the diagnosis of benign PUD is made there is no need to repeat imaging
Small Bowel Obstruction	AXR CT	1. AXR 2. CT: only required if AXR are equivocal or necessary to show precise site and elucidate etiology
Splenic Abscess	CT	1. CT: preferred screening technique 2. radionuclide scan: specifically identify mass as an abscess
Ulcerative Colitis	BE or colonoscopy	1. sigmoidoscopy: direct visualization 2. BE or colonoscopy: to determine full extent of disease and detect CA

Table 12. Urinary Tract Pathology		
Pathology	Modality of Choice	Approach to Imaging
Cancer of the Kidney (diagnosis)	CT	1. U/S or CT: U/S good for screening; contrast-enhanced CT is most sensitive
Cancer of the Kidney (staging)	CT or MRI	1. CT or MRI: MRI for lymphadenopathy; chest CT for metastases 1a. +/- U/S with Doppler to elucidate vascularity 2. radionuclide bone scan: for metastases 3. arteriography (often used pre-operatively to infarct kidney)
Hematuria Painless	cystoscopy CT	1. U/S: efficient for detecting neoplastic renal masses and vascular anomalies; does not exclude bladder tumour or cystitis 2. IVP: excellent for stones and papillary necrosis; cannot exclude bladder or urethral pathology 3. cystoscopy: required in any adult with unexplained hematuria 4. CT: more sensitive than U/S for renal masses
Painful	CT	1. IVP: preferred for screening, can define site and degree of obstruction 2. U/S: detect ureteral dilatation, stone 3. CT: detect stones
Polycystic Kidney Disease (Adult)	CT	1. U/S or CT
Pyelonephritis Acute	imaging only required if patients fail to respond to treatment or severely ill	1. CT 2. U/S: less sensitive than CT for subtle changes; efficient for hydronephrosis *NOTE: contrast is contraindicated if patient is febrile/toxic
Chronic	IVP	1. IVP: characteristic focal cortical scar 2. U/S
Renal Failure	U/S	1. U/S 2. DTPA Radionuclide scan at timed intervals (non-nephrotoxic) *NOTE: biopsy often required if ARF and large (> 12 cm) or normal-sized kidneys for definitive dx
Renovascular Disease	arteriography	1. U/S with Doppler 2. Arteriography
UTI Infant & child	radionuclide or voiding cystography	1. radionuclide or voiding cystography: most sensitive for vesicoureteral reflux 2. U/S: preferred screening *NOTE: complete investigation important because of high probability of anatomic abnormality 3. IVP 4. CT if indicated
Older child/Teenager Adult	U/S U/S	1. U/S: only study needed if child has only lower urinary tract signs and symptoms and normal U/S 1. IVP: structure and function of urinary tract 2. U/S: preferred imaging modality for critically ill patient with suspected UTI 3. CT: indicated if U/S and urography normal but strong clinical suspicion *NOTE: uncomplicated UTI in a female requires NO imaging

Table 13. Reproductive Pathology		
Pathology	Modality of Choice	Approach to Imaging
Abnormal uterine bleeding	hysteroscopy/colposcopy	1. U/S: usually initial screening 2. sonohystogram: more detail
Acute Testicular Pain	U/S with Doppler	1. U/S with colour Doppler 2. radionuclide flow study: can demonstrate torsion
Dysmenorrhea	U/S	1. U/S 2. laparoscopy
Emergent/acute situations (e.g. torsion, ectopic, abscess)	U/S	1. U/S
Endometrial Cancer (diagnosis)	sonohystogram CT	1. U/S 2. sonohystogram 3. CT
Endometrial Cancer (staging)	MRI	1. CT 2. MRI
Infertility	hysterosalpingography or laparoscopy with dye injection	1. hysterosalpingography 1a. U/S with contrast (i.e. Sonovist) injection 2. U/S or MRI: if above is normal, to detect congenital anomalies of female tract (10%) 3. laparoscopy with dye injection: if history of endometriosis/PID
Pelvic Mass	MRI	1. U/S 2. CT 3. MRI
Testicular Mass	MRI	1. U/S 2. MRI

Table 14. Neuropathology		
Pathology	Modality of Choice	Approach to Imaging
Acute head trauma	CT	1. CT: preferred for "bone and blood" 2. MRI: indicated only when CT has failed to detect an abnormality in presence of strong clinical suspicion; valuable in subacute and chronic phases *NOTE: no indication for plain skull radiography
Acute subdural hematoma	CT	1. CT 2. MRI: not sensitive for detecting acute bleed but coronal images may be of value if CT fails
Bell's Palsy	MRI	1. MRI: to exclude a mass or demyelinating lesion
Brain Tumour	MRI	1. CT: nearly always done at first presentation 2. MRI
CVA	MRI	1. CT: non-contrast scan preferred initial procedure in suspected acute stroke 2. MRI: unenhanced MRI with angiography is more sensitive than CT
Dementia	MRI	1. MRI: most sensitive for lesions 2. SPECT 2a. PET: used as adjunct in suspected Alzheimer's
Headache	MRI	1. CT: in practice, often first line if level of urgency high (i.e. hemorrhage/mass lesion suspected) 2. MRI: most sensitive for cerebral lesions
Lacunar Infarction	MRI	1. CT: usually done first to exclude acute/treatable pathology; lack of findings serves as indication for MRI 2. MRI: only modality that can consistently demonstrate the lesions
Meningitis (Acute)	CT	1. CT: most important role is to exclude a mass (abscess) prior to LP (main diagnostic test)
Meningitis (Subacute/chronic)	MRI	1. MRI: contrast required, demonstrate edema, abscess, neoplasm, and inflammation 2. plain chest film: search for underlying TB or sarcoidosis
MS	MRI	1. MRI: most sensitive for detection of demyelination
Orbital Blow-out fracture	CT	1. plain film (Waters view): preferred screening for bony abnormalities and soft-tissue mass, air-fluid levels 2. CT: definitive study
Seizure Disorder	MRI	1. CT: non-contrast recommended as initial study if postictal or if residual neurologic deficit 2. MRI: most sensitive for detecting cerebral lesions, F/U in 3-6 months if fail to detect a source 3. PET: improves localization of seizure focus
TIA	MRI	1. duplex, colour-flow Doppler U/S 2. echocardiography 3. MRI 4. intra-arterial digital subtraction angiography 4a. MR Angiography
Tinnitus	CT MRI	1. CT: preferred for ear bone abnormalities 2. MRI: preferred for small tumours of CN VIII
Vertigo	MRI	1. MRI: detecting posterior fossa and cerebellopontine angle abnormalities 2. CT: indicated for middle ear pathology



Drawing by Teddy Cameron