Musculoskeletal Radiology
1. Cervical spine fracture
   a. Clinical findings
      1. Trauma
      2. Pain in the neck
      3. Neurologic signs
         *above are unreliable if the patient is intoxicated
         or has a decreased level of consciousness.

   b. Imaging approach
      1. AP and lateral films and open mouth of odontoid
      2. If a portion of the c-spine is not visualized do a CT
      3. If suspicious areas, raising the question of fracture, do a CT
      4. If cord issues do MRI
2. Fractures possibly involving a joint
   a. Clinical findings
      1. Trauma
      2. Joint effusion
      3. Loss of joint function
      4. Swelling and tenderness
   b. The Imaging Approach
      1. Plain radiograph with at least two views
      2. CT very useful but especially for displaced tibial plateau fractures and comminuted calcaneal fractures.
      3. Techniciam 99 Bone Scan can be used to exclude fracture in weight bearing areas such as the hip
3. Hip fracture
   a. Clinical findings
      1. History of fall
      2. Difficulty weight bearing
      3. Pain in the hip
      4. External rotation of the upper thigh
   b. The imaging approach
      1. Plain radiographs; AP and lateral projections
      2. Occasionally CT may be necessary
      3. If plain film is negative but there is a high clinical suspicion MRI should be obtained.
         Patient should be non-weight bearing until the question of fracture is ruled out.
4. Stress fracture

a. Clinical findings
   1. History of repetitive activity or activity in the patient with osteoporosis
   2. Localized pain
   3. Specific locations (tibia, metatarsals, low back, groin)

b. Imaging approach
   1. Plain radiographs
   2. If radiographs are negative either do a TC bone scan; or rest patient and re-x-ray in 10-14 days.
5. Shoulder pain
   a. Clinical findings
      1. Pain and limitation of motion
   b. Imaging
      1. Plain films, internal and external rotation with axillary view
      2. MR with or without arthrography
6. Painful prosthesis

a. Clinical findings
   1. Pain in the area
   2. Elevated white count with temperature

b. Imaging
   1. Plain radiography; In the hip use AP pelvis and frogleg lateral
   2. Bone scan
7. Knee
   a. Clinical findings
      1. Pain
      2. Locking
      3. Instability
      4. Swelling, questionable joint effusion
      5. Previous injury
   b. Imaging
      1. Post trauma; AP and lateral; in patients with acute trauma-cross table lateral
      2. Oblique views in cases suspicious for tibial plateau fracture
      3. Sun rise view in suspected patella fracture
      4. CT or multi-planar reconstruction to detect occult tibial plateau fracture or to evaluate complex plateau fracture.
      5. For arthritis obtain standing AP, lateral and sunrise view of the patella
      6. Meniscal or cruciate ligament tear, obtain MRI. For Baker’s cyst or thrombophlebitis- ultrasound
8. Bone Metastases
   a. Clinical Findings
      1. Bone pain
   b. Imaging
      1. Radio nuclei bone scan (except in patients with multiple myeloma for which radiographic skeletal survey should be done). Bone scan should only be performed if it will alter management
      2. X-ray positive lesions, seen on scan in patients that one would suspect arthritis or possible old fractures that accounts for positive signs on the bone scan
      3. In scans that are positive but the radiographs are negative, obtain MR
9. Osteomyelitis

a. Clinical findings
   1. Fever
   2. Elevated WBC
   3. Ulceration or cellulitis over bone in the diabetic foot or in patients with decubitus ulcer

b. Imaging Approach
   1. Plain x-rays in two planes
   2. CT in specific locations i.e. SI or sternoclavicular joints
   3. Bone scan
   4. In the spine, for suspected discitis of osteomyelitis do MR
10. Osteoporosis

a. Clinical findings
   1. Fractures with minimal trauma in such locations as vertebral body, upper extremity or intertrochanteric region
   2. Predisposing factors
   3. Loss of height and increasing kyphosis

b. Imaging approach
   1. Plain radiographs
   2. Bone density scan
   3. Remember serial studies are generally necessary to determine rate of bone loss
   4. Result of medication
GI
A. Preparation for GI study
   1. Clinician should describe the examination to the patient before the patient goes for the radiologic examination.
   2. Clinician should give to each patient a specific set of instructions that the radiologist has provided for each specific GI study. The clinician should explain the rationale and need for proper preparation.

A. The clinician should fill out a request which includes pertinent 1.) Clinical history 2.) Physical examination findings 3.) Laboratory data 4.) Medications that may cause complications or alter the study for example, opiates 5.) Surgical history. This is important so the radiologist can understand what type of surgical anatomy he will encounter so that he can appropriately perform the correct study.
1. Dysphasia
   a. Clinical findings
      1. Difficulty initiating swallow
      2. Nasal regurgitation
      3. Substernal dysphasia, chest pain, heart burn
   
   b. Imaging Studies
      1. Videopharyngoesophagram
      2. Double contrast esophagus
      3. Single contrast esophagus
      4. Check for reflux
2. Dyspepsia (chest pain related to the GI tract)
   a. Chest pain and upper abdominal pain with symptoms of nausea, upper abdominal bloating

   b. Recommended imaging
      1. Question of endoscopy vs. double contrast esophogram
3. **Upper abdominal pain**
   a. **Clinical Findings**
      1. Pancreatic
      2. Cholecystitis
      3. Bowel obstruction or infarction
      4. Renal colic
      5. Appendicitis
      6. Ruptured viscus
      7. Abdominal aortic aneurysm

   b. **Imaging modalities**
      1. Plain film include supine, erect, or perhaps decubitus films
      2. Upper GI series
      3. Ultrasound
      4. CT
      5. ERCP
4. Acute right lower quadrant pain
   a. Clinical findings
      1. Periumbilical
      2. Right lower quadrant pain, nausea vomiting
   b. Imaging approach
      1. In children start with ultrasound
      2. In pregnant or ovulating women, ultrasound
      3. CT using oral and IV contrast

Plain films to search for appendolith
5. Left lower quadrant pain
   a. Persistent left lower quadrant pain with some guarding and tenderness, fever

Imaging
   a. CT with and without oral contrast with delay (long drink) and IV contrast
6. Right upper quadrant pain
   a. Clinical findings
      1. Right upper quadrant pain and positive Murphy’s sign
      2. Palpable gall bladder

   b. Imaging
      1. Ultrasound and if necessary Hida examination
7. Mass lesions in the liver
   a. Clinical findings
      1. Tenderness, ascitis, jaundice
      2. Abnormal liver function tests
      3. Cirrhotics

   b. Imaging approach
      1. If the question is a focal hepatic mass
         1. Do a CT with and without contrast
      2. Patients with specific primaries breast, lung tumors, pheochrocytoma, renal cell carcinoma, thyroid carcinoma, choriocarcinoma, carcinoid; unenhanced CT followed by biphasic CT
      3. Cirrhotic patient – MRI
      4. Questionable angioma: use labeled red blood cell study or MR; if lesion is smaller than 2cm and unable to be seen on nuclear medicine study do MRI.
A. Intravenous contrast agents

1. The clinician should alert the radiologist if there have been any prior problems with intravenous contrast agents. The clinician should know if there are risk factors that may preclude the use of IV contrast agents. A partial list of prior contrast reactions include urtication, shortness of breath, chest pain, laryngospasm, bronchospasm, hypotension, shock.

Risk factors include previous significant contrast reaction, asthma, and severe allergic history. Also patients with cardiac dysfunction, angina, and patients with sickle-cell disease or multiple myeloma should have their examinations altered. Patients using the oral hyperglycemic agent metformin should stop taking the drug forty-eight hours prior to the use of IV contrast. Most important is to remember that any patient with impairment of renal function it is contra indicated to give contrast.

B. Contrast Material

All ionated contrast material is similar. This includes all contrast agents used for IVP’s, angiography computer tomography, retrograde urethrography, cystography, retrograde pyelography, sinus or fistula injections, or hysterosalpingography. Use water soluble contrast as well for GI tract studies when a question of perforation has been raised.

There are some medications which are associated with an increased risk of adverse reactions to the patients after contrast agents. These include metformin (glucophage). This drug should be discontinued forty-eight hours prior to contrast injection and not reinstated until forty-eight hours after contrast injection and until the patient’s renal function has been restudied. This is also true for interleukin-2. There may be a delayed reaction to these drugs up to two week post contrast injections. Also, nephrotoxic medications such as aminoglycoside antibiotics, steroidial drugs and anti-inflammatory agents. The use of these medications may increase the possibility of the patient developing contrast induced renal failure. Also beta adrenergic blockers have an increased incidence of adverse reaction.
1. Painless Hematuria
   a. Clinical findings
      1. Hematuria may be gross or microscopic
   b. Imaging
      1. Many causes of hematuria in adults are due to lower tract bleeding either infection or other abnormalities. A trial of antibiotics prior to work-up is often helpful. Significant persistent hematuria should be referred to a urologist. The initial study is a CT study to look for possibility of abnormalities in the upper tracts and in the bladder. Also a cystoscopy should be performed.
2. Acute flank pain
   
a. Clinical findings
   
   1. Acute flank pain is often severe and patients may have nausea and vomiting. Symptoms may be periodic and pain may proceed down the flank into the scrotum.

b. Imaging

   1. Unenhanced CT from xyphoid to pubis is the state of the art recommendation to look for stones in the kidney, ureter, or bladder. In pregnant patients or in children, ultrasonography to look for stones or hydronephrosis is helpful. Plain abdominal film can occasionally be helpful.
3. Elevated PSA

a. Clinical findings
   1. PSA levels are obtained to screen for prostate cancer in men over fifty years of age. Under 4mg per ml is considered normal. PSA levels between four and ten are worrisome for prostate cancer but can be seen in benign prostatic hypertrophy especially in elderly patients. Over 10mg/ml, many patients are referred for prostate biopsy.

b. Imaging
   1. Digital rectal examination should initially be performed. If a nodule is felt transrectal biopsy can be performed.

   If no nodule is felt, then ultrasonography of the prostate is performed. Any hypoechoic lesion, or gland asymmetry should be biopsied under ultrasound guidance. MRI may be an extremely useful and a helpful tool in evaluating for prostatic carcinoma. In patients with a markedly elevated PSA, well over 10mg/ml then bone scan and plain films are recommended.
4. Acute Testicular Pain

a. Clinical presentation
   1. Acute testicular pain may occur in the absence or as a result of trauma. Some causes require immediate surgery

b. Imaging approach
   1. Sonography with color doppler scan is the method of choice.
   2. Occasionally nuclear medicine scan may be helpful
5. Acute Renal Failure

   a. Clinical findings
      a. Acute renal failure is the precipitous decrease in glomerular filtration for a short period. There are many etiologies.

   b. Imaging
      a. Often the possible etiology of acute renal failure can be obtained via either a history of a specific medication or a medical history. Ultrasound is a good first test to look for size, shape, and configuration of the kidney and for the possibility of obstruction. Please look for the possibility of renal vein or renal artery occlusion. Other possibilities could be angiography, or venography but MR is now a viable alternative.
6. Urinary Tract Infections

a. Clinical findings
   1. Most patients who have urinary tract infections, the infection is due to cystitis that can be rapidly cured by antibiotics. Recurrent episodes of cystitis may occur in women and only after several episodes should they be worked-up. In men, even one bout should be viewed with some degree of suspension. Possible causes include reflux, urolithiasis or congenital tract abnormalities such as, neurogetic bladder or various forms of obstruction

b. Imaging
   1. In children, voiding cystourethrography is performed and this technique is also helpful in women. This can be done via radionuclide scanning. Ultrasound is the first imaging modality to use to rule out obstruction, or stone formation, and can give one a good understanding of kidney size and renal cortical size. In complicated patients, CT urography can be used to determine the complete extent of the inflammatory process, and to direct subsequent therapy, which could include percutaneous procedures.
7. Renal Trauma

a. Clinical
   a. Trauma can be blunt or penetrating, and trauma is common. Most injuries are the result of blunt trauma. These produce renal contusions. Renal laceration, is a tear of the renal cortex extending through the capsule. Renal fractures extend completely through the kidney. Renal vascular pedicle injuries are due to severe and often penetrating trauma. Most injuries do not require surgery but remember that in a kidney that has no vascularity, surgery and revascularization must be performed in approximately a six hour window. Do not waste time with imaging.

b. Imaging
   a) In patients with microscopic hematuria due to blunt trauma it is extremely unlikely these patients have any significant abnormality which requires surgery and often imaging is not needed. When imaging is needed, due to significant hematuria, CT both with and without contrast is the most sensitive in evaluating major injuries. This is also true for patients post-renal biopsy who are bleeding.
8. Lower GU Trauma

a. Clinical approach
   1. Trauma to the lower GU tract is suspected when there is blunt trauma to the pelvis after a motor vehicle accident or penetrating gunshot wounds. Also, remember these injuries can occur secondary to a traumatic catheterization.

b. Imaging
   1. In patients post traumatic insertion of a urethral catheter, a retrograde urethrogram should be performed. Significant trauma in these patients is often treated with a suprapubic bladder catheter.

   In significant pelvic trauma, a plain film to determine the degree of pelvic injury should be obtained. If injury to the bladder is suspected, cystography before a CT is helpful. One must determine if the bladder rupture is intra or extra peritoneal. Treatment is completely different.
9. Retroperitoneal Hemorrhage

a. Clinical presentation
   1. Patients with retroperitoneal hemorrhage present with abdominal or back pain. They may be hypotensive and their hematocrit has usually dropped.
   2. Causes may be due to rupture of the abnormal aorta or iatrogenic. Trauma may also be a cause

b. Imaging approach
   1. In a hemodynamically stable patient, if one worries about abdominal aortic aneurysm rupture, CT is the study of choice. If the patient is unstable, no imaging should be done but take the patient immediately to surgery. In a patient with suspected retroperitoneal hematoma after cardiac catheterization, unless the patient is uncomfortable and the hematocrit drops, no definite imaging is needed. If bleeding is protracted, and recurrent, an unenhanced CT should be performed. Occasionally, especially in trauma, angiography may be helpful since one can embolize the vessel that is bleeding.
Chest
1. Chest Diseases
   a. Most patients with problems in the chest, present with either cough, dyspnea, hemoptysis or chest pain. The x-ray is the first radiologic examination performed in these patients. In addition, many asymptomatic patients may have a “screening” chest x-ray performed. Occasionally an unsuspected abnormality such as a tumor or a nodule may be found in these patients. One must approach the finding in a systematic and appropriate manner in order to avoid wasteful and inappropriate use of the more expensive “high-tech” imaging modalities such as CT, angiography, and nuclear scans.
2. Solitary pulmonary nodule
   a. Clinical Findings
      1. Initially a solitary pulmonary nodule must be worked-up as if it was a malignancy until proven otherwise. This applies to patients who are symptomatic or asymptomatic. Most often these nodules turn out to be benign but they must be investigated.

   b. Imaging
      1. The most important thing is to see whether there are prior chest x-rays available for comparison. A nodule which has been stable in size for two or more years is considered to be benign. Do remember, however that some malignant tumors such as carcinoid, or hamartomas may grow very slowly.
      2. CT is the modality of choice to investigate the characteristics of a nodule. Look for size, shape, as well as calcium internally. See whether there are areas of necrosis or whether tumor growth has been along the alveolar walls.
3. Persistent pneumonia with or without volume loss

a. Clinical findings

1. Pneumonias which reoccurs in the same lung segment or lobe must be viewed with suspicion. If the pneumonia fails to resolve or when there is volume loss, then an endobronchial obstructing lesion, possibly a carcinoma, must be suspected.

b. Imaging

1. In a patient without complete resolution, the possibility of an obstructing bronchial lesion must be considered. Repeat x-ray in four to eight weeks. This is especially true if there is associated loss of volume as demonstrated by shift of the diaphragm, fissures, or mediastinum.
2. If this is present then do CT with thin sections.
4. Hemoptysis
   a. Clinical findings
      1. Be certain that the blood arises from the lung, and not from the nose, throat, or GI tract.
      2. Remember that the most common cause of hemoptysis is acute chronic bronchitis or pneumonia. History and physical examination will help in this determination.
      3. In a patient with recently developed hemoptysis, please be wary of patients over the age of forty and obtain a smoking history.
   b. Imaging
      1. Chest x-ray is the initially modality
      2. CT is recommended when bronchogenic carcinoma or bronchiectasis is suspected. If the CT is unrevealing then bronchoscopy should be performed.
      3. Bronchoarteriography with the potential for embolization can be used in the diagnosis and treatment of persistent hemoptysis in patients with chronic pulmonary disease such as cystic fibrosis, or other granulomatous disease.
5. Dyspnea secondary to interstitial or vascular lung disease
   a. Clinical findings
      1. A large differential is possible for patients with dyspnea secondary to pulmonary disease. The chest x-ray helps to differentiate between the many causes. One should attempt to differentiate between whether the process is either in the interstitium or in the alveolar compartment of the lung. Interstitial disease is linear whereas, alveolar disease is ill defined or fluffy. The entities may be acute or chronic.
   
   b. Imaging
      1. Chest x-ray is the initial imaging modality. If interstitial lung disease is suspected them high resolution CT should be the next procedure. CT will also clearly define an alveolar process. Often lung biopsy is necessary to differentiate between these entities.
6. **Aortic dissection**
   
a. **Clinical findings**
   
   1. Aortic dissection presents with severe acute neck or chest pain in a patient who is hypertensive. If not treated, the initial mortality is approximately twenty-five percent in the first twenty-fours and ninety percent at one year.
   
   2. Certain entities have an increased incidence of dissection such as Marfan’s syndrome, bicuspid aortic valve, aortic coarctation, and rarely in pregnancy.

b. **Imaging**
   
   1. Chest radiograph. This is useful and will at times rule out other etiologies such as pneumonia or pulmonary edema.
   
   2. The next step is generally CTA. Occasionally TEE or MRI is useful.
   
   3. Aortography remains as a viable technique.
7. Pulmonary Embolism

a. Clinical findings
   1. Chest pain, tachypnea, hemoptysis are common signs. Occasionally some patients are asymptomatic. Always think of this diagnosis in patients on oral contraceptives, and those with deep venous lower leg thrombosis. Also, patients on prolonged bed rest, a history of recent MI or congestive heart failure.

b. Imaging
   1. Chest radiograph is the first study done to rule out other possibilities such as pneumonia, pneumothorax, etc.
   2. The next test is CTA
   3. Remember that one can use the VQ scan to diagnose pulmonary emboli especially in a patient who has a normal chest x-ray. The profusion scan can be used alone in patients in which radiation becomes an issue such pregnancy or in young adults.
   4. Pulmonary angiography is also potentially useful.
8. Chest pain secondary to cardiac issues
   a. Clinical findings
      1. Any patient with chest pain, the first issue is to determine whether it is due to cardiac, pleura, chest wall, lung, or possible GI etiologies
         a. Crushing retrosternal chest pain radiating to the left shoulder – suggests acute MI.
         b. Pain in the lower portion of the chest associated with deep inspiration or coughing – suggests pleura effusion or inflammatory process.
         c. Pain with coughing in the upper chest – suggests central tracheobronchial issues.
         d. Chest pain after eating a large meal may be associated with GI reflux.

   b. Imaging
      1. Chest radiograph is useful to look for other etiologies.
      2. Other imaging modalities such as echocardiography or nuclear imaging must be considered. If acute MI is suspected coronary angiography with potential angioplasty is an option
9. Mediastinal mass
   a. Clinical findings
      1. Often asymptomatic, and once discovered the
         importance of localizing the mass to either the anterior,
         middle, or posterior mediastinum is important. Remember that a fair number of mediastinal masses
         can be missed on plain radiographs.
   b. Imaging
      1. Chest x-ray. See if one can determine which
         mediastinal component the mass is in and whether
         there is calcification
      2. CT helps greatly. CT is the method of choice for further evaluation.
10. Hilar masses
   a. Clinical findings
      1. Once again there are no definitive clinical symptoms associated with most hilar masses. A chest x-ray to determine if there is a hilar mass is the first step and remember the importance of visualizing the central hila on the lateral film. It is important to distinguish between a hilar mass and large pulmonary arteries.

   b. Imaging
      1. An old film is often helpful to determine enlargements of the hila structures.
      2. Contrast CT is the most useful in determining mass from pulmonary vessels or other thoracic abnormalities. In patients with a contrast allergy, MRI maybe helpful
11. Pneumothorax
   a. Clinical findings
      1. Patient present with acute chest pain. Remember that the chest x-ray taken in expiration is the best way of finding a pneumothorax. Look for the thin pleura line displaced away from the thoracic wall. In supine films remember air will collect in the nondependent portion of the thorax. Be careful of patients with bullous emphysema and remember signs such as the deep sulcus sign. A small pneumothorax can be very difficult to detect.
   
   b. Imaging
      1. Plain chest film taken in the erect position, both in inspiration and expiration.
      2. Occasionally a lateral decubitus film be helpful.
      3. CT is very sensitive in detecting unsuspected pneumothorasis although remember lateral decubitus film in difficult patient can be almost as effective and is much cheaper with much less radiation exposure.
12. Pleural effusion

a. Clinical findings
   1. Many patients present with pleuritic chest pain, which is sometimes referred to the shoulder. Cough, fever, and a history of previous pneumonia or congestive heart failure are significant.

b. Imaging
   2. Thoracentesis to determine the composition of the pleura fluid is important. Patient position is important and remember to use both lateral decubitus films. Supine films make the determination of effusion difficult.
13. Lung trauma
a. Clinical finding
   1. Trauma is a leading cause of death in people under the age of forty. Chest injury is a major consideration in these patients. Remember to consider things such as pneumothorax, aortic rupture, multiple rib fractures, trachobronchial tear, and diaphragmatic rupture.

b. Imaging
   1. Most often portable chest x-ray is the initial screening study.
   2. If the patient is stable, a CT with and without contrast is extremely important to evaluate all the potential injuries to the chest.
   3. Remember in patients with possible esophageal rupture, to do a barium swallow using water soluble contrast.
   4. Echocardiography can be performed to look for cardiac contusion or pericardial diffusion.
14. Bronchiectasis

a. Clinical findings

1. Patients classically have chronic cough producing copious amounts of purulent secretions. Many have had several episodes. This is also associated with a dry cough, occasional hemoptysis, and pleuritic chest pain. Many of the patients have sinusitis.

b. Imaging

1. Chest x-ray
2. CT