GASTROINTESTINAL

Understanding how and when to image the GI tract

Objective questions:

1. What modalities are used in evaluating the GI system?
2. What is an esophagram and when should I order it?
3. What is an upper GI and how is it used?
4. How is the small intestine studied radiographically?
5. How is the colon imaged and how is barium enema used in practice?
6. What are the uses and limitations of barium studies?
7. What are the optimal examinations for specific evaluation of the gallbladder, liver, pancreas, and spleen?
8. What does esophageal cancer look like on an esophagram?
9. What does an ulcer look like on an upper GI?
10. What are the barium enema findings in colon cancer, diverticulitis, ulcerative colitis, and polyps?

What modalities are used in evaluating the GI system?

Usually, the first imaging modality used to study the GI tract is a plain X-ray of the abdomen. Even when other GI examinations are planned, we frequently begin with plain films, or *scouts*, of the abdomen. The scout is used to assess the bowel gas pattern, to look for pathologic calcifications, and especially to determine whether the bowel has been adequately cleared of stool before a more specialized imaging test can be administered.

The barium esophagram is performed through the ingestion of opaque contrast. The contrast coats the esophageal mucosa and forms a temporary cast of the internal features of the esophagus.

An upper GI series uses the same technique as an esophagram, but the imaging is carried through to the duodenum. The patient is asked not to drink or eat after midnight the evening before the examination.

A barium enema is performed through a rectal tube. Contrast is administered retrograde through the colon to the cecum or the terminal ileum. Again, the temporary cast made by the contrast allows us to detect areas of constriction from cancer or inflammatory disease, areas of barium filling such as diverticulosis or ulcers, and areas of filling defects such as polyps.

CT is excellent for the solid visceral organs of the GI tract, the liver and pancreas. CT is not as good as barium studies for most bowel problems or as good as ultrasound for the gallbladder. CT is excellent for diagnosing appendicitis, diverticulitis, and pancreatitis.

The primary role of MRI is to provide additional information when the CT scan is equivocal. MRI is used to image inflammatory bowel disease such as Crohn's disease. It can help clarify disease processes in the solid visceral organs.

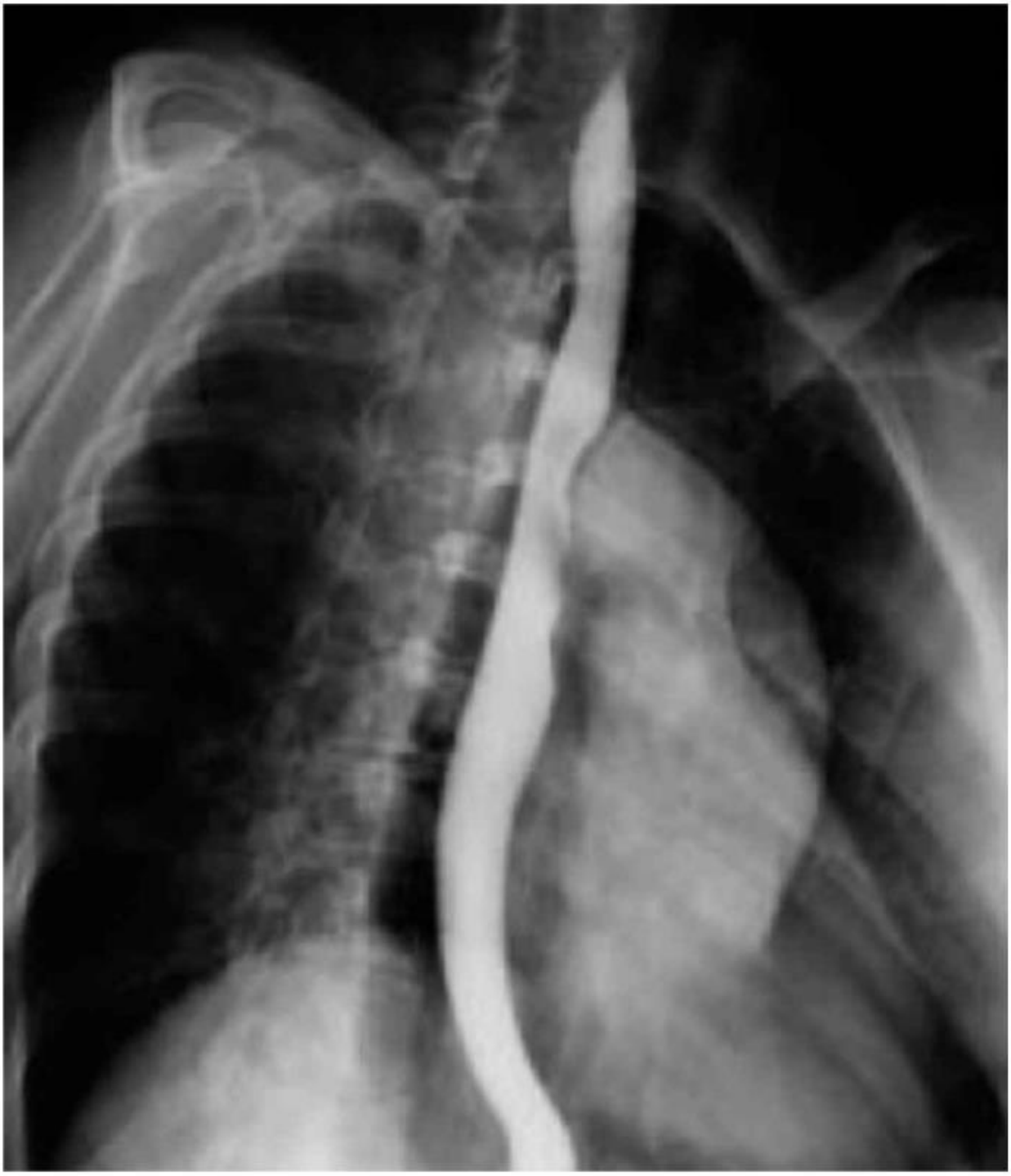
There are two main reasons why the gallbladder is best imaged with ultrasound. First, the gallbladder is a fluid-filled structure, and evaluating fluid collections is the forte of ultrasound. Second, the gallbladder, being located adjacent to a solid, easily recognized structure like the liver, is easy to find sonographically. In addition, the extrahepatic and intrahepatic bile ducts are nicely imaged with ultrasound.

What is an esophagram and when should I order it?

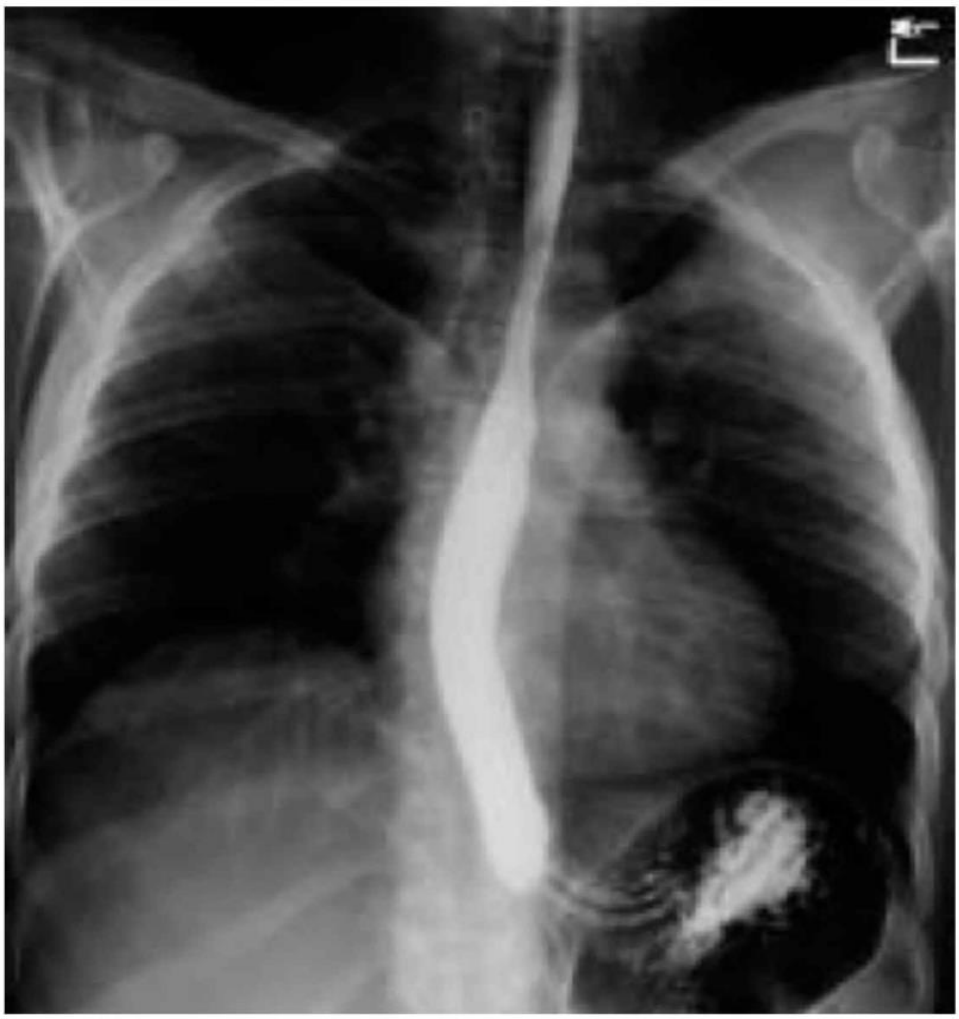
An esophagram, also called a *barium swallow*, is performed by having the patient swallow barium, which is an inert, nonabsorbable mineral that creates an easily identifiable opacity on X-rays. (The patient must be able to drink fluids safely.) The column of contrast is followed through its course in the esophagus and X-ray pictures are obtained in multiple projections in all areas of the esophagus. When mixed with water, barium forms a chalky liquid that can distend the hollow structures of the gastrointestinal tract and coat its mucosa. All barium studies are based on the principle of forming a cast of the hollow organ. The barium suspension insinuates itself into the mucosal folds. If a mass is present, it can displace the barium, resulting in a filling defect. In the opposite way, an ulcer crater is a hole that is filled up with barium and presents on the X-ray as a projection of barium into the nonopacified bowel wall.

Reasons to order an esophagram:

- Dysphagia (difficulty swallowing)
- Odynophagia (painful swallowing)
- Foreign body sensation, food or other foreign body
- Chest pain suspected to be related to gastroesophageal reflux disease (GERD)
- Esophageal cancer
- Zenker's diverticulum
- Hiatal hernia
- Barrett's esophagus



Normal esophagram (oblique view)



Normal esophagram (AP view)

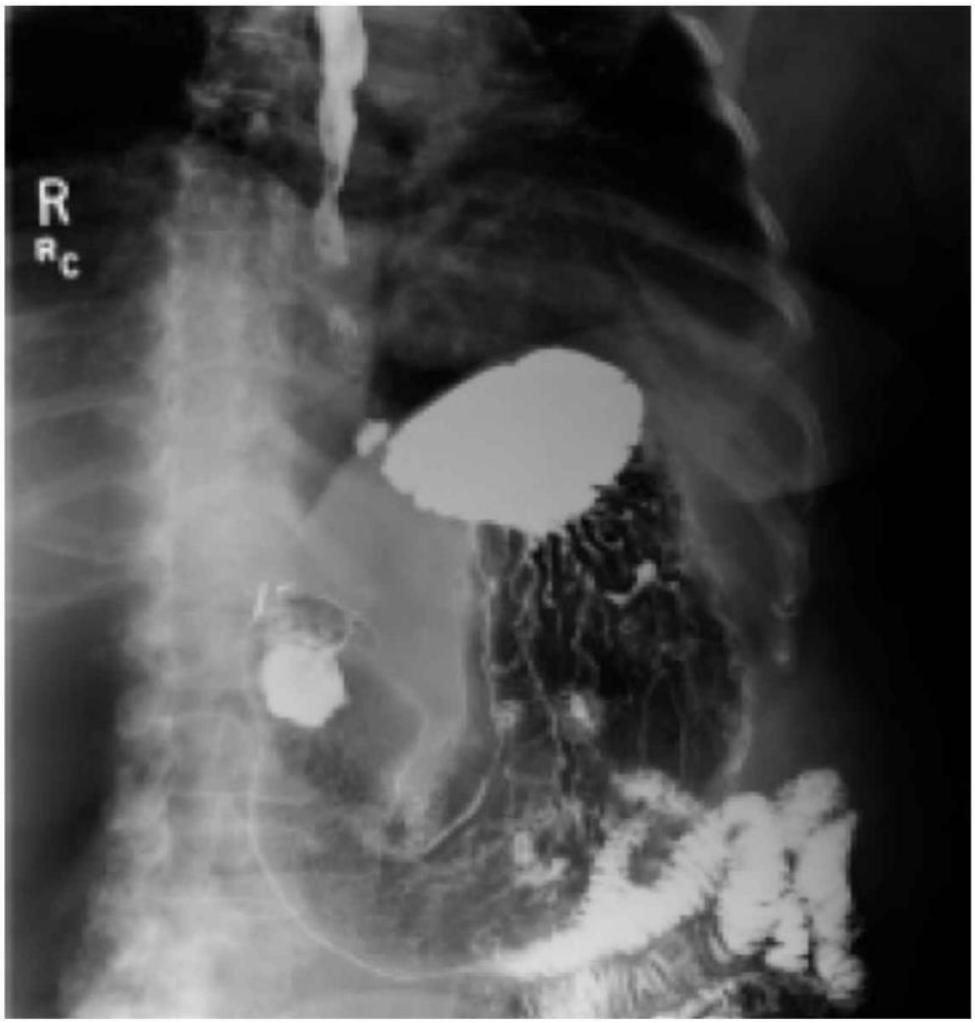
What is an upper GI and when is it used?

In an upper GI, the patient swallows barium and the radiologist performs real-time X-rays (fluoroscopy). Barium can be followed from the mouth to the duodenum. Static X-ray images are obtained documenting the course, caliber, and distention of the esophagus, stomach, and duodenum. *Single contrast* indicates that only the barium suspension is used to form a cast of these hollow organs. *Double contrast* indicates the use of both barium and air, which is introduced into the stomach by carbon dioxide-releasing crystals. The air allows the mucosa to be coated by a thin layer of barium, providing a much more sensitive and accurate means to detect mucosal disease such as polyps and ulceration. There is usually no need to specify air-contrast upper GI on your orders, since most radiologists use it unless the patient is unable to tolerate it because of age or other factors.

Reasons to order an upper GI:

- Abdominal pain
- Gastric or duodenal ulcer
- Bezoar
- Mass pathology

| Gastric obstruction

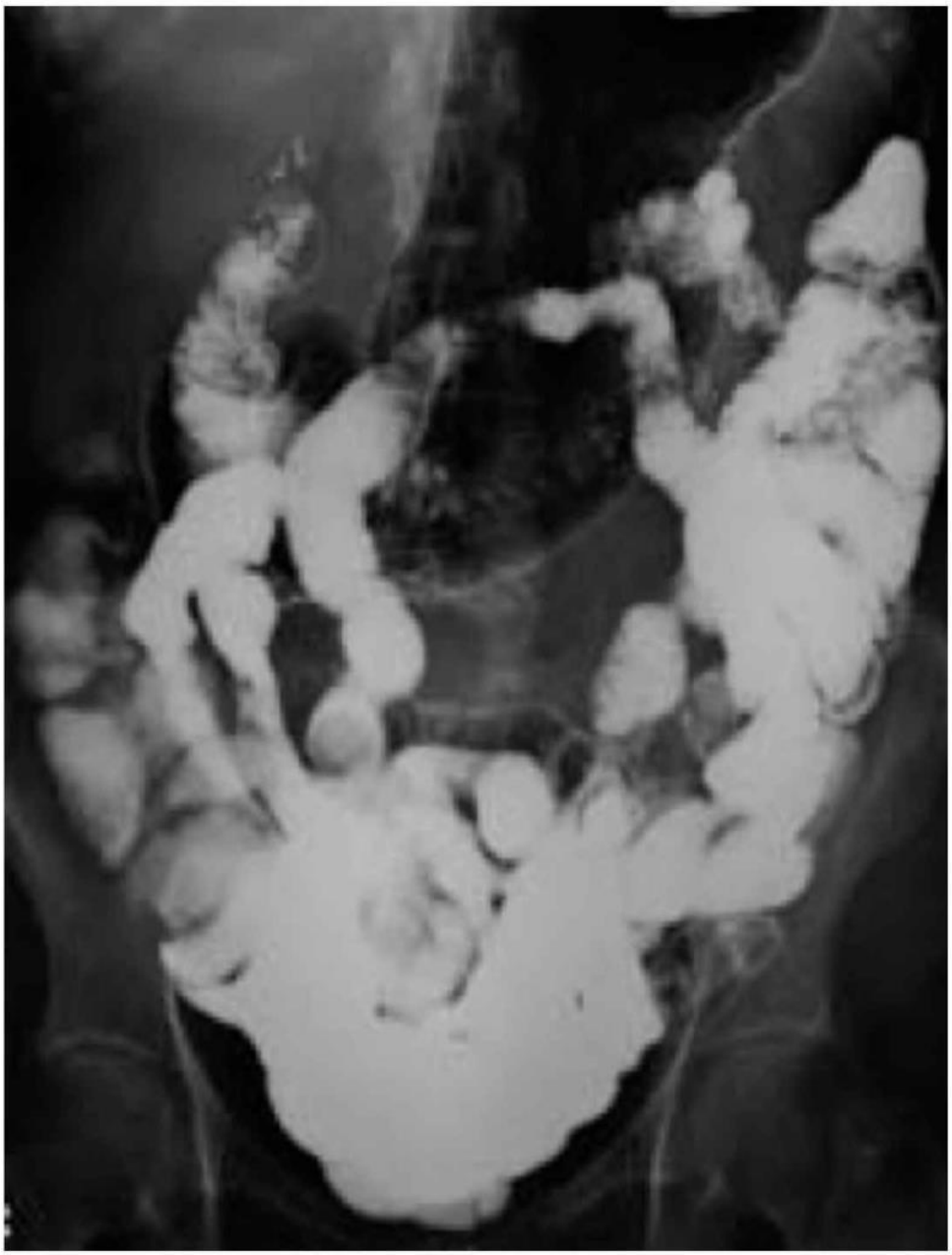


Normal air contrast—upper GI

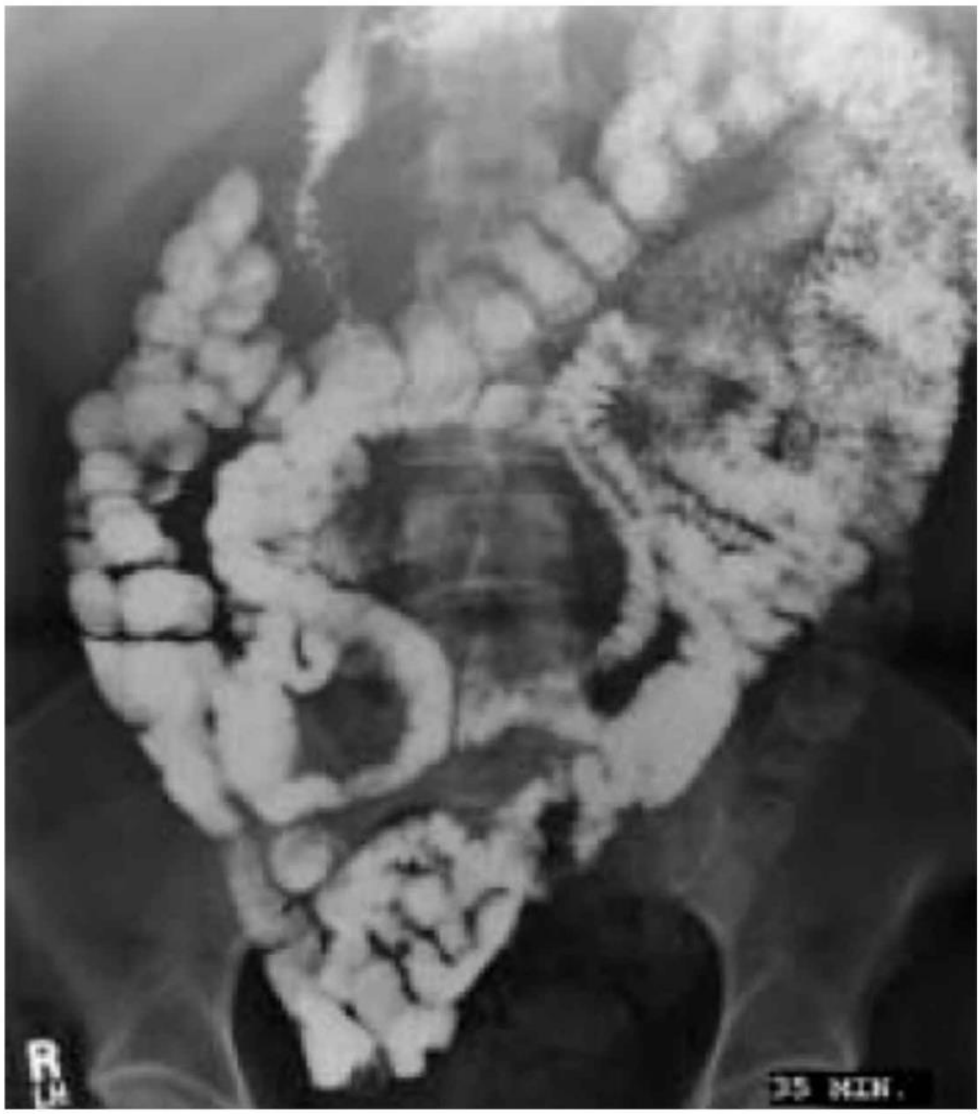
How is the small intestine studied radiographically?

There are two common ways to study the small intestine without CT. The most common method is a *small bowel follow-through* (SBFT), which is performed just as it sounds. A barium suspension is given by mouth and serial abdominal radiographs are obtained as the contrast traverses the small intestine. The study is concluded when the barium reaches the colon and—because of the propensity for Crohn's disease to affect the distal small bowel—specific spot radiographs are obtained to document the terminal ileum and the ileocecal valve. The second method, *enteroclysis*, is more time-consuming but also more accurate. A long tube is inserted through the nose or mouth and positioned at the junction of the duodenum and jejunum as marked by the upper sweep of the fourth arm of the duodenum. A bolus of thick contrast is injected through the tube, followed by a methyl cellulose solution (not visible on X-rays). This solution pushes the contrast forward, coats the small intestinal mucosa, and distends the bowel for accurate assessment of the mucosa. Enteroclysis is reserved for difficult cases, small bowel tumors, polyps, or conditions where fine mucosal detail would be helpful. Consider ordering a small bowel study for

Chronic diarrhea
Gluten sensitivity (nontropical sprue)
Small bowel lymphoma or other suspected malignancy
Weight loss of unknown cause
Steatorrhea (fatty stool)
Inflammatory bowel disease



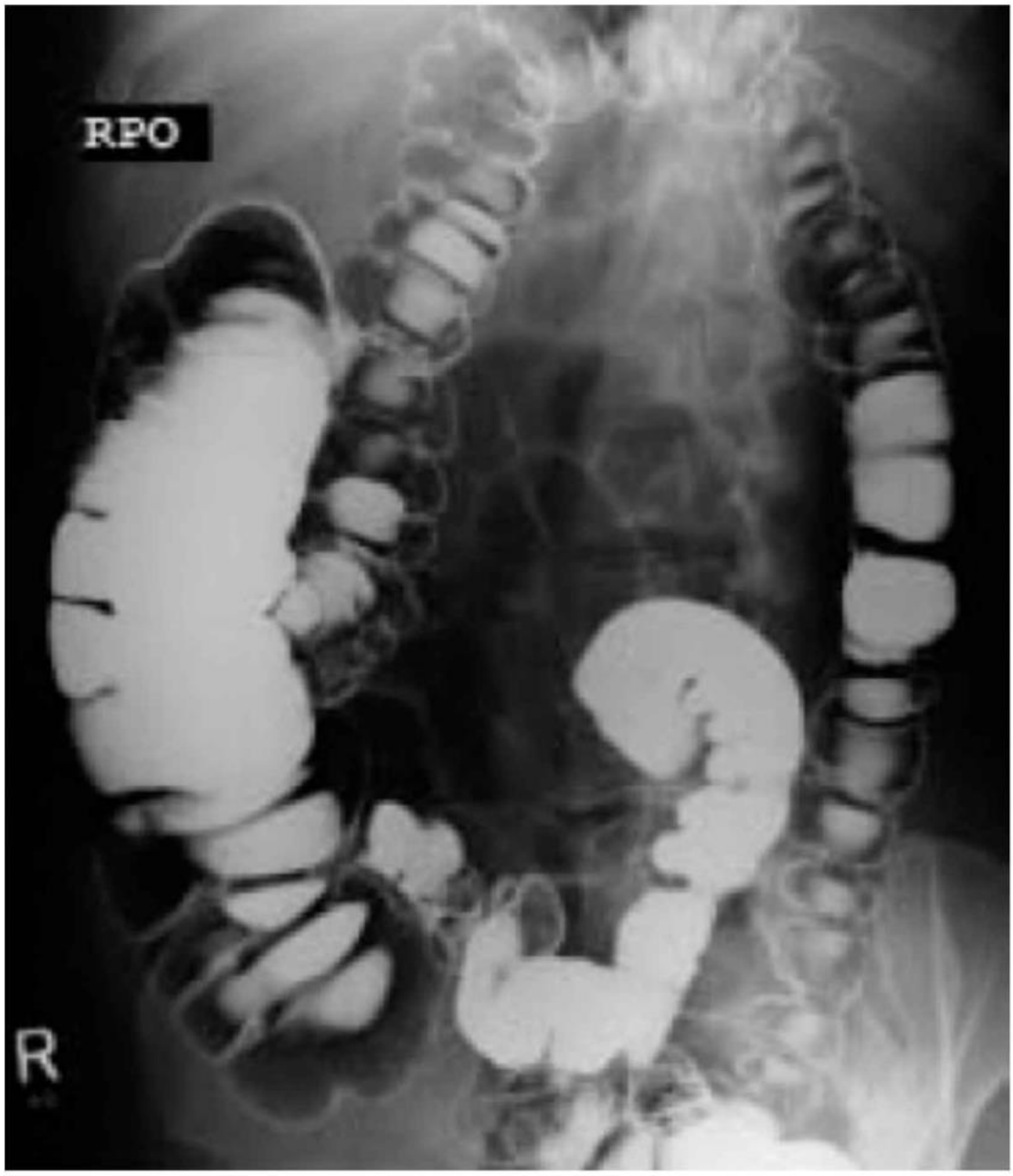
Normal small bowel follow-through



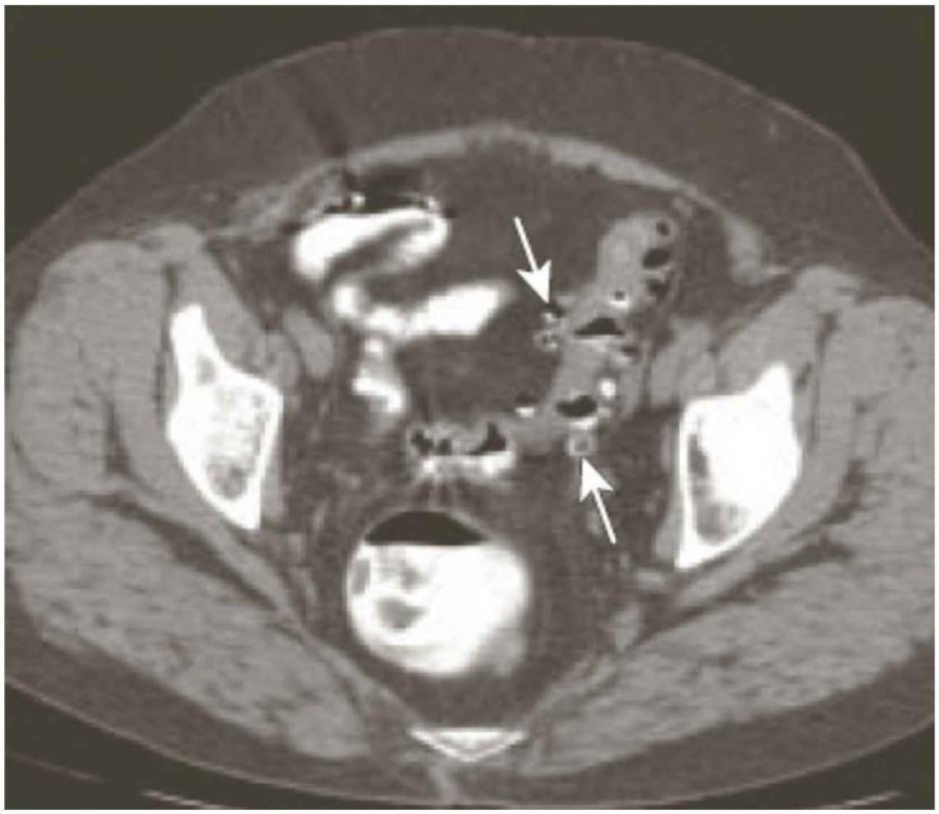
Normal small bowel

How is the colon imaged and how is barium enema used in practice?

Colonoscopy has replaced barium enema, with a few exceptions, because it is a little more sensitive for the detection of polyps and because biopsy can be performed at the time of colonoscopy. Barium enema is used if the endoscope cannot be advanced all the way to the cecum. Water-soluble contrast is used if obstruction is suspected and rapid diagnosis is required. Barium enema can be an initial screening test in those few patients who refuse colonoscopy. A single-contrast barium enema is performed by gravity drainage of a barium-filled enema bag into the colon. The contrast is followed by fluoroscopy (real time X-ray imaging) to the cecum. Multiple X-ray views are taken. Because polyps are better seen with double contrast, most barium enemas are completed using a combination of thick barium (to coat the mucosa) and air (to distend the colon).



Normal air contrast: barium enema



CT: sigmoid diverticulosis

What are the uses and limitations of barium studies?

The barium studies discussed above—esophagram, upper GI, small bowel follow-through, and barium enema—are often performed for screening purposes or on occasion to confirm or reevaluate a finding seen during endoscopy. Because the radiologist watches the barium column in real time with fluoroscopy, physiologic information such as peristalsis can be obtained.

Barium examinations are excellent for evaluating the caliber of hollow viscera. Areas of narrowing can be evaluated for their length and contour. Strictures with irregular margins raise concern for cancer. Inflammatory strictures can be identified anywhere from the esophagus to the rectum.

Filling defects such as polyps or masses create an area of contour abnormality. However, while we can predict whether a stricture, polyp, or mass appears to be benign or malignant, only biopsy can provide a definitive answer. Endoscopy has the advantage of the option for biopsy or treatment. Barium studies are diagnostic only. In addition, endoscopy is at least as accurate as barium examinations, and most physicians believe that it is more accurate.

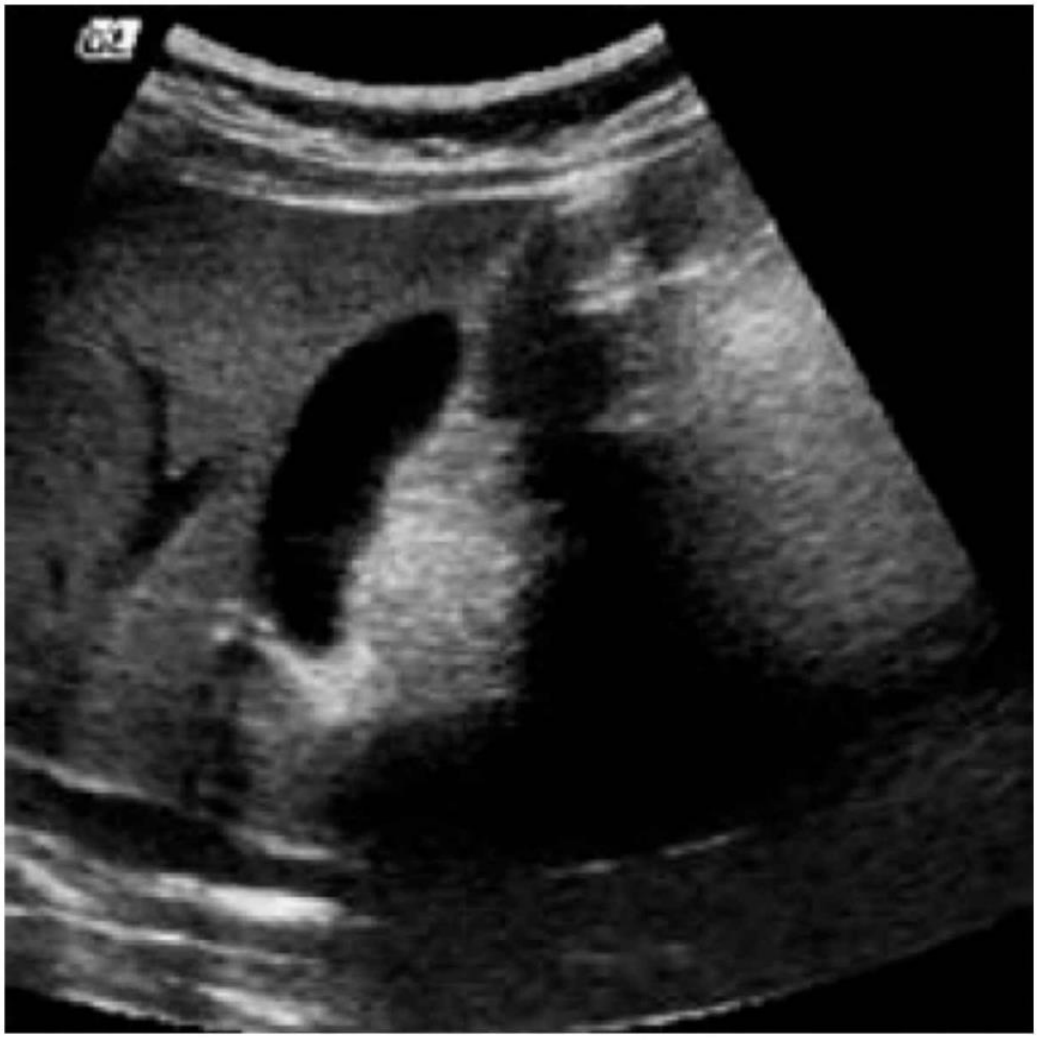
What are the optimal examinations for specific evaluation of the gallbladder, liver, pancreas, and spleen?

Once you have decided to image a specific organ, the next important consideration is how best to study it. The gallbladder, being a fluid-filled structure, is best imaged with ultrasound. When you request a gallbladder ultrasound, you will also get information

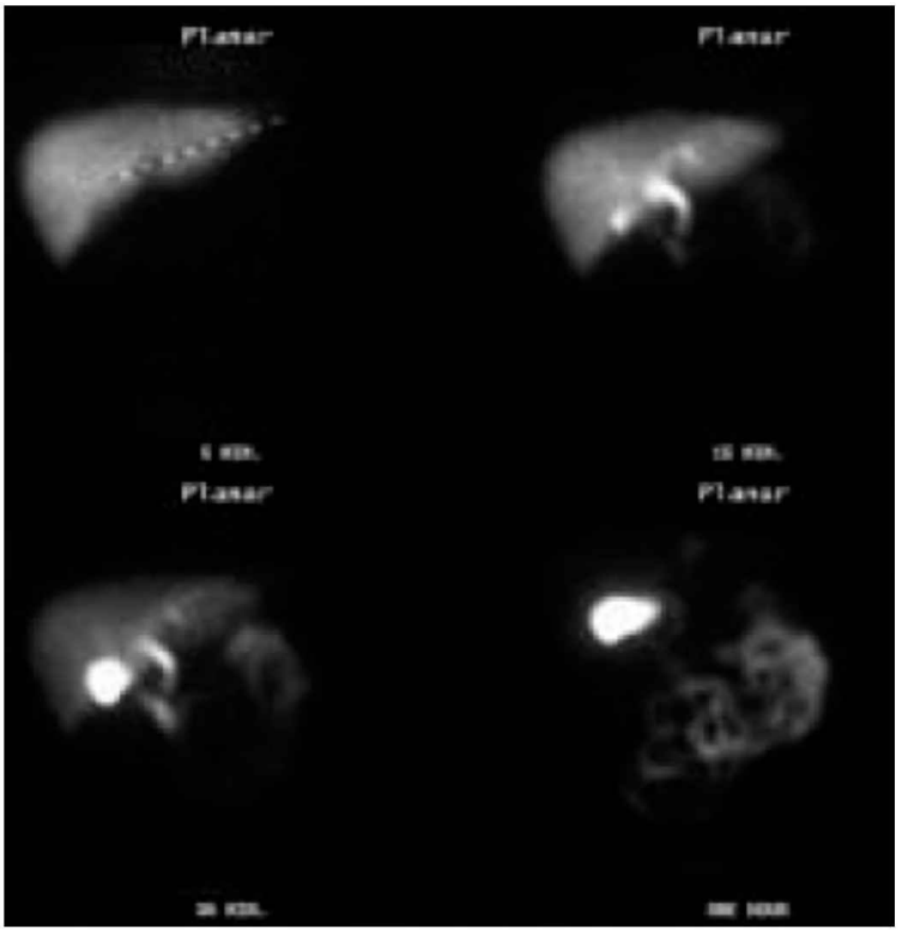
about the liver, bile ducts, right kidney, and pancreas. There are few if any contraindications to gallbladder ultrasound.

Gallbladder ultrasound should be performed prior to a HIDA scan, especially when a gallbladder ejection fraction is requested. The HIDA scan is a nuclear imaging study that gives information about the patency of the cystic duct and common bile duct. The HIDA scan is especially useful for the diagnosis of acute cholecystitis (edema results in occlusion of the cystic duct and therefore no tracer will be seen in the gallbladder) and chronic cholecystitis (delayed visualization of the gallbladder). The nuclear HIDA scan provides excellent physiologic information but limited anatomic detail. Once the radio tracer has accumulated in the gallbladder, an intravenous injection of a gallbladder-stimulating compound allows the technologist to calculate the gallbladder ejection fraction. This physiologic information is helpful to determine the functional status (contractility) of the gallbladder.

The liver, pancreas, and spleen are best imaged with CT. Although ultrasound can provide excellent information, overlying gas often obscures portions of these organs. If CT is equivocal, MRI is the best imaging study to clarify a finding or to help refine the differential diagnosis.



Normal gallbladder ultrasound



Normal HIDA scan

What does esophageal cancer look like on an esophagram?

The most common presentation of esophageal cancer is an asymmetric stricture of the lower esophagus. The barium cast of the esophageal lumen is narrow and irregular. There are often small ulcerations where barium collects, as well as areas of irregular filling defects. The proximal portion of the esophagus may be dilated from the obstruction. Varicoid carcinoma can occur in the stomach or the esophagus, presenting as wormlike filling defects that may be confused with varices. Early esophageal cancer can be as subtle as segmental mucosal roughening or irregularity. Inflammatory esophageal strictures present with smooth, symmetrical luminal narrowing. Whether a stricture is thought to be benign or malignant from an imaging standpoint, endoscopy with mucosal biopsy is always indicated.

What does an ulcer look like on an upper GI?

An ulcer is a hole in the mucosa that collects barium contrast. The rim of the ulcer is often edematous, creating a smooth, collar-like surrounding filling defect. An ulcer in the stomach should always raise concern for carcinoma. Gastric carcinoma often presents with ulceration. The filling defect of the gastric mass may be more subtle than

the ulcer itself. An ulcer in the duodenum is most often inflammatory (peptic ulcer disease). The adjacent mucosa may be edematous and the mucosal folds thickened. Punctate ulcerations are pinpoint contrast collections. Seen head on, ulcers present like targets: a central opaque bariumcontaining ulcer crater and a surrounding low-density rim or collar. Seen in profile, ulcers are seen as projections of barium into the mucosa.

What are the barium enema findings in colon cancer, diverticulitis, ulcerative colitis, and polyps?

The typical colon cancer encircles the lumen of the colon, producing the aptly named finding of an "apple core" lesion. This localized luminal constriction displays irregular margins like tooth marks on an apple core. It is also sometimes called a "napkin ring" because of the abrupt change in the caliber of the bowel lumen. When colon cancer presents earlier, there may be an irregular elevation of the mucosa. In the rectum, the appearance of raised nodular mucosa when seen in profile is referred to as a "carpet lesion." In any case, the normally smooth contour of barium and air adjacent to the smooth colon mucosa is irregular and microlobulated.

A diverticulum is an out-pouching of the colon wall. A noninflamed diverticulum appears as a smoothly margined sac-like structure with a narrow waist and broad balloon-like body. Diverticula may occur anywhere from the esophagus to the rectum, but they are most common by far in the sigmoid colon. When inflamed, the smooth sac is replaced by a jagged triangular or thorn-shaped barium collection. As the mucosal inflammation continues, this sawtooth pattern is often accompanied by constriction of the colon lumen.

Ulcerative colitis is a diffuse inflammatory process involving bowel mucosa. Early in the process, the ulcerations are tiny, producing granular defects in the mucosa. As the ulcers deepen, they can resemble small diverticula, or so-called collar-button ulcers. Diffuse mucosal involvement is present, while in the skip lesions of Crohn's disease it is not. In addition, the rectum is almost always affected by ulcerative colitis and less commonly in Crohn's disease. Care must be taken when ordering a barium enema in acute ulcerative colitis, as the enema may precipitate toxic megacolon, a state of severe colitis with marked colon distention, placing the colon at risk for perforation and/or ischemia. Late-stage ulcerative colitis results in a smooth, featureless colon mucosa secondary to chronic inflammation. This appearance on barium enema has been referred to as a "pipestem" colon.

Polyps in the GI tract are small filling defects. They may appear as small broad-based bumps on the mucosa, sessile polyps, or on a stalk as pedunculated polyps. Small polyps less than 5 mm in size are easily overlooked on a barium enema. These are often hyperplastic polyps without malignant potential. Adenomatous polyps are usually larger than 5 mm and do carry a risk of harboring adenocarcinoma.

MUSCULOSKELETAL

Understanding the indications and modalities used for imaging the musculoskeletal system and basic interpretation skills

Objective questions:

1 What modalities are used to evaluate bones and joints?
2 How do I find a fracture on an X-ray?
3 How can I best describe fractures?
4 What is the Salter-Harris classification of growth plate fractures?
5 What is dislocation and how can I recognize and describe it?
6 What does arthritis look like on an X-ray?
7 How is osteomyelitis diagnosed?
8 How are bone tumors classified and described?
9 When is CT better than plain film X-rays?
10 When is CT better than MRI?
11 When should I order an MRI?
12 When is a bone scan indicated?
13 Postural evaluation: what is the procedure to evaluate for leg-length discrepancy?
14 What is a scanogram?
15 How do I examine the cervical spine?
16 How do I examine the thoracic spine?
17 How do I examine the lumbar spine?
18 What is DEXA and how does it measure bone density?

What modalities are used to evaluate bones and joints?

X-ray modalities (plain film and CT) are excellent for studying the detail of cortical and trabecular bone. Soft issues, including cartilage, ligaments, tendons, muscles, and bone marrow, are usually best imaged with MRI. Nuclear imaging gives us less anatomic information but more physiologic data. A bone scan is performed by injecting a material that is readily taken up by actively growing bone. This material has been tagged with a radioactive pharmaceutical that decays and produces a gamma ray, which in turn can be imaged by a gamma camera. Actively growing bone can be found

in healing fractures, in tumors, and around infections. These areas are said to be “hot” on a bone scan because there will be a greater concentration of the radiopharmaceutical.

Summary of bone and joint imaging modalities:

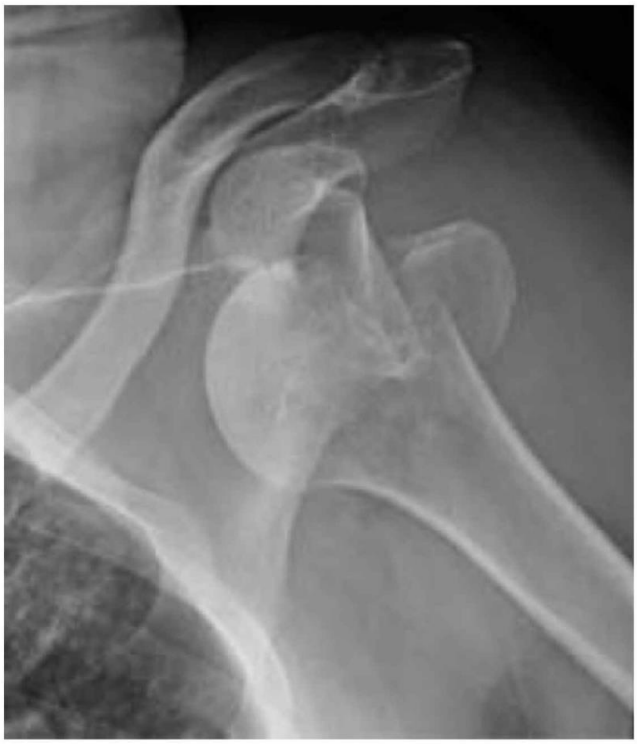
> Plain film radiographs
> CT
> MRI
> Nuclear bone scanning

How do I find a fracture on an X-ray?

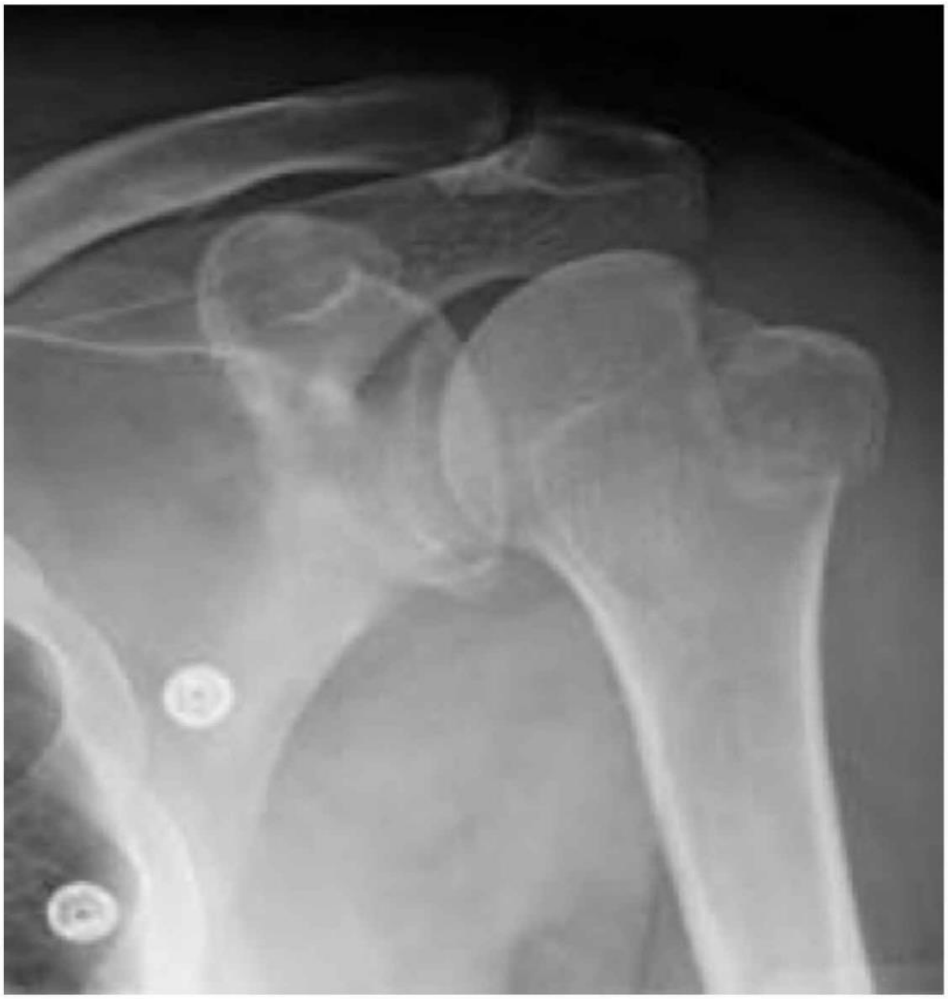
I suggest a three-step process in the evaluation of bones and soft tissues for the signs of fracture. The first, and perhaps the most sensitive, is the assessment of the soft tissues for swelling or signs of joint effusion, mainly displacement of intra-articular fat pads. The last two involve the careful scrutiny of cortical continuity and contour abnormalities.

Three-step process to find a fracture on X-ray:

> Start with soft tissues, looking for swelling or fat pad displacement.
> Examine the cortex along the entire length of the bone.
> Look for cortical irregularity, buckling, or evidence of impaction.



Fracture-dislocation—right humeral head



Reduction films

How can I best describe fractures?

The primary goal of fracture description is to paint an accurate verbal picture of the injury. Once you have identified the fracture line, determine whether it extends completely through the bone (complete versus incomplete). Next, evaluate the course of the fracture line: transverse, oblique, longitudinal, or spiral. Determine if there is displacement or angulation of the distal fracture fragment. The term *comminuted* applies if there are more than two pieces of bone or more than one fracture line. Look closely at the articular surfaces nearest the fracture. If the fracture line extends into a joint, it is very important to communicate this finding so that all efforts can be made to restore alignment along the articular surface. Finally, if bone is exposed to air, either because of associated laceration or because the fragment protrudes through the skin, this is an open fracture at risk for infection.

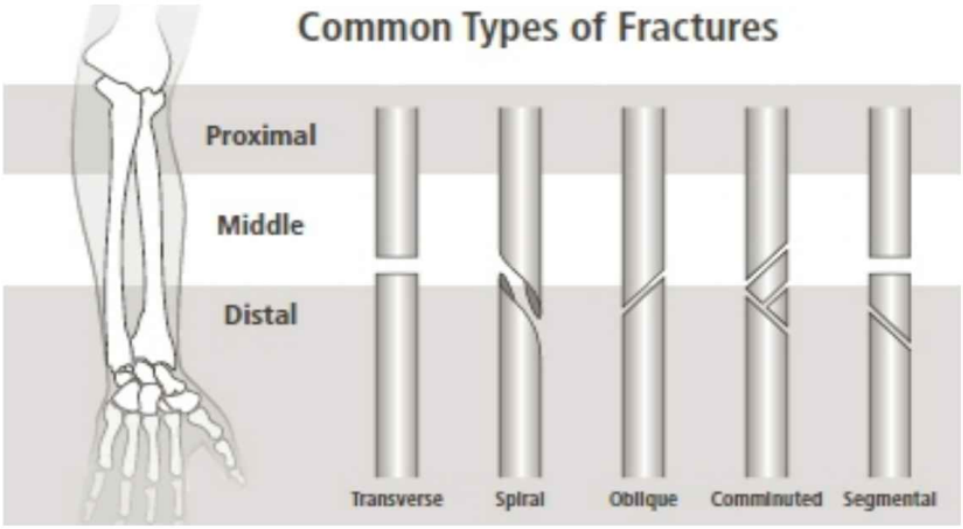
Fracture description checklist of long bone fracture descriptors:

Direction of the fracture line: transverse, oblique, longitudinal, spiral
Displacement
Angulation

Comminution
Articular involvement
Open or closed

Summary of fracture recognition and description

1. Check the name, date, and orientation of the part being examined.
2. Get a global impression of the study, noting alignment, bone density, and any gross deformity.
3. Carefully examine the soft tissues for swelling, foreign body, or soft tissue air.
4. Look for displacement of fat pads around all joints. A positive posterior fat pad in the elbow is always regarded as a fracture even if the fracture itself is not visible.
5. Follow the dense white cortex of bone along each and every surface of visible bone and on all three projections (AP, lateral, and oblique).
6. Examine articular relationships for subluxation or dislocation of a joint.

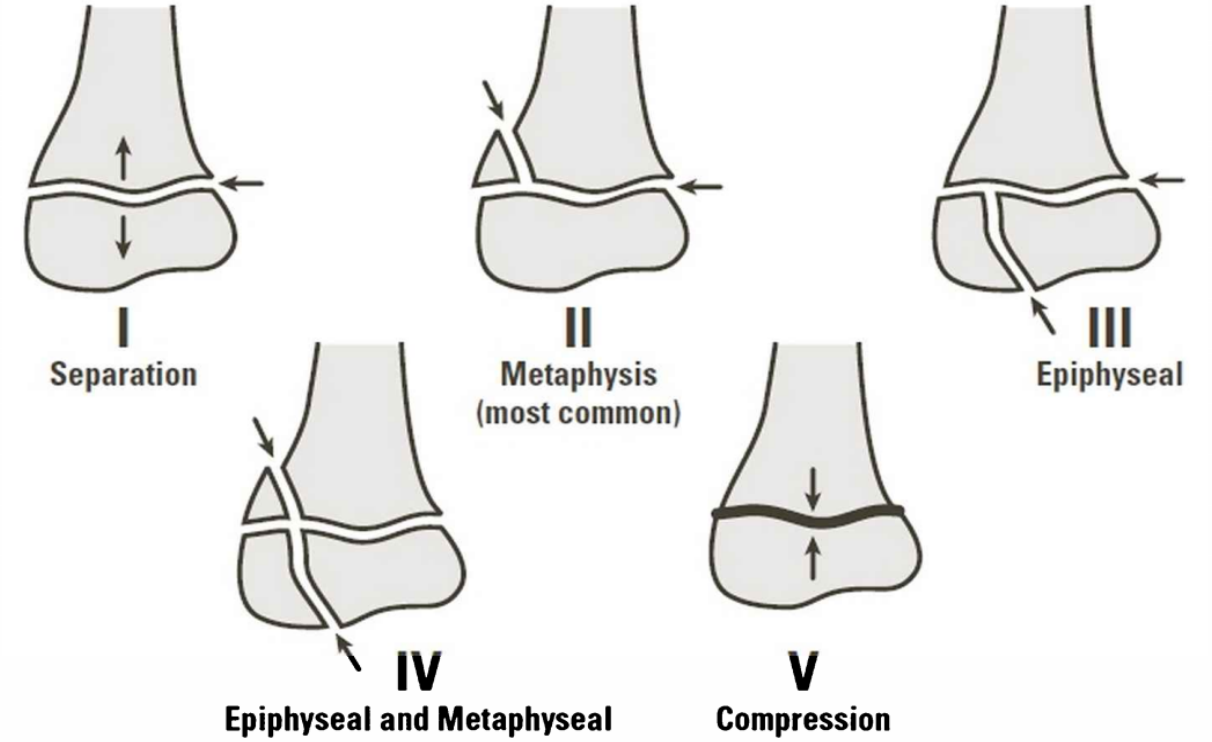


Fracture patterns

What is the Salter-Harris classification of growth plate fractures?

Salter and Harris were prominent Canadian surgeons who recognized, described, and classified specific patterns of growth plate injury in children (1963). There are nine categories of injury, but only five occur frequently enough to be in general use for most practitioners. Detecting and classifying these injuries is important to allow for the prediction of potential functional disability resulting from the growth plate damage. *Type I* is separation of the epiphysis from the metaphysis. The fracture line travels across the growth plate and results in a gap between the epiphysis and the metaphysis. This finding can be very subtle and may require a comparison view of the opposite limb to be recognized. Functional disability is rare. *Type II* is the most common Salter-Harris injury. The fracture line extends partially through the growth plate and then travels obliquely through the metaphysis. Functional disability is uncommon. A *type III* fracture extends longitudinally through the epiphysis to the growth plate. Because the fracture extends to the articular surface, the possibility of future disability is greater

than with types I and II. *Type IV* is a fracture that extends longitudinally through the epiphysis and also obliquely through the metaphysis. This injury has components of both types II and III and may result in disability due to joint involvement. *Type V* is a compression injury of the growth plate. This too is a subtle injury that is recognized by narrowing of the growth plate when compared to other growth plates. This crush injury may result in growth disturbance because of premature closure of the growth plate.

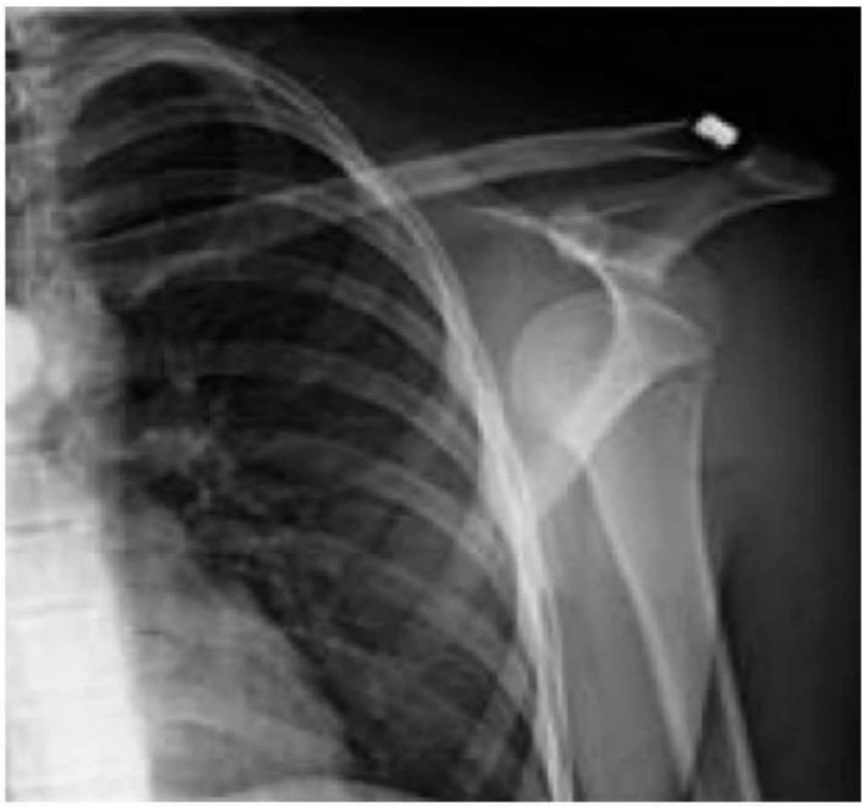


Salter-Harris classification

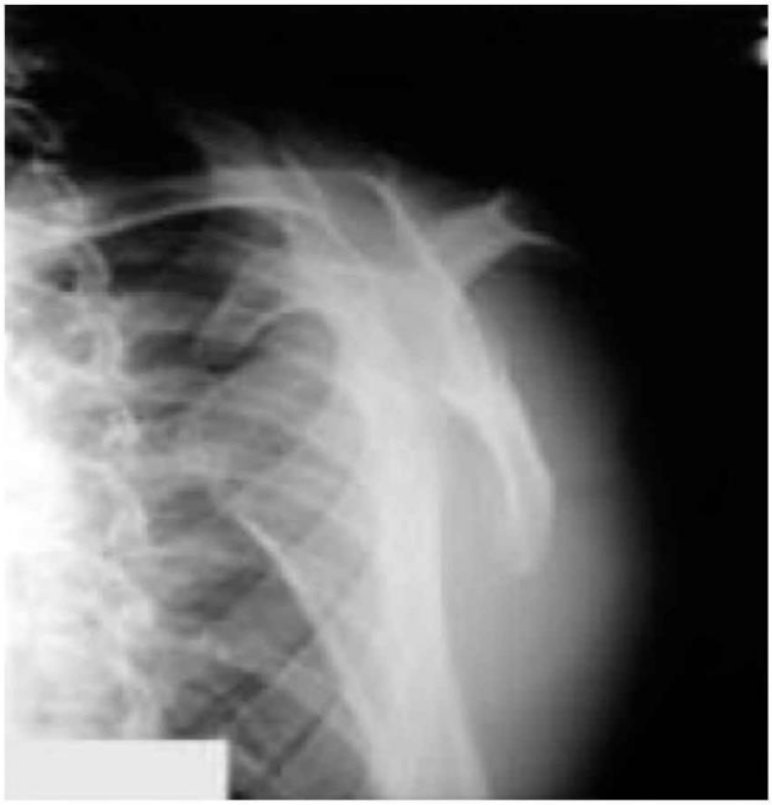
What is dislocation and how can I recognize and describe it?

Dislocation is complete displacement of a bone from its articulation (joint). An anterior or subcoracoid dislocation of the humerus is most common in the shoulder. A posterior dislocation of the radius and/or ulna is most common in the elbow. A posterior dislocation is also the most common way the femoral head is dislocated in the hip. The patella tends to dislocate in a lateral direction. The talus most often dislocates laterally in the ankle.

Dislocation is recognized when anatomic alignment of the joint is lost. In the shoulder, on the AP view, the dislocated humerus is seen to lie inferior to the coracoid process of the scapula rather than its usual position below the acromion. A scapular "Y" or axillary view should be obtained to help you determine that the humeral head is anteriorly displaced. Posterior dislocation of the shoulder is more difficult to detect, especially on the AP view. It tends to occur because of an intense muscular contraction of back muscles, such as during a grand mal seizure or electric shock. Therefore, the AP view alone is not sufficient: the standard views of the shoulder include an AP in internal rotation, an AP with external rotation, and a scapular "Y" projection.



Anterior subcoracoid shoulder dislocation

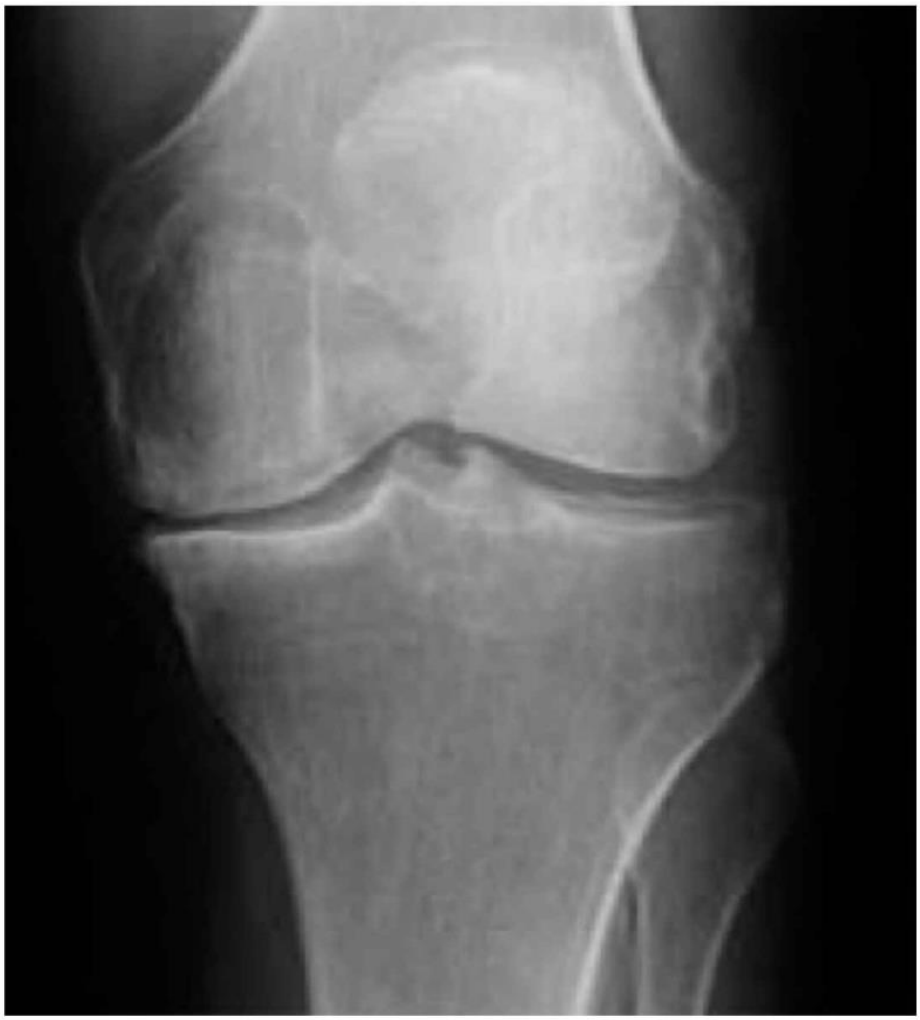


Scapular “Y” view of anterior dislocation

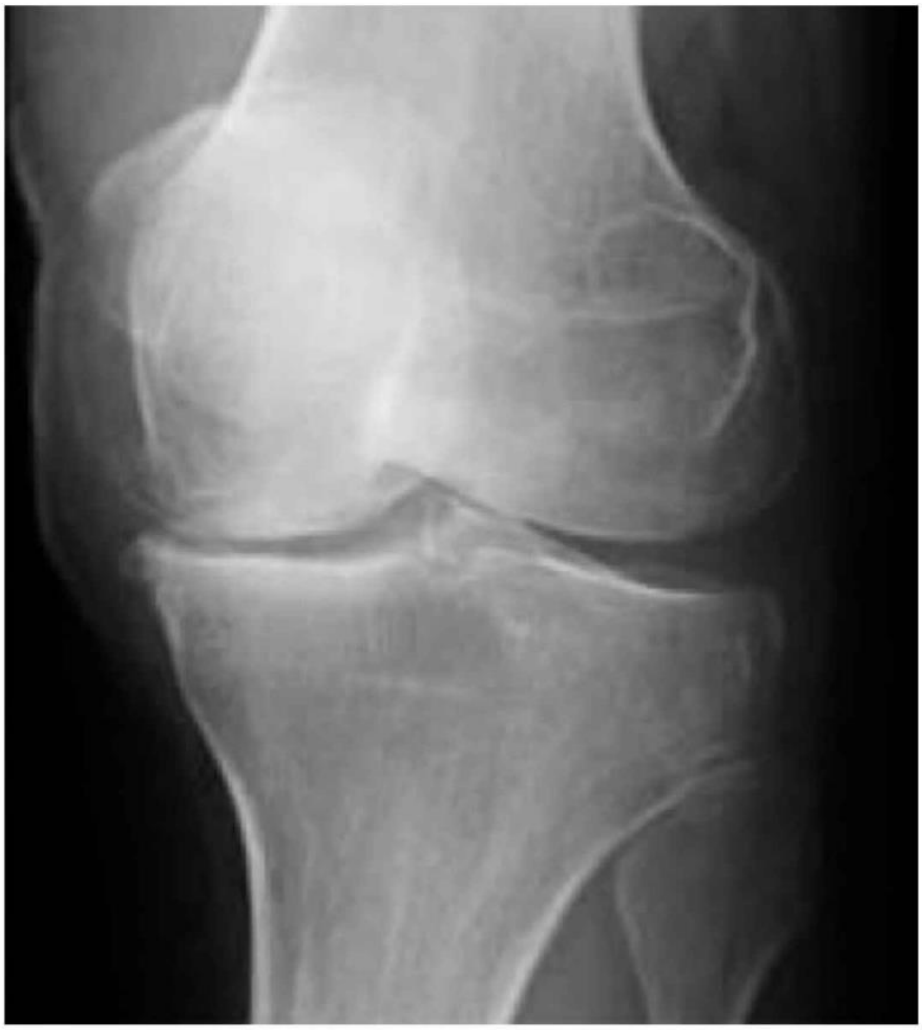
What does arthritis look like on an X-ray?

Arthritis can be divided into two categories: *degenerative* (or *osteoarthritis)* and *inflammatory*. In osteoarthritis, the joint space narrows and the bone reacts to the increased pressure by becoming dense (sclerosis) and by forming para-articular new bone (osteophytes). Osteoarthritis can affect any joint, but it is common in the hips and knees and the facet joints of the spine. It favors the distal interphalangeal joints of the hand.

Inflammatory arthritis includes rheumatoid arthritis, gout, pseudogout, psoriatic arthritis, and septic arthritis. In these conditions, there is usually some degree of joint destruction and osseous erosion. Increased blood flow (hyperemia) results in diminished bone density adjacent to the joint (juxta-articular osteopenia). Inflammatory synovium erodes bone at the margins of the joint where cartilage does not cover the bone (bare areas). The joint space narrows, ligaments become lax, and, late in the disease, characteristic subluxations occur. In rheumatoid arthritis, the proximal phylangeal articulations of the hand are more commonly involved than the distal joints.



Degenerative joint disease, left knee



Degenerative osteophytes—medial femur and tibia

How is osteomyelitis diagnosed?

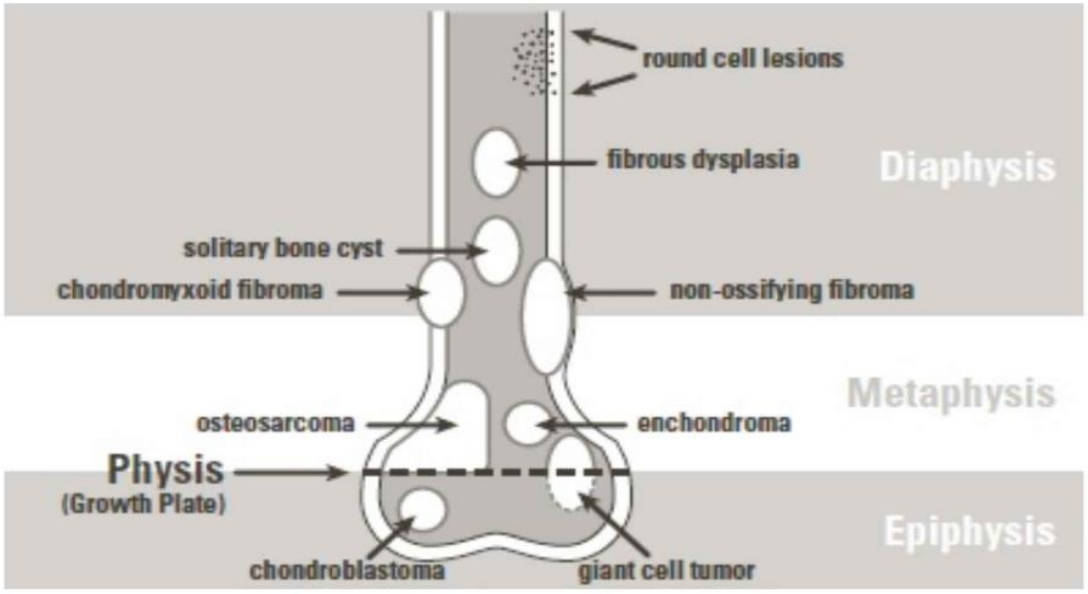
Plain X-rays are usually the first step in imaging. Para-articular soft tissue swelling and joint effusion present as hazy fluid accumulation around a joint that may displace normal fat pads. The periosteum may thicken or may be elevated away from the cortex. The osseous structure loses density (osteopenia). Bone destruction, however, is the only primary sign of osteomyelitis. When bone begins to vanish, the infection has usually been present for weeks. A bone scan or MRI is much more sensitive than a plain film for the detection of early osteomyelitis. With bone scanning, a three-phase technique is used. Technetium 99m is tagged to MDP (methyldiphosphonate) and injected intravenously. A flow study is the first phase. It will demonstrate increased vascular flow to the area of infection. Early (immediately after the injection) and delayed (three to six hours after the injection) imaging will demonstrate progressive, intense uptake of the MDP into the area of infection as the bone struggles to rebuild from the destructive process. MRI demonstrates increased fluid in and around the area of osteomyelitis. The bone marrow will become less intense on T1 (fluid) and more intense on T2. When gadolinium contrast is administered, there is enhancement of the inflammatory tissues.

How are bone tumors classified and described?

Bone tumors are classified in several ways. First, the tumor may be *benign* or *malignant*. If the tumor is malignant, the aggressiveness of disease can be predicted with plain film, CT, and MRI findings. Malignant tumors are further classified as *primary* and *metastatic*. It is extremely important to consider the age of the patient. Bone tumors occur predictably within certain age ranges, and they characteristically occur in specific areas. Diagnosing a bone tumor is like picking real estate. The three most important factors are location, location, and location.

Certain primary tumors tend to spread to bone, such as breast and prostate cancer. Metastatic lesions are classified as *lytic* (causing destruction) or *blastic* (associated with dense metastatic tissue elements).

There are three key descriptors of bone tumors. In order of least aggressive to most aggressive, they are *geographic*, *moth-eaten*, and *permeative*. A geographic tumor is well-defined and has a sharp zone of transition and sclerotic borders (an example is a fibroxanthoma). A moth-eaten tumor is more aggressive. The zone of transition between the tumor and normal bone is less clear and there are no sclerotic margins (an example is multiple myeloma). A permeative tumor is the most aggressive. There is no visible wall, the transition from tumor to normal bone is obscure, and the periosteum is often pushed to become at right angles to the bone (an example is osteosarcoma).



Distribution of bone tumors

When is CT better than plain film X-rays?

CT has the advantage of computer-generated three-dimensional reconstruction. Thin-section CT gives great anatomic detail of cortical and medullary bone without overlapping tissue shadows. The following fractures are best characterized using CT:

- Tibial plateau fracture, especially with coronal reconstruction, to look for depression or displacement of a fracture fragment
- Acetabular fracture
- Calcaneal fracture
- Facial bone or orbital fracture

Talar fracture
Sternal fracture, especially with coronal reconstruction

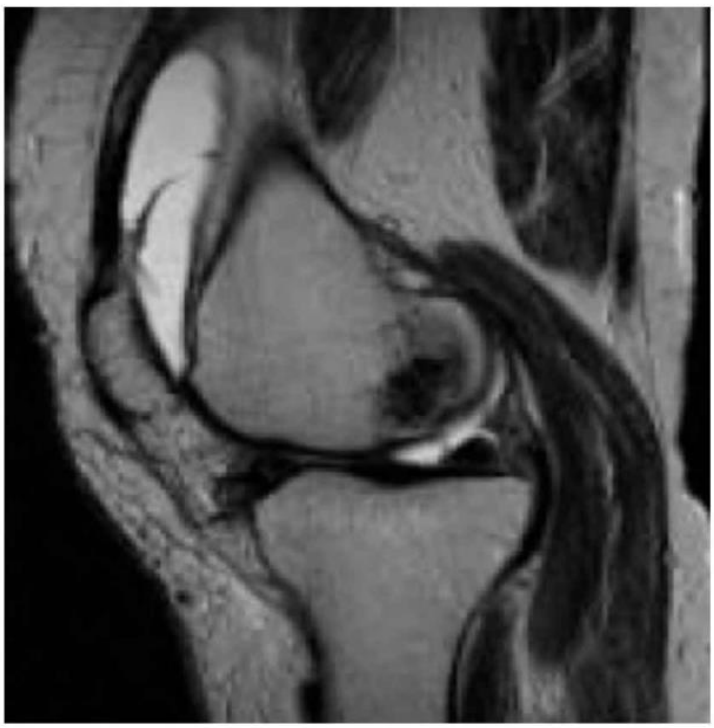
When is CT better than MRI?

CT is better than MRI when we are looking at the relationships between cortical bone and joint surfaces in the acetabulum and tibial plateau or when there may be multiple complex fracture lines. The key word is *cortical* bone. The cortex is white and easy to see on CT and is devoid of signal with MRI.

When should I request an MRI?

When you think of soft tissue imaging, think MRI. Soft tissue includes not only muscle, tendon, ligament, and cartilage, but also bone marrow. Fluid collections are easy to see on an MRI. Fluid presents with bright white signal on T2-weighted images.

Suspected muscle, tendon, cartilage, or ligament tears
Bone marrow disorders
Suspected stress or radiographically occult fracture
Soft tissue or bone tumors
Ischemic necrosis



MRI suprapatellar effusion

When is a bone scan indicated?

Bone scanning is physiologic imaging of living bone. Bone scans are indicated for

Stress fracture
Radiographically occult fracture
Osteomyelitis
Osseous metastatic disease (blastic type)
Prosthesis loosening

Postural evaluation: what is the procedure to evaluate for leg-length discrepancy?

A postural study is used to estimate leg length, sacral base tilting, and lumbosacral angle. An AP film of the pelvis is obtained with the patient standing. A plumb line (a thin chain with a weight on the end) is pinned to the patient's gown for reference, and the difference in heights between the two lines is measured drawing a perpendicular line from the plumb line to the superior margin of each femoral head. If the femoral heads are on the same plane, there is no leg-length discrepancy.

To evaluate the sacral base plane, on the same AP film of the pelvis a line is drawn connecting dots at the lowest point of the sacral sulcus on the left and right. If this line is perpendicular to the plumb line, there is no sacral base tilt (normal).

The weightbearing line is constructed on a lateral view of the lumbar spine. With normal alignment, a line drawn parallel to the plumb line should fall from the midbody of L3 to the anterior third of the sacral base.

What is a scanogram?

A scanogram is an X-ray examination performed in the AP projection with a specialized ruler included in the radiograph. It is the most accurate X-ray method to measure leg length. The femurs are measured from the superior margin of the femoral head to the inferior margin of the medial femoral condyle. The tibiae are measured from the medial tibial plateau to the articular margin of the distal tibia.

How do I examine the cervical spine?

There are five basic views of the cervical spine: lateral, AP, left oblique, right oblique, and open-mouth odontoid. The lateral view is the most important because it contains information about vertebral alignment, integrity of the cortex, heights of the vertebral bodies, and presence of precervical soft tissue swelling. The steps to follow in evaluating the cervical spine X-ray are as follows:

1. Count the segments. You should see as far inferiorly as T1 and always C7.
2. Examine alignment (anteriorly and posteriorly). Alignment is assessed by closely examining the three arcs of the cervical spine. See figure.
3. Examine the precervical soft tissues (normal up to 6 mm at C2 and 22 mm at C6).
4. Follow the cortex of each vertebral segment.
5. Compare disk spaces at each level.
6. Identify the odontoid process on lateral and open-mouth views
7. Check for alignment of the lateral masses of C1 and C2 on the open-mouth odontoid view.
8. Check for midline position of the spinous processes on the AP view.

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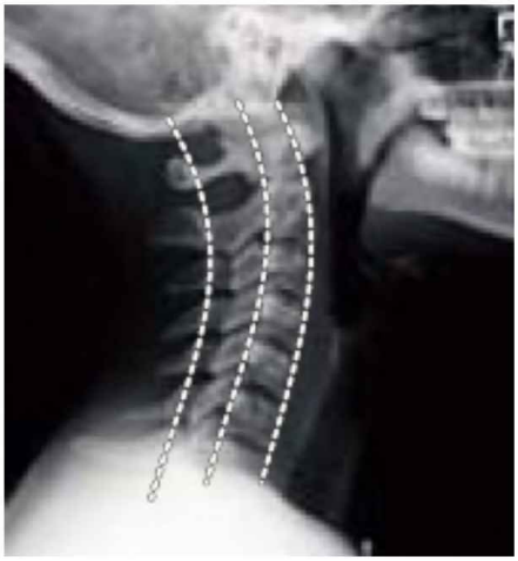
"6 at 2 and 22 at 6," referring to the upper normal soft tissue measurement between the cervical spine and the airway at C2 and at C6.



Lateral cervical spine—X-ray and cervical spine—"three arcs"

How do I examine the thoracic spine?

AP and lateral views are standard in thoracic spine radiography.

1. On the AP view, count the number of thoracic segments and corresponding ribs.
2. On the AP view, check each pedicle. The pedicles are seen as oval structures on either side of the vertebral bodies. Metastatic disease favors the pedicles.
3. On the AP view, look at the soft tissues on each side of the thoracic spine for evidence of paraspinal mass pathology.
4. On the lateral, evaluate thoracic vertebral body heights and disk spaces.
5. Note the thoracic kyphosis—is it exaggerated?
6. Check the integrity of the cortex throughout the spine.

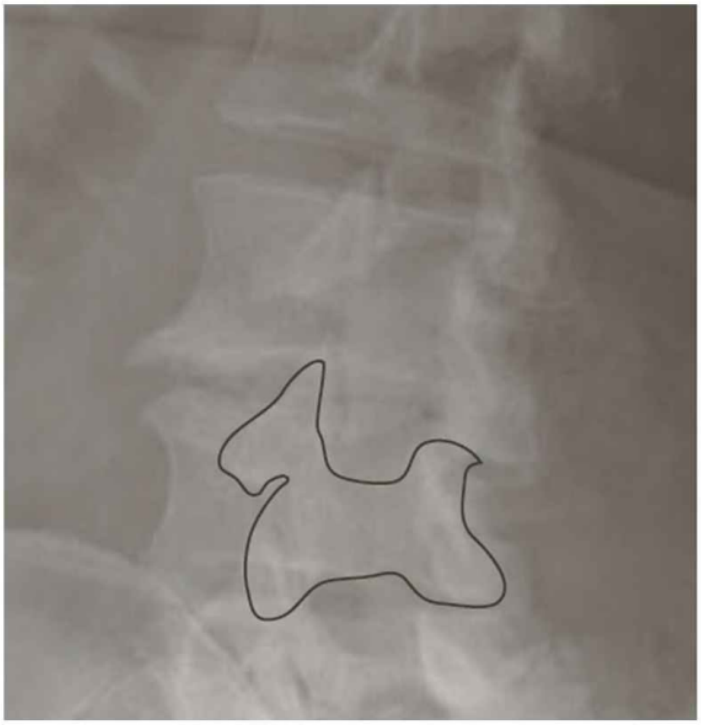
How do I examine the lumbar spine?

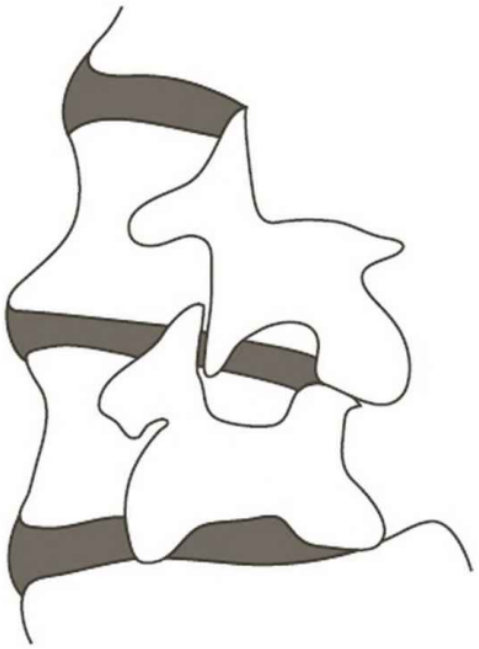
There are five projections of the lumbar spine: AP, lateral, spot lateral at L5-S1, right oblique, and left oblique. The oblique views are helpful for visualization of the pars interarticularis (the part between the superior and inferior articulating facets). On the oblique view, the "Scottie dog" can be seen, named for the shape created by the articular facets, the pedicle, and the pars interarticularis (the neck of the Scottie dog). When the pacs interarticularis is fractured or congenitally absent, this is called a *pars defect* or *spondylolysis*. Bilateral spondylolysis can result in forward slipping of the upper vertebral body relative to the lower one. This slipping is called *spondylolesthesis* and is graded from I to IV.

Steps in evaluating the lumbar spine:

1. On the AP view, check vertebral alignment, pedicles, and transverse processes.

2. On the oblique views, check for spondylolysis and facet alignment.
3. On the lateral view, evaluate vertebral body heights and disk spaces.
4. Note the lumbar lordosis: is it flattened or exaggerated?
5. The spot lateral view at L5-S1 is done to give an accurate assessment of the disk space. The two most common areas for disk disease in the lumbar spine are L4–5 and L5-S1.





"Scottie dog"

What is DEXA and how does it measure bone density?

Dual X-ray absorptometry is the method used to pass a known quantity of X-rays through the bones of the lumbar spine and hip. A computer compensates for the patient's body type and weight and then calculates the bones' ability to block the X-rays. The denser the bone, the more the X-rays will be blocked. Density measurements are calculated within each of the lower four vertebral bodies and within five areas of the hip. Bone mass density scoring relates the findings to the patient's score compared to a normal healthy female of any age (the T score) and also to female patients of the same age (the Z score).

Normal	T = −1.4 or higher
Osteopenia	T = −1.5 to −2.49
Osteoporosis	T = −2.5 or lower