## RadCases

# Emergency Radiology

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### Rad Cases Emergency Radiology

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We dedicate this book to our families for their continued support and encouragement.

#### Rad Cases Series Preface

The ability to assimilate detailed information across the entire spectrum of radiology is the Holy Grail sought by those preparing for the American Board of Radiology examination. As enthusiastic partners in the Thieme RadCases Series who formerly took the examination, we understand the exhaustion and frustration shared by residents and the families of residents engaged in this quest. It has been our observation that despite ongoing efforts to improve Webbased interactive databases, residents still find themselves searching for material they can review while preparing for the radiology board examinations and remain frustrated by the fact that only a few printed guidebooks are available, which are limited in both format and image quality. Perhaps their greatest source of frustration is the inability to easily locate groups of cases across all subspecialties of radiology that are organized and tailored for their immediate study needs. Imagine being able to immediately access groups of high-quality cases to arrange study sessions, quickly extract and master information, and prepare for theme-based radiology conferences. Our goal in creating the RadCases Series was to combine the popularity and portability of printed books with the adaptability, exceptional quality, and interactive features of an electronic case-based format.

The intent of the printed book is to encourage repeated priming in the use of critical information by providing a portable group of exceptional core cases that the resident can master. The best way to determine the format for these cases was to ask residents from around the country to weigh in. Overwhelmingly, the residents said that they would prefer a concise, point-by-point presentation of the Essential Facts of each case in an easy-to-read, bulleted format. This approach is easy on exhausted eyes and provides a quick review of Pearls and Pitfalls as information is absorbed during repeated study sessions. We worked hard to choose cases that could be presented well in this format, recognizing the limitations inherent in reproducing high-quality images in print. Unlike the authors of other case-based radiology

review books, we removed the guesswork by providing clear annotations and descriptions for all images. In our opinion, there is nothing worse than being unable to locate a subtle finding on a poorly reproduced image even after one knows the final diagnosis.

The electronic cases expand on the printed book and provide a comprehensive review of the entire subspecialty. Thousands of cases are strategically designed to increase the resident's knowledge by providing exposure to additional case examples—from basic to advanced—and by exploring "Aunt Minnie's," unusual diagnoses, and variability within a single diagnosis. The search engine gives the resident a fighting chance to find the Holy Grail by creating individualized, daily study lists that are not limited by factors such as radiology subsection. For example, tailor today's study list to cases involving tuberculosis and include cases in every subspecialty and every system of the body. Or study only thoracic cases, including those with links to cardiology, nuclear medicine, and pediatrics. Or study only musculoskeletal cases. The choice is yours.

As enthusiastic partners in this project, we started small and, with the encouragement, talent, and guidance of Tim Hiscock at Thieme, we have continued to raise the bar in our effort to assist residents in tackling the daunting task of assimilating massive amounts of information. We are passionate about continuing this journey, hoping to expand the cases in our electronic series, adapt cases based on direct feedback from residents, and increase the features intended for board review and self-assessment. As the American Board of Radiology converts its certifying examinations to an electronic format, our series will be the one best suited to meet the needs of the next generation of overworked and exhausted residents in radiology.

Jonathan Lorenz, MD Hector Ferral, MD Chicago, IL

#### **Preface**

Emergency Radiology is the front line of medical imaging; it is where we are most relevant, most engaged, and most alive as a diagnostic medical specialty. It is best practiced face-to-face with the radiologist in the emergency room, or one door away. It's where we demonstrate our impact and where we get the most personal reward for our skills and art. It's where a resident or staff develops friendship and clinical trust based on face-to-face service. It's everything teleradiology is not. Teleradiology may perhaps be the most cost-effective model with the leanest staffing and the optimal utilization of subspecialist skills, but the interpersonal disconnection from the point of care will cost us our specialty. Radiology is not mere pattern recognition, because that, in isolation of clinical context, can never achieve the level of clinical relevance that our referring physician (or our patient) wants.

Further, our absence from the emergency room creates a vacuum that will be readily filled by other services.

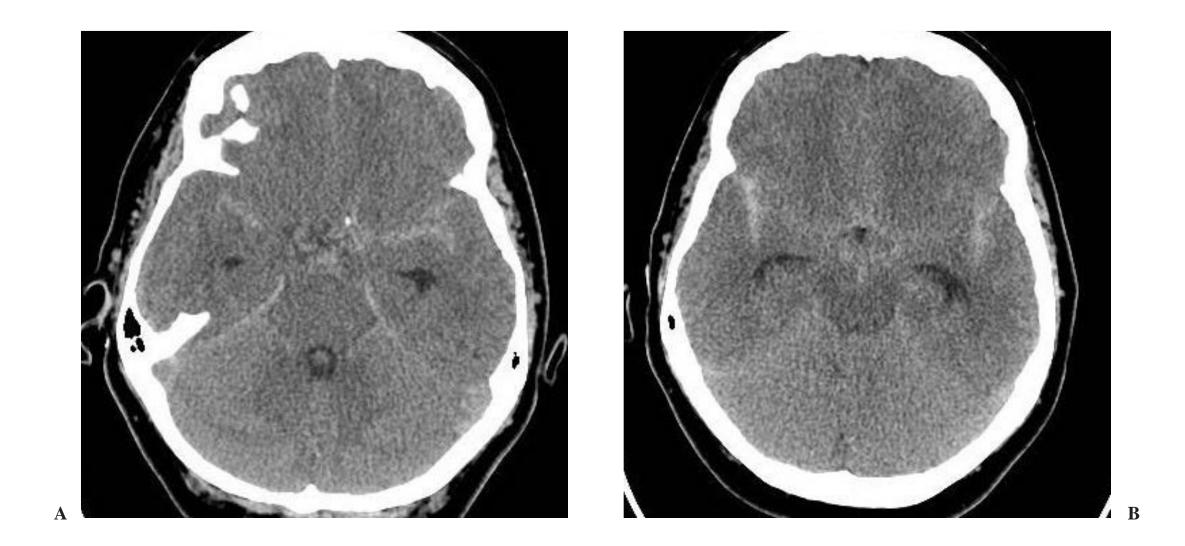
This book is written for the young trainee radiologist who will be in the trenches on call, and the radiologist who is taking general call and wants to refresh their knowledge. Remember that to err is human, and we all have and will. Listen to the little voice in your head when it tells you to look at something again. Be bothered by things, pick up the phone and call the emergency department or walk out that door and ask the staff or resident what's going on and explain your conundrum. They will recognize that you are showing commitment and good conscience. Thank you for using our book and its accompanying electronic version; may these serve you well.

Kieran Murphy, MB, FRCPC, FSIR

### Acknowledgments

We are grateful for the hard work and efforts of the many medical students, residents, fellows, and colleagues who gave their time and expertise in helping write this book. Without their support, this book would not have been possible. A special thanks to the medical students from the Royal College of Surgeons in Ireland (RCSI), Dublin, who spent the summer of 2012 working on this project with us, including Rimpy Cheema, Keri Delaney, Alexandra Haw, Ramia Jameel, Hilary Kerr, Ravneet Mann, Caitlin Moran, Kevin Moran, Sameer Patel, Priya Sapra, and Noorin Walji.

Case 1

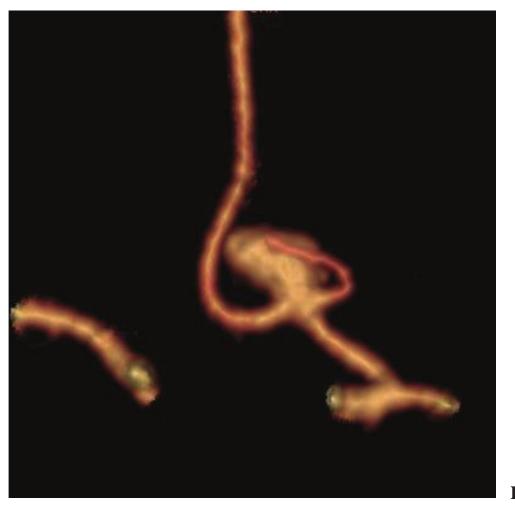


#### Clinical Presentation

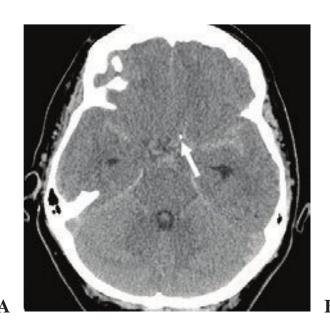
A 54-year-old woman with sudden onset of severe headaches and decreased level of consciousness.

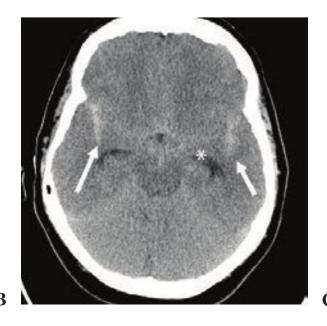
### **■ Further Work-up**

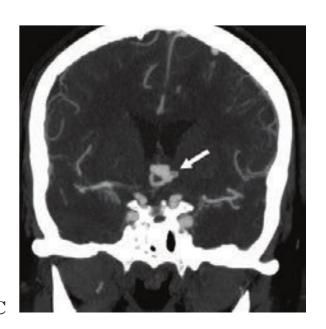


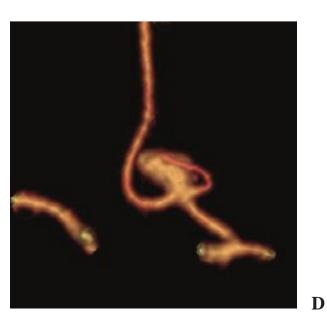


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(A, B) Non-contrast-enhanced computed tomography (NECT) shows the hyperdensity in the subarachnoid spaces in the supratentorial subarachnoid cisterns extending laterally to the sylvian f ssures (arrows). There is mild dilatation of the temporal horns of the lateral ventricles (asterisk), a sign of early hydrocephalus. (C, D) Coronal computed tomography angiography (CTA) maximum intensity projection (MIP) reformats show a superiorly oriented anterior communicating artery (ACoA) aneurysm (arrow), better characterized on the three-dimensional (3D) reformatted image.

#### Dif erential Diagnosis

- Aneurysmal subarachnoid hemorrhage (SAH): The presence of SAH in the basal cisterns extending laterally to the sylvian fissure, especially if it is associated with early hydrocephalus, must raise the suspicion for a ruptured aneurysm. CTA should be performed immediately for the initial assessment and treatment planning.
- Nonaneurysmal SAH: Fifteen percent to 20% of patients with nontraumatic SAH will have no visible cause on CTA or digital subtraction angiography (DSA). Around 50% of these cases will have a classic bleeding pattern with a more benign clinical course, the so-called perimesence-phalic SAH.
- "Pseudo" SAH: Patients with diffuse brain edema may show increased density of the basal cisterns because of crowding of the meninges and engorgement of the venous structures.

#### **■** Essential Facts

- SAH represents 6% of all strokes, with an incidence of , 9/100 per year.
- Eighty-five percent of nontraumatic SAH hemorrhages are secondary to a ruptured aneurysm.
- The most common locations for ruptured aneurysm are the ACoA (29.0%), posterior communicating artery (19.6%), basilar artery (14.7%), and middle cerebral artery (11.8%).
- Size and location are the main factors used to predict the risk of rupture.
- Risk factors include female gender, age, personal or family history of SAH, smoking, hypertension, and alcohol abuse.
- Treatment options include surgical clipping and endovascular coiling. The latter has better outcomes for aneurysms suitable for both strategies.

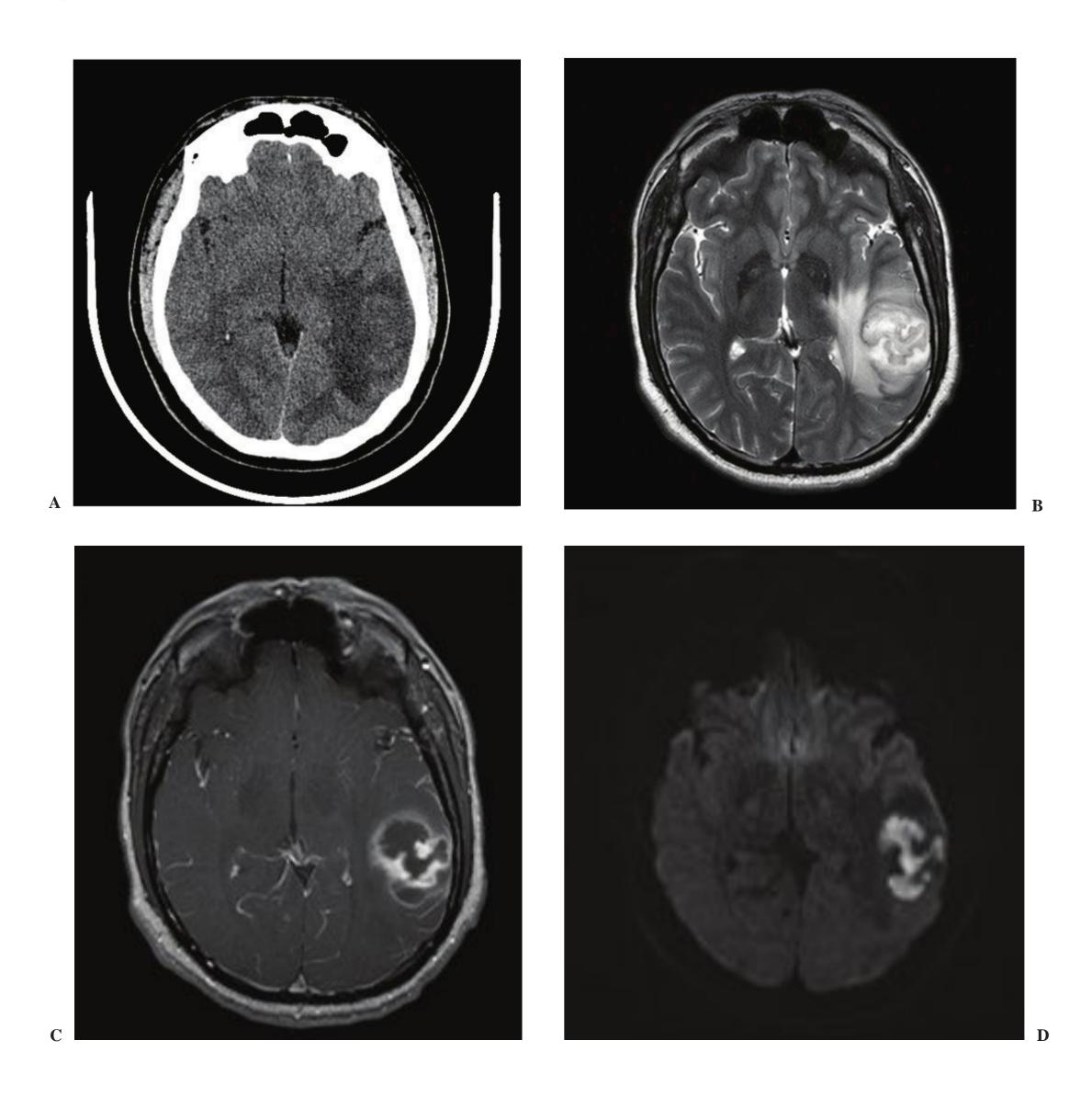
- Prognosis is poor with 35% mortality and 45 to 64% risk of dependency.
- Risk of a new aneurysmal SAH in survivors is 15 times higher than it is in the general population.

#### Other Imaging Findings

- Computed tomography perfusion (CTP): Increased mean transit time (MTT) with normal cerebral blood volume (CBV) may depict areas at risk for delayed brain ischemia before the onset of vasospasm.
- Magnetic resonance/magnetic resonance angiography (MR/MRA):
- Fluid-attenuated inversion recovery (FLAIR): increased signal of the cerebrospinal fluid (CSF) spaces due to blood
- MRA: Time of flight (TOF) or contrast-enhanced magnetic resonance angiography (CE-MRA) are also good options for detecting the aneurysm, although less sensitive for smaller lesions.

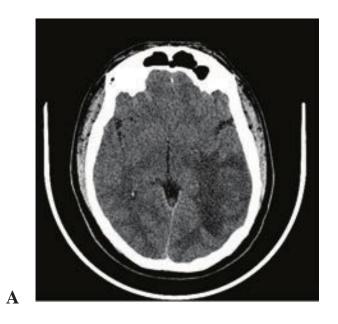
- ✓ CTA has a high sensitivity and specificity for detecting aneurysms.
- ✓ aging work-up must prove the necessary details for treatment decision (location, size, neck, at-risk branches).
- reformatted images may help in differentiating a vessel loop from a small aneurysm.
- hrombosed aneurysms and nonsaccular aneurysms (i.e., blood blister, dissecting) may have a false-negative CTA.

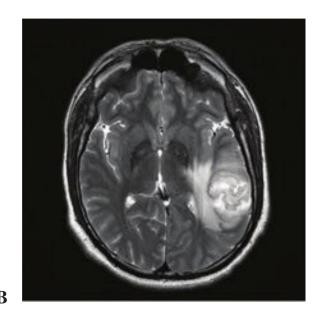
Case 2

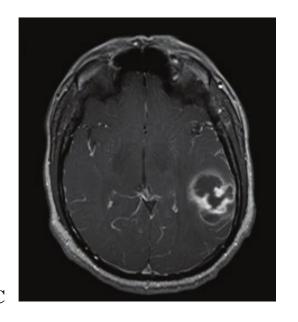


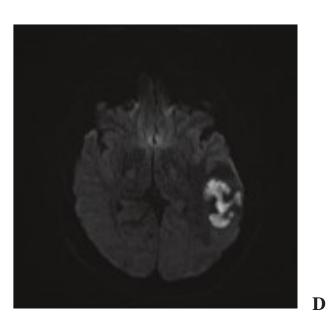
#### Clinical Presentation

A 27-year-old man with congenital heart disease on Coumadin (Bristol-Myers Squibb, New York, NY) presents with new headache and aphasia.









(A, C) Unenhanced axial computed tomography (CT) shows a large area of low axial T1-weighted, gadolinium-enhanced image attenuation in the left temporal lobe. There is an irregular nodular rim enhancement along the area of slight hyperattenuation. (B) Axial T2-weighted margins of the lesion. (D) Diffusion weighted study and image shows the presence of vasogenic edema and an apparent diffusion coefficient (ADC) image (not shown) demonstrates the lesion to be irregularly shaped lesion with a low signal rim restricted.

#### **■** Dif erential Diagnosis

- Cerebral abscess: This is a focal pyogenic infection of the brain. The causes are bacterial, fungal, or parasitic. Imaging findings vary with the stage of abscess formation. Seen as a ring-enhancing lesion with central high signal (restricted diffusion) on diffusion weighted imaging (DWI). T2 imaging may show a hypointense rim with surrounding edema.
- Primary tumor: Radiographically can mimic an abscess. Has a thick nodular enhancing wall with surrounding edema. Neoplasms typically show low signal on DWI. More often a gradual onset of symptoms. Lack of elevated white cell count and fever.
- Demyelination: Tumefactive demyelination can present as a mass lesion with irregular enhancement. Peripheral ring enhancement often incomplete. Look for other characteristic lesions of multiple sclerosis such as corpus callosum involvement, foci in the posterior fossa, and "Dawson fingers" representing perivenular demyelination.

#### Essential Facts

- Can affect any age group
- Males are affected twice more than females.
- Headache is the most common symptom; others include seizure and decreased level of consciousness.
- Peak incidence is in the third and fourth decades.
- Common causes include hematogenous seeding from a distant infective source, mastoiditis, meningitis, and penetrating injury.

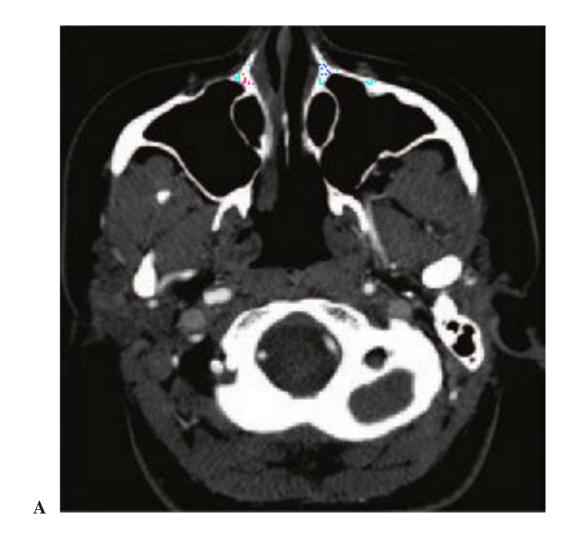
• Surgical drainage with or without excision is the primary therapeutic approach.

#### Other Imaging Findings

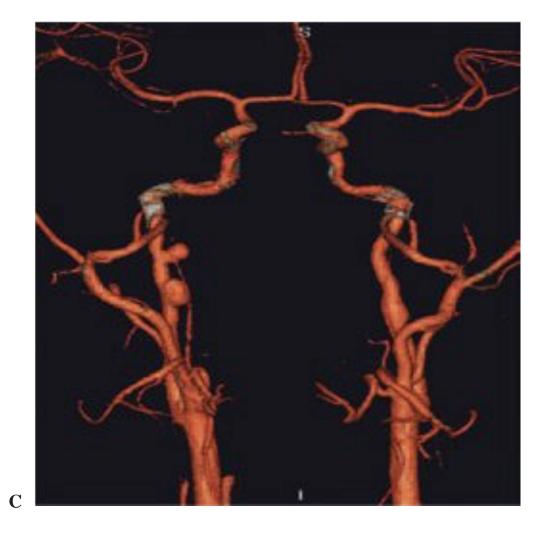
- CT: low-density mass with edema and mass effect, peripheral enhancement
- Magnetic resonance imaging:
- T1WI: hypointense mass
- T2WI: hypointense abscess rim with surrounding edema; centrally high signal
- TI with contrast: enhancing rim; irregular margins
- DWI: increased signal intensity, low ADC

- ✓ is important to investigate local causes such as sinusitis, otitis media, and mastoiditis.
- patients who are successfully treated, the T2 hypointense abscess rim resolves before enhancement.
- ssess for communication with the ventricular system—increased risk of ventriculitis and hydrocephalus.
- ✓ Cinical history showing acute onset with associated malaise, fever, and elevated white cell count are helpful clinical features.

Case 3

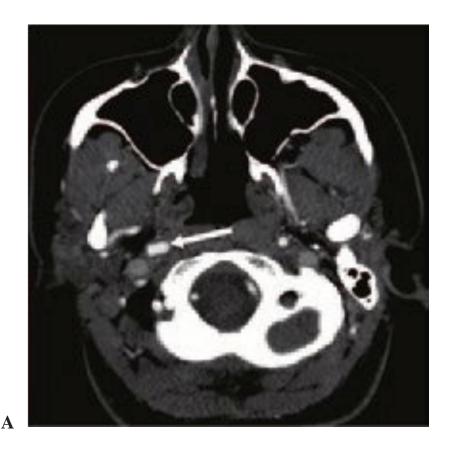




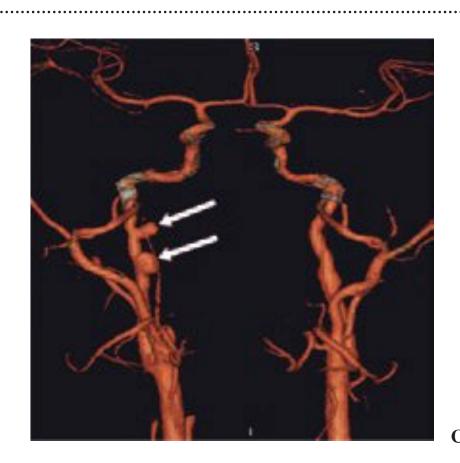


#### Clinical Presentation

A 26-year-old woman involved in a road traffic accident and presents with neck pain and an acute right Horner syndrome.







(A) Axial contrast-enhanced computed tomography (CT) scan demonstrates a medial bulge arising from the right internal carotid artery (arrow). (B, C) Coronal maximum intensity projection (MIP) image and three-dimensional (3D) computed tomography angiography (CTA) reconstruction demonstrate two medial areas of focal outpouching arising from the right internal carotid artery (ICA) (arrows).

#### ■ Dif erential Diagnosis

- Traumatic pseudoaneurysms: These "false" aneurysms appear as a focal outpouching from the wall of the affected artery. A pseudoaneurysm is a focal hematoma that is not contained by the normal components of the vessel wall.
- Fibromuscular dysplasia (FMD): FMD lesions appear as a characteristic beading of the carotid arteries. In the internal carotid arteries, FMD usually affects the extracranial portion at the C1–C2 levels.
- Mycotic pseudoaneurysm: Mycotic aneurysms are more likely to be saccular, eccentric, or multilobulated. There may also be accompanying inflammation around the vessel. A clinical history of sepsis or the presence of a septic source is contributory to the diagnosis.

#### Essential Facts

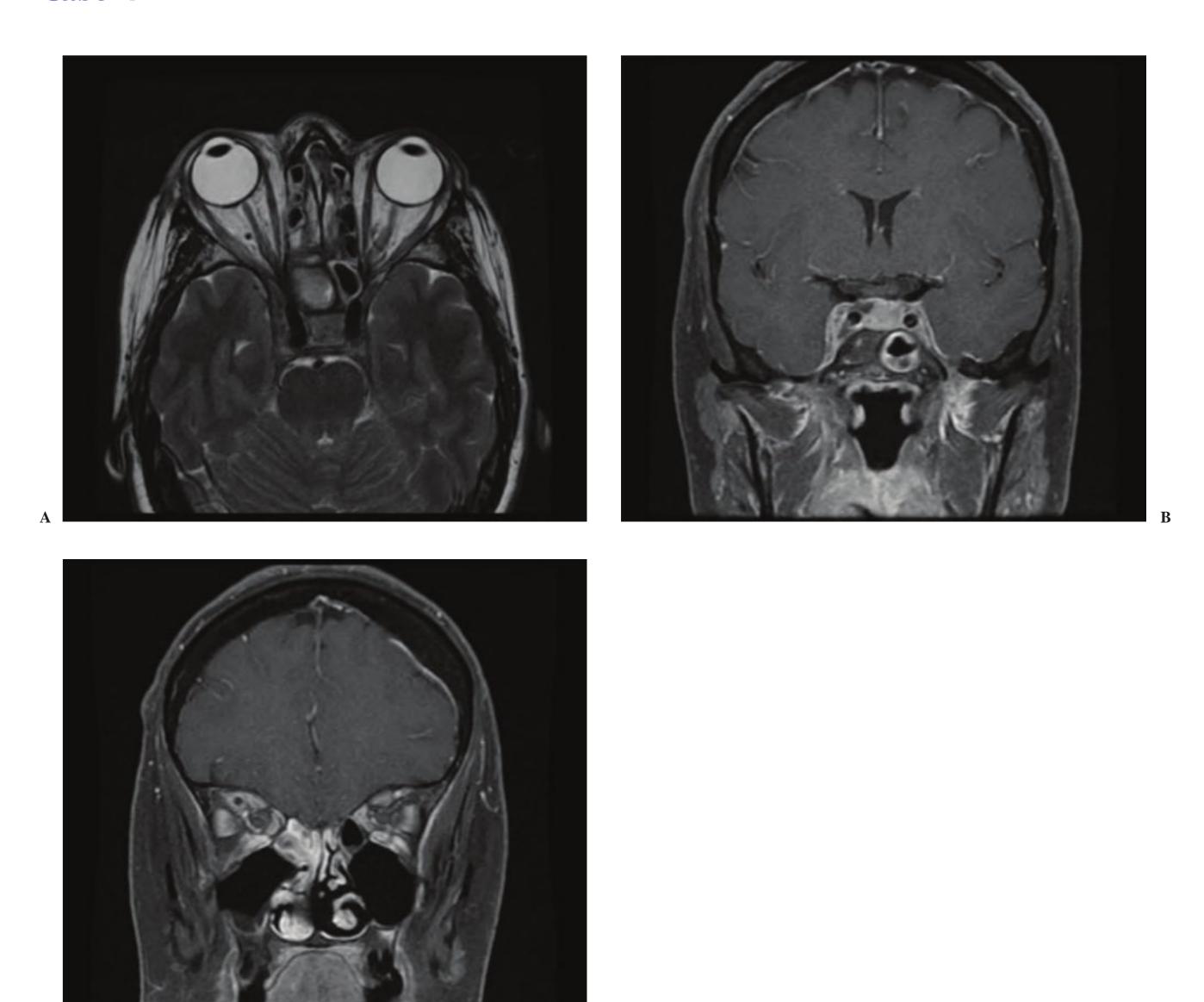
- Usually caused by blunt or penetrating trauma that disrupts the arterial wall and allows blood to leak into the surrounding tissue
- Traumatic pseudoaneurysms occur due to penetrating and nonpenetrating injuries and are responsible for less than 1% of all aneurysms.
- Pseudoaneurysms can also arise secondary to deep neck space infection, atherosclerosis, collagen vascular disorders, radiation therapy, and tumor invasion.

- The risk of hemorrhage in posttraumatic pseudoaneurysms is, 20% with a peak incidence of rupture at 2 to 3 weeks after injury resulting in 30 to 50% mortality.
- Horner syndrome indicates an associated disruption of the sympathetic nerves, which travel with the carotid artery.

#### Other Imaging Findings

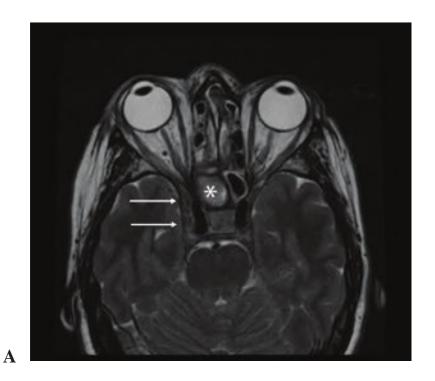
- CT:
- "Blister-like" bulge in the vessel wall on CTA
- Magnetic resonance imaging (MRI):
- Focal outpouching from the vessel wall
- May see a thrombosed surrounding "wall" that contains the pseudoaneurysm
- Wall may enhance
- Gradient-recalled echo (GRE) imaging will show intense low signal corresponding to clot within the pseudoaneurysm.

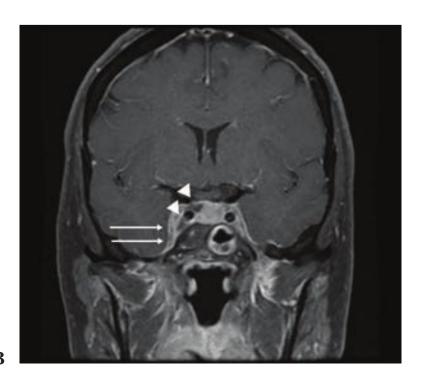
- ✓ Selayed onset of cranial nerve palsy may be a sign of pseudoaneurysm formation following neck trauma.
- ✓ waluate the brain for evidence of stroke and multiple emboli.

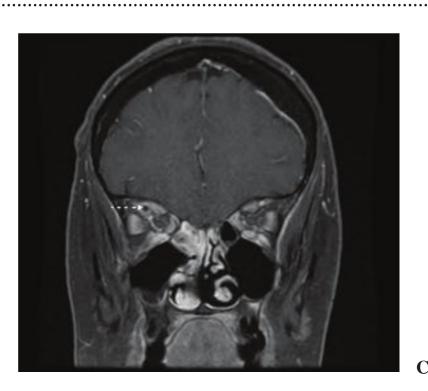


#### Clinical Presentation

A 52-year-old woman with right-sided headache, right-sided ptosis diplopia, and fever. Blood cultures positive for *Staphylococcus aureus*. Elevated leukocyte count in cerebrospinal fluid (CSF).







(A, B) Axial T2 image with fat saturation and coronal T1 postgadolinium with fat saturation show expansion of the right cavernous sinus (arrows in A and B). The right lateral rectus muscle is also slightly T2 hyperintense, consistent with extraocular muscle edema. Filling defects are seen within the right cavernous sinus (arrowheads in B). There is total opacification of the bordering right sphenoid sinus with T1 hypo- and T2 heterogeneous signals as well as peripheral enhancement consistent with sinusitis. The left sphenoid sinus and some ethmoidal air cells also show mucosal inflammatory changes (asterisk in A). (C) There is expansion of the right superior ophthalmic vein as well as a filling defect within this vein (dashed arrow).

### Dif erential Diagnosis

- Cavernous sinus thrombosis: Complication of midface infection (including sinusitis, orbital or skin infection, tonsillitis) or trauma. Most cases are secondary to bacterial infection (most commonly *S. aureus*). Presents with expansion and convexity of the cavernous sinus/filling defects within the cavernous sinus. Dilatation/filling defects within the superior ophthalmic vein may be present.
- Cavernous sinus neoplasm: Most frequently meningiomas but other lesions such as metastases, lymphoma, leukemia, hemangioma, or nerve sheath tumors may occur in this location.
- Cavernous sinus inf ammation: Either secondary to systemic disease (such as Wegener granulomatosis or sarcoidosis) or idiopathic (Tolosa-Hunt syndrome). Look for the presence of sinonasal or lung involvement in Wegener granulomatosis. In addition to typical chest findings in sarcoidosis, intracranial and/or orbital involvement must be sought. Any part of the orbits can be involved in sarcoidosis; however, lacrimal gland involvement is more frequent.

#### Essential Facts

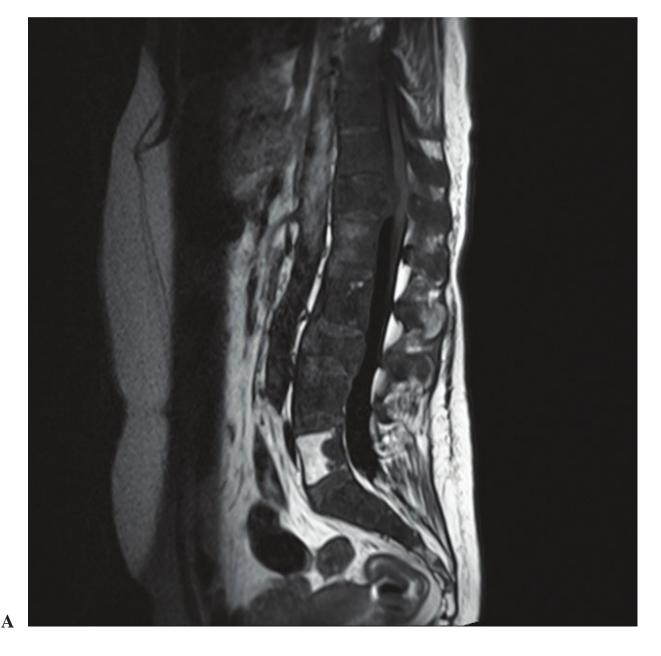
- The cavernous sinuses receive blood from multiple valveless veins. Infection from anatomical structures with venous drainage to the cavernous sinus (e.g., the sphenoid sinus) is the major risk factor for cavernous sinus thrombophlebitis.
- Patients will typically present with proptosis, cranial nerve palsy, and headache.

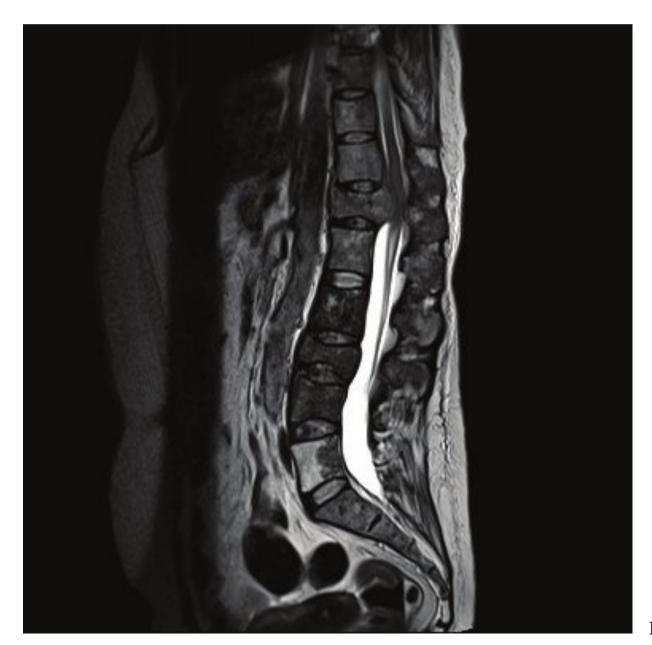
#### Other Imaging Findings

- CT:
- On postcontrast CT, the normal cavernous sinus has a flat or concave lateral margin. The internal carotid

- artery normally cannot be differentiated from the normal, opacified, cavernous venous sinus.
- With thrombosis, the lateral margin of the cavernous sinus becomes convex. The ICA can be identified from the thrombosed, nonopacified, cavernous sinus.
- CTA may allow for identification of ICA involvement (stenosis, occlusion, or pseudoaneurysm formation).
- Look for sinusitis or signs of midface or orbital infection.
- MRI:
- Must use high-resolution MRI to assess cavernous sinuses including 1- to 3-mm thick sections through the orbits and cavernous sinuses in the axial and coronal planes
- T1: May show T1 hyperintense subacute venous thrombosis in cavernous sinus and/or superior ophthalmic vein.
- T2 with fat saturation or short T1 inversion recovery (STIR): Variable but often hyperintense clot signal. May show extraocular muscle edema and intraorbital fat stranding.
- T1 postcontrast with fat saturation: may show filling defects within the cavernous sinus/superior ophthalmic vein
- Magnetic resonance venography: May show other sites of dural venous sinus thrombosis
- Diffusion weighted imaging (DWI): may be useful in identifying thrombosis and/or abscess formation

- ✓ ware of cavernous sinus thrombosis in the setting of midface, orbital, or sinonasal infection especially in patients presenting with cranial nerve palsy and/or proptosis.
- ✓ Cerform appropriate high-resolution MRI of the orbits and cavernous sinuses before excluding the possibility of this diagnosis.
- ✓ Cearch for secondary ICA and intracranial complications.
- ✓ Catients who have diabetes and are immunocompromised are at risk of developing invasive fungal infection.

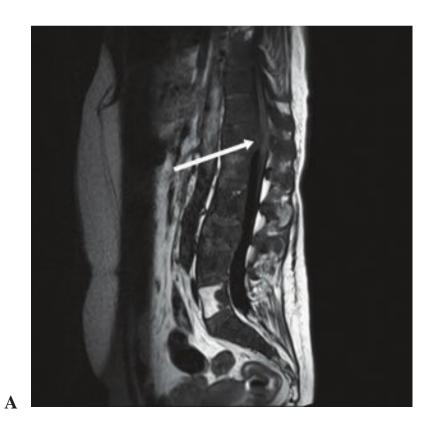


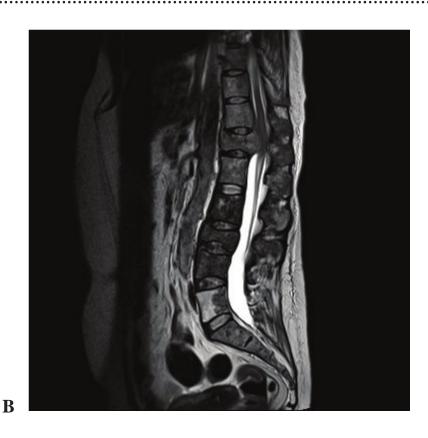


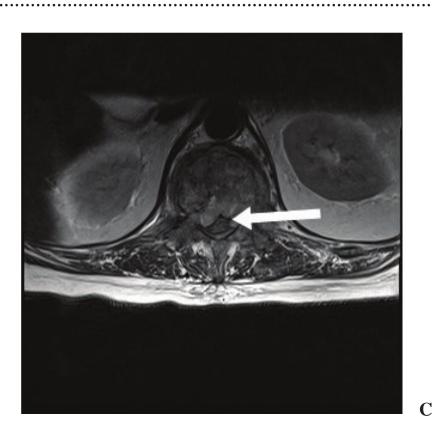


#### Clinical Presentation

A 44-year-old woman with a history of previously treated breast carcinoma presents with new left L2-L3 numbness and back pain.







(A) Sagittal T1-weighted image (T1WI) magnetic resonance (MR) shows diffuse hypointensity throughout the vertebral column and posterior elements due to metastatic disease. Epidural extension causes cord compression at T12 (arrow). (B) Sagittal T2-weighted image (T2WI) MR shows heterogeneous hypointensity in the vertebral column and posterior elements with moderate collapse of T12 and L3 and mild collapse of L4. Again, cord compression is seen at T12. (C) Axial T2-weighted image (T2WI) MR shows heterogeneous hypointensity within the body and posterior elements of T12. Epidural extension of tumor causes cord compression (arrow).

#### Dif erential Diagnosis

- Vertebral column metastases from breast carcinoma: Generalized vertebral hypointensity on T1WI and T2WI are in keeping with diffuse sclerotic metastases; may diffusely enhance with gadolinium. May cause pathologic fracture with epidural retropulsion.
- Multiple myeloma: Most often occurs in spine, skull, ribs, and pelvis. Multiple well-circumscribed lytic lesions on radiography. Multifocal, diffuse, or heterogeneous T1 hypointensity. Bone scintigraphy typically negative.
- Lymphoma: Bone destruction with soft tissue extension seen on radiography. Most lesions are homogeneous and hypointense on T1 and enhance uniformly with gadolinium.

#### Essential Facts

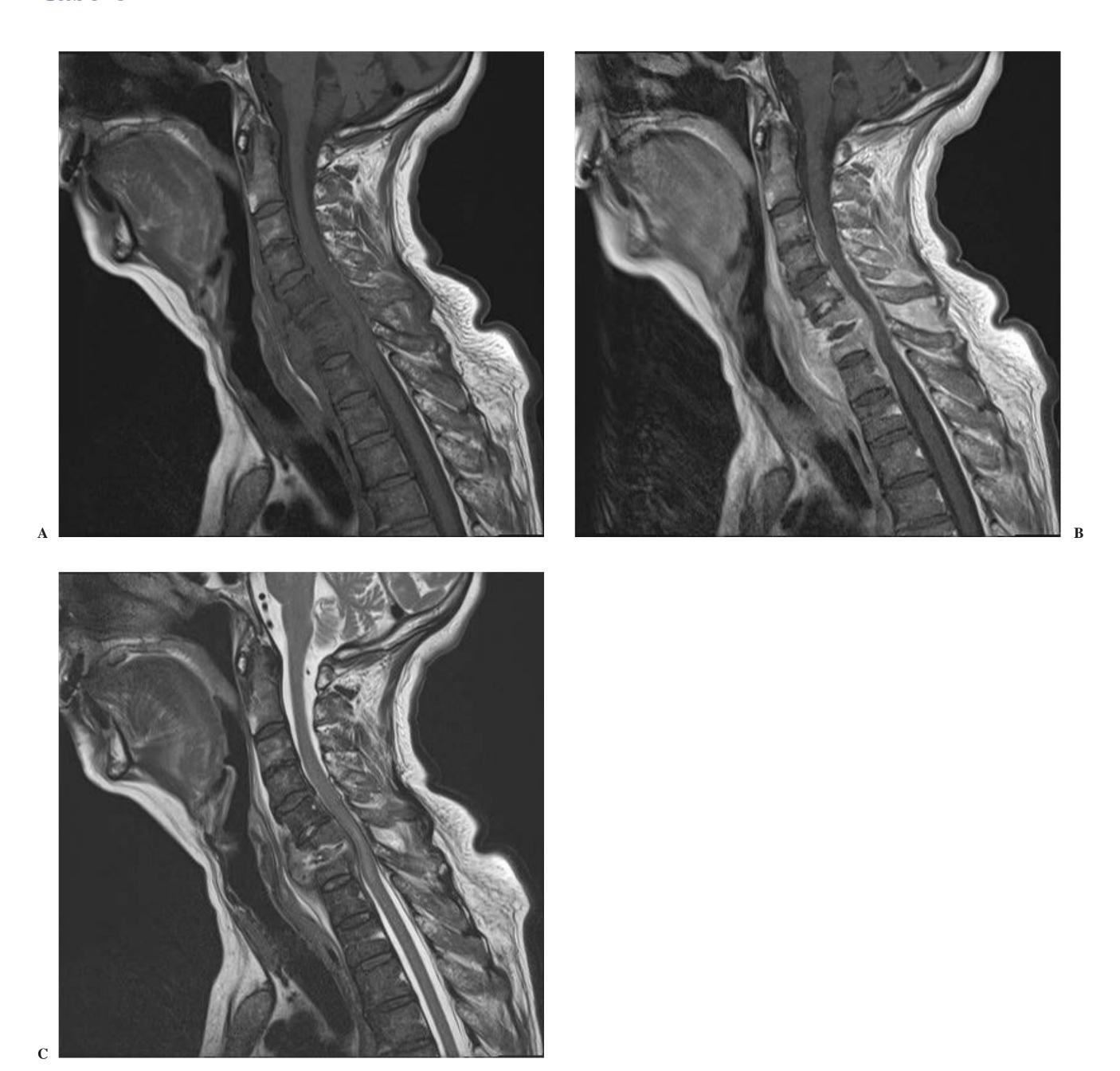
- Vertebral column metastases occur in 60% of patients with breast cancer. Epidural spinal cord compression occurs in 4% of patients with breast cancer.
- Myelopathy can occur in the form of limb weakness, numbness, paresthesia, and alterations in bladder and bowel function.
- Once spinal cord compression is diagnosed, steroids should be administered immediately along with emergency radiation therapy and/or surgical decompression.

#### Other Imaging Findings

- Plain spine radiographs: require 50 to 70%bone destruction for detection
- Anteroposterior (AP): "absent pedicle sign"

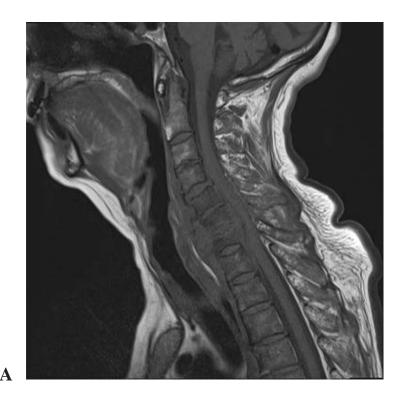
- Lateral: destroyed posterior cortical line on lateral view
- Look for areas of lucency or sclerosis.
- Computed tomography (CT): Location proportional to red marrows (lumbar [L] > thoracic [T] > cervical [C] spine). Posterior vertebral body involved in almost all cases/paraspinous/epidural soft tissue mass. May see lytic and/or sclerotic foci of disease.
- Nuclear medicine: Technetium-99m (Tc-99m) singlephoton emission computed tomography (SPECT) bone scan has high sensitivity for vertebral metastases. Diffuse disseminated disease can give rise to a "super scan."

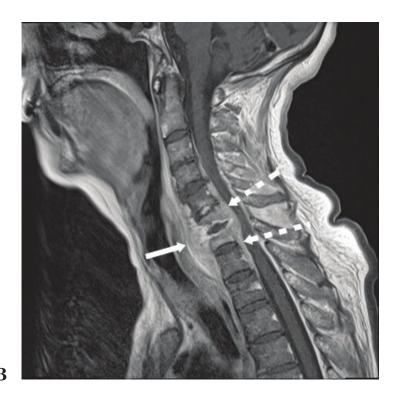
- resistence of low T1 marrow signal after radiation therapy may be either residual active tumor or fibrosis.
- ✓ Cadolinium administration is used to assess for leptomeningeal metastases.
- vertebral lesions; this can make these lesion less conspicuous as they may become isointense with normal vertebral yellow marrow. Consider obtaining postcontrast T1 sequences with fat saturation to avoid this potential pitfall. Alternatively, precontrast T1 images would also help in this regard.

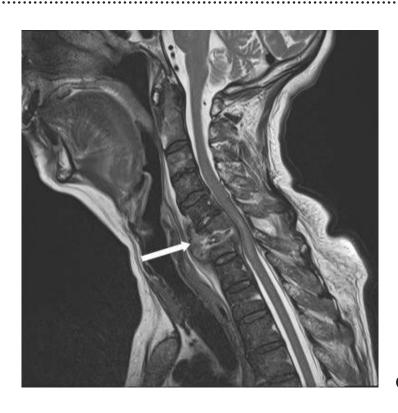


#### Clinical Presentation

An 86-year-old woman presents with fever, neck pain, and confusion. The patient was treated recently for sinusitis.







Sagittal T1 (A), T1 postgadolinium contrast (B), and T2 (C) images of the cervical spine show irregularity along the vertebral body endplates bordering the C6–C7 disk. There is abnormal enhancement along the endplate margins and there is also abnormal enhancing soft tissue protruding anteriorly into the prevertebral space (solid arrow). Posteriorly, there is also thick enhancing tissue running up and down along the anterior epidural space (dashed arrows). Note the mass effect on the cervical cord that demonstrates high parenchymal signal on the T2-weighted image.

### Dif erential Diagnosis

- Diskitis: This is a bacterial infection of an intervertebral disk and adjacent vertebral bodies. Characteristic imaging features include disk height loss, endplate erosion, and irregularity. Marrow edema within the vertebral bodies is evident. The disk and endplates often enhance and show a bright T2 signal. Complications include the presence of epidural and prevertebral phlegmon (as seen in this case) as well as frank abscess formation.
- Degenerative disk disease: This includes spondylosis deformans (degenerative changes to the annulus fibrosus and ring apophysis with the formation of osteophytes) and intervertebral osteochondrosis (degenerative changes to the nucleus pulposus and adjacent vertebral endplates). Results in characteristic progression of Modictype changes (I, II, III) in the vertebral endplates. Imaging features include the presence of signal change in the disk (can be T2 bright or low depending on the stage of disease), endplate sclerosis and irregularity, disk herniation, and rim osteophyte formation.
- Neuropathic spine: Arises in patients with decreased proprioception and pain perception (patients with diabetes and spinal cord trauma). Prone to repetitive stress on the spine, leading to injury to the disks and facets. Most commonly in the lumbar spine. Features include disk height loss, marked vertebral and endplate sclerosis, osteophyte formation and deformity, fracture, and pseudoarthrosis.

#### Essential Facts

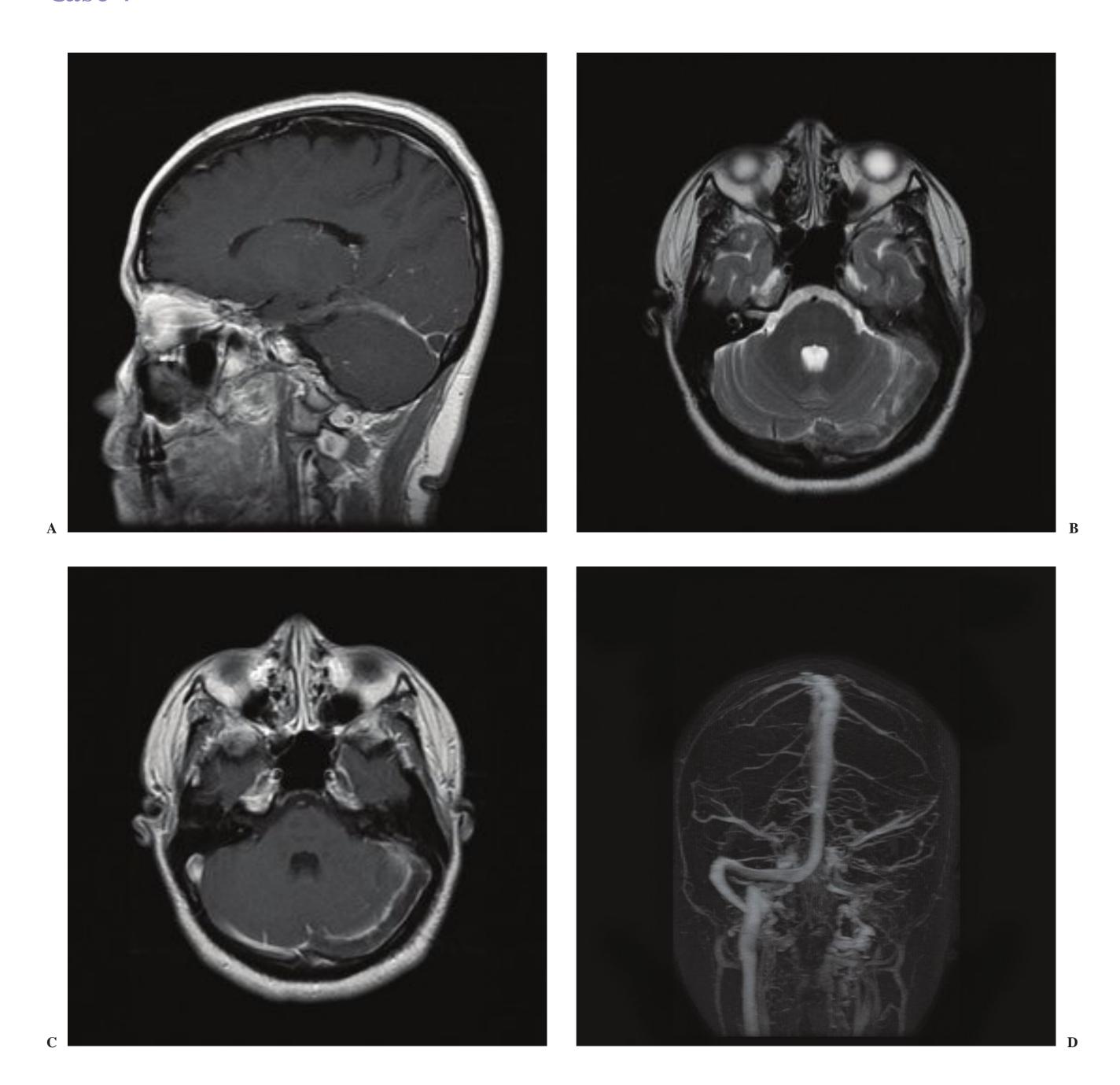
- Most commonly secondary to hematogenous seeding from a bacteremia such as upper respiratory tract or genitourinary tract infections
- Diskitis is most common in the lumbar spine.
- Staphylococcus aureus is the most common invading pathogen; Salmonella is common in patients with sickle cell anemia.

- Risk factors: intravenous (IV) drug users, immunocompromised individuals, recent invasive (spine) procedures (surgery, diskography, myelography)
- Diskitis can also arise from the contiguous spread of infection from adjacent areas of inflammation, such as diverticulitis and appendicitis.

#### Other Imaging Findings

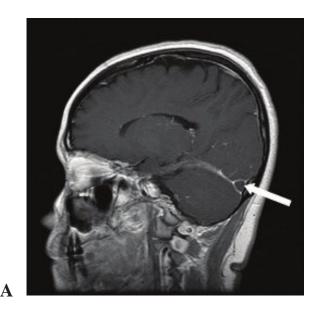
- Conventional radiography: Can be normal early in disease. Endplate erosions, disk height loss, paraspinal opacity (representing possible paraspinal edema, abscess).
- Computed tomography (CT): Similar features as with plain film imaging. Loss of disk height and endplate erosion. Also may see disk and vertebral body enhancement. Will better depict paraspinal abscess.
- Magnetic resonance imaging (MRI): Edema within the vertebral bodies and disk will manifest at low T1 and bright T2 signal. Disks and vertebrae will often enhance with gadolinium. Fat saturation or short T1 inversion recovery (STIR) imaging will best show the presence of edema and fluid.
- Nuclear medicine imaging: Three-phase technetium 99m (Tc-99m) diphosphonate bone scan, gallium scan, and white blood cell scan will show areas of elevated uptake.

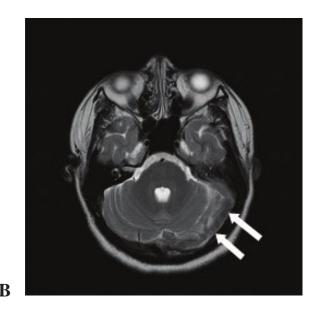
- Value film radiography can be falsely negative if completed too early; it may be 2 to 6 weeks before findings are evident.
- ✓ MRI is the imaging modality of choice.
- Varliest imaging sign is the loss of disk space height.
- ✓ Mways assess for paravertebral and epidural extension of inflammation. The presence of an abscess may necessitate surgical drainage.
- ✓ Tuberculous spinal infection is characterized by multilevel involvement, paraspinal abscess formation, vertebral collapse, and kyphotic deformity.

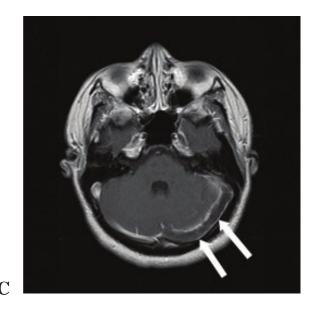


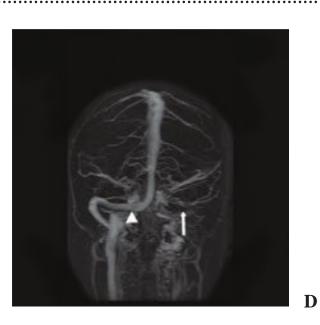
#### Clinical Presentation

A 29-year-old woman, 3 months postpartum, with a left frontal headache. Patient was started on oral contraceptive pill 2 months postpartum.









(A) Sagittal T1-weighted image (WI) with contrast demonstrates a filling defect in the transverse sinus with surrounding dural enhancement ("empty delta" sign, white arrow). (B) Axial T2WI demonstrates loss of the normal flow void in the left transverse sinus (white arrows). (C) Axial T1WI with contrast demonstrates a large filling defect in a distended left transverse sinus (white arrows). (D) Frontal three-dimensional maximum intensity projection from a magnetic resonance (MR) venogram demonstrates absence of flow-related enhancement in the left transverse sinus (white arrow) as compared with the normal right transverse sinus (white arrowhead).

#### Dif erential Diagnosis

- Dural venous sinus thrombosis: This is caused by occlusion of the dural venous sinus. Associated cortical vein thrombosis is not uncommon. Thrombosis of the venous sinus has a varied appearance on both computed tomography (CT) and magnetic resonance imaging (MRI) depending on the age of the clot. CT and MR venography are considered the mainstay for diagnosis and typical imaging features include a filling defect in the affected sinus on venography and absence of the expected flow void on MRI.
- Arachnoid granulation: Arachnoid granulations are aggregates of tissue that are contiguous with the subarachnoid space and are the passageway through which cerebrospinal fluid (CSF) circulates. These structures protrude into the lumen of the dural venous sinus, creating ovoid filling defects, which can mimic a dural venous thrombus. They do not enhance and the main distinguishing characteristic is that they follow CSF density and signal on all CT and MR sequences, respectively.
- Dural venous sinus aplasia/hypoplasia: This congenital anatomic variant is most commonly associated with the transverse sinus. A hypoplastic sinus will appear small but smoothly patent on CT and MR with an associated small ipsilateral bony groove in the calvarium, best seen on CT. Angiography will demonstrate an absent sinus in the setting of aplasia, which can mimic dural sinus thrombosis.

#### **■** Essential Facts

- Dural sinus thrombosis is most commonly seen in the setting of dehydration (particularly in infants), trauma, malignancy, coagulopathy, infection, and with certain medications (such as oral contraceptives and chemotherapy).
- There is a varied clinical presentation of headaches, visual disturbances, seizures, and focal neurologic deficits, which can develop over the course of a few hours to several weeks.
- The superior sagittal and transverse sinuses are most commonly involved.

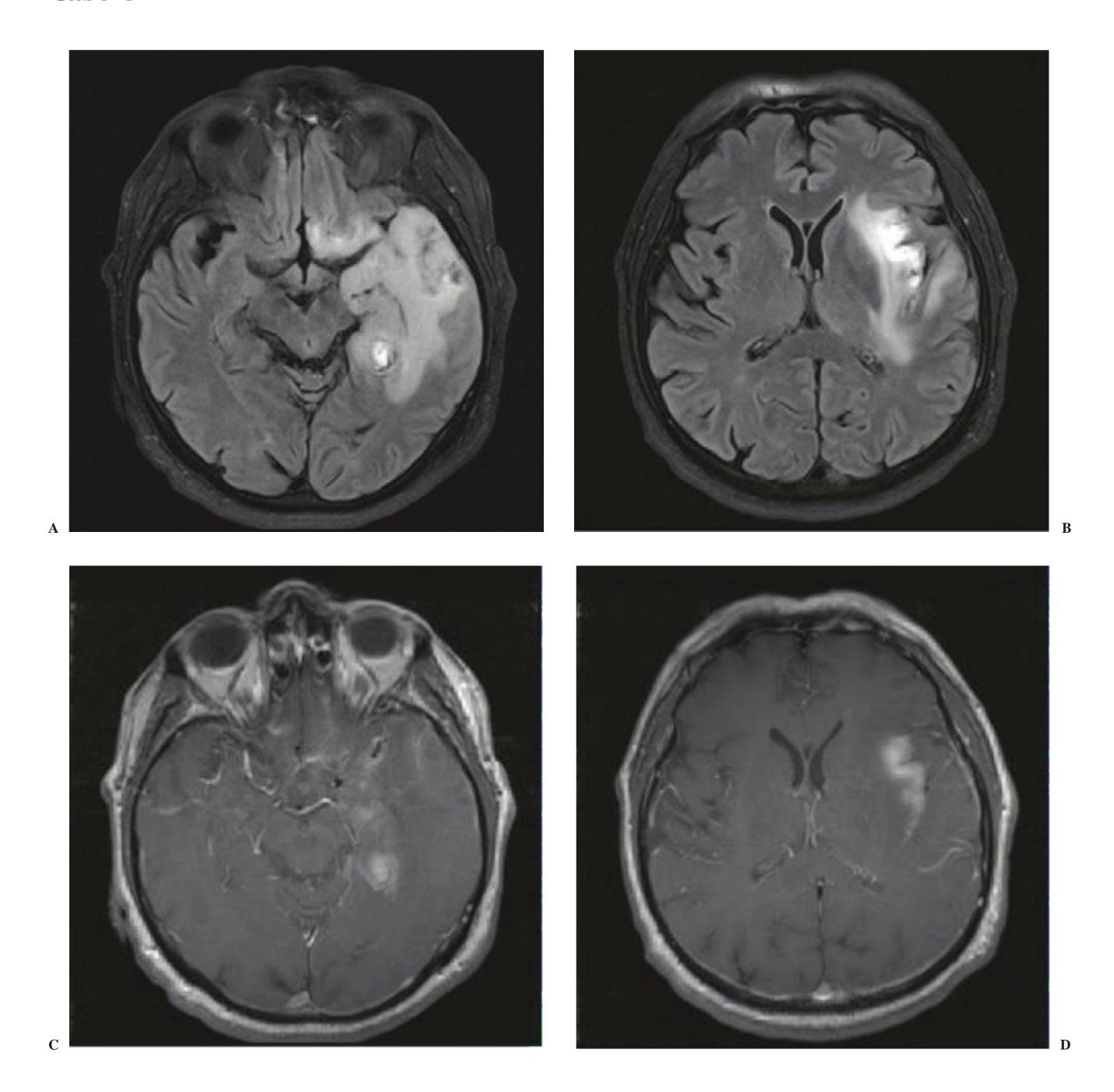
- In the setting of renal insufficiency or other contraindications to intravenous (IV) contrast, a time-of-flight MR angiography can be performed, which utilizes a "flow-related enhancement" phenomenon technique to determine vascular patency.
- Treatment is usually with anticoagulation; endovascular recanalization is reserved for more severe cases.

#### Other Imaging Findings

- Common CT and MRI features:
- Filling defect on contrast-enhanced imaging
- The appearance of clot varies with age.
- Empty delta sign—filling defect in the venous sinus surrounded by enhancing dura
- Numerous enlarged collateral veins adjacent to the thrombosed sinus
- Additional CT features:
  - Acute thrombus can appear hyperdense on noncontrast imaging.
- Additional MR features:
  - T2: loss of the normal flow void

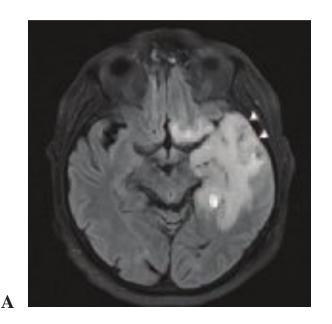
- ✓ Consider dural sinus thrombosis in the setting of hemorrhagic or atypical cortical or subcortical infarcts in a distribution that does not correspond to any major arterial territory.
- hyperdense in the setting of acute thrombus, which can mimic a subdural hematoma, meningioma, leptomeningeal carcinomatosis, and arteriovenous malformation (AVM).
- the acute setting, thrombus will be hypointense on Tl and T2 to the brain, which can give the false impression of a preserved flow void. An associated blooming artifact can be seen on gradient and susceptibility weighted imaging.
- we whom infants have higher hematocrit levels, making the dural sinuses appear hyperdense on noncontrast CT head imaging.

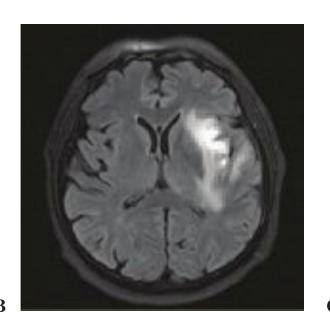
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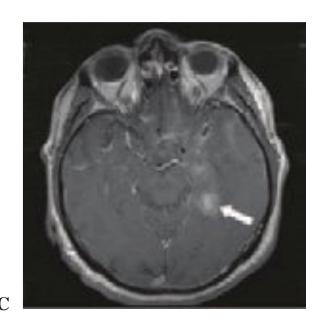


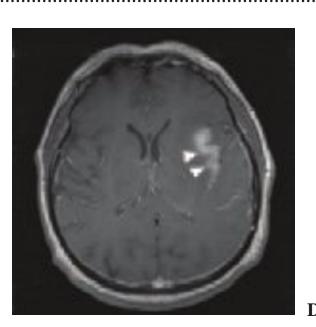
### Clinical Presentation

A 68-year-old man with a 2-week history of aphasia.









(A) Axial fluid-attenuated inversion recovery (FLAIR) image demonstrates an irregular area of T2-weighted (T2W) hyperintensity involving the left inferior frontal lobe, anterior temporal lobe, and parahippocampal gyrus. This is associated with mild local mass effect and sulcal effacement (arrowheads). (B) A second FLAIR image shows extension of hyperintensity into the peri-insular region, with sparing of the deep gray nuclei. (C, D) Axial T1-weighted images post-gadolinium administration shows patchy enhancement peripherally along the left insular gyri (arrowheads) and within the medial temporal lobe (arrow).

#### Differential Diagnosis

- Herpes encephalitis: This necrotizing meningoencephalitis causes a characteristic distribution of abnormal signal and enhancement in the medial temporal lobes, inframedial frontal lobes, insular cortex, and angular gyrus, often with sparing of basal ganglia. Involvement is typically bilateral but asymmetric. A subacute petechial hemorrhage may be present. Frequently caused by reactivation of herpes simplex virus type 1 (HSV-1) in an immunocompetent patient, with acute-onset febrile headache/seizure and nonspecific neurologic deficits.
- Anoxia/ischemia: Anoxic or ischemic injury can cause hyperacute-onset T2 hyperintense edema within cortical white and gray matter. Affected regions follow typical vascular distributions. Cortical, gyriform enhancement may be present if subacute.
- Infiltrating neoplasm: Infiltrative glial neoplasms including gliomatosis cerebri, anaplastic astrocytomas, and anaplastic oligodendroglioma can appear as T2 hyperintense lesions with infiltrative margins. These lesions can vary in size and morphology but often involve the temporal and frontal lobe cortex and subcortical white matter. The degree of enhancements is variable. Clinical course is frequently protracted.

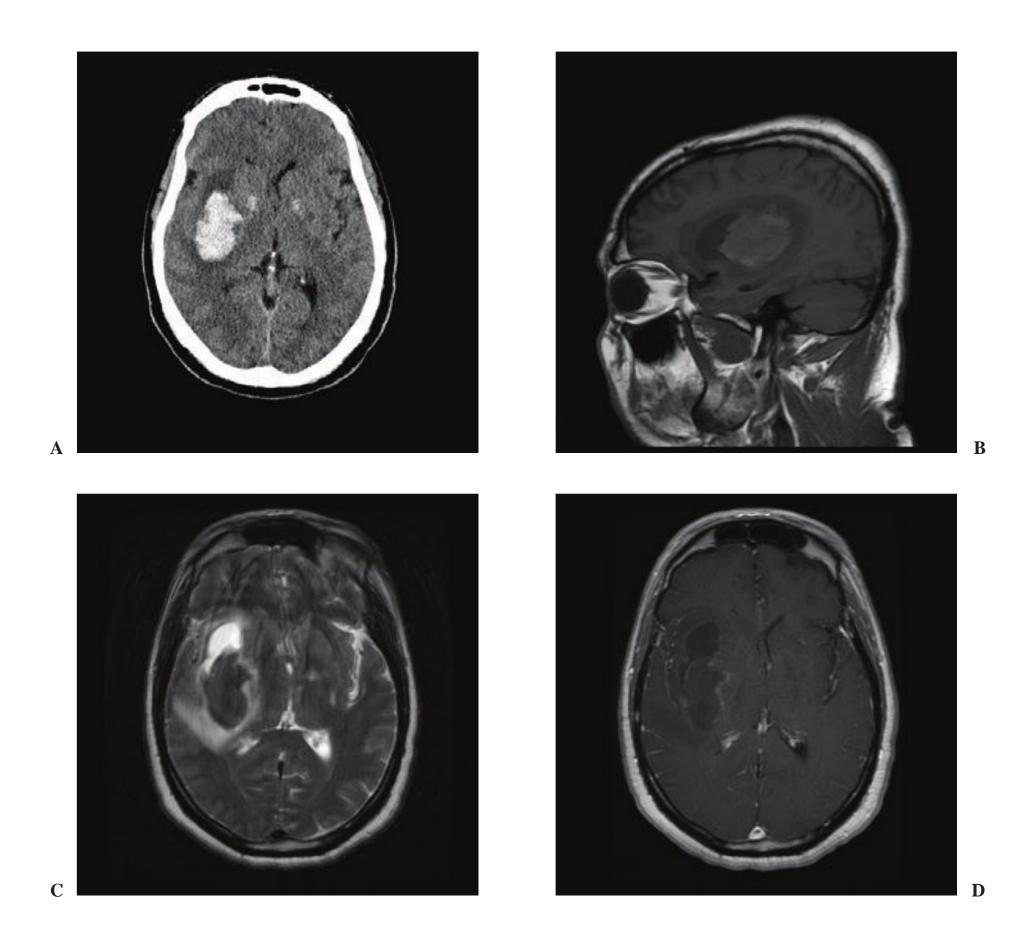
#### Essential Facts

- HSV is the most common cause of sporadic, acute fatal encephalitis in the Western world.
- Ninety-five percent of herpes simplex encephalitis (HSE) is caused by HSV-1 in an immunocompetent patient.
- Patients typically present with nonspecific symptoms: acute onset of febrile headache and/or seizures.
- Prompt therapy with acyclovir is essential and should be initiated at the first suspicion of HSE.
- High mortality (50 to 75%) in untreated or delayed therapy

#### Other Imaging Findings

- Computed tomography (CT): hypoattenuation, mild mass effect in medial temporal lobes and insula
- Contrast-enhanced computed tomography (CECT): patchy or gyriform contrast enhancement in the temporoparietal regions in late acute/subacute stage
- Magnetic resonance imaging (MRI):
- T1: low signal with loss of gray-white junction and mass effect
- Increased signal corresponds to petechial hemorrhage, if present
- T2: hyperintense edematous cortex/subcortex, with relative sparing of the subcortical white matter
- T1 with contrast: cortical gyriform and occasional leptomeningeal enhancement
- FLAIR: hyperintense edematous cortex/subcortex, with relative sparing of subcortical white matter
- T2\*: Gradient-recalled echo (GRE) can show hypointense hemorrhagic blooming.
- Diffusion weighted imaging (DWI): early restricted diffusion in limbic system

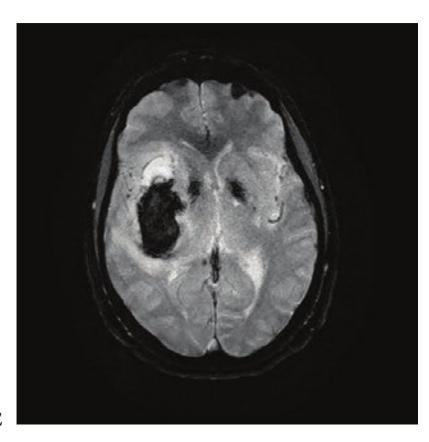
- ✓ ♠RI, specifically T2W FLAIR sequences and DWI, is highly sensitive for HSE.
- ✓ Characteristic involvement of medial temporal lobe(s) differentiates HSE from other more diffuse infective encephalitides.
- The radiologist should have a low threshold in diagnosis of HSE for any T2 bright temporal lesion in a patient with fever, seizure, and/or altered mental status.
- RI can remain negative for at least 48 hours from onset of symptoms.



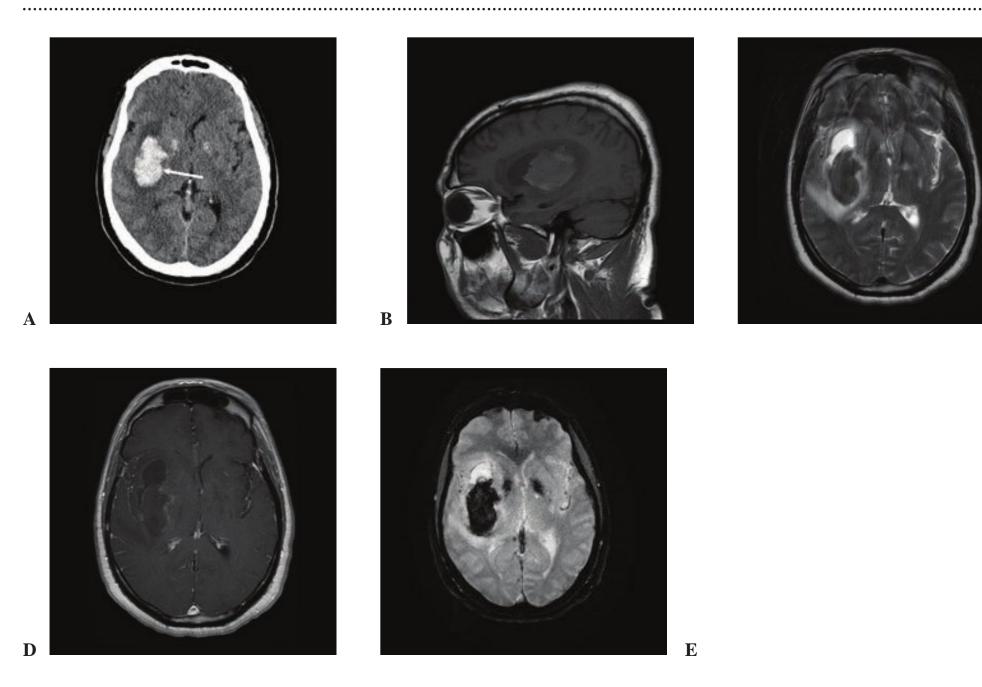
#### Clinical Presentation

A 54-year-old man with a long-standing history of hypertension presents with a sudden onset of right-sided headache and moderate left-sided neurologic deficits.

#### **■** Further Work-up



E



(A) Axial unenhanced computed tomography (CT) image shows a large area of high attenuation (arrow) within the right basal ganglia and external capsule in keeping with acute hemorrhage. (B–D) Sagittal T1-weighted, axial T2-weighted, and axial T1 post–gadolinium-enhanced images confrm the presence of a large hematoma. The mild T1 hyperintensity and low T2 signal are in keeping with the presence of intracellular methemoglobin. Mild rim enhancement is also present. (E) Axial gradient-recalled image shows marked low signal of the hematoma.

#### ■ Dif erential Diagnosis

- Hypertensive bleed: The most common location is between the putamen and insular cortex. The size of the bleeds can vary from microbleed(s) to several centimeters. The striatocapsular region, including the putamen and external capsule, is most often involved. Hypertension is the most common cause of primary intracranial bleed between 45 and 70 years of age.
- Tumor hemorrhage/vascular malformation: Can arise secondary to underlying lesions such as a primary or secondary neoplasm and vascular malformation (arteriovenous malformation [AVM], dural fistula). Presence of abnormal or prominent vessels suggests the possibility of an underlying vascular malformation. Underlying tumor mass may show areas of enhancing tissue and/or a more complex, mixed signal hematoma.
- Amyloid angiopathy: Typically lobar in distribution. Affects elderly patient population, which is normotensive. Often multiple foci located at the corticomedullary junction.

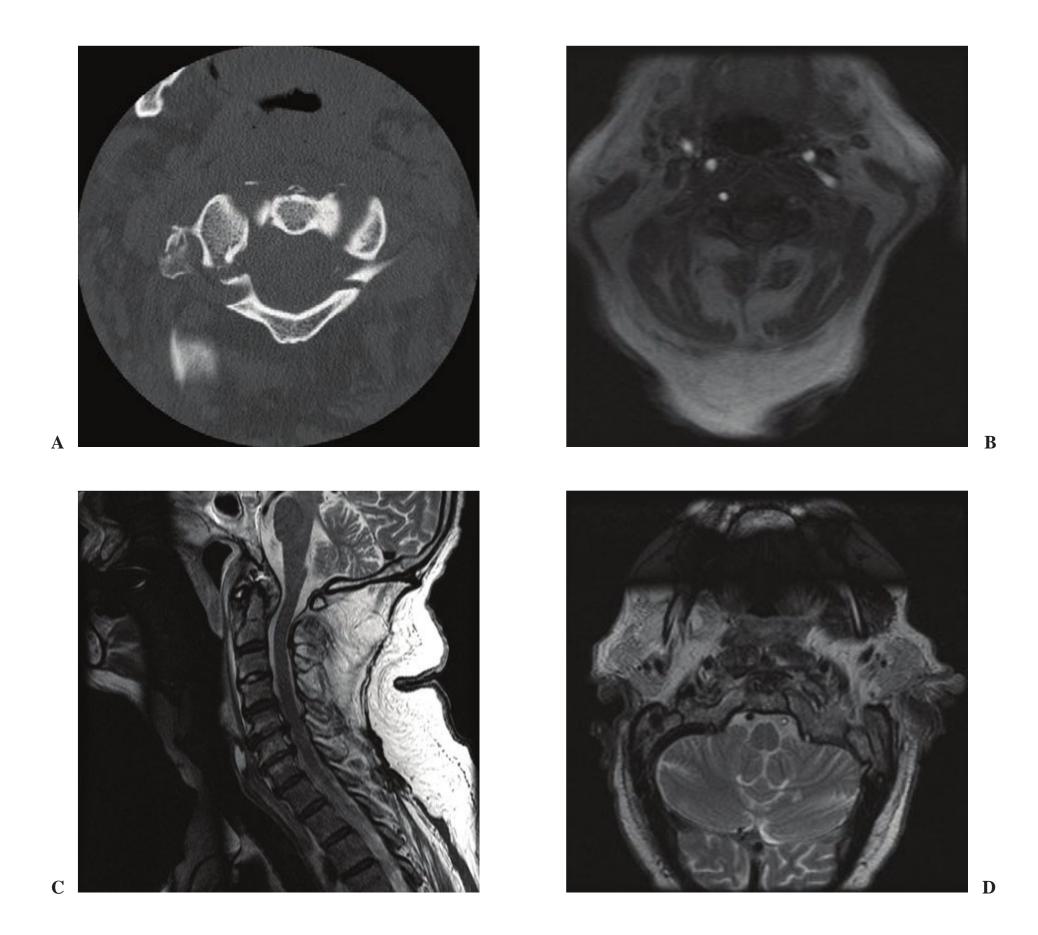
#### Essential Facts

- Arises at sites supplied by penetrating vessels from the middle cerebral and basilar arteries
- Hypertensive bleeds account for 10 to 15% of all strokes.
- Males are affected more than females.
- Hypertensive bleeds account for 50% of primary nontraumatic intracranial hemorrhage.
- Be wary of subsequent rebleed if the patient is still hypertensive.

#### Other Imaging Findings

- CT: high-density parenchymal lesion characteristically in the basal ganglia
- Magnetic resonance imaging:
  - T1: hypertensive to brain
  - T2: hypointense to brain
  - T2\* gradient-recalled echo (GRE) or susceptibility weighted imaging: hypointense lesions
  - Gadolinium contrast: No enhancement; subacute stage may see rim enhancement.

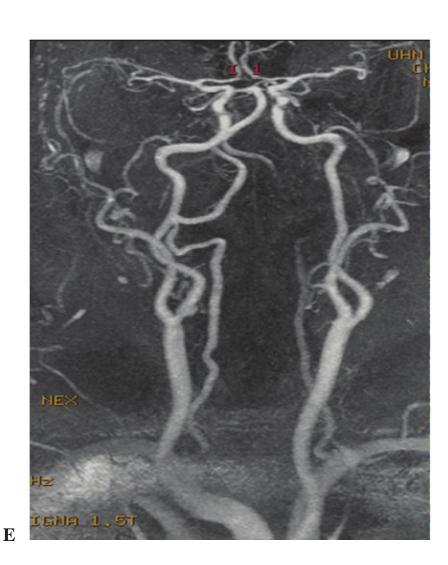
- ✓ Cematoma in the putamen and external capsule in a hypertensive patient is characteristic of a hypertensive bleed.
- ✓ Con-contrast-enhanced computed tomography (NECT) is recommended for older patients with hypertension and high suspicion for hypertensive bleed.
- ✓ €atures suggestive of an underlying mass lesion in a parenchymal hematoma include the presence of mixed stages of blood product, delayed evolution of the hematoma, persistent surrounding edema, and mass effect.
- Consider reimaging of hematoma with contrast/follow-up imaging to rule out the possibility of an underlying mass or vascular malformation, which may initially be "masked" by parenchymal blood.

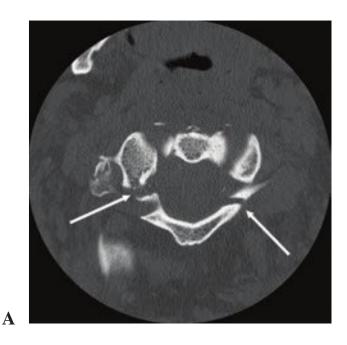


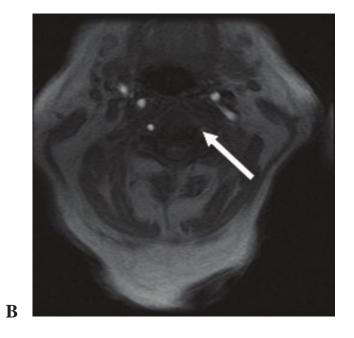
#### Clinical Presentation

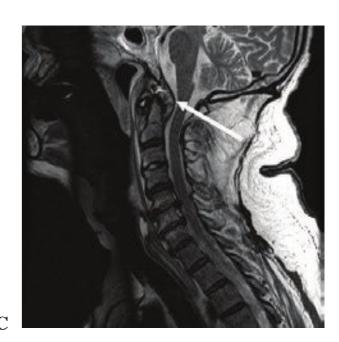
A 72-year-old man with swallowing difficulty. Patient fell 2 weeks prior.

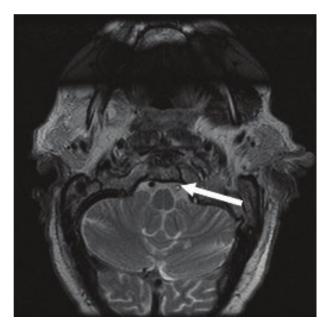
### ■ Further Work-up

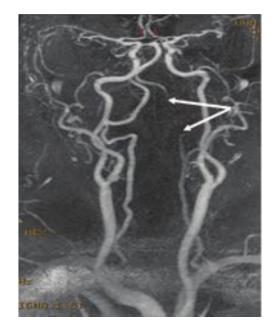












(A) Axial computed tomography (CT) show fractures to the C1 ring with mild diastasis (arrows). (B) Time-of-flight magnetic resonance angiography (MRA) shows a lack of flow in the left vertebral artery (VA) (arrow). (C) Sagittal T2 image of the spine shows a large hematoma in the anterior epidural space at the level of C1 (arrow). (D) Axial T2 image shows loss of the normal flow void in the left VA (arrow). (E) Coronal image from a contrast MRA shows a lack of opacification and flow within a large segment of the left VA (arrows).

#### Dif erential Diagnosis

- Jefferson fracture and VA dissection: There is an obvious fracture involving the ring of C1. Sagittal magnetic resonance imaging (MRI) shows a subacute anterior epidural hematoma at the level of the C1 vertebra. Complete lack of flow within the left VA on contrast MRA is characteristic of dissection. As the dissection proceeds inward involving the media and intima, the vessel becomes occluded. The intradural VA is more susceptible to rupture than the extradural VA.
- Ischemic stroke: Mean age at presentation is 73 years.

  Loss of flow on MRA and T2 imaging is possible but complete occlusion is unlikely. Stroke favors the carotid circulation. Ischemic penumbra is often visible on CT.

  Hematoma after ischemic stroke is uncommon.
- Vertebrobasilar atherothrom botic disease: Occurs between the ages of 70 and 80 years. Half of patients report transient ischemic attacks (TIAs) prior to acute presentation. Small ischemic changes secondary to branch occlusion are visible on magnetic resonance (MR). MRA may show either stenosis or occlusion of the vertebrobasilar circulation.

#### Essential Facts

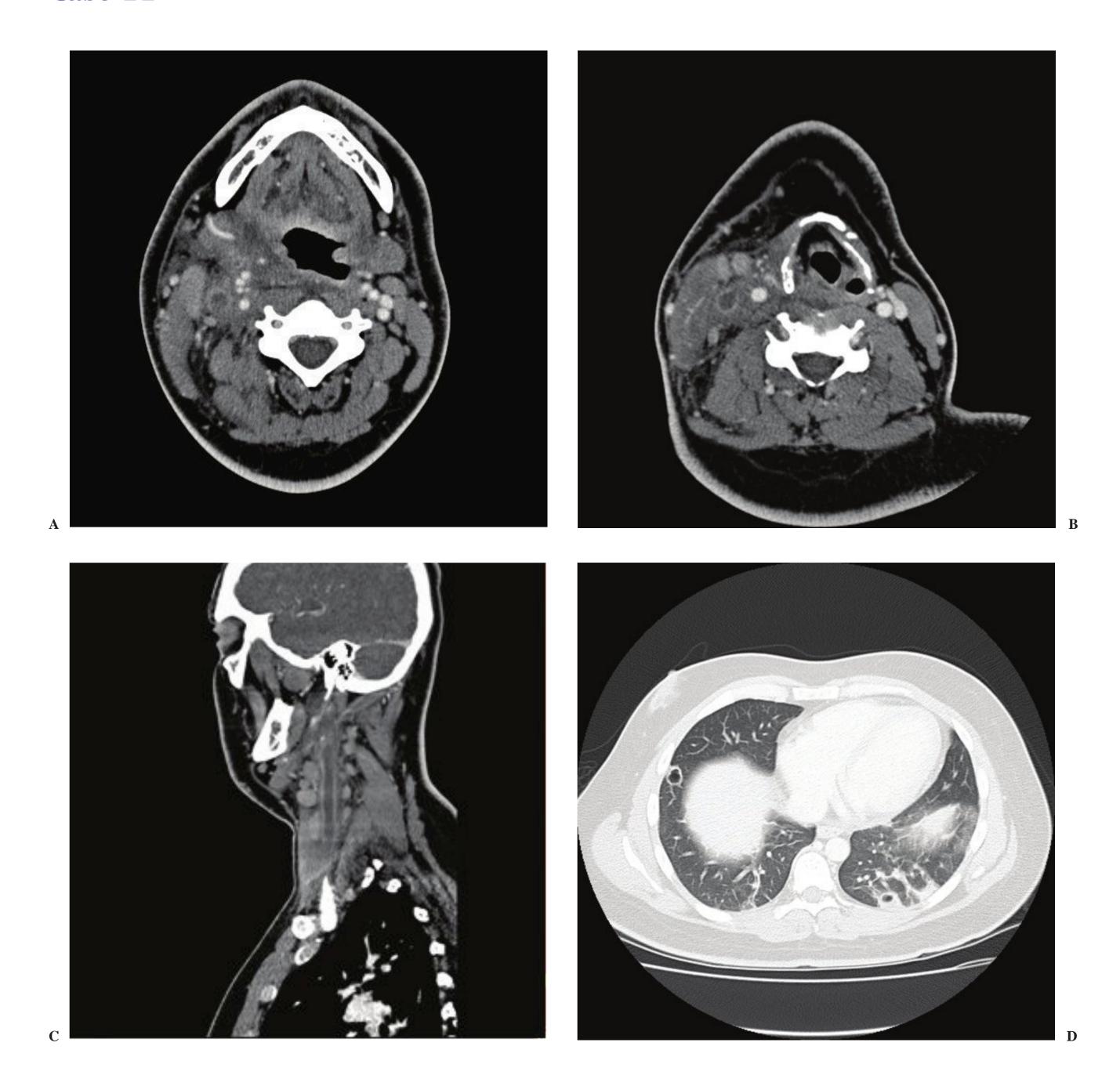
- Jefferson fractures are often the result of a compressive force to the top of the head.
- Motor vehicle accidents account for over 50% of blunt VA injuries.
- The specific traumatic insult usually involves the intima.
- Risk factors for dissection include hypertension, Marfan syndrome, and fibromuscular dysplasia.
- Growing hematoma is the causative lesion in vertebral artery dissection (VAD).

• Vertebral dissections are most common in patients 30 to 45 years of age.

#### Other Imaging Findings

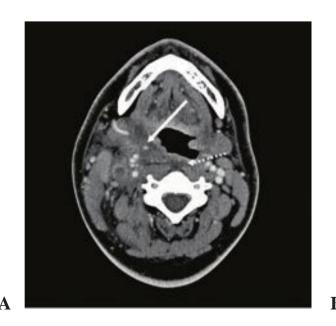
- Conventional radiography: A Jefferson fracture may be very subtle and manifest as a lateral displacement of the lateral masses of C1 on the open mouth view. Widening of the predental space (. 2.5 mm) secondary to transverse ligament injury.
- CT: A C1 fracture is usually easily seen on axial imaging as areas of lucency and diastasis. Lateral displacement of the lateral mass(es) of C1. Prevertebral soft tissue swelling.
- MR:
- T1 and T2: hematoma in the epidural space; loss of flow voids in dissected vessels
- T1: Fat-saturated T1 series may show characteristic bright signal mural hematoma in the vessel wall.
- Short T1 inversion recovery (STIR) imaging: high signal edema in the prevertebral soft tissues, fracture fragments
- Computed tomography angiography (CTA) and MRA: features of vessel dissection—abrupt and irregular vessel narrowing or tapering, vessel occlusion; "string sign"; pseudoaneurysm

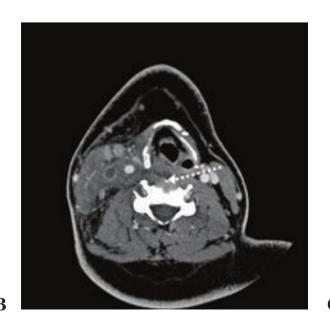
- \* Atherosclerotic disease can resemble cervical arterial dissection.
- ✓ Meck, ear, and face pain or discomfort accompany over 60% of VA dissections.
- ✓ In absence of blunt trauma on history does not exclude this possibility; patients may discount the severity of a fall or accident.
- ✓ Most patients will have no obvious neurologic deficit.

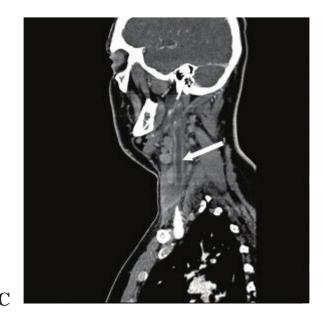


#### Clinical Presentation

A 27-year-old man with sore throat, odynophagia, malaise, and swollen right neck.









(A-C) Computed tomography (CT) scans with intravenous contrast enhancement; two axial images—at the level of the suprahyoid neck—and one sagittal image demonstrate marked swelling of the right lateral oropharyngeal wall with extensive edema and fat stranding (solid arrow in A). Fluid is present within the retropharynx (dashed arrow) and there is obliteration of the right parapharyngeal space. A filling defect is present in the right internal jugular vein (arrow in C) consistent with suppurative thrombosis. (D) Axial CT scan of the chest shows peripheral cavitary lesions in the left and right lower lobes (arrows).

#### Dif erential Diagnosis

- Lemierre syndrome: Refers to a syndrome characterized by pharyngotonsillar infection with parapharyngeal space involvement and secondary internal jugular vein thrombophlebitis and septic emboli. Internal jugular vein thrombosis associated with septic pulmonary emboli and infarcts are the most common radiographic findings.
- Jugular vein thrombosis: May occur spontaneously, but it can also arise secondary to central venous catheterization, head and neck malignancy, trauma, intravenous drug abuse, and other hypercoagulable states. Duplex ultrasound is the test of choice, showing iso-echogenic, noncompressible luminal contents.
- Lung metastases: Metastatic pulmonary nodules from solid organ tumors vary in size and location. findings include multiple, peripherally located, round, variable-sized nodules (hematogenous spread), as well as diffuse thickening of the interstitium (lymphangitic carcinomatosis).

#### Essential Facts

- This is a rare syndrome characterized by a primary pharyngotonsillar or odontogenic infection with lateral pharyngeal space invasion leading to internal jugular vein thrombophlebitis and septic emboli.
- Causative agent is Fusobacterium necrophorum; other Fusobacterium species are also common offending microorganisms.
- Presenting symptoms include pharyngitis (which does not resolve in 3 to 5 days), fever, chills, rigors, abdominal pain, nausea, vomiting, dysphagia, dyspnea, hemoptysis, cervical neck discomfort, arthralgia, malaise, and night sweats.
- The majority of cases present in the second and third decades of life.
- Mortality rate of, 5%
- Associated with complications related to septic emboli: 1) Thoracic: mediastinitis, pulmionary emboli,

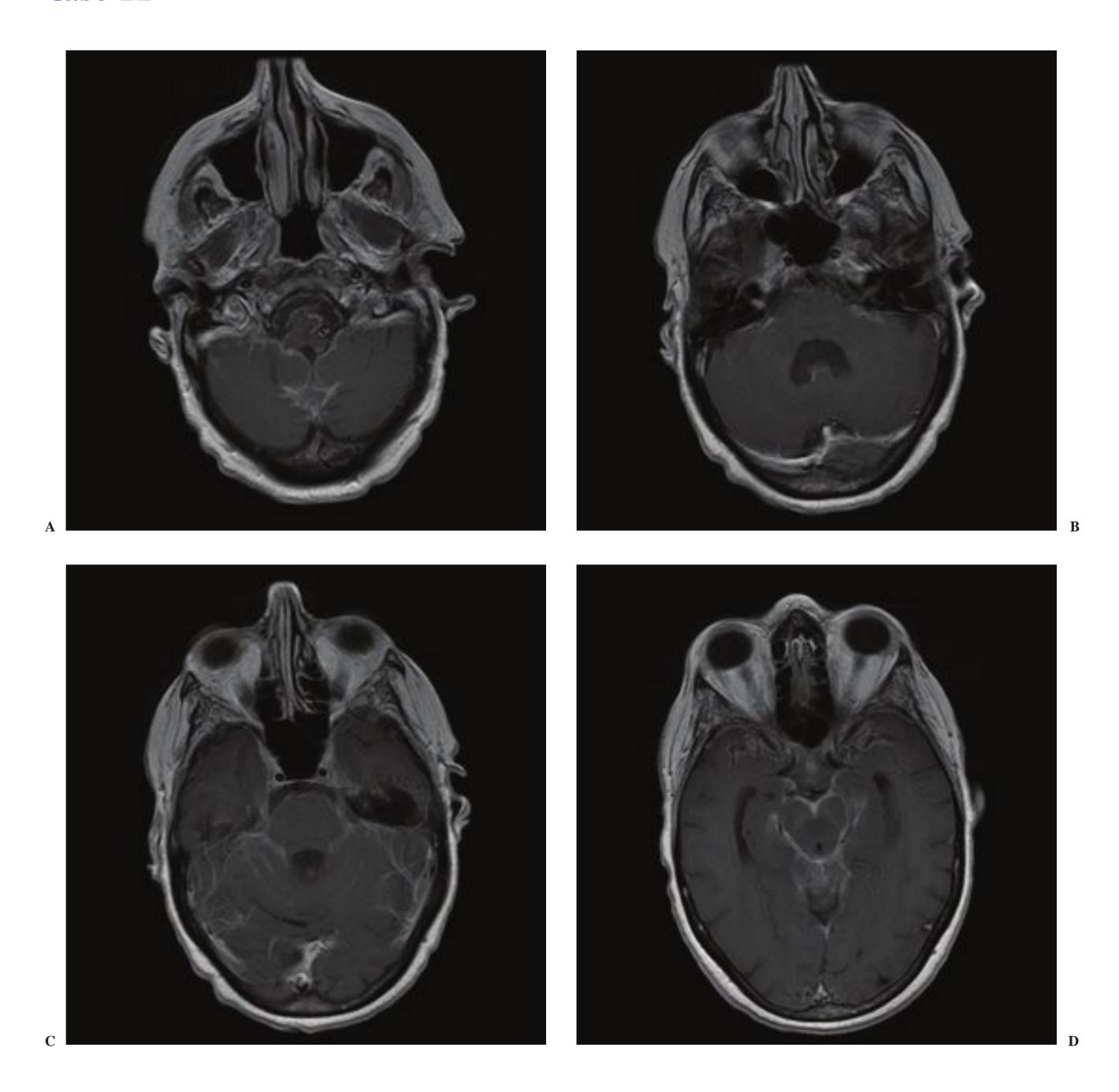
- pneumonia, empyema; 2) Neurologic: meningitis, epi- and subdural abscess; 3) Cardiac: tamponade, pericarditis, endocarditis; 4) Musculoskeletal: septic arthritis, osteomyelitis; 5) Abdominal: infarctsm abscesses to liver, spleen, kidneys.
- Treatment consists of prolonged (3–6 weeks) antibiotics 1/2 anticoagulation. Metronidazole is considered the antibiotic of choice.

#### Other Imaging Findings

- Duplex ultrasonography:
- Findings suggestive of thrombophlebitis include an engorged, noncompressible vein containing an echogenic thrombus. However, an acute thrombus may be anechoic and difficult to distinguish from flowing blood.
- Chest radiography:
  - parenchymal airspace disease, mass lesions, cavitary mass
- Contrast-enhanced chest CT:
  - Septic pulmonary emboli: multiple peripheral round, wedged-shaped areas that progress to cavitation; airspace in filtrates
- Contrast-enhanced neck CT:
- Internal jugular vein thrombosis: low attenuation filling defect and adjacent fat stranding
- Inflammatory changes and complications related to the oropharyngeal infection including peritonsillar abscesses, soft tissue swelling, and lymphadenopathy

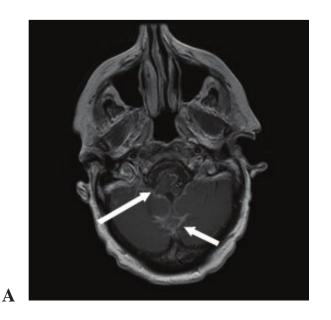
- ✓ eep in mind the possibility of nonpulmonary complications related to septic emboli such as cerebral subdural and epidural empyema, and septic arthritis involving the joints.
- ✓ Carly antibiotic use may prevent the development of the full spectrum of the syndrome.
- ✓ pproximately 45% of cases will not have significant neck findings.

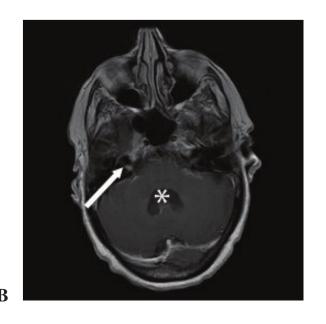
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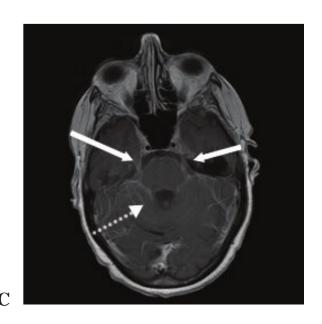


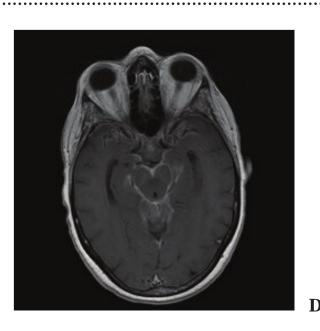
#### Clinical Presentation

A 67-year-old woman with a 3-week history of dizziness and confusion.









(A) Axial enhanced T1-weighted imaging shows curvilinear enhancement on the cerebellar surface (arrows). (B) Enlarged fourth ventricle (asterisk), indicative of obstructive hydrocephalus. Abnormal enhancement is present within the right (arrow) and left internal auditory canals. (C) Enhancement along the fifth cranial nerves bilaterally (solid arrows), as well as along the cerebellar folia (dashed arrow). (D) Thick enhancement along the surface of the midbrain. Note the prominent temporal horns, secondary to hydrocephalus.

#### ■ Dif erential Diagnosis

- Leptomeningeal carcinomatosis (LC): Diffuse metastatic seeding of the leptomeninges along the pial surface of the brain and spinal cord. The pattern of enhancement is described as a "zuckerguss" or sugar-icing pattern on computed tomography (CT) or magnetic resonance (MR) and can occur in central nervous system (CNS) invasion of metastasis. Multiple anatomical elements of the CNS are usually affected. Can be seen with primary brain neoplasms or as a manifestation of distant metastases from gastrointestinal (GI), lung, and breast primaries.
- Meningitis: Thick basilar meningitis can be seen with tuberculosis (TB) and fungal infection. Cisterns may appear obliterated on CT and magnetic resonance imaging (MRI). Acute, febrile presentation is an important differentiator. TB may also demonstrate parenchymal brain lesions—"tuberculoma." Both TB and fungal infection may also have associated parenchymal lung disease.
- Neurosarcoidosis: Enhancement of the infundibulum is common. Base of the brain is most often affected, including the leptomeninges and basal cisterns. Parenchymal brain lesions can be seen. Elevated serum angiotensin-converting enzyme (ACE) level, adenopathy, and interstitial disease on chest imaging studies are supportive findings.

#### Essential Facts

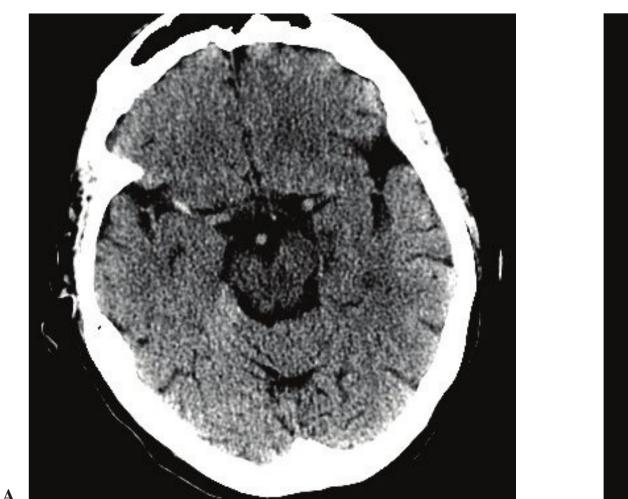
- Most cases are diagnosed by cerebrospinal fluid (CSF) cytology or leptomeningeal biopsy.
- Natural history of LC affords a mean life expectancy of 4 to 6 weeks.

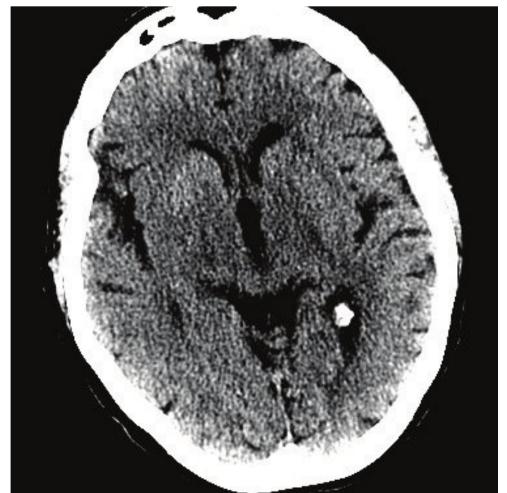
- Increased intracranial pressure and hydrocephalus may develop due to impaired CSF drainage.
- LC is present in 5 to 15% of leukemias and 1 to 5% of solid cancers.
- Incidence increases with primary disease duration.

#### Other Imaging Findings

- CT: sulcal enhancement and cortical edema
- MR:
- T1: nodular or nonnodular enhancement covering the basal cisterns, cerebellar folia, and cortical sulci; spinal nerve root and cauda equina enhancement and thickening
- Fluid-attenuated inversion recovery: Subarachnoid space shows a "dirty signal," which is greater than CSF.
- Iridium-111 diethylenetriamine cisternogram: poor diffusion/flow at 6 and 24 hours indicative of obstructive hydrocephalus

- ✓ cptomeningeal enhancement is greater with solid primary tumors than with lymphoma and leukemia.
- ✓ is crucial to assess for obstructive hydrocephalus in patients with LC.
- ✓ Contrast MR is the best noninvasive test to accurately detecting leptomeningeal disease involving the brain.
- ✓ involving the spine may appear radiologically as areas of clumping, nodularity, or thickening along the roots of the cauda equina.

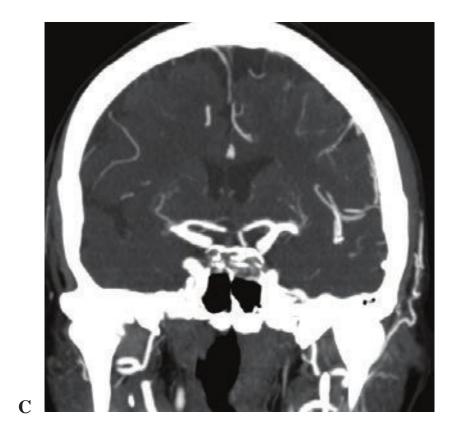


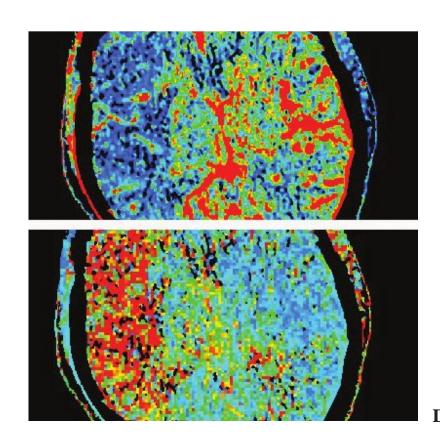


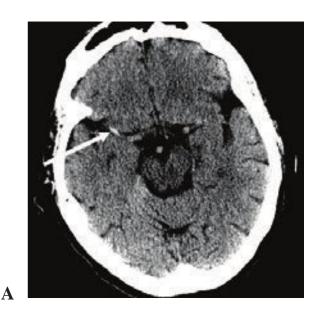
Clinical Presentation

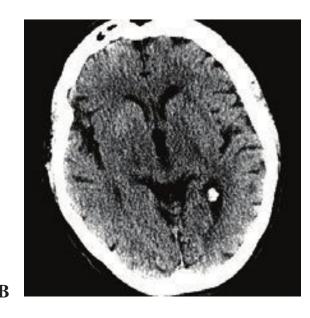
A 74-year-old woman with sudden onset of left dense hemiplegia and facial droop 5 hours ago.

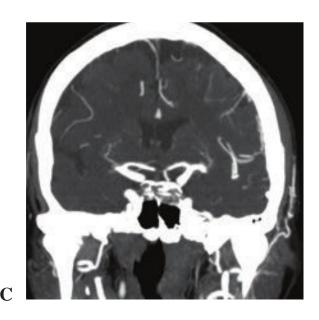
# ■ Further Work-up

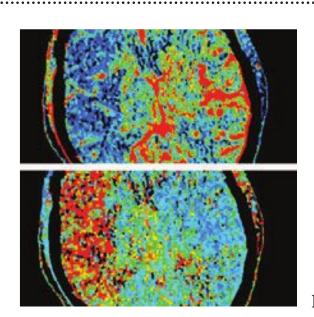












(A, B) Axial non-contrast-enhanced computed tomography (NECT) shows a hyperdense middle cerebral artery (MCA) on the right (arrow), with loss of the gray—white matter differentiation of the insula. (C) Computed tomography angiography (CTA) coronal maximum intensity projection (MIP) reformat shows an occluded proximal right MCA. (D) Computed tomography perfusion (CTP) color maps reveal a large matched perfusion defect (low cerebral blood flow [CBF], increased mean transit time [MTT]) involving the deep and superficial right MCA territory.

### Dif erential Diagnosis

- MCA stroke: The NECT shows early signs of brain infarct (insular cortical ribbon sign) with a hyperdense MCA sign. The CTA confirms the right MCA occlusion. CTP color maps reveal a matched perfusion defect, in keeping with a large infarct core with no salvageable brain parenchyma. Aggressive revascularization strategies are not indicated, given the high risk of hemorrhagic transformation and low probability of good outcome.
- Herpes encephalitis: Herpes simplex virus (HSV) encephalitis presents usually with diffuse neurologic deficits and seizures. It occurs more often in younger population. Imaging findings may be similar, with loss of gray—white matter differentiation characteristically seen in the temporal poles (unilateral or bilateral but asymmetric) involves more than one vascular territory (MCA and posterior cerebral artery [PCA]). Empirical antiretroviral therapy and lumbar puncture are mandatory in case HSV encephalitis is suspected.
- Status epilepticus: Patients in status epilepticus may present with temporal lobe edema, usually involving more than one arterial territory. CTA will show patent intracranial arteries and CTP will show increased cerebral blood volume (CBV) and MTT (hyperperfusion) as opposed to brain infarcts, which show decreased CBV. Clinical history is by far the most important element for differentiating both entities.

#### Essential Facts

- Stroke is one of the leading causes of dementia and disability.
- More than 85% are ischemic.
- Thirty percent to 35% large artery atherosclerosis; 20 to 25% cardioembolic; 15 to 20% small vessel disease
- Mortality is almost 10% and 50% of the surviving patients are disabled.
- Intravenous (IV) thrombolytic therapy (recombinant tissue plasminogen activator [r-tPA]) administered within 4.5 hours after stroke onset increases the chances of a good outcome by 30%, at the expense of increased rate of symptomatic intracranial hemorrhage (0.6 vs. 6.4%)
- Large arteries with a large clot burden have less than 30% recanalization rates with IV r-tPA only.

• Depending on the technique, mechanical thrombectomy demonstrates recanalization rates greater than 80% for large arteries.

# Other Imaging Findings

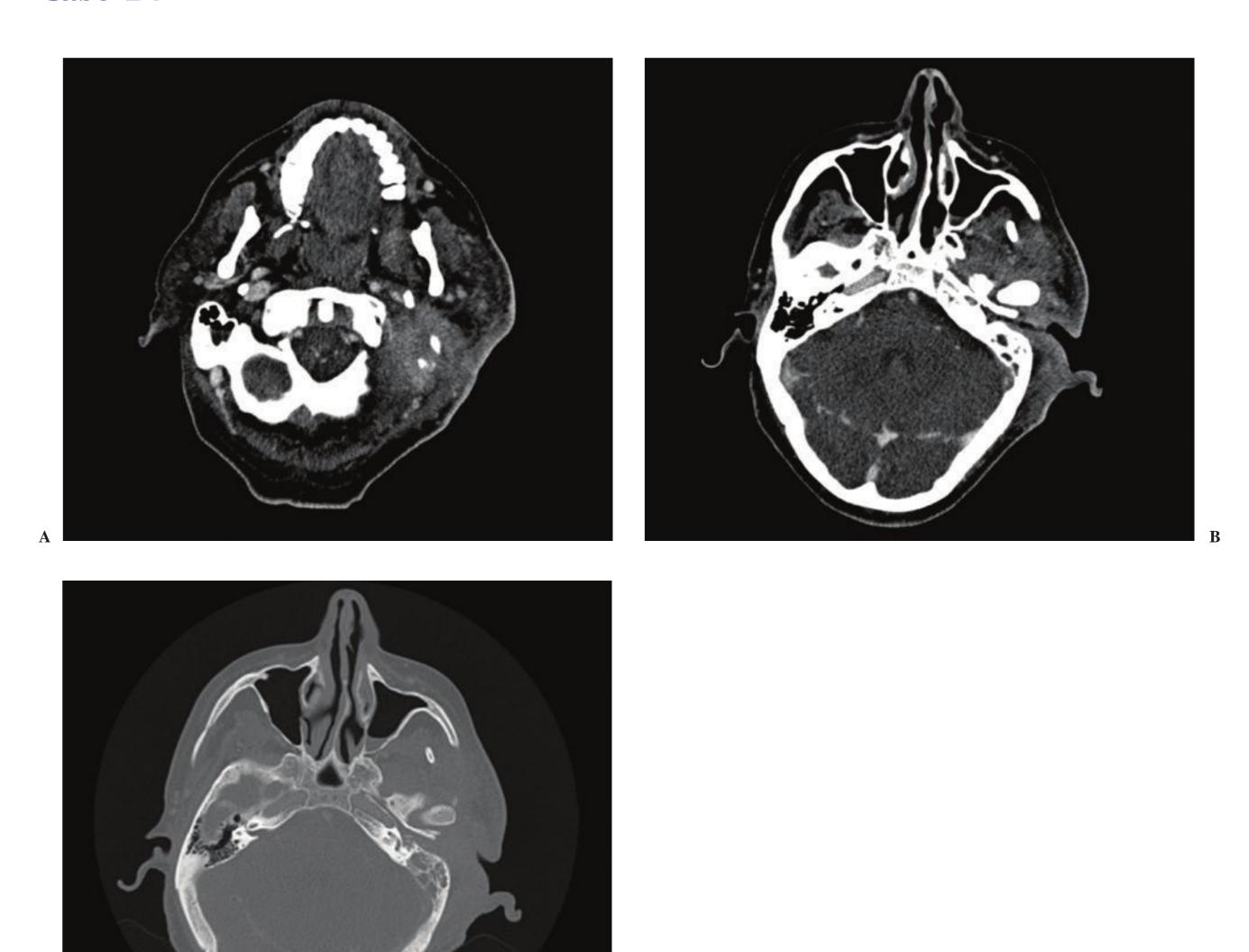
#### • CT:

- CTP: may differentiate the infarct core (low CBF, low CBV, increased MTT) from the tissue at risk or penumbra (normal or low CBF, normal or mildly decreased CBV, increased MTT)
- CTA: Depending on the technique, the source CTA images may be flow weighted (CTA first, then CTP) or volume weighted (CTP first, then CTA).

#### • MR:

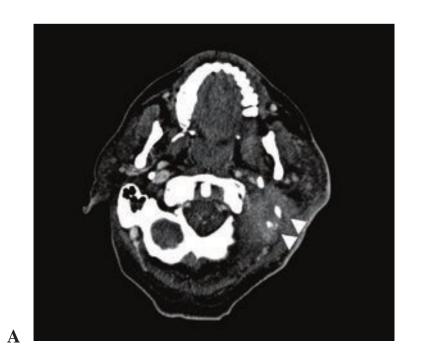
- Diffusion weighted imaging (DWI): Most sensitive imaging technique. Restricted diffusion (high DWI, low apparent diffusion coefficient [ADC] values) can be seen as early as 30 minute of symptoms onset.
- Fluid-attenuated inversion recovery (FLAIR): Increased signal can be seen after 4 hours of onset, which may be helpful in cases of unknown time onset (i.e., wake-up stroke).
- Dynamic susceptibility contrast (DSC) perfusion: DSC perfusion may differentiate the infarct core (DWI restricted) from the tissue at risk, which will show prolonged MTT or time to peak (TTP).
- Dynamic contrast enhanced (DCE) perfusion: DCE perfusion will show areas of blood-brain barrier disruption, which may be helpful in predicting the risk of hemorrhagic transformation.

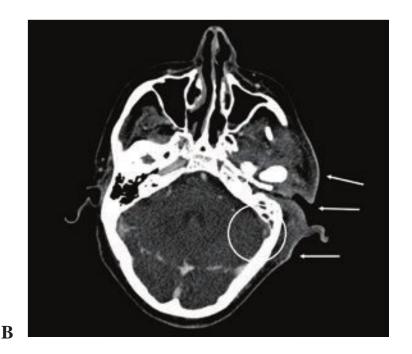
- ✓ Che main role of imaging is to rule out a hemorrhagic stroke or a stroke mimic.
- ✓ Carly recanalization can improve prognosis in ischemic stroke.
- ✓ wew stent retriever devices show recanalization rates above 85%, compared with prior devices with rates below 70%.
- spite of high recanalization rates, good clinical outcomes are seen in ~45% of patients (futile recanalization).

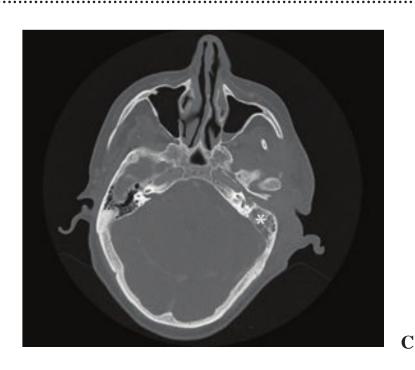


# Clinical Presentation

A 67-year-old man with leukemia and extensive left facial swelling.







(A–C) Axial contrast-enhanced computed tomography (CT) images show the presence of inflammatory changes (including fat stranding, skin thickening, and soft tissue swelling) within the left periauricular soft tissues. This also involves the soft tissues around the temporomandibular joint and the external auditory canal (EAC) (arrows). There is effusion within the left mastoid and tympanic cavity (asterisk). There are no areas of bony erosion associated with the left petrous temporal bone. There is thickening and ill-defined margin of the left sternocleidomastoid muscle consistent with myositis (arrowheads). The left-sided sigmoid sinus is incompletely opacified (circle), concerning for dural venous sinus thrombosis.

#### Dif erential Diagnosis

- Necrotizing otitis media: Invasive infection of the EAC with involvement of the skull base and surrounding soft tissue. This is typically seen in elderly diabetic patients often secondary to *Pseudomonas aeruginosa*. The infection typically spreads from the EAC to the subtemporal soft tissues through the fissures of Santorini. Involvement of the skull base may lead to cranial nerve involvement. Intracranial complications include abscesses, empyemas, and dural venous sinus thromboses.
- EAC squamous cell carcinoma: May have identical imaging features. EAC squamous cell carcinomas are usually secondary to chronic infection, are more frequent in females, and have a worse prognosis. Extension to the middle ear further decreases survival.
- Temporal bone osteoradionecrosis: May occur several years after radiation therapy. This condition has a more indolent course. EAC is most at risk of developing osteoradionecrosis, especially in combination with mastoidectomy.

#### Essential Facts

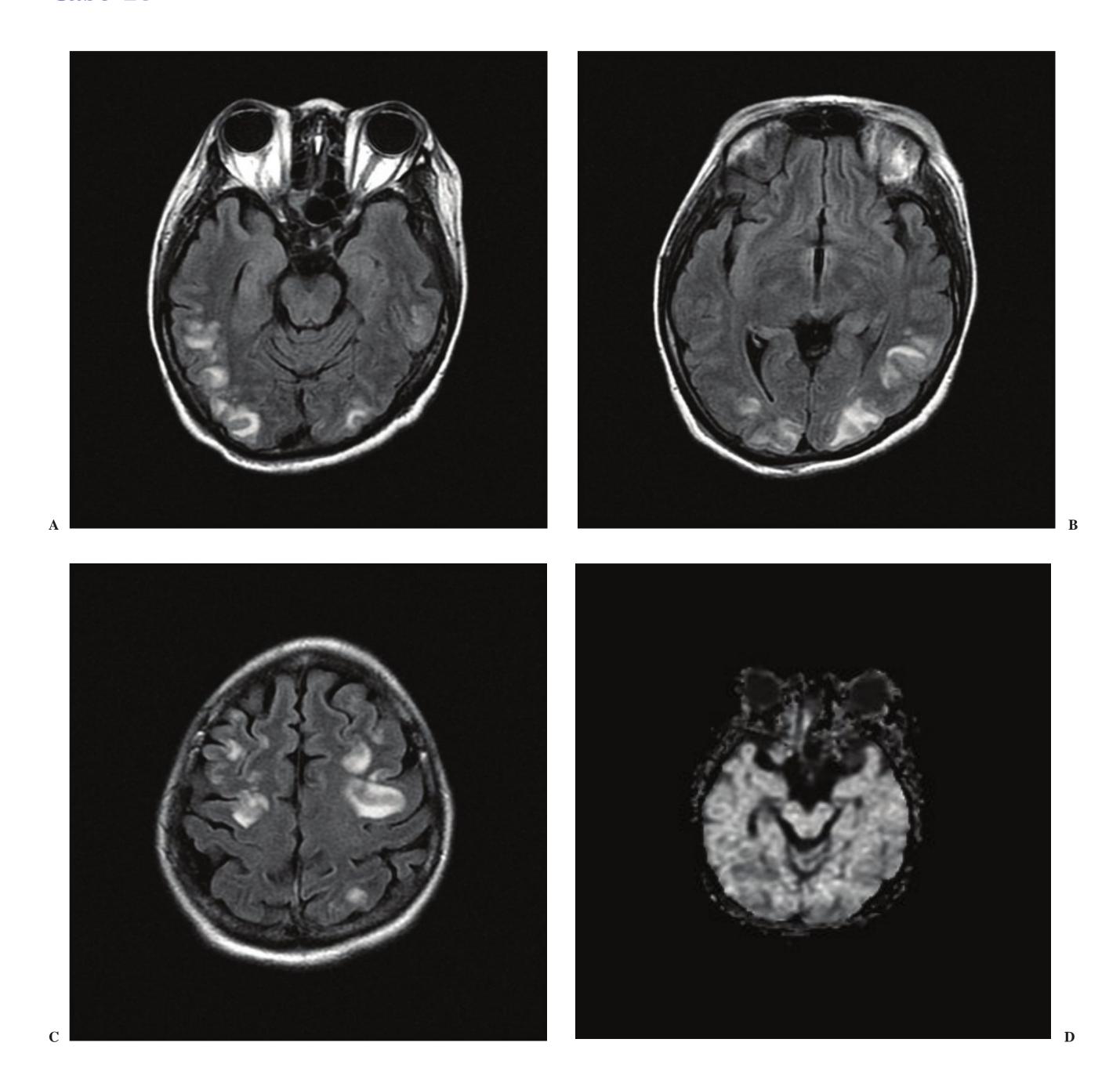
- Severe invasive infection of the EAC with secondary involvement of the skull base and subtemporal soft tissues.
- Most frequently encountered in elderly diabetic patients and typically secondary to *P. aeruginosa*
- Clinical correlation is important as EAC squamous cell carcinoma and other nonneoplastic conditions may have similar imaging findings.
- The primary treatment involves surgical debridement and drainage of abscesses along with antibiotics.
- HIV or immunocompromised patients may have a more fulminant course with higher mortality. Fungal infection, especially *Aspergillus fum igatus*, may be encountered in this setting.

#### Other Imaging Findings

- CT: Thickening of EAC walls, fat stranding surrounding the EAC (phlegmon), rim-enhancing abscesses. CT better demonstrates bony erosion along EAC and cortical erosion of the skull base or temporomandibular joint.
- Magnetic resonance imaging:
- Better demonstration of bone marrow involvement within the skull base and intracranial complications
- T2 and T1 postcontrast should be done with fat saturation.
- T1: Loss of normal fatty bone marrow signal with skull base osteomyelitis.
- T2 with fat saturation or short T1 inversion recovery (STIR): demonstrates bone marrow edema and otomastoid and temporomandibular joint (TMJ) effusion
- T1 postcontrast with fat saturation: allows distinction of phlegmon from abscess formation
- Magnetic resonance venography: allows evaluation of dural venous sinus thrombosis
- DWI: May be useful in differentiating skull base osteomyelitis from tumor infiltration.
- Nuclear medicine: Bone scan (technetium 99mm-methylene diphosphonate [MDP] and gallium scan usually done together) may be useful in confirming the diagnosis and in treatment monitoring. Typical finding in necrotizing otitis externa is a larger area of gallium uptake compared with technetium.

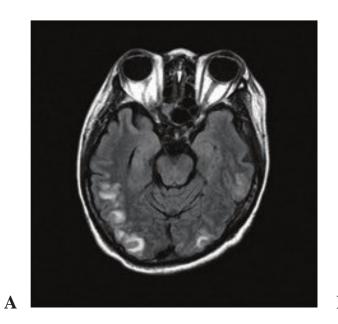
- ✓ Cook for erosion along EAC, subtemporal soft tissue infiltration, or skull base changes when patients present with otitis externa.
- ✓ thorough search should be made to evaluate for intracranial complications.
- ✓ CT and magnetic resonance (MR) are complementary.

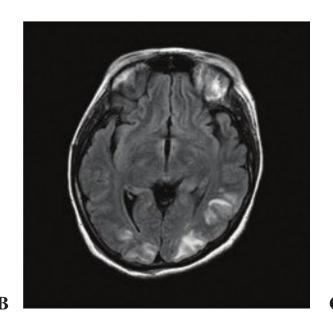
  Nuclear medicine may be useful in equivocal situations.
- ✓ equires clinical correlation to exclude neoplastic (EAC squamous cell carcinoma) or other nonneoplastic inflammatory conditions.

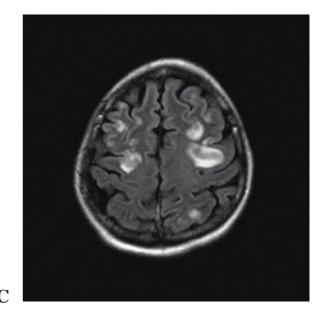


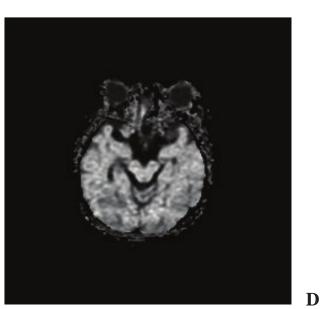
# Clinical Presentation

A 47-year-old woman presents to the emergency room with seizures, an altered level of consciousness, vision disturbance, and headaches. Blood pressure was noted to be 170/100 mm Hg.









(A–C) Axial fluid-attenuated inversion recovery (FLAIR) magnetic resonance imaging (MRI) of the brain reveals the presence of bilateral high signal within the subcortical white matter of the cerebral hemispheres. The locations involve the frontal, temporal, and parietal white matter. (D) Diffusion weighted image and apparent diffusion coefficient (ADC) map (not shown) shows no evidence of restricted diffusion.

# ■ Dif erential Diagnosis

- Posterior reversible encephalopathy syndrome (PRES): bilateral posterior cortical—subcortical vasogenic edema; usually symmetric, no mass effect, diffusion negative
- Acute cerebral ischemia/infarction: Watershed-type infarcts can show a similar distribution of bilateral parenchymal signal change; will show restricted diffusion ("bright" on diffusion weighted imaging [DWI], "dark" on ADC).
- Dural sinus thrombosis: Thrombosis of the venous sinus can result in secondary venous infarction. A nonarterial distribution of parenchymal signal abnormality can develop. Computed tomography (CT) or magnetic resonance venography will show absence of flow within the affected sinuses. May see the classic "empty delta" sign on contrast CT or MRI corresponding to clot in the sagittal sinus viewed in the axial plane.

#### Essential Facts

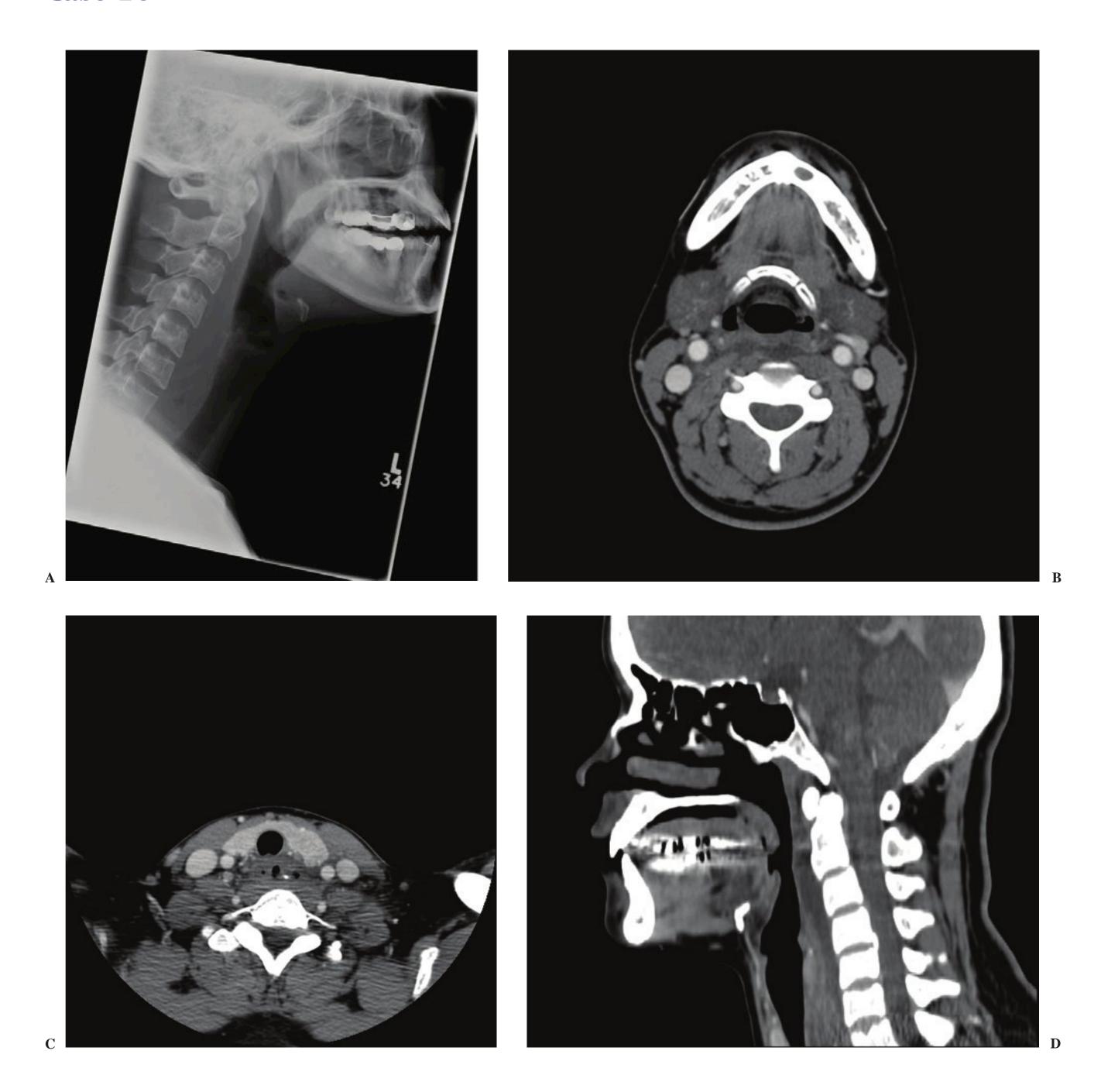
- Posterior reversible encephalopathy syndrome (PRES) refers to a neurologic syndrome of reversible vasogenic edema in the brain seen in the setting of neurotoxicity.
- PRES is related to the presence of endothelial dysfunction and disruption of cerebral autoregulation/blood-brain barrier.
- Associated with many conditions/toxicities such as preeclampsia, hypertension, immunosuppressive drugs (e.g., cyclosporine, tacrolimus), autoimmune diseases, and renal failure
- Clinically characterized by headache, visual symptoms, seizures, and altered mental status

• Posterior circulation involvement is usually seen but can also involve frontal, inferior temporal—occipital area, basal ganglia, capsular regions, brainstem, and cerebellum.

# Other Imaging Findings

- Imaging findings on CT and MRI:
- Bilateral subcortical areas of parenchymal abnormality
- Posterior distribution—occipital parietal and temporal
- Subtle marginal gyral enhancement
- Brain MRI:
  - Diffusion (DWI) is usually normal but may be positive in up to 26% cases.
  - Susceptibility weighted imaging: 17% cases positive, compatible with presence of hemorrhage
- Post-gadolinium T1 imaging may show patchy parenchymal or leptomeningeal enhancement (37% cases).

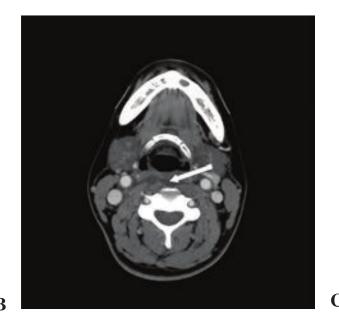
- ✓ ©ecessary to rule out venous thrombosis, as this can also show bilateral symmetric parenchymal signal change.
- ✓ cptomeningeal enhancement can be seen with PRES.
- ✓ Chere are 2.6% of patients who can have unilateral features.
- ✓ Crainstem and cerebellar as well as frontal involvement does not rule out PRES.

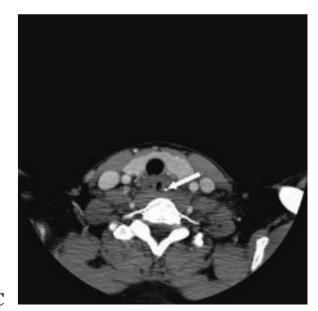


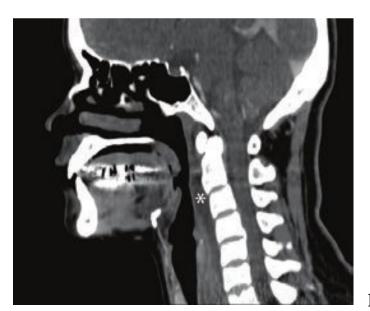
# Clinical Presentation

A 29-year-old woman with severe odynophagia after eating fish.









(A) A lateral neck X-ray shows marked increase in thickness of prevertebral soft tissues (asterisk). Note the one small focus of air lucency also present within the prevertebral tissues (arrow). (B) An axial contrast-enhanced computed tomography (CT) shows retropharyngeal space fluid (arrow). (C) An axial contrast-enhanced CT shows the cross-section of a hyperdense foreign body within the wall of the esophagus compatible with a fish bone (arrow). (D) A sagittal contrast-enhanced CT shows the vertical extent of the retropharyngeal space fluid (asterisk), which extends from the level of the C1 arch down to the level of C6.

#### Dif erential Diagnosis

- Retropharyngeal space (RPS) abscess: Widened prevertebral distance on plain X-ray. Tense fluid collection in RPS with wall enhancement may be seen on CT.
- Nonabscess f uid: Seen with radiotherapy for head and neck malignancies, internal jugular vein (IJV) thrombosis, pharyngitis, and longus colli tendinitis. Imaging shows RPS fluid without wall enhancement or mass effect.
- Suppurative nodes: Cystic-appearing nodes in lateral RPS with adjacent cellulitis in septic patients. May progress to an RPS abscess without proper medical management.

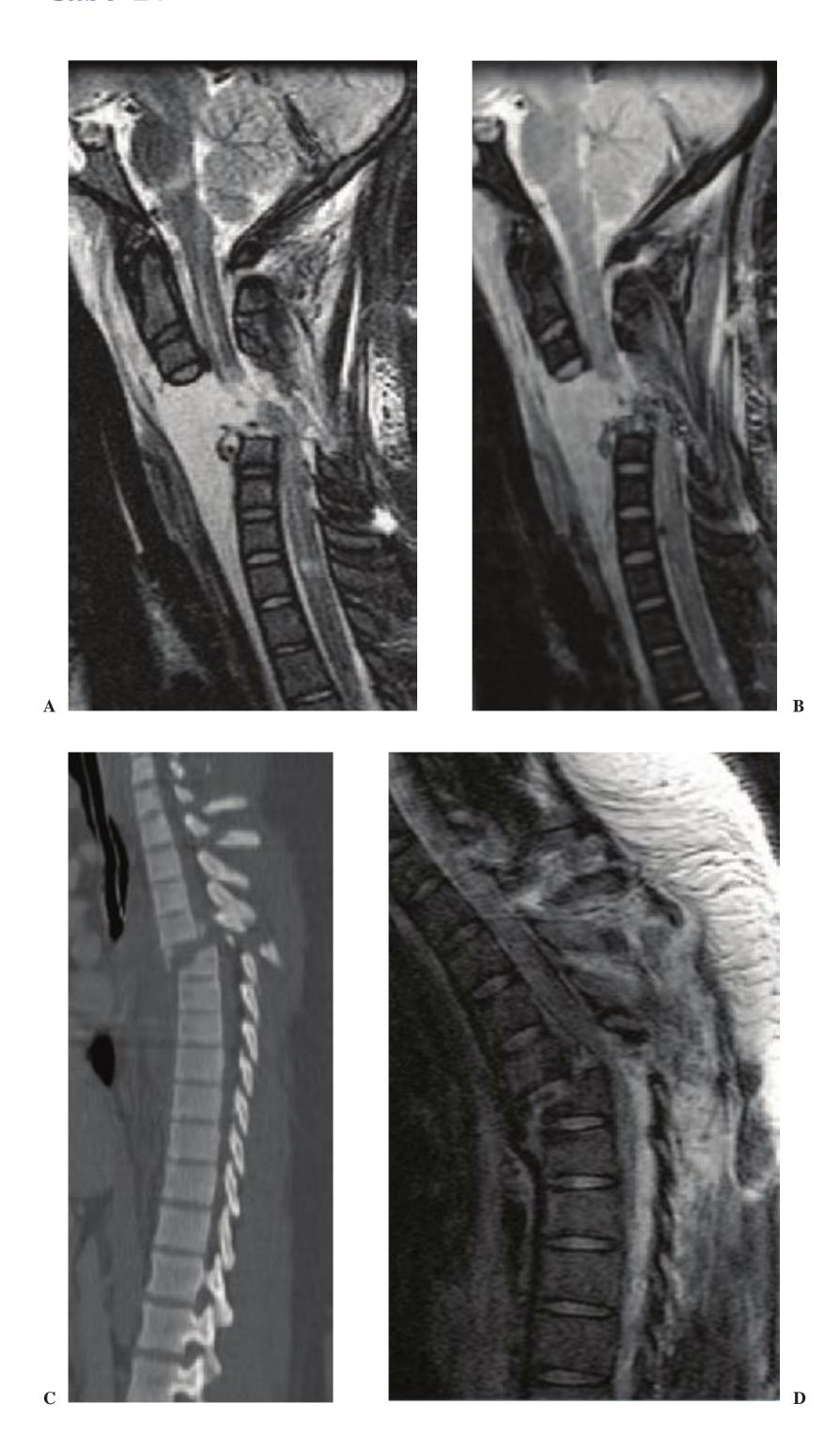
#### Essential Facts

- RPS is located between the pharyngeal constrictor muscle and the prevertebral fascia.
- Typically affects the pediatric population; elderly and immunocompromised patients are also at risk.
- RPS abscess may originate from a pharyngeal penetrating foreign body, ventral spread of infective processes in the cervical spine, or head and neck infections, which lead to suppurative retropharyngeal lymphadenopathy.
- Patients commonly present with odynophagia and sepsis.
- Rim-enhancement on cross-sectional imaging suggests abscess formation but is not always present.

### Other Imaging Findings

- Plain radiography:
- Prevertebral soft tissue swelling
- May see radio-opaque foreign bodies
- CT:
- Axial and sagittal imaging with contrast will show the presence of fluid within the retropharyngeal space.
- Assesses status of airway and the jugular and carotid vessels for thrombosis or inflammation
- Assesses for presence of suppurative adenopathy or diskitis

- ✓ Cross-sectional imaging is necessary to distinguish retropharyngeal from prevertebral infection.
- ✓ Comportant to evaluate the full extent of the abscess, because it may extend inferiorly to mediastinum through danger space of neck. Be sure to image at least to the level of the carina.
- ✓ Check the status of the airway and alert clinician in cases of compromise.
- but cannot distinguish between prevertebral and retropharyngeal swelling.
- ✓ Cook for potential causes such as cervical spine diskitis and a penetrating foreign body.



# Clinical Presentation

Two separate patients both involved in a motor vehicle accident, presenting with paralysis. Patient 1, an 18-year-old man. Patient 2, a 22-year-old man.









(A) Patient 1: Sagittal short T1 inversion recovery (STIR) image shows distraction and complete transection (arrow) of the spinal cord at C3–C4 secondary to cervical spine fracture-dislocation. (B) Patient 1: Sagittal gradient-recalled echo (GRE) image on the same patient shows blooming at the transection site consistent with hemorrhage (arrow). (C) Patient 2: Different patient demonstrates complete transection of the spinal column and functional cord transection. Computed tomography (CT) demonstrates an oblique fracture through a thoracic vertebral body with a small retropulsed fragment (arrow) and ventral subluxation. (D) Patient 2: Sagittal T2-weighted image demonstrates stretching of the spinal cord, resulting in abnormal cord signal and caliber. There is disruption of the anterior longitudinal ligament (long arrow), stripping of the posterior longitudinal ligament (short arrow), and a ligamentum flavum tear (arrowhead).

### Differential Diagnosis

- Spinal cord transection: Complete transection above the C4 level leads to respiratory muscle involvement, whereas lower cervical to upper thoracic (T6) transection will lead to autonomic dysfunction (neurogenic shock). Partial transection includes hemitransection most commonly due to penetrating trauma; central cord syndrome due to hyperextension injury and anterior cord syndrome resulting from vascular compromise.
- Spinal cord contusion/edema: Swelling of the cord characterized by increased T2 signal intensity. Single level edema generally resolves in 3 weeks; however, multilevel edema can persist beyond this time frame.
- Spinal cord hemorrhage: Indicative of a higher grade injury with poor prognosis for recovery of function. Initially, the hemorrhage is hypointense on T2-weighted imaging; however, it can become hyperintense as blood products evolve into early subacute stage. Hemorrhage is hypointense on susceptibility weighted sequences.

#### Essential Facts

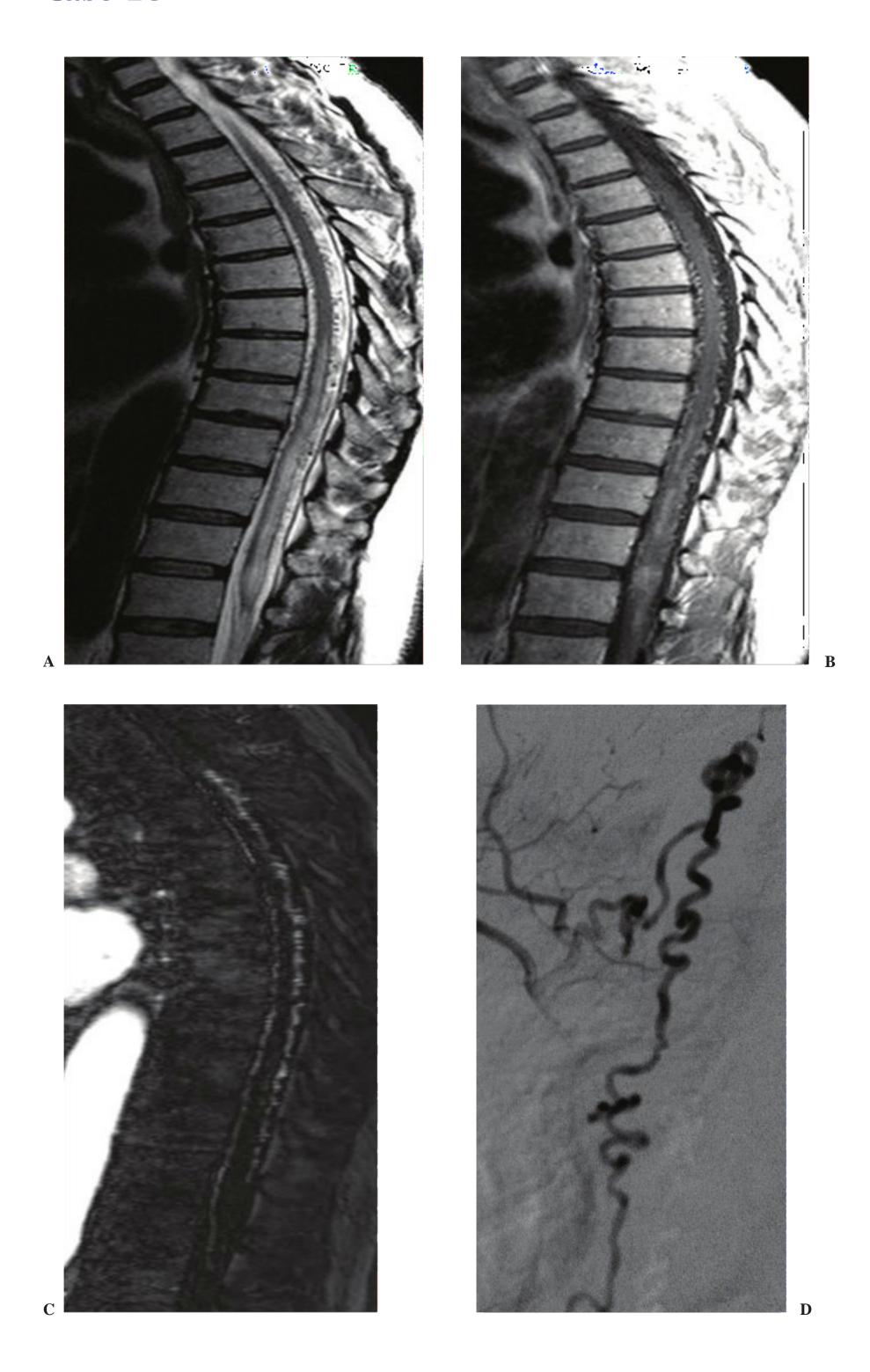
- Traumatic spinal cord injury most commonly involves males younger than the age of 40 years. Approximately 50% of the cases are secondary to motor vehicle accidents.
- Diagnosis of complete anatomical transection of the spinal cord is straightforward. However, functional cord transection can exist even when the cord is still physically intact, resulting in a similar clinical outcome.
- Syndromes of neurologic injury are more commonly due to contusion and hemorrhage than true cord disruption.
- Poor prognosis with little to no recovery after transection. Greatest recovery occurs in the first 6 months after a cord injury.

# Other Imaging Findings

- CT: Best modality to assess for fractures and subluxations. Reformats in the sagittal and coronal planes are needed for a complete evaluation. Important to recognize abnormal widening of disk spaces, facet complexes, and interspinous spaces because they are indirect findings of soft tissue injury (ligament, joint capsule). Most severe injury occurs after hyperflexion/compression injuries, producing a flexion teardrop fracture fragment and dislocation.
- Magnetic resonance imaging (MRI):
- T1: Possible hyperintensity in the cord due to hemorrhage. Traumatic disk herniations and fracture lines may be better visualized than on T2-weighted sequences.
- T2: assesses for abnormally increased cord signal intensity and morphology
- STIR: ligamentous injury denoted by hyperintensity (normally low signal intensity), displacement, or complete disruption
- GRE: Low signal intensity in the cord due to blood products. It can also be used to assess ligamentous integrity.
- Acute epidural hemorrhage: heterogeneous hyperintensity on T2-weighted imaging and isointensity (compared with cord) on T1-weighted image

- ✓ Cey prognostic factors for nontransection injuries are an absence of cord hemorrhage and cord edema limited to single rather than multilevel.
- ✓ Qust identify ligamentous injury along with fractures for appropriate stabilization
- ✓ weighted sagittal images are most important for the evaluation of cord injury.
- ✓ ©egative CT exam does not exclude spinal cord injury or dynamic instability particularly in children.
- ✓ RI should be done if neurologic symptoms are present.

Case 18

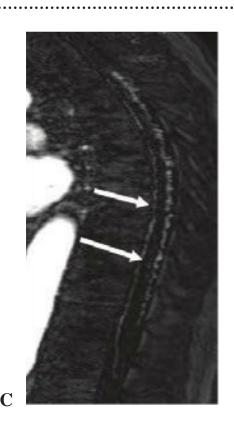


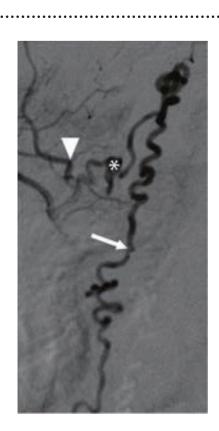
# Clinical Presentation

A 53-year-old man with lower back pain, progressive bilateral lower limb weakness, and recent bladder and bowel dysfunction.









(A) A sagittal T2-weighted image (T2WI) shows diffuse, ill-defined hyperintensity extending from the conus to the midthoracic level (arrowheads). Multiple flow voids are present in the extramedullary intradural space consistent with enlarged perimedullary veins (arrow). (B) Sagittal T1 with contrast shows ill-defined intramedullary contrast enhancement in the lower cord (arrowheads) and enhancing perimedullary veins (arrow). (C) Arterial phase of a dynamic sagittal T1-weighted image (T1WI) with contrast (magnetic resonance angiography [MRA]) demonstrates the abnormal vessels (arrows). (D) Digital subtraction angiography (DSA) image with a catheter within an intercostal artery at the T8 level demonstrates an abnormal direct communication (asterisk) between the feeding artery (arrowhead) and a dilated, tortuous draining vein (arrow).

# ■ Dif erential Diagnosis

- Spinal dural arteriovenous f stula (dAVF): These are abnormal connections between a radicular feeding artery and venous plexus of the spine without an intervening capillary bed. dAVFs result in venous hypertension and congestion, spinal hypoxia, and progressive myelopathy.
- Spinal cord tumor: An intramedullary mass can present with diffuse expansion of the cord, T2 hyperintensity, and enhancement. The length of cord expansion is usually relatively short and the mass may be associated with a syrinx. The absence of enlarged dorsal perimedullary veins on imaging does not exclude a spinal dAVF. However, the presence of these makes a tumor less likely.
- Spinal cord arteriovenous malformation (AVM): The presentation is often acute rather than insidious. On imaging, an AVM is also associated with cord edema and enlarged draining veins. An intramedullary nidus may be seen as enhancement or flow voids. A spinal AVM is more likely to result in intramedullary or subarachnoid hemorrhage.

#### **■** Essential Facts

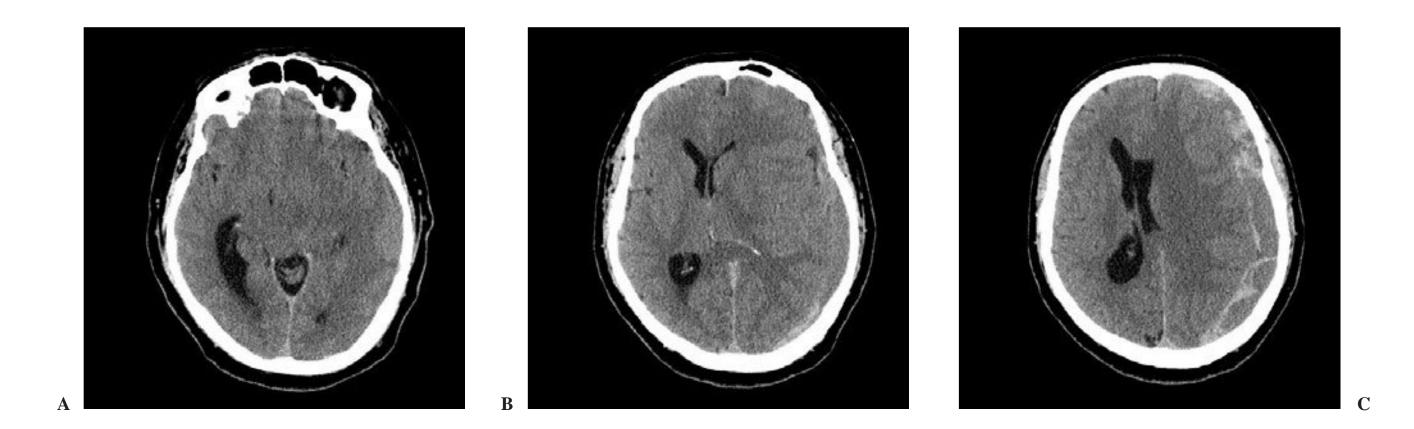
- Spinal dAVFs (type I spinal arteriovenous fistula [AVF]) are the most common vascular malformation of the spine (70% of spinal vascular lesions).
- Eighty percent are located between T6 and L2.
- They are shunts that form in the lateral epidural space between a radiculomeningeal artery and a radicular vein.
- An increase in spinal venous pressure leads to spinal cord venous congestion or reversal and myelopathy.
- Contrast-enhanced MRA is useful to confirm the diagnosis by demonstrating early venous filling and to locate the level of the lesion.
- DSA is essential to plan treatment.
- Prompt treatment of spinal dAVFs can limit the progression of symptoms.

# Other Imaging Findings

- Contrast-enhanced computed tomography (CT): may show enlarged distal spinal cord and enlarged perimedullary vessels
- Multidetector CT angiography: can be used to determine the location of the fistula and draining veins
- Magnetic resonance imaging (MRI):
- T1: diffusely enlarged, hypointense spinal cord
- T2: Ill-defined central hyperintensity with peripheral sparing. Multiple perimedullary flow voids.
- T1 with contrast: Enhancement of multiple, enlarged perimedullary vessels. Patchy intramedullary enhancement from blood-spinal cord barrier breakdown following venous congestion.
- Contrast-enhanced MRA: determines level of fistula, defines dilated veins, guides planning for DSA
- DSA: Selective injection of spinal or intercostal arteries to determine location of fistula and configuration of involved vessels for treatment planning. Delayed washout of arterial contrast suggestive of venous congestion.

  Normal venous return after injection of the anterior spinal artery effectively excludes spinal dAVF.

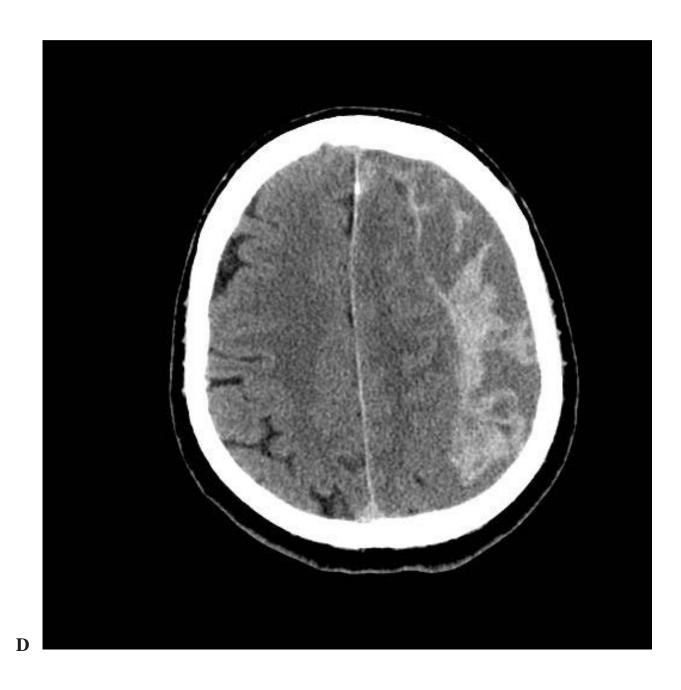
- resentation of dAVF is nonspecific, insidious, and includes mixed upper and lower motor neuron signs. Imaging may be the first opportunity to make the diagnosis.
- ✓ The presence of cord edema with enlarged perimedullary veins and without an intramedullary nidus is typical for spinal dAVF.
- ✓ Vord edema almost invariably involves the conus.
- ✓ Fost-contrast imaging may reveal abnormal vessels not appreciated on T2WI.
- \*The location of pathologic vessels and level of cord signal abnormality is not related to the level of the fistula.

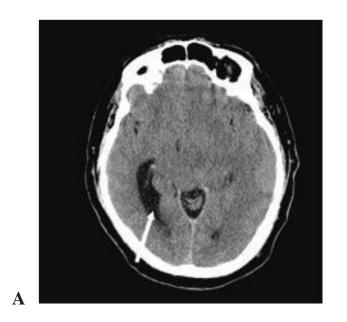


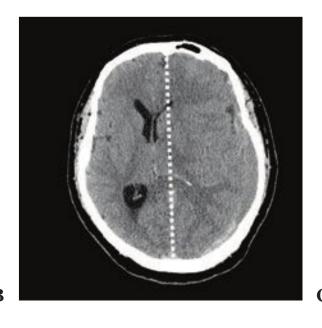
# Clinical Presentation

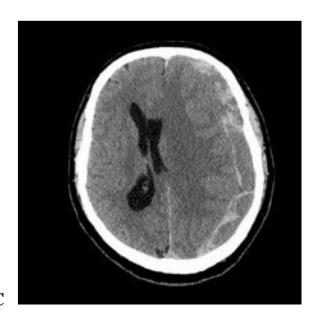
A 61-year-old man with a 5-day history of headache, confusion, and right-sided weakness.

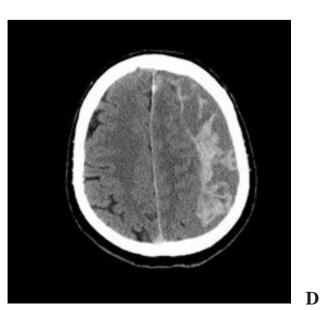
# **■** Further Work-up











(A–D) Axial unenhanced computed tomography (CT) images of the brain demonstrate a large heterogeneous mixed density collection overlying the left cerebral convexity. Note the presence of subfalcine midline shift toward the right as evidenced by the displacement of the lateral ventricles across midline (dashed line in B). The enlargement of the right lateral ventricle (arrow) signifies "trapping" of its outflow due to compression of the right foramen of Monro.

# Dif erential Diagnosis

- Subdural hematoma (SDH): Extra-axial hemorrhage that collects between the dural and arachnoid layers of the meninges. SDH can compress and displace the underlying brain. These are typically crescent shaped and hyperdense on CT. These hematomas can cross sutures and they tend to diffusely spread over the affected hemisphere. The hematoma does not cross over dural attachments but may travel along the falx or tentorium.
- Epidural hematoma (EDH): Accumulation of blood found between the dura mater and the skull. CT will depict a biconvex/rounded shape unlike the crescent shape of the subdural hematoma and will be more localized. The hematoma can cross dural attachments but is restricted by sutures. Usually has an associated calvarial fracture.
- Subdural empyema: Collection of pus in the subdural space. Commonly secondary to a frontal sinusitis. Has a crescentic shape. Subsequent contrast injection demonstrates intense rim enhancement surrounding the collection. Diffusion magnetic resonance imaging (MRI) shows restricted diffusion. Clinical history is also helpful, as the patients will often be systemically ill, febrile, and with elevated white cell counts. Be sure to evaluate the scan for precipitating causes such as frontal sinusitis or mastoiditis.

#### Essential Facts

- Imaging findings necessitate urgent verbal communication of findings to the clinician.
- SDH is most commonly due to trauma, which injures bridging cortical veins in the subdural space.
- Risk factors include elderly patients on anticoagulation.
- Mixed density within an SDH signifies the presence of acute or chronic hemorrhage.
- Mixed density SDH in a child may be a sign of nonaccidental trauma.

### Other Imaging Findings

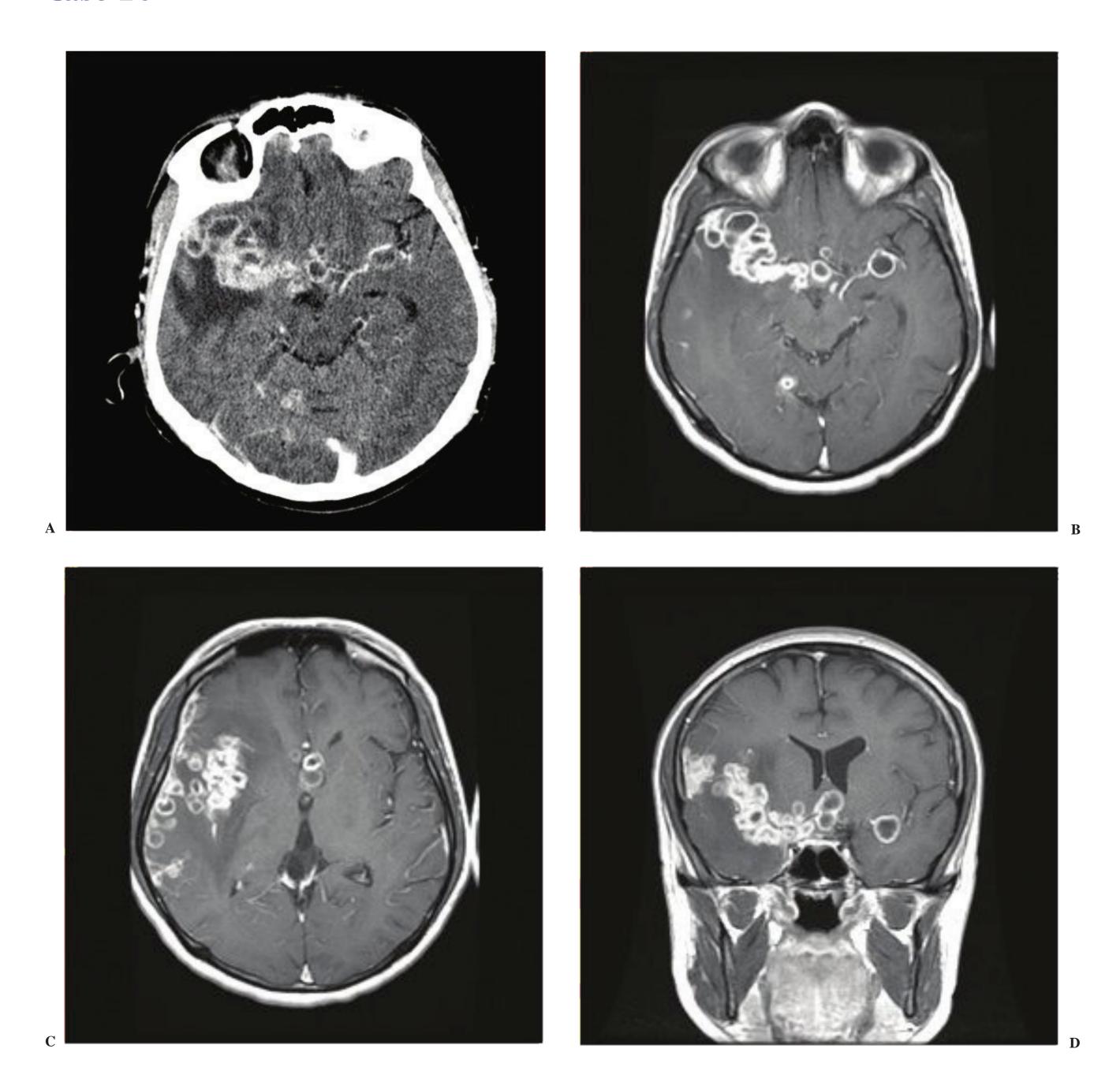
#### • CT:

- Hyperdense, crescent-shaped collection overlying the cerebral convexity
- SDH may also extend along the falx and tentorium.
- Heterogeneity of the SDH may indicate acute or chronic hemorrhage—"swirl" sign of active bleeding.
- Infiltration of cerebrospinal fluid (CSF) into hematoma will also give a mixed appearance to the SDH.
- A hematocrit level may be present, which indicates chronicity.
- May get peripheral enhancement in subacute SDH that can arise anywhere from 3 days to 3 weeks after onset.

#### • MRI:

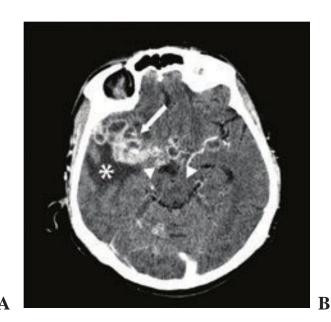
- Blood will be of variable signal intensity depending on the age and type of blood product.
- Acute blood is typically isointense on T1WI and hyperintense on T2WI.
- Susceptibility or gradient imaging: Blood is of low signal diffusion weighted imaging (DWI).
- Diffusion imaging: Blood will be of variable signal intensity.

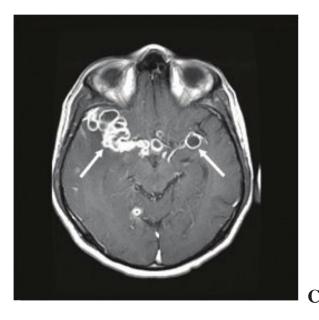
- ✓ CT is the first-line imaging modality for assessment of acute intracranial hemorrhage.
- ✓ Cute hemorrhage on CT is almost always hyperdense.
- certain conditions that may give rise to lower attenuation acute hematoma includes a very low hematocrit/anemia or the presence of CSF intermixing with blood.
- ✓ ways look for secondary effects: midline shift, hydrocephalus, and infarction.
- ening the window level on the picture archiving and communication system (PACS) viewer will help increase conspicuity of blood and aid in detection.
- ✓ Cinical presentation can vary from asymptomatic to the loss of consciousness; may also include a lucid interval.
- ✓ Cematoma thickness of a midline shift. 20 mm may indicate poor outcomes.

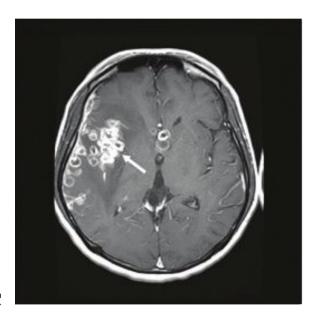


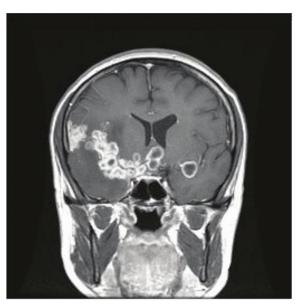
# Clinical Presentation

A 35-year-old man who presents with a known history of disseminated tuberculosis (TB) is brought to the hospital after being found unconscious.









D

(A) Axial contrast-enhanced computed tomography (CT) image demonstrates numerous rim-enhancing lesions along the basal pial surfaces within the right sylvian f ssure (arrow) and suprasellar region (arrowheads). Marked edema is shown in the right frontal and temporal operculum (asterisk). (B–D) Axial and coronal T1-weighted images postgadolinium show numerous clustered rim-enhancing lesions in the sylvian f ssures bilaterally (arrows), with associated edema.

# Dif erential Diagnosis

- Tuberculous meningitis: Central nervous system (CNS) infection with TB most commonly causes a basal leptomeningitis. Involved meninges show diffuse contrast enhancement with obliteration of basal cisterns. Meningeal, parenchymal, and ependymal tuberculoma formation can accompany meningitis. Parenchymal involvement is predominantly supratentorial in adults, commonly marked by cerebral edema surrounding one or more solid or rim-enhancing granulomas at the corticomedullary junction. Imaging properties of granulomas vary depending on presence of caseous necrosis and liquefaction.
- Abscess: Racemous cysticercosis, a rare presentation of neurocysticercosis, is characterized by proliferative lobulated meningeal cysts mostly in the basal meninges. Imaging may show characteristic scolices (intracystic parasite) within some cysts. It occurs predominantly in young adults due to fecal—oral contamination from a tapeworm carrier. Toxoplasmosis and fungal infections can cause multiple rim-enhancing lesions in immunocompromised patients.
- Neurosarcoidosis: Sarcoid involvement of the CNS most commonly causes a diffuse or nodular thickening and enhancement of the leptomeninges of the basal cisterns. With leptomeningeal involvement, the pituitary stalk, optic chiasm, and nerve are often involved. Parenchymal granulomatous mass lesions are rarely found associated with leptomeningeal disease, and are usually noncaseating, hypointense on T2-weighted imaging (T2WI) and show nodular enhancement. Usually, concurrent systemic disease is present.

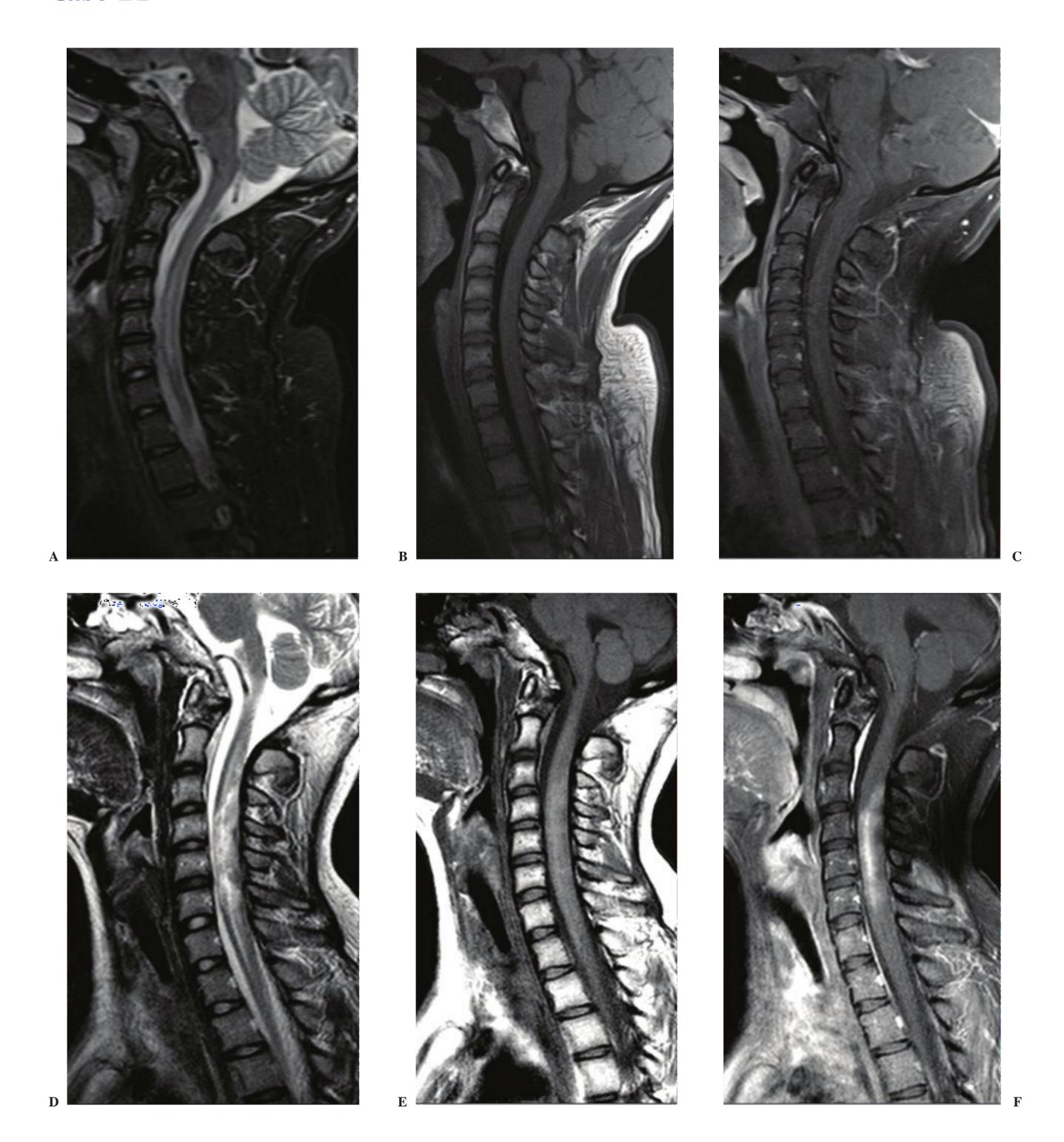
#### Essential Facts

- Almost always secondary to hematogenous spread from pulmonary primary TB
- Communicating hydrocephalus and ischemic basal ganglia/internal capsule infarction are common complications.
- Cranial nerves II, III, IV, and VII are often involved clinically.
- Acid-fast bacillus smear positivity is low (, 40%) on initial lumbar puncture (LP).
- Twenty-five to 30% mortality; 80% long-term morbidity

# Other Imaging Findings

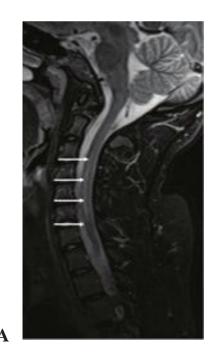
- CT: effacement of basal cisterns by iso- to hyperdense exudates
- Hypo- to hyperdense round or lobulated parenchymal nodules with surrounding edema may be present, corresponding to tuberculomas.
- Communicating hydrocephalus may be present.
- With contrast: intense basilar meningeal enhancement with solid or rim-enhancing nodules
- Magnetic resonance imaging (MRI):
- T1: iso- to hyperintense meninges/variable intensity nodules; caseating granulomas may have hyperintense rim
- T2: iso- to hyperintense meninges/variable intensity nodules with hypointense rim and surrounding edema
- Fluid-attenuated inversion recovery (FLAIR): hyperintense exudates in basal cisterns and sulci
- Diffusion weighted imaging (DWI): can detect ischemic complications, if present
- T1 with contrast: marked meningeal enhancement/ nodular, homogeneously enhancing or rim-enhancing granulomas
- Angiography: can detect narrowing of supraclinoid internal carotid artery (ICA), M1, A1, small/medium-sized arteries if arteritis is present

- ✓ Casilar leptomeningitis with parenchymal involvement is highly suggestive of CNS TB.
- ✓ aging of the spine should be done to rule out concomitant spinal lesions in cases of CNS TB.
- ✓ CT and MRI characteristics of tuberculous granulomas vary depending on if the granuloma is caseating with a liquid center or solid center, or noncaseating.
- ✓ Cadiologic response to antituberculous therapy usually takes 4 to 6 weeks.
- asilar leptomeningitis in the absence of parenchymal lesions is nonspecific and has a wide differential diagnosis.

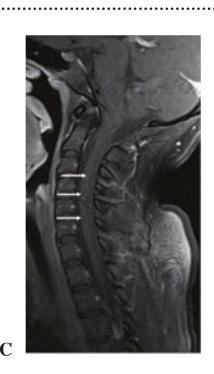


### Clinical Presentation

A 17-year-old girl developed sudden onset sharp pain and paresthesia in the left shoulder while on a flight. Later, paresthesia progressed to involve the bilateral arms, trunk, and bilateral lower extremities. She noted weakness almost immediately after the onset of the paresthesia, with rapid progression to quadriparesis. Images A, B, and C are from initial presentation. Images D, E, and F are from 3 weeks later.













(A) Sagittal T2-weighted magnetic resonance (MR) image demonstrates mild cervical cord expansion with central intramedullary hyperintensity spanning seven vertebral segments from C2 to T1/T2 (white arrows). (B) Sagittal T1-weighted MR image exhibits mild cervical cord expansion (white arrowheads) with subtle hypointensity. (C) Sagittal T1-weighted image postcontrast demonstrates no significant enhancement (white arrows). (D) Three-week follow-up imaging shows interval progression of patchy intramedullary T2 hyperintensity (white arrows). (E) Sagittal T1-weighted MR image shows interval increase of cord expansion (white arrowheads). (F) Sagittal T1-weighted image postcontrast demonstrates a confluent area of enhancement from C3 to C6 (white arrows). Patchy enhancement in the lower cervical and upper thoracic spinal cord (not shown here) was also seen.

#### **■** Dif erential Diagnosis

- Transverse myelitis: Typically involves the central cord affecting more than two-thirds of cross-sectional area of the cord. The lesion spans more than two vertebral body levels and causes smooth spinal cord expansion. Enhancement characteristics are variable, ranging from no enhancement to solitary and multifocal disease. It is more commonly seen when cord expansion is present and in the subacute stage.
- Multiple sclerosis: Primary demyelinating disease of central nervous system with multiple lesions disseminated over time and space. Ninety percent of the time, concomitant intracranial lesions are seen. When isolated spinal cord disease is present, the cervical spine is most frequently affected. In contrary to transverse myelitis, multiple sclerosis predominantly involves the peripheral dorsolateral aspect of the cord, spanning less than two vertebral body levels and less than half of the cross-sectional area of the cord. Lesions typically are oval with peripheral distribution.
- Spinal cord infarction: Cord infarction secondary to vessel occlusion typically involves the anterior radicular artery (artery of Adamkiewicz) and, therefore, the anterior two-thirds of the distal half of the thoracic cord. This presents as hyperintense central gray matter within the cord on T2-weighted imaging (T2WI), giving an "owl's eye" appearance and slight cord expansion in acute phase. Its onset is abrupt, with weakness more pronounced than loss of sensation and rapid progression to maximum deficit within hours.

#### Essential Facts

- Transverse myelitis (TM) refers to an idiopathic form of inflammatory condition interrupting both motor and sensory tracts at one level, resulting in bilateral motor, sensory, and autonomic dysfunction.
- TM is a diagnosis of exclusion. Etiology is unknown, but possible association includes prior viral infection or vaccination. Alternative diagnoses (compressive etiology,

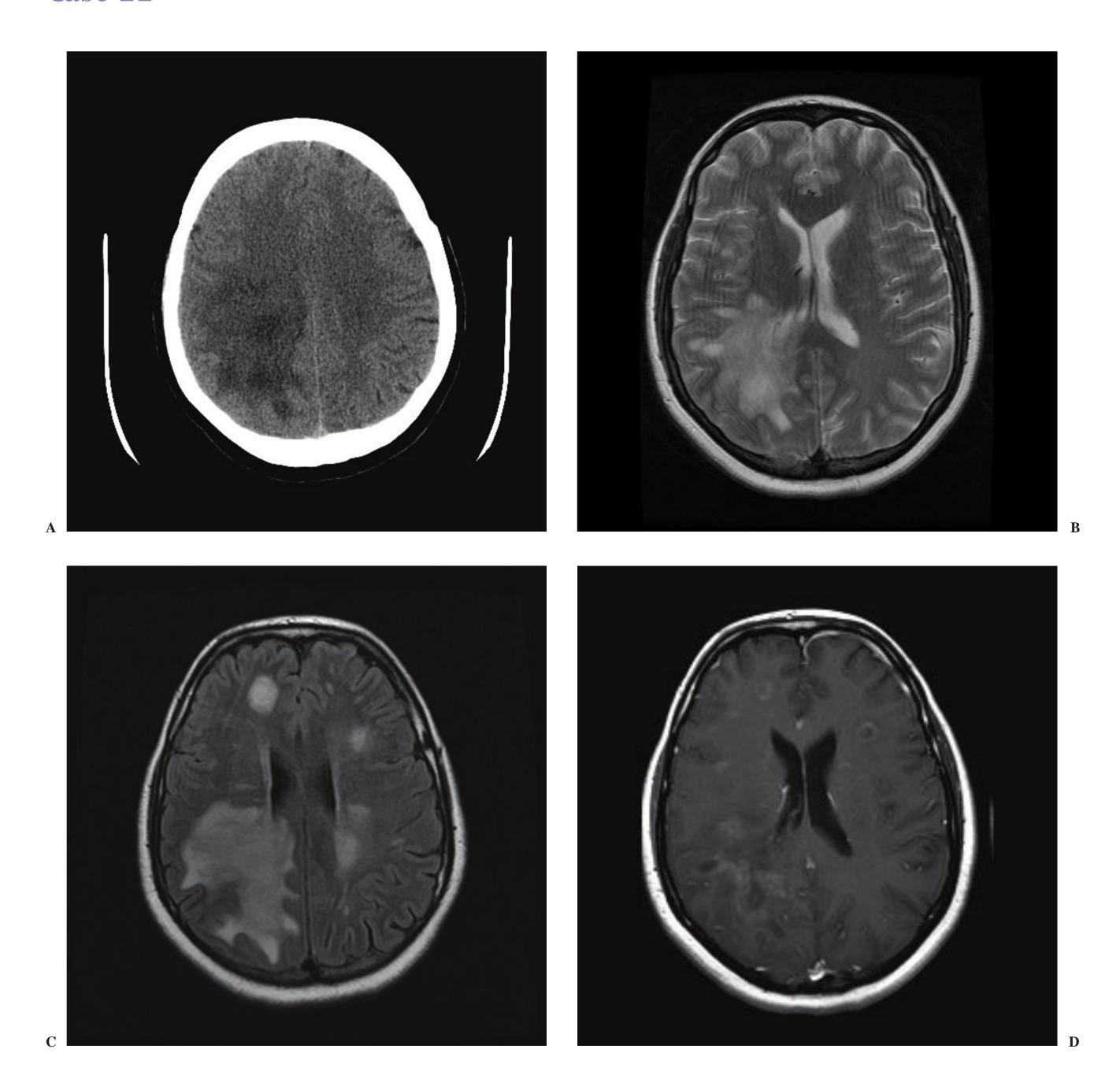
- connective tissue diseases, infarction, arteriovenous malformations [AVMs], and infections) with similar clinical presentation need to be excluded.
- Onset may be acute or subacute.
- Thoracic spinal cord is most commonly affected, followed by the cervical spine.
- All ages can be affected, with two peaks at 10 to 20 years old and 30 to 40 years old.
- TM results in necrosis, which involves both gray and white matter, with destruction of neurons, axons, and myelin.

# Other Imaging Findings

- Computed tomography (CT) is of limited value but can identify spinal cord expansion. CT myelography can exclude extra-axial compressive causes and demonstrates blockage of cerebrospinal fluid (CSF) flow secondary to cord swelling.
- Magnetic resonance imaging (MRI) is the modality of choice:
  - T1: smooth cord expansion with isointense to hypointense signal abnormality
- T2: Hyperintense lesion involving a long cord segment (more than three or four vertebral segments), with central predominance and relative sparing of the periphery. "Central dot sign" refers to isointensity of spinal cord core with peripheral T2 hyperintensity. This is thought to represent gray matter surrounded by edema.
- T1 postcontrast: Variable enhancement pattern ranging from none to multiple lesions. It is more common in subacute stage when cord enlargement is present and resolves over time.

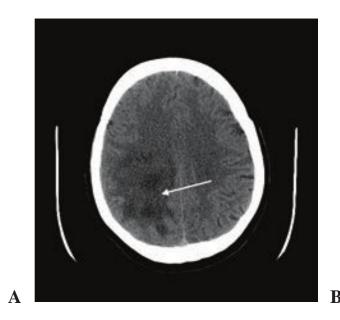
- ✓ Giopathic transverse myelitis is a diagnosis of exclusion with multiple differential considerations.
- ✓ is important to evaluate the brain and optic nerves to exclude intracranial lesions that point to alternative diagnosis of multiple sclerosis or neuromyelitis optica.

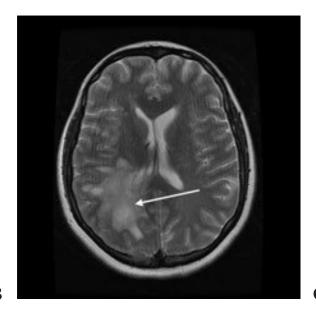
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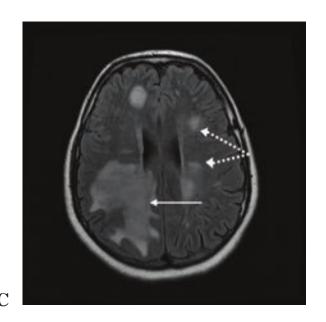


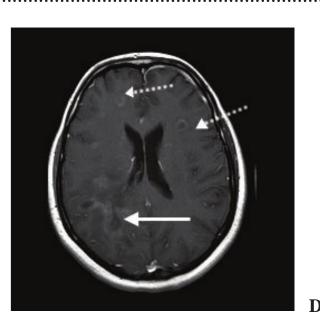
# Clinical Presentation

A 34-year-old woman with subacute onset of left arm weakness.









(A) Noncontrast computed tomography (CT) image of the head demonstrates a large mildly heterogenous hypodensity in the right parietal lobe with mild mass effect and sparing of the overlying cortex (white arrow). (B) Axial T2-weighted magnetic resonance (MR) image of the brain demonstrates corresponding abnormal high T2 signal in the right parietal lobe (white arrow). (C) Axial fluid-attenuated inversion recovery (FLAIR) MR image of the brain demonstrates corresponding abnormal FLAIR signal in the right parietal lobe (solid white arrow) and additional rounded, ovoid, and linear foci of increased FLAIR signal in the periventricular and subcortical white matter (dotted white arrows). (D) Axial T1-weighted MR image of the brain with contrast demonstrates associated thick, peripheral, discontinuous enhancement surrounding the right parietal focus (solid white arrow). Additional nodular and ringlike enhancing foci are present in both cerebral hemispheres (dotted white arrows). Note the lack of vasogenic edema.

### Dif erential Diagnosis

- Tumefactive multiple sclerosis (MS): This demyelinating lesion can be a diagnostic dilemma in the absence of a known diagnosis of MS. Magnetic resonance imaging (MRI) often demonstrates a single tumorlike mass centered within the white matter, which usually measures greater than 2 cm. Unlike other malignant processes, there is little or no mass effect or surrounding vasogenic edema. Smooth, discontinuous rim of peripheral enhancement is considered the hallmark of tumefactive MS; however, identifying typical patterns of MS such as linear and ovoid periventricular high T2 white matter lesions (known as "Dawson fingers") are also helpful in arriving at the correct diagnosis.
- Multifocal glioblastoma multiforme: These grade
  4 astrocytic tumors can occur in any age. They are rapidly
  growing, aggressive tumors, which appear irregular on
  CT and MRI. Typically, extensive surrounding vasogenic
  edema and mass effect is seen. They commonly enhance
  solidly; however, in the setting of central necrosis, they
  can demonstrate thick, irregular, continuous peripheral
  enhancement. Involvement of the supratentorial white
  matter and corpus callosum is common. On MRI, these
  lesions often appear T2 hyperintense without associated
  restricted diffusion. In the setting of intralesional
  hemorrhage, a blooming artifact can be seen on gradient
  or susceptibility weighted imaging (WI).
- CNS lymphoma: Primary CNS lymphoma is a non-Hodgkin lymphoma, which preferentially occurs in the supratentorial brain. The prevalence is significantly higher in immunocompromised patients, as compared with immunocompetent patients. These lesions typically arise in the periventricular region. Perivascular and corpus callosal extension are not uncommon. On unenhanced CT imaging, these cellular lesions appear hyperdense; however, a negative study does not exclude the diagnosis. MRI is considered the modality of choice. Due to its high cellular nature, these tumors often appear hypointense on T2, unlike gliomas and

demyelinating disease, and hyperintense on diffusion WI. Continuous ring enhancement pattern is seen in the immunocompromised patient population secondary to central necrosis.

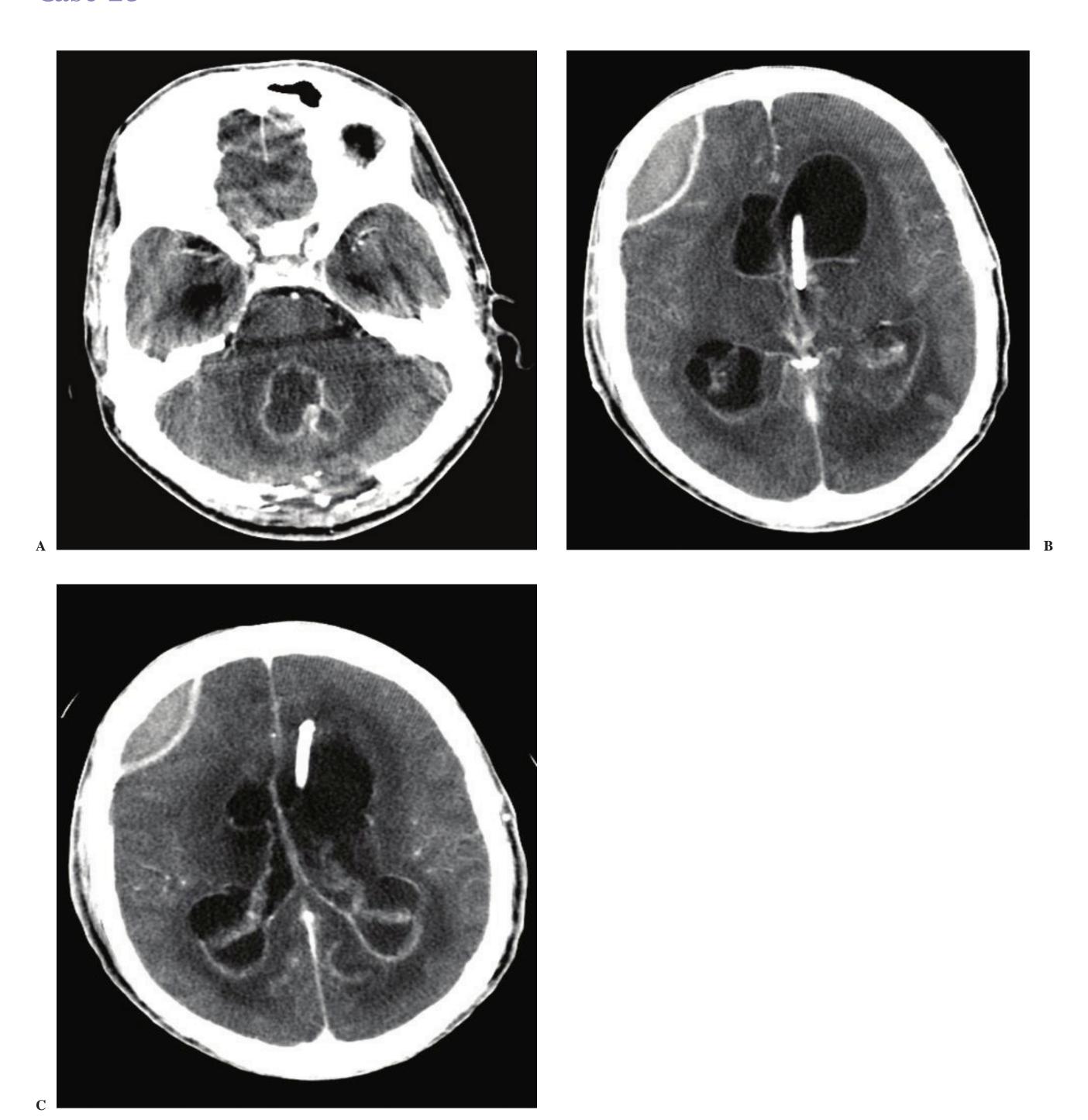
#### Essential Facts

- Clinically, patients will present with neurologic deficits, which are related to the size and location of the lesion.
- In the absence of a known history of multiple sclerosis, these lesions may result in surgical biopsy or excision.
- Treatment with corticosteroids often results in marked reduction in size and or resolution of the lesions, thus helping to differentiate them from other more malignant processes.

#### Other Imaging Findings

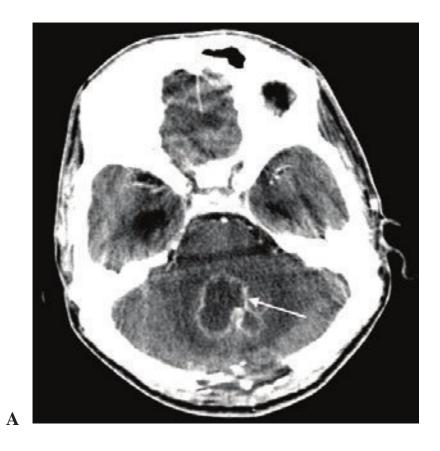
- CT imaging: nonspecific area of hypoattenuation with minimal or no mass effect and sparing of overlying cortex
- MRI:
- Circumscribed, supratentorial white matter lesion
- Little or no associated mass effect or vasogenic edema
- Discontinuous, smooth ("arclike") peripheral enhancement, typically with the open portion of the ring directed to the gray matter
- T2: can occasionally see a central dilated intralesional vein
- Perfusion imaging: usually decreased perfusion, unlike the increased perfusion seen with high-grade primary and metastatic intra-axial neoplasms

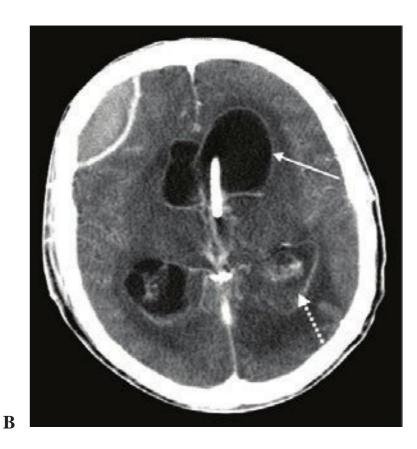
- ✓ Corpus callosal involvement is nonspecific for tumefactive MS and can be seen with CNS lymphoma and glioblastoma multiforme.
- ✓ Centifying the stigmata of MS can help confirm the diagnosis.
- ✓ Complete ring enhancement is a specific finding of demyelinating disease; however, rarely, it can be seen with cerebral abscess and neoplasm.



# Clinical Presentation

A 30-year-old man presents with decreased level of consciousness 3 days post-posterior fossa surgery for benign disease.







(A–C) Axial contrast-enhanced computed tomography (CT) images show the presence of a ventricular catheter placed through a left frontal approach with the tip in the region of the third ventricle. There is hydrocephalus as well as abnormal rim enhancement along the ventricular lining (arrows). Abnormal haziness is also present within the fourth ventricle and the dependent portions of the lateral ventricles (dashed arrow in **B**). Low attenuation along the periventricular white matter is also noted.

# Dif erential Diagnosis

- Ventriculitis: This is an infection of the ventricular ependyma that can be related to a ruptured brain abscess, meningitis, neurosurgical procedures, or as a complication of ventricular catheter placement. Imaging reveals ventriculomegaly and debris within the ventricles and enhancement of the ependymal lining of the ventricle. Impairment of cerebrospinal fluid (CSF) drainage and flow hydrocephalus. Periventricular low attenuation is secondary to transependymal CSF transudation. An extra-axial empyema is also present in this case as evidenced by the rim-enhancing collection overlying the right frontal lobe.
- Ependymal tumor spread: This may cause ventriculomegaly and ependymal enhancement. Primary brain tumors that spread in this manner include glioblastoma multiforme and medulloblastoma. Metastatic disease from lung and breast primaries may also metastasize into the ependyma.
- Lymphoma: Lymphoma may also involve the ependyma. Associated parenchymal disease is usually present as evidenced by enhancing lesions in the basal ganglia.

#### Essential Facts

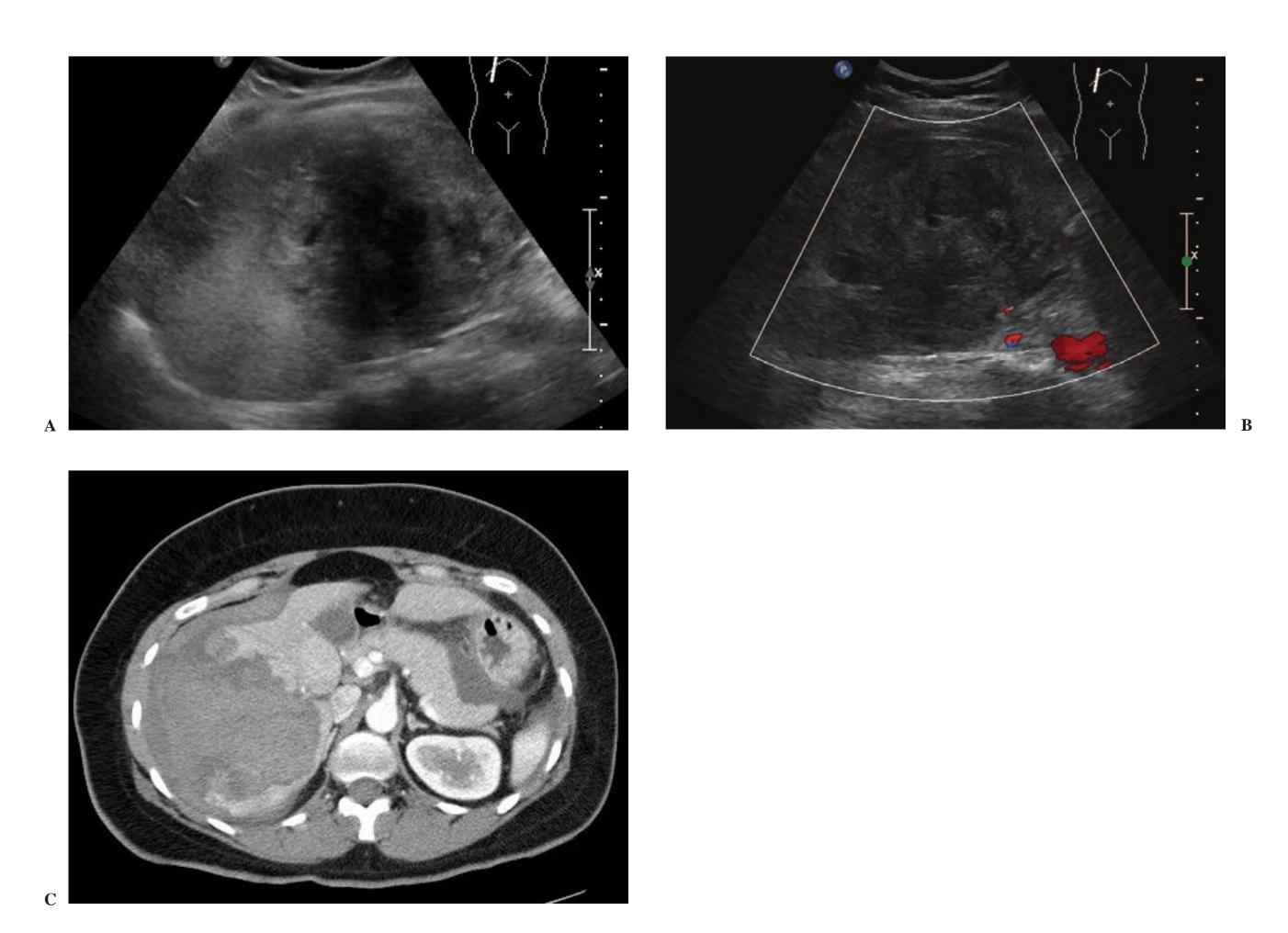
- Ventriculitis is an infection of the ventricular lining.
- Males are affected more commonly than females.
- Can affect infants as a complication of meningitis
- The mortality rate is high, ranging from 40 to 80%.
- The primary treatment involves surgical irrigation and drainage along with antibiotics.

• Common organisms include *Staphylococcus* and *Enterobacter* species.

# Other Imaging Findings

- CT: Diffuse enhancement of ventricular walls. Ventriculomegaly with debris levels.
- Magnetic resonance imaging (MRI):
  - T1: ventriculomegaly with hyperintense debris; ependymal enhancement
- T2: periventricular hyperintensity
- Choroid plexitis may be seen—enhancement and enlargement of the choroid.
- Diffusion weighted imaging (DWI): diffusion restriction of debris
- Ultrasonography: In infants, ventriculomegaly, periventricular echogenicity. Echogenic debris layering in ventricle.

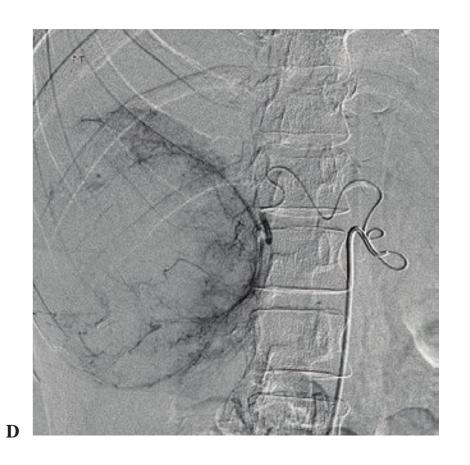
- ✓ Cltrasound is the best diagnostic tool in infants.
- ✓ Gresence of ventricular debris and hydrocephalus are among the most common imaging findings.
- ✓ Syogenic ventriculitis can be clinically indolent; imaging and a high index of suspicion are required to ensure a prompt diagnosis.
- ✓ Giagnosis is made by a combination of CSF analysis and neuroimaging.

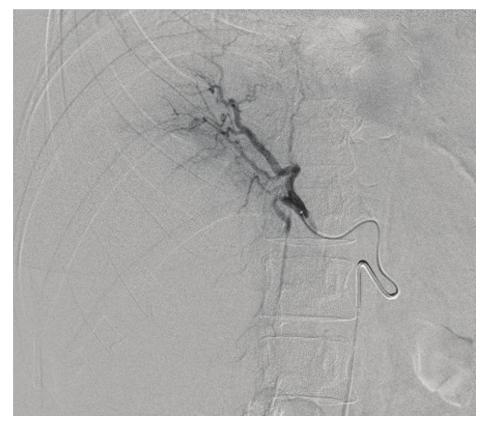


# Clinical Presentation

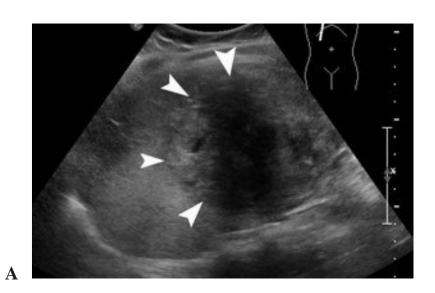
A 37-year-old woman walking to work developed sudden upper abdominal pain and collapsed on the sidewalk. An abdominal ultrasound (US) was performed to exclude cholecystitis. This was followed by a contrast-enhanced computed tomography (CT) of the abdomen.

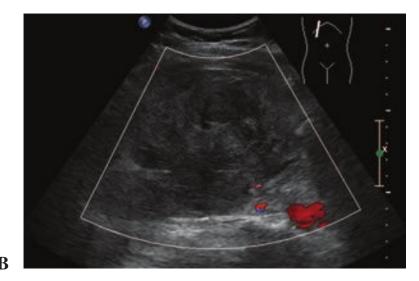
# **■ Further Work-up**





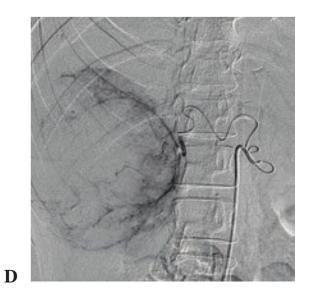
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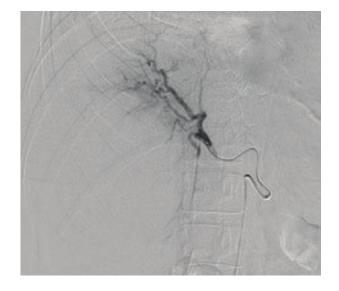






C





(A) The initial US demonstrates a well-defined heterogeneous mass within the right hepatic lobe (arrowheads represent the border of the mass).

(B) Doppler imaging does not demonstrate the mass to be vascular.

(C) Axial image of an enhanced CT demonstrates normal enhancing liver parenchyma with most of the right lobe replaced with mildly enhancing mass. Peripheral to the liver, fluid of differing densities is present representing acute hemorrhage of differing ages (asterisk represents acute blood and xrepresents older blood). (D) Asubselective hepatic angiogram demonstrates the dominant feeding vessel to the right hepatic mass.

(E) Postembolization. Vascular feeding to the mass has been eradicated.

### Dif erential Diagnosis

- Hepatocellular adenoma (HA) with nontraumatic intraperitoneal hemorrhage: US of HA with intratumoral bleeding appears heterogeneous in echogenicity. On portal venous phase and delayed CT scans, HA appears isoattenuate relative to healthy liver tissue and well demarcated. On unenhanced CT scan, HA may display hypoattenuation. Areas of intratumoral bleeding are hyperattenuating and hyperdense foci unless actively bleeding. Angiography shows hypervascular masses with vascular supply arising peripherally. Areas corresponding to hemorrhage appear hypovascular.
- Hepatocellular carcinoma (HCC): HCC often appear poorly demarcated with irregular, coarse internal echoes on US. Attenuation pattern on CT is variable, the most common being iso-hyper-isoattenuation on the prophase, arterial phase, and venous phase.
- *Liver abscess:* Liver abscess appears with poorly def ned boundaries on US. Echogenicity is variable (from hypoechoic to hyperechoic). CT appearance of liver abscess is variable but low-density lesions can be seen in the center of abscess.

### Essential Facts

- Rare, benign tumor of the liver
- Present predominantly in 20- to 44-year-old women
- Strongly associated with prolonged oral contraceptive use, anabolic androgen use, and glycogen storage diseases
- Solitary in 70 to 80% of cases

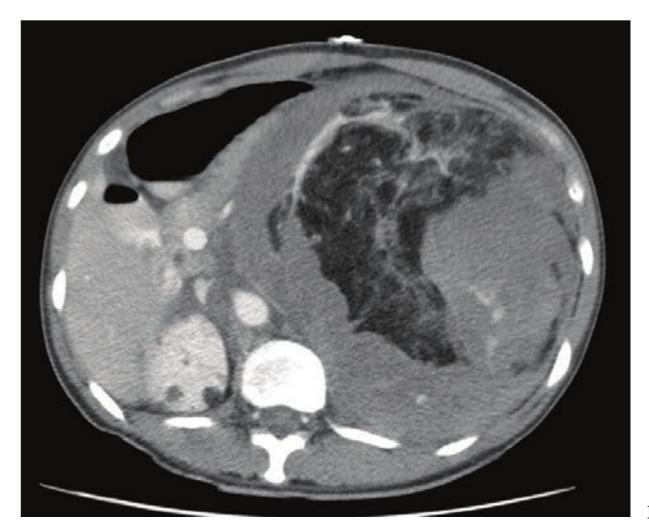
- Associated with hemorrhage, rupture, and malignant transformation
- Often detected when patients undergo imaging for unrelated or nonspecif c symptoms

### Other Imaging Findings

- Magnetic resonance (MR):
  - T1: hyperintensity often due to presence of hemorrhage or fat
  - T2: predominantly hyperintense, can also be heterogeneous due to presence of hemorrhage and necrosis
    - Dynamic gadolinium-enhanced gradient echo shows early enhancement. On delayed images, becomes isointense relative to liver.

- ✓ Carterial phase contrast CTs often demonstrate subtle hypervascular enhancement of the adenoma, whereas venous phase can be hypodense or isodense with the background enhancement the liver.
- ✓ agnetic resonance imaging (MRI) scans enhance early after gadolinium injection.
- ✓ Codenomas are "cold" on nuclear medicine imaging in contrast to focal nodular hyperplasia.
- denomas usually have sharply defined borders and can be confused with metastatic tumors on CT scans.
- denomas are benign tumors, which at no time require surgical intervention.

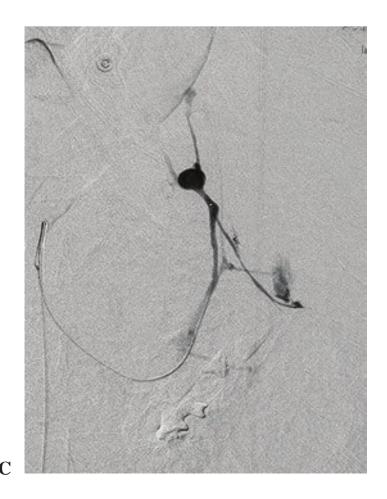




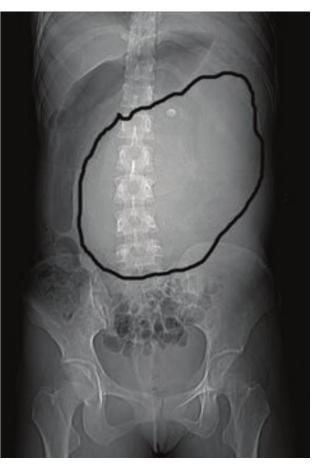
#### Clinical Presentation

A 41-year-old otherwise healthy Asian woman suddenly passed out at work and was brought to the emergency room. She was found to be hypotensive and tachycardiac with abdominal guarding. An initial anteroposterior (AP) radiograph of the abdomen was obtained followed by a contrast-enhanced computed tomography (CT) of the abdomen.

### **■** Further Work-up

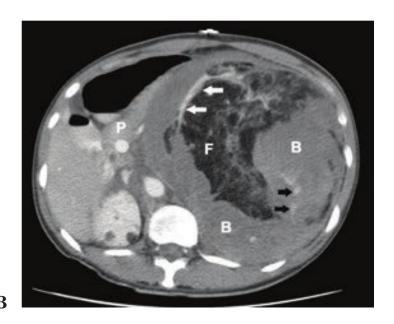


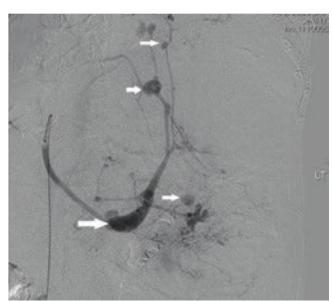




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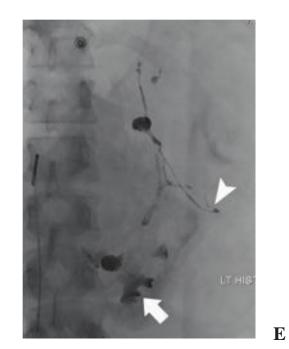












(A) Abdominal X-ray shows increased opacity in the abdomen on the left (black ring) with bowel loops pushed to the right indicating substantial mass effect. (B) Axial contrast-enhanced CT demonstrates a large fatty mass on the left interspersed with blood vessels. The white arrows indicate renal parenchyma. Black arrows represent active arterial bleeding/extravasation. (B), blood surrounding the fatty mass (F); (P), pancreas displaced to the right. (C) Selective left renal angiogram shows multiple aneurysms (arrows). (D) Subselective injection opacifies a single arterial branch (white arrows), which is actively bleeding (black arrow). (E) A single spot image following glue embolization demonstrates glue casting through the arteries and the bleeding vessel occluded at the point of extravasation (arrowhead). Note contrast within the remnant collection system of the kidney (arrow).

#### **■** Dif erential Diagnosis

- Ruptured aneurysm in a renal angiomyolipoma (AML): Angiogram of a renal AMLshows hypervascularity with interlobar and interlobular arteries. Intratumoral arteries are tortuous, irregular, and could be aneurysmal. On CT scans, AMLs are often well demarcated, with a heterogeneous attenuation due to areas of fat (attenuation of, 2 20 HU) and necrosis. Lesions usually involve the cortex of the kidney. The area of intratumoral bleeding has the appearance of hyperattenuation and a hyperdense foci unless actively bleeding.
- Renal cell carcinoma: Lesions appear to have soft tissue attenuation on noncontrast CT. With larger lesions, necrosis may be observed. On contrast CT, small lesions appear to be homogeneous, but heterogeneity can be appreciated with larger lesions due to areas of necrosis. Angiomyolipomas are usually differentiated with renal cell carcinoma by the presence of macroscopic fat.
- Retroperitoneal liposarcoma: This is a cancer of mesenchymal tissue that may arise in a fat-containing organ. CT will show heterogenous attenuation demonstrating varying areas of fat and soft tissue. Soft tissue will be enhanced and multiple septae can be seen. The kidney will be distinct from the mass.

# Essential Facts

- Angiomyolipoma is a benign neoplasm consisting of vascular, smooth muscle and fat elements.
- Highly associated with tuberous sclerosis

- Eighty percent of cases are sporadic.
- Females are more susceptible than males (F:M 5 4:1).
- A 4-cm size is considered the accepted cutoff size for risk of major spontaneous bleeding.

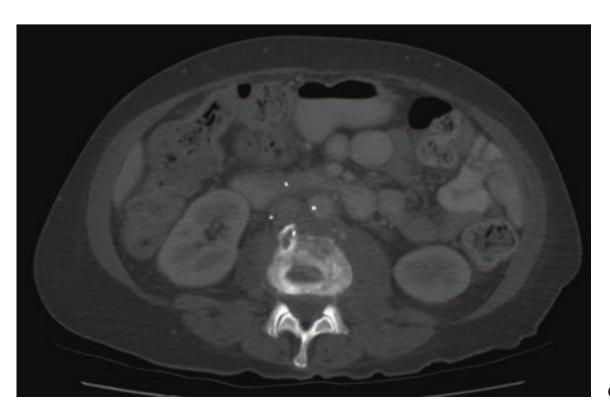
### Other Imaging Findings

- Magnetic resonance:
- T1: Presence of fat is observed with high signal intensity.
- T2: Signal is of similar intensity as perinephric fat.
- Ultrasound:
- Echogenicity is intense and acoustic shadowing may be present.
- Hemorrhagic, necrotic areas appear hypoechoic.
- Less echogenic areas of angiomyolipoma associated with bleeds, necrosis, or calyxes

- ✓ Cnenhanced CT will provide a better differentiation of fat as contrast-enhanced CTs will potentially average out the fat.
- \* Angiomyolipomas that are fat poor and are difficult to differentiate with renal cell carcinoma (5% of patients are false negative for angiomyolipoma); this is particularly true for angiomyolipomas that present with tuberous sclerosis.







 $\mathbf{c}$ 

### Clinical Presentation

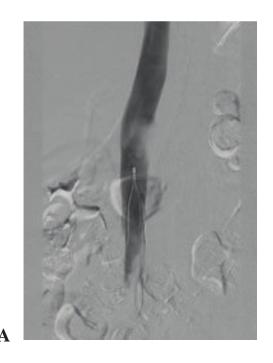
A 54-year-old female patient with deep vein thrombosis had an uneventful placement of an inferior vena cava (IVC) filter for prophylaxis prior to hip surgery. (B) Three months later, the patient complains of mild back pain. (C) Another three months later, the patient re-presents with worsening back pain.

# **■** Further Work-up





 $\mathbf{E}$ 













placement. However, with close inspection, sclerosis of the vertebral body endplate anteriorly (arrow) is evident. (C) Enhanced computed tomography (CT) obtained on re-presentation demonstrates three legs have perforated the IVC into the duodenum and aorta (white arrows) and the vertebral body (black arrow) with a reactive bony exostosis. (D) A sagittal CT reconstruction shows destruction of the bony endplates at L2/3 with loss of the disk space. (E) A magnetic resonance imaging (MRI) sagittal image demonstrates enhancing tissue abutting the destroyed disk space (arrows).

(A, B) An anteroposterior (AP) abdominal X-ray obtained for back pain demonstrates good positioning of the IVC filter a few months after

#### **■** Dif erential Diagnosis

- Diskitis/osteomyelitis (infective spondylitis): Early-stage changes are not evident on X-rays; however, disk space narrowing could be present in later stages, accompanied by irregular anterior metaphyseal regions of affected bones. CT shows similar findings as X-ray but has higher sensitivity to early-stage manifestations. T1-weighted MRI shows hypointense, extensive inflammatory changes at affected vertebral level in patients with diskitis. Vertebrae affected by osteomyelitis may show periosteal reaction, cloaca, sequestration, and paravertebral abscesses.
- Spinal metastasis: X-rays may show hypodense lytic or hyperdense sclerotic lesions in the vertebrae. Bone scintigraphy will show metastatic lesions as "hot zones." CT and MRI will show well-delineated cortical destruction of vertebrae and is typically more diffuse than focused on one or two vertebral body levels.
- Osteoarthritis: X-ray should show narrowing of the joint space, sclerosis, and osteophyte formation. No bony destruction as seen in infections.

#### Essential Facts

• Osteomyelitis usually affects nontubular bones (e.g., hip, vertebrae).

- Bimodal age distribution; pediatric and late middle age/ older patients (, 50 years of age)
- Staphylococcus aureus is the most common cause of osteomyelitis.
- Affects, 0.1 to 1.8% of adult healthy population
- Diabetes is the greatest risk factor for developing osteomyelitis.
- Disease usually forms secondary to an adjacent infection.

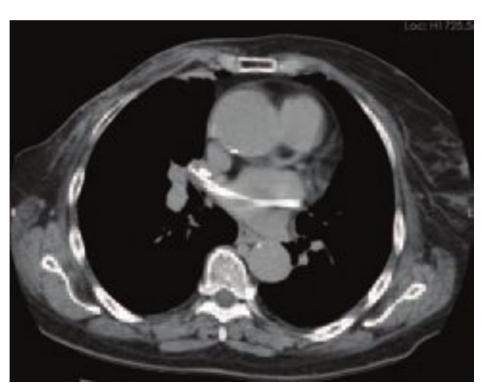
# Other Imaging Findings

- Magnetic resonance:
- T2-weighted MRI shows hyperintensity at affected area.
- Bone scan:
- Increased signal can be observed at site affected.
- More sensitive test than CT

- T may not be good for a differential diagnosis but useful for guided joint aspiration to identify the causative organism of infection.







 $\mathbf{C}$ 

# Clinical Presentation

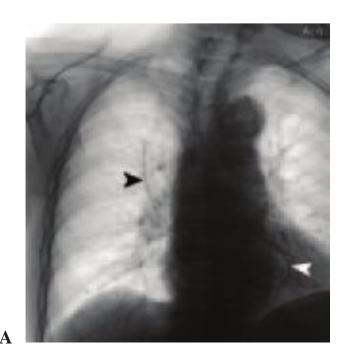
A 57-year-old female patient arrives at the clinic for removal of chemotherapy port placed a year earlier but not in use for 4 months. At the time of removal, the catheter was not found. The patient was asymptomatic. A radiograph, a venogram, and unenhanced computed tomography (CT) chest was performed.

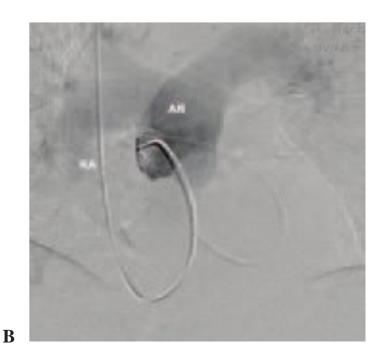
# **■** Further Work-up





D







C





E

(A) Initial chest X-ray reveals a catheter fragment partially embolized to the heart (arrowheads). (B) During attempted retrieval via the right internal jugular vein, a venogram was performed. AR, aortic root; RA, right atrium. (C) Plain chest CT shows the catheter passing from the superior vena cava (SVC) and the left atrium (LA). (D) Intravascular ultrasound (IVUS) demonstrates the catheter fragment (arrows) in both the right (RA) and left atriums (LA). Long arrow indicates a large hole between the right and left atrium. (E) Plain chest radiograph obtained 4 months before port removal demonstrates embolization of catheter to the heart had already occurred (arrowheads). Although reported, the radiologist had not informed anyone of this finding beyond his typed report.

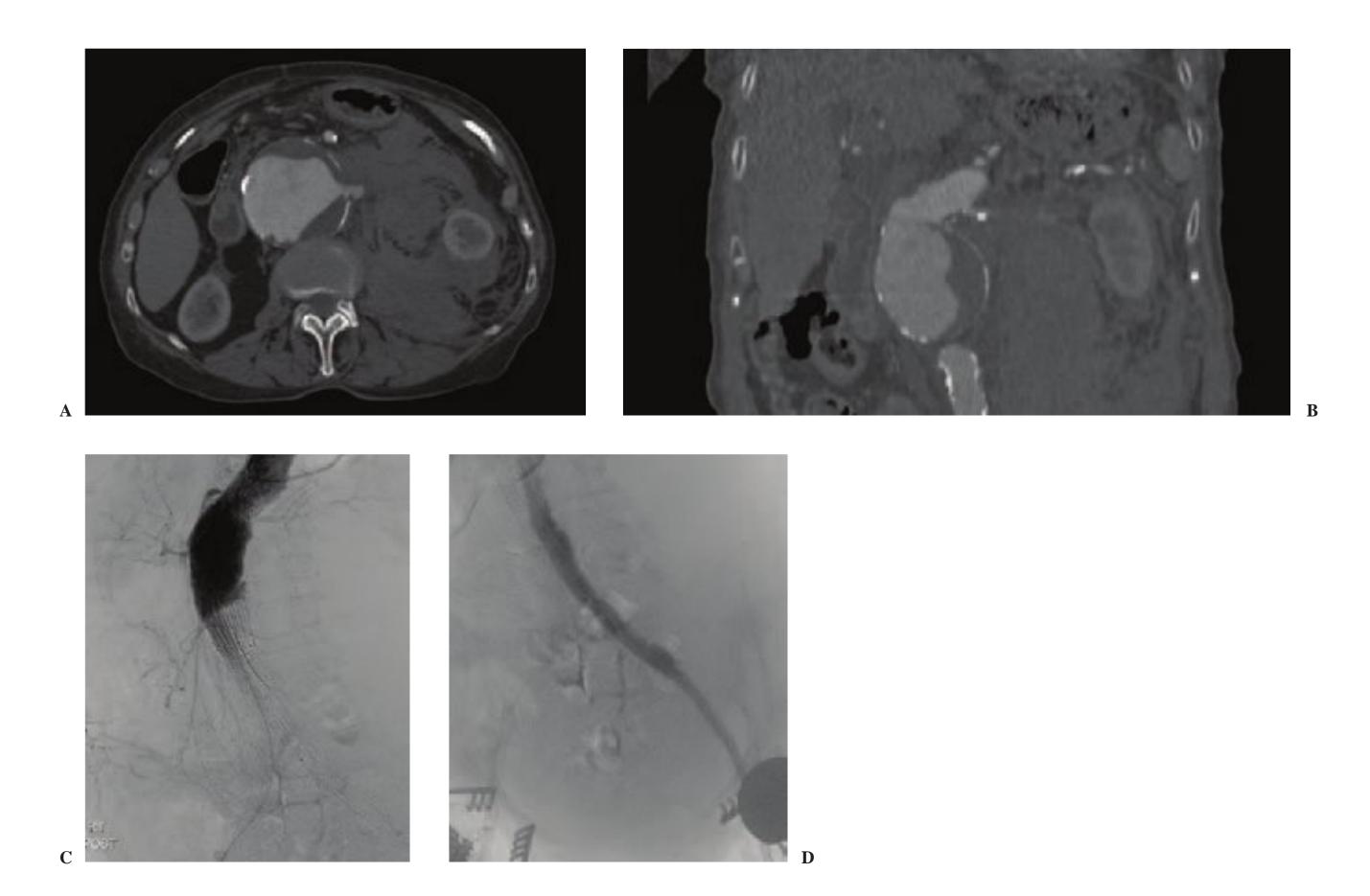
#### ■ Dif erential Diagnosis

• Embolization of chemoport catheter through a patent foramen ovale

#### **■** Essential Facts

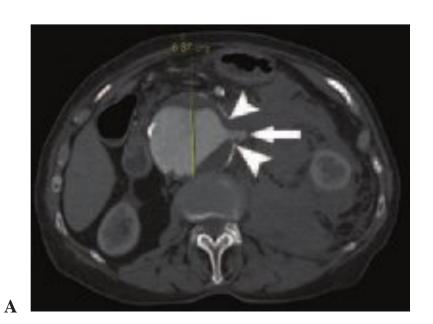
- The prevalence of patent foramen ovale is 25 to 30% of the general population.
- The autopsy incidence is 6% for a large defect (0.6 to 1.0 cm). A large defect has a significantly larger resting shunt, although most are asymptomatic.

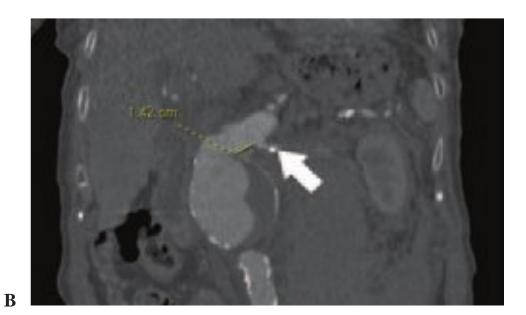
- ✓ The first diagnostic imaging study of choice is chest radiography.
- ✓ Cercutaneous retrieval should be attempted first prior to considering surgical retrieval.
- the catheter fragment being left in is clinically inconsequential.
- he radiologist does not have a duty to acutely and directly inform the referring physician beyond a written report.

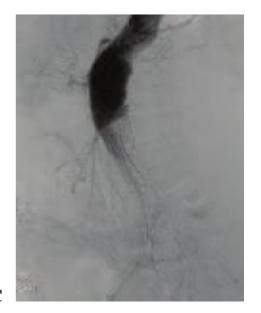


# Clinical Presentation

An 88-year-old woman presents to the emergency room syncopal and hypotensive with a pulsatile abdominal mass. An enhanced computed tomography (CT) of the abdomen and pelvis was obtained.









### Differential Diagnosis

- Acute rupture of an abdominal aortic aneurysm (AAA):
  Ultrasound of the abdomen demonstrates the aortic
  aneurysm, and free fluid and/or poorly marginated soft
  tissue density in the retroperitoneum indicates acute
  rupture. Occasionally, a hematocrit level may be seen.
  Enhanced CT also demonstrates the aneurysm but allows
  for determination if there is a disruption in the arterial wall
  and active extravasation from the AAA may be identified. In
  addition, isointense soft tissue density in the retroperitoneum indicates recent bleeding. An enhanced CT also allows
  for determination of suitability for endograft placement by
  determining neck size and length and size of the iliac arteries, which partially determine suitability. In addition, the
  iliac arteries can be assessed for aneurismal dilation as well.
- Retroperitoneal hemorrhage: Enhanced CT will often demonstrate a normal caliber abdominal aorta and active extravasation from a retroperitoneal blood vessel. If an AAA is coincidentally present, a fat plane is usually maintained between the aorta and retroperitoneal hematoma.
- Renal colic: Ultrasound may show hydronephrosis and/or hydroureter. The stone itself may be seen. A normal aortic size is typically seen. With an unenhanced CT of the abdomen, stones can often be identified as well. Enhanced CT with subsequent renal excretion of contrast often obscures the stone(s). If there is some conflict as to diagnosis, an unenhanced CT followed by an enhanced CT may be obtained.

#### Essential Facts

- AAAs are most common among male smokers older than the age of 65 years.
- Intervention is recommended when aneurysm size exceeds 5.5 cm with an annual risk of rupture of 3% or more beyond this size.

(A) The enhanced CT demonstrates an enlarged abdominal aorta (7-cm diameter) with disruption of aortic wall calcification (arrowheads) and extension of contrast beyond the aortic lumen (arrow) into the retroperitoneum. In addition, on the left, there is extensive soft tissue density restricted to the retroperitoneal space displacing the left kidney laterally. (B) Coronal reconstruction demonstrates the distance between the left renal artery (arrow) and the origin of the aneurysm to be 1.4 cm. (C, D) Successful exclusion of the aortic aneurysm with a bifurcated abdominal aortic endograft.

- Annual risk of aneurysm rupture increases with increasing aneurysm size.
- Most endografts require a minimal nonaneurysmal infrarenal aortic neck length of 10 mm and iliac diameters for delivery of the grafts of 7 mm or larger (in general).
- Retroperitoneal hemorrhage unrelated to AAA is most often a spontaneous complication of anticoagulation.

#### Other Imaging Findings

- Magnetic resonance (MR):
- Has no defined role for diagnosis in this acute condition.
- If the patient cannot undergo computed tomography angiography (CTA) for sizing of an endograft, magnetic resonance angiography (MRA) allows for appropriate sizing of the aneurysm to determine suitability for endograft placement.

- ✓ Carterial phase contrast CTs are more sensitive for arterial extravasation than catheter angiography.
- ✓ a fat plane is maintained between the aorta and retroperitoneal hemorrhage, another source of bleeding should be considered.
- Timaging at 1-mm intervals with coronal and sagittal reconstructions provides more diagnostic information and also assists in assessing patients for endograft suitability.
- nenhanced CTs provide sufficient anatomical information in assessing the patient for endograft placement.
- pen surgical repair is associated with similar mortality and morbidity as endovascular repair.







# Clinical Presentation

A 30-year-old man with foot pain following a fall from height.









(A) Anteroposterior (AP) radiograph of the right foot shows no fracture or dislocation. (B) Oblique radiograph of the right foot demonstrates a small osseous fragment between the bases of the second and third metatarsals (arrowhead) with malalignment at the medial aspect of the second and third tarsometatarsal joints (arrow). (C) Lateral radiograph of the foot shows diffuse dorsal soft tissue swelling but no bony injury. (D) Follow-up weight-bearing AP radiograph of the foot shows a significant step deformity at the second tarsometatarsal joint.

#### Dif erential Diagnosis

- Lisfranc fracture dislocation: Malalignment at the second and third tarsometatarsal joints with a small fracture fragment. The fracture fragments are often subtle and small but signify significant forces across the midfoot.
- Fracture base of second (or third) metatarsal: Isolated fracture may occur particularly due to direct localized trauma but should not be associated with malalignment.

#### Essential Facts

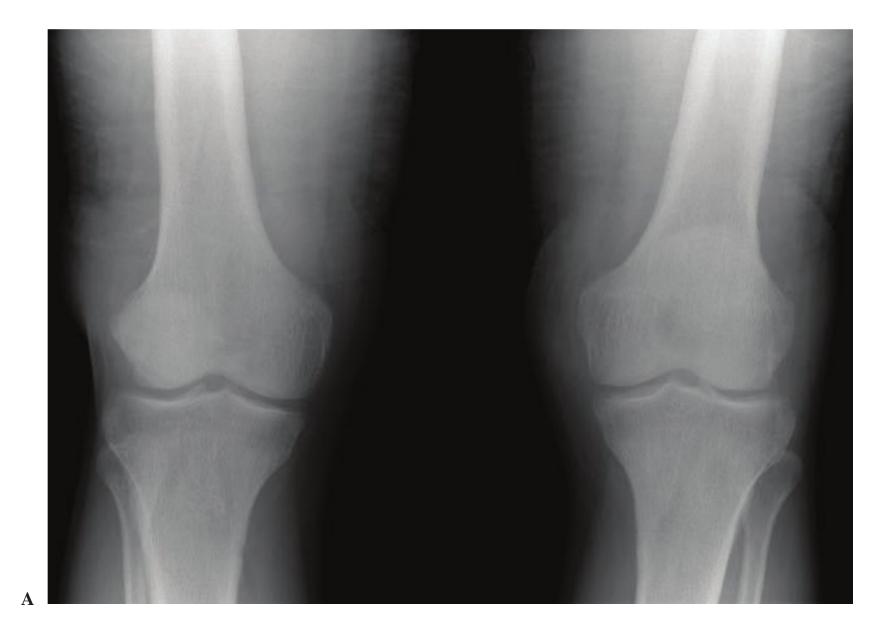
- There are complex set of ligaments across the tarsometatarsal joints to maintain stability. The Lisfranc ligament connects the medial cuneiform to the base of the second metatarsal and consists of multiple bands.
- Lisfranc injuries may occur as a result of low-energy axial loading particularly with plantarflexion or high-energy trauma.
- Lisfranc fracture dislocations are often missed at first presentation and can lead to chronic disability and osteoarthritis.

### Other Imaging Findings

- Radiographs: Disruption of normal alignment of medial base of second metatarsal with medial cortex of middle cuneiform on AP view and the medial base of third metatarsal with medial cortex of lateral cuneiform on oblique view. Divergent (first metatarsal medially and all other metatarsals laterally displaced) or homolateral (all metatarsal bases displaced in one direction, usually laterally). Small fracture fragments.
- Computed tomography (CT): Small fracture fragments.

  Malalignment.
- Magnetic resonance imaging (MRI): Bone marrow edema in midfoot. Disruption or signal change in Lisfranc ligament.

- ✓ widfoot edema may be the only sign on a non-weightbearing view.
- ✓ ©eight-bearing views may be the only imaging study to show malalignment.

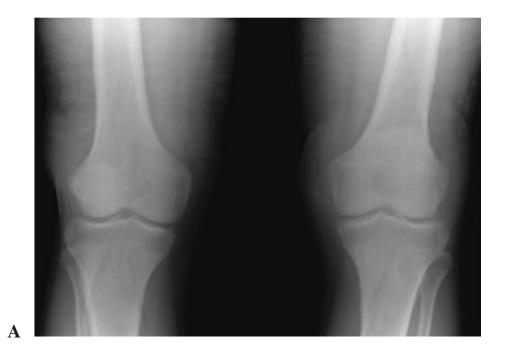






# Clinical Presentation

A 47-year-old man with bilateral knee pain and inability to bear weight following minor trauma.









(A) Bilateral anteroposterior and lateral radiographs demonstrate abnormal patellar positioning bilaterally with patella alta on the left (B) and rotation and tilting of the patella on the right (white arrow in C). There is infrapatellar soft tissue swelling on the left (white arrow in B) and suprapatellar soft tissue swelling on the right (black arrow in C) and (white arrow in D) confirmed on three-dimensional (3D) computed tomography (CT).

#### Dif erential Diagnosis

- Concomitant quadriceps and patellar tendon ruptures in chronic renal failure: High-riding patella (patella alta) with associated soft tissue swelling suggests patellar tendon rupture. Tilting of the patella with suprapatellar soft tissue swelling is indicative of quadriceps tendon rupture. Bilateral involvement after minor trauma is suggestive of an underlying abnormality (chronic renal failure in this case).
- Partial tears of the extensor mechanism: Typically, the position of the patella remains normal. The quadriceps tendon has contributions from the rectus femoris and vastus medialis, intermedius, and lateralis. Each of these components may be injured in isolation or with other tendons.

#### Essential Facts

- Quadriceps ruptures are more common than patellar tendon rupture.
- Rupture typically occurs as a result of eccentric quadriceps contraction with the knee flexed and the foot planted.
- Predisposing factors include chronic tendinopathy, prior surgery (anterior cruciate ligament [ACL] graft harvest, total knee arthroplasty), chronic steroid therapy, chronic renal disease, diabetes, and chronic inflammatory conditions (rheumatoid arthritis, systemic lupus erythematosus [SLE]).

- The most common location for traumatic ruptures is at the enthesis at the superior or inferior pole of the patella.
- Depending on the extent of the tear, there may be a complete loss of extension or there may be an extensor lag.

### Other Imaging Findings

- Radiographic assessment of patellar positioning: Multiple methods described. Insall-Salvati ratio is commonly used. Ratio of patellar tendon length to length of patella (from posterosuperior corner to anteroinferior corner). Ratio of . 1.2 is typically taken to reflect patella alta (. 1.5 on MRI).
- Ultrasound is highly accurate in assessing severity and location of the tear. Tendon discontinuity with intervening hematoma.
- MRI is also highly accurate in assessing the tear. Complete disruption with mixed signal hematoma.

- ✓ tear of the patellar tendon causes upward displacement of the patella (patella alta), whereas a tear of the quadriceps tendon causes the reverse to occur (patella baja).
- ✓ winor trauma that causes a significant injury should be examined for an underlying pathology.
- ★ long delay between injury and repair is associated with poorer outcome.





В

## Clinical Presentation

A 36-year-old man after a fall from a bike.





R

Lateral (A) and anteroposterior (AP) (B) radiographs of the wrist demonstrate loss of the articulation between the proximal pole of the capitate and the distal articular surface of the lunate (arrowheads in B). The scaphoid has fractured through the waist (arrow in A) and the distal component has also dislocated dorsally with the distal carpal row, whereas the proximal pole is articulating with the lunate (arrowhead in A). The AP demonstrates a more triangular appearance to the lunate and Gilula arcs are disrupted. The lunate is articulating with the distal radius, although volarly tilted.

### ■ Dif erential Diagnosis

- Transscaphoid, perilunate fracture dislocation: A transscaphoid fracture is evident with dorsal dislocation of the capitate and the distal carpal row. Injury occurs as a result of hyperdorsiflexion.
- Midcarpal dislocation: With midcarpal dislocations, the AP view is similar to a perilunate dislocation but the lateral view demonstrates volar tilting and subluxation of the lunate. In this case, there is no volar subluxation of the lunate.

#### Essential Facts

- Perilunate injuries are a four-stage process. The injury begins radially with a tear of the scapholunate ligament and/or fracture of the scaphoid. In stage II, the capitate and scaphoid displace dorsally with distraction and opening of the space of Poirier, a relatively weak area volarly. The forces are then transmitted through the lunotriquetral ligament causing a tear or a triquetral fracture. In stage IV, the lunate dislocates volarly. The forces may also be transmitted through the radial and ulnar styloids.
- Perilunate dislocations may be purely ligamentous injuries (lesser arc injuries) or fracture dislocations

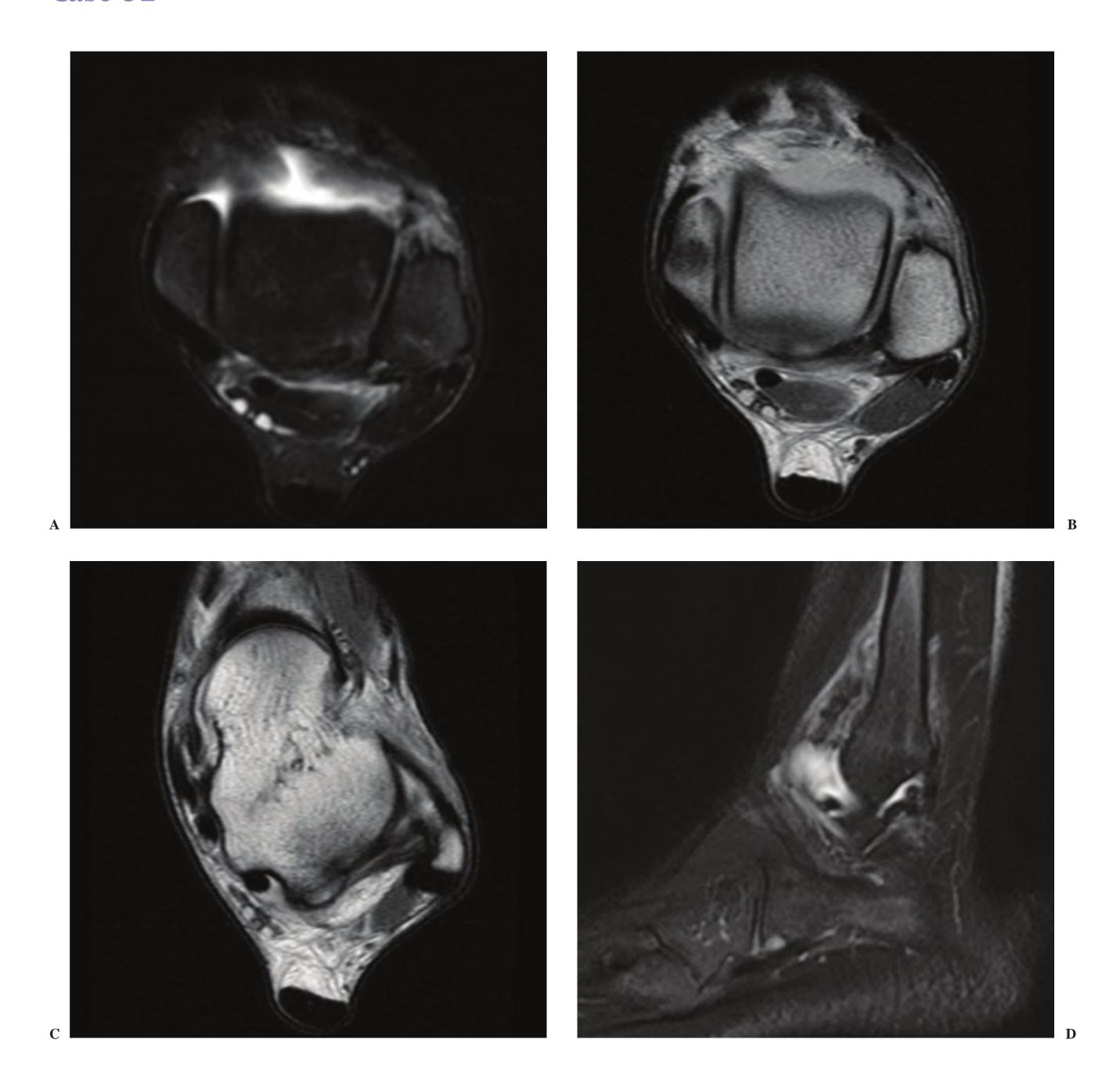
- (greater arc injuries). Greater arc injuries are more common with the transscaphoid perilunate dislocation being most common.
- The initial reduction may be closed or open. Open reduction is indicated for open injuries or with median nerve dysfunction. Without wrist stabilization, significant arthritis may ensue.

### Other Imaging Findings

• Computed tomography (CT) may be of value postreduction for assessment of fracture patterns. Magnetic resonance imaging (MRI) is typically not indicated.

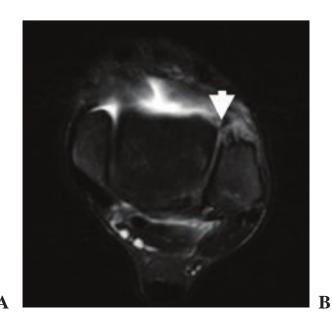
- ✓ Che lateral view is most useful for distinguishing between the various types of carpal dislocations.
- ✓ neither the capitate nor the lunate is aligned with the distal radius, a midcarpal dislocation is present.
- p to 25% of perilunate dislocations may be missed at initial presentation.

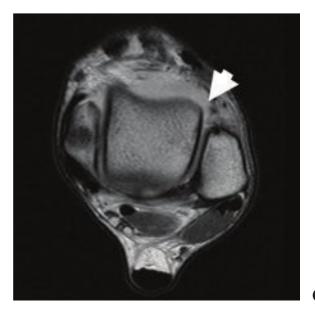
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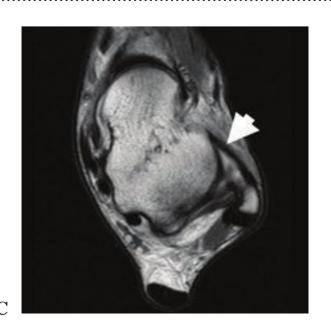


# Clinical Presentation

A 24-year-old male hockey player with an ankle injury.









(A, B) Axial fat-suppressed T2-and intermediate-weighted magnetic resonance images at the level of the ankle mortise demonstrate complete discontinuity of the anterior inferior tibiofibular ligament (AITFL) (arrowheads). The posterior inferior tibiofibular ligament (PITFL) is intact. (C, D) Axial intermediate-weighted magnetic resonance imaging (MRI) more inferiorly demonstrates an intact anterior talofibular ligament (arrowhead in C). Sagittal fat-suppressed T2-weighted MRI demonstrates significant thickening and edema along the expected course of the AITFL (arrowhead in D).

### Dif erential Diagnosis

- Complete AITFL tear: The AITFL is the anterior component of the syndesmotic ligaments. Demonstration of complete discontinuity and abnormal signal with no clear attachment to the tibia or fibula indicates a full-thickness tear.
- Lateral ligamentous injury: Anterior talofibular tears initially, followed by the calcaneofibular ligament and least commonly the posterior talofibular ligaments. In this case, the anterior and posterior talofibular ligaments are intact.

#### Essential Facts

- Syndesmotic injuries (also called *high ankle sprains*) are less common than lateral ligamentous sprains.
- The syndesmotic stabilizers consist of the interosseous membrane, AITFL, PITFL, and the inferior transverse tibiofibular ligament.
- Injuries commonly occur with hyperdorsiflexion or external rotation.
- Syndesmotic injuries may occur with lateral ligamentous injuries or may be isolated. The latter is typically seen with hyperdorsiflexion in skates or boots.
- They usually take longer to heal and may lead to longstanding instability and osteoarthritis.

### Other Imaging Findings

• Radiography: Soft tissue swelling 1 to 2 cm above the plafond and typically more superiorly than seen with lateral ligamentous injuries. Tibiofibular clear space (distance between incisura fibularis of tibia and the medial border of the fibula) 1 cm above mortise is normally, 5 mm on anteroposterior (AP) view. Tibiofibular overlap is normally. 1 cm on AP view. Widening of medial clear space on mortise view (normal, 4 mm). Stress views may show widening if routine views were normal. May be associated with avulsion fractures. Avulsions may occur at the tibial attachment (Tillaux-Chaput fracture) or the fibular attachment (Wagstaffe-Lefort fracture). Chronic cases may exhibit heterotopic mineralization at the level of the syndesmosis.

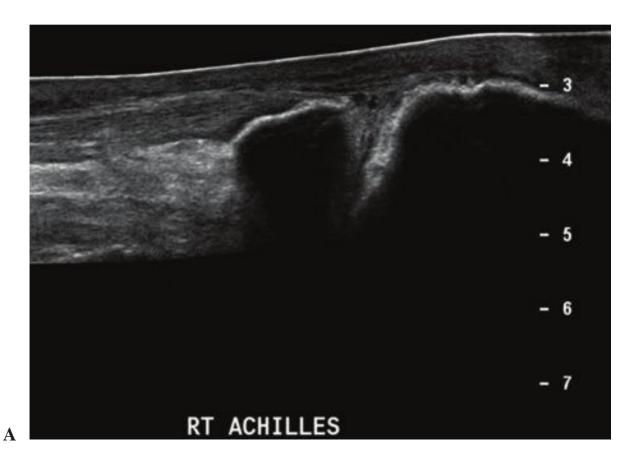
- ✓ Colated posterior or medial malleolar fractures raise the possibility of a syndesmotic injury.
- The AITFLis more commonly injured than the PITFLin syndesmotic injuries.





# Clinical Presentation

A 56-year-old man with heel and foot pain.





(A) Longitudinal ultrasound image of the Achilles tendon shows a large echogenic focus with posterior shadowing in the distal Achilles tendon consistent with a calcific/ossific density. The Achilles tendon inserts onto this calcific density and there is a gap between the calcific density and the calcaneus.

(B) Lateral ankle radiograph. There is a thin sliver of cortical bone in the expected location of the distal Achilles tendon. There is a corresponding cortical defect of the posterior calcaneus.

## Dif erential Diagnosis

- Osseous avulsion of the Achilles tendon: The sliver of bone matches the cortical defect of the calcaneus and is retracted along the line of the Achilles tendon. The ultrasound shows that the tendon attaches onto the fragment, not directly onto the calcaneus.
- Chronic calcif c Achilles tendinosis: The calcification seen on X-ray in calcific tendinosis would be globular and amorphous, without a cortical margin, and without the defect seen in the calcaneus. The ultrasound would show a thickened Achilles tendon without discontinuity.
- Achilles tendon rupture: Calcification is not a feature of an acute tear although it may be seen in the setting of prior partial tears or at sites of previous surgery. With an acute rupture, there is a defect filled with either echogenic or hypoechoic material (hematoma, in various stages of evolution). The acute hematoma does not demonstrate shadowing.

### Essential Facts

- Avulsion of the Achilles tendon can occur due to sudden muscle contraction with the foot planted or during a hyperdorsiflexion injury.
- It is less common than Achilles rupture.
- Posterior process fractures are more common in diabetic patients and those with underlying bone lesions.
- This is an important injury to recognize because the treatment is different to and often more successful than treatment for a tendon rupture.

• Fractures may involve the whole attachment (treated with surgical fixation), the superficial attachment only (surgical fixation), or the deep attachment (conservative treatment may be used).

### Other Imaging Findings

- X-ray: The Achilles tendon attaches to the middle third of the posterior tuberosity of the calcaneus, so avulsion fractures may involve this part only or extend to the bursal projection.
- Computed tomography (CT): usually not required but will accurately show the size of the avulsed fragment
- Magnetic resonance imaging (MRI): The osseous fragment is best seen on T1-weighted images. Some edema is typically seen on T2-weighted images at the donor site and in the fragment.

- ✓ mineralization is present, look for a matching defect in the calcaneus and whether it represents calcification or ossification.
- ✓ Cook for underlying lesions in the calcaneus.





В

#### Clinical Presentation

A 30-year-old woman with severe pain in her right knee after being kicked in the knee during soccer.









(A, B) Anteroposterior (AP) and lateral radiographs of the knee show an avulsion fracture of the fibular styloid process (arrow). This is obscured by the tibia on the lateral view. (C) Coronal intermediate-weighted image magnetic resonance imaging (MRI) demonstrates the avulsed fragment with the conjoint tendon consisting of the fibular collateral ligament (arrowhead) and biceps femoris (arrow) attached to the bony fragment. (D) Sagittal fat-suppressed T2-weighted MRI revealing a complete midsubstance tear of the anterior cruciate ligament (ACL) (arrow) and extensive edema along the posterior capsule with disruption of the capsule (arrowhead).

## ■ Dif erential Diagnosis

- Fibular head/styloid process avulsion: Injury can occur as a result of direct force to the anteromedial aspect of the knee or with rotation of the femur upon a planted leg. When the avulsion just involves the styloid process, it is known as the *arcuate sign*.
- Segond fracture: This is an avulsion fracture of lateral cortex of the lateral tibial rim. This is commonly seen with a rotational injury and has a high association with an ACL tear. It is an avulsion of the lateral capsular ligament and the posterior fibers of the iliotibial band and is typically vertically oriented in contrast to the arcuate sign where the fragment is horizontally oriented.

## Essential Facts

- Posterolateral stabilizers of the knee include the fibular collateral ligament, biceps femoris, popliteus, popliteofibular ligament, arcuate ligament, fabellofibular ligament, and lateral head of gastrocnemius.
- Clinical examination may be difficult in the acute setting.
- Arcuate fracture involves the attachment of the popliteofibular, fabellofibular, and arcuate ligaments, which attach more superiorly and medially than the

- attachment of the conjoint tendon (fibular collateral ligament and biceps femoris).
- Highly associated with cruciate ligament tears
- Untreated posterolateral corner injuries lead to posterolateral knee instability and failure of cruciate ligament reconstructions.

### Other Imaging Findings

- MRI is indicated for identification of associated injuries:
- Posterior cruciate ligament (PCL) and ACL
- Medial collateral ligament (MCL)
- Posterior capsule
- Chondral and meniscal injuries

- ✓ though the "arcuate sign" appears innocuous radiographically, it is often associated with severe ligamentous injuries.
- ✓ In internal oblique radiograph is useful for identification of the avulsed fragment.

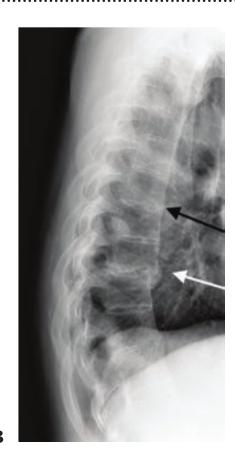




## Clinical Presentation

A 65-year-old man with chronic back pain exacerbated by minor trauma 5 months ago.







ı C

Anteroposterior (AP) radiograph of the thoracic spine (A) demonstrates ossification of the interspinous ligaments (arrow). Lateral view of the thoracic spine (B) demonstrates extensive syndesmophyte formation anteriorly in the upper to midthoracic spine (black arrow). The appearances are those of ankylosing spondylitis (AS). The lateral view also demonstrates a step deformity in the lower thoracic spine (white arrow) with anterior new bone formation and sclerosis. Sagittal computed tomography (CT) reformat (C) confirms the above findings as well as fractures of the articular process at the facet joint at the same level (arrows).

### Dif erential Diagnosis

- AS with associated Chance-type fracture: The interspinous ossification and syndesmophytes are in keeping with long-standing AS. There is injury through the disk space and the posterior elements involving all three columns. The new bone formation and sclerosis suggests a subacute to chronic fracture.
- Seronegative spondyloarthropathy with previous diskitis: The presence of the posterior element fractures are more in keeping with a traumatic injury rather than infection.

### Essential Facts

- AS patients have a rigid spine, and as such, minor trauma can lead to significant fractures.
- Presentation may be delayed.
- Vertebral injury in AS is most common at the thoracolumbar junction followed by the cervical spine.
- Classic Chance fracture is a flexion distraction injury seen with lap belt or falls with a fracture of the vertebral bodies and transverse fracture of the posterior elements.
- Chance fractures may be bony, purely ligamentous/soft tissue, or a combination (most common). All three columns are involved.

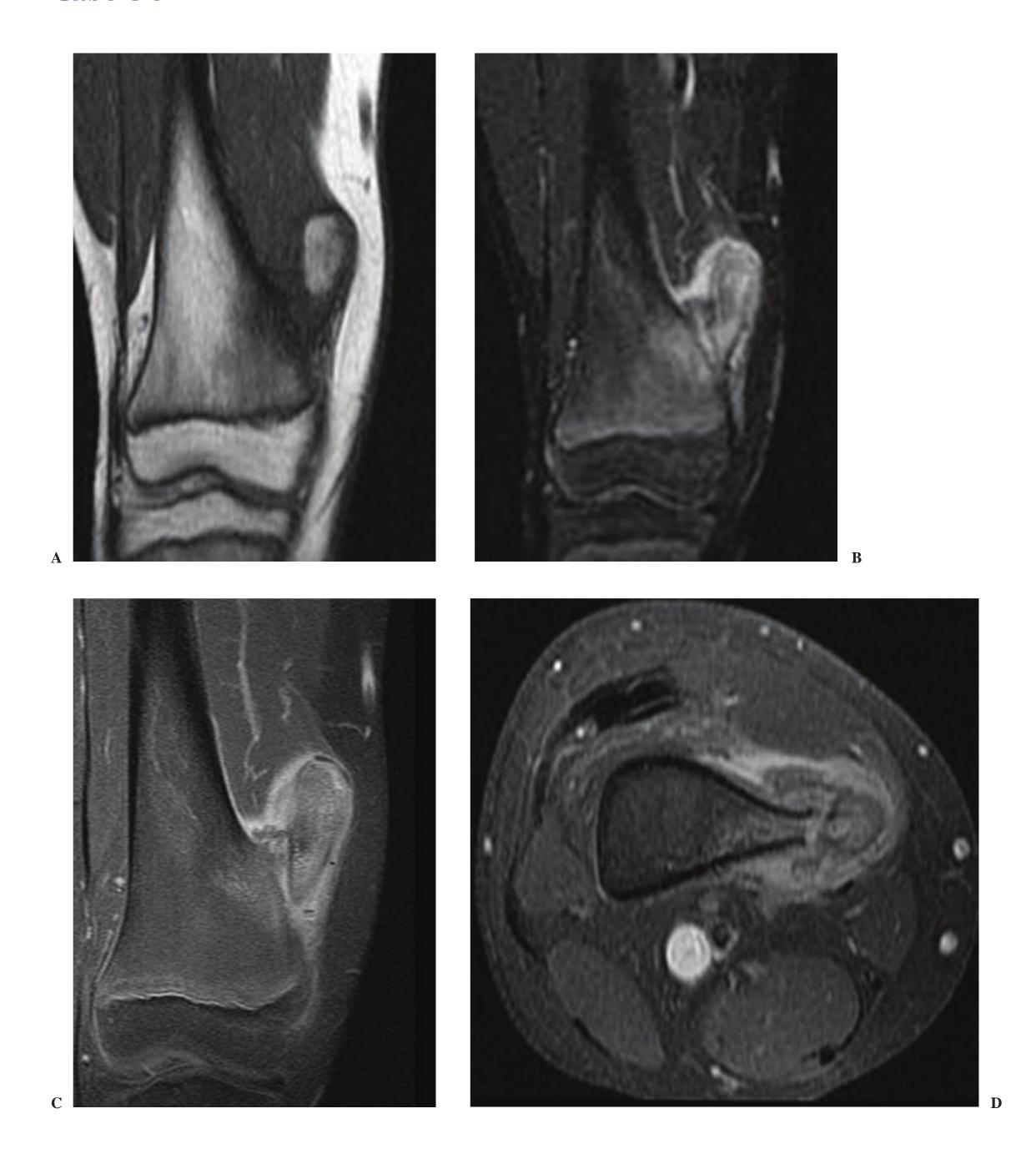
- Pseudoarthrosis is a common complication of such fractures in AS, because often, adjacent segments are ankylosed and motion occurs at the injured segment.
- Can be associated with neurologic deficit, particularly in the cervical spine

#### Other Imaging Findings

• Magnetic resonance imaging (MRI): Mild compression of the vertebral body. Rupture of the supraspinous and interspinous ligaments. Pedicle fractures. Epidural hematoma. Cord edema or hematoma depending on severity of injury. In AS, the anterior longitudinal ligament is typically disrupted in contrast to a classic Chance fracture.

- ✓ Chance fracture is due to significant trauma, there is a high association with intra-abdominal injuries that are the main cause of morbidity and mortality.
- ✓ Cony injuries have a better potential for healing.

Case 36



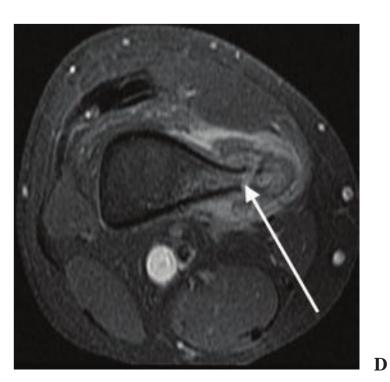
# Clinical Presentation

A 15-year-old boy with pain in his left knee following a soccer game.









(A–D) Coronal T1-weighted, coronal fat-suppressed T2-weighted, coronal fat-suppressed T1-weighted postgadolinium, and axial fat-suppressed T1-weighted postgadolinium images of the left knee showing an osteochondroma arising from the medial femoral metaphysis with edema and enhancement within and surrounding the osseous component. There is a cleft at the base of the osteochondroma (arrows). There is a thin crescent of nonenhancement at the tip of the osteochondroma (arrowhead in C).

# Dif erential Diagnosis

- Fracture of osteochondroma: Osseous excrescence arising from the metaphysis with a cleft through the base consistent with a fracture. This is typically due to direct trauma. Perilesional edema is due to the fracture.
- Bursitis surrounding osteochondroma: Asymptomatic bursae are common but may undergo inflammatory changes. On magnetic resonance imaging (MRI), the bursa appears as fluid signal intensity with rim enhancement on postgadolinium images in contrast to this lesion where there is diffuse enhancement. There is a small bursa in this case.
- Malignant transformation of osteochondroma: A hallmark of malignant transformation is thickening of the cartilage cap, typically exceeding 1.5 to 2 cm in adults. The cartilage cap demonstrates heterogeneous septal and rim enhancement. The edema and enhancement in this case is secondary to the fracture extending along the stalk of the osteochondroma and the femoral metaphysis beyond the expected location of the cartilage cap.

#### Essential Facts

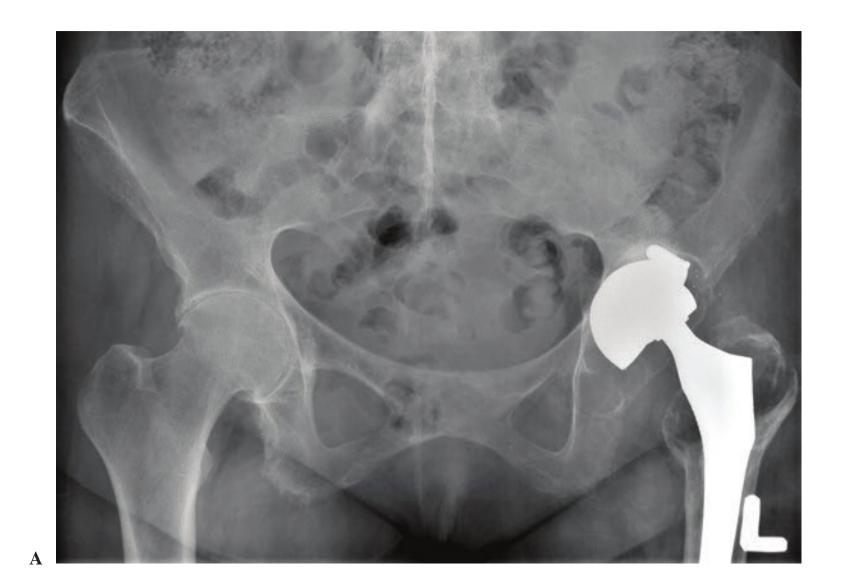
- Most solitary osteochondrom as are asymptomatic. Osteochondrom as constitute 10 to 15% of all bone tumors.
- Pain may be a feature of malignant transformation, but it is most commonly due to benign causes such as bursitis, impingement on soft tissue, or neurovascular structures, causes unrelated to the osteochondroma or fracture.

- Radiographs are insensitive to the early stage of malignant transformation. Possible signs include progressive enlargement in adults, irregular surface, bony erosions and lucencies within the bony component, scattered calcification in the cap, or progressive loss of areas of mineralization.
- Childhood radiation therapy may result in the development of osteochondromas.

### Other Imaging Findings

- Plain radiography: sessile or pedunculated excrescence projecting away from the epiphysis, bony deformity (especially in hereditary multiple exostoses [HME] and if large number of sessile osteochondromas), widening of metaphysis
- Computed tomography (CT) demonstrates the cortical and medullary continuity, noncalcified cartilage cap, and lower attenuation than muscle.
- MRI: The cartilage cap may be heterogeneous (calcified and noncalcified cap).

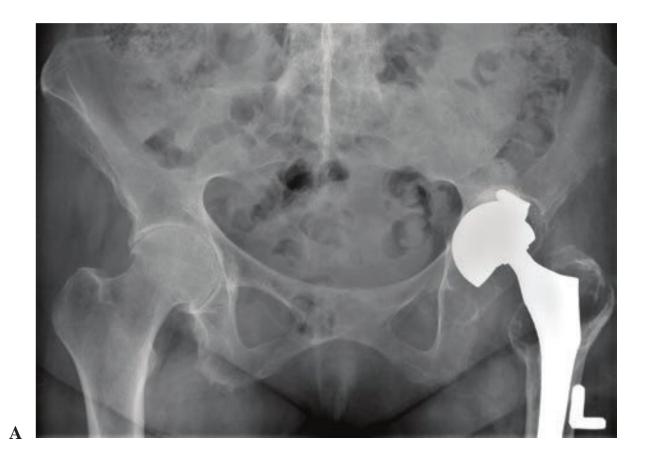
- ✓ the absence of cortical and medullary continuity, an alternative diagnosis is likely.
- ✓ Complications involving osteochondromas are more frequent in patients with HME.





Clinical Presentation

A 68-year-old woman with acute chronic left hip pain.





(A, B) Anteroposterior and lateral radiographs of the pelvis and left hip showing a previous noncemented total hip arthroplasty with asymmetric positioning of the femoral head. There is a rounded lucency involving the greater trochanter with a fracture cleft through the greater trochanter (arrow). There is no periosteal reaction. There is ankylosis of the sacroiliac joints and uniform joint space loss in the right hip.

### **■** Dif erential Diagnosis

- Total hip arthroplasty for ankylosing spondylitis with polyethylene wear and small particle disease of the proximal femur with an associated fracture of the greater trochanter: Eccentric positioning of the femoral head suggests asymmetric polyethylene wear. The rounded lucency in the intertrochanteric region is in keeping with small particle disease with pathologic fracturing.
- Infection: Infection may also present as lytic areas radiographically but with an acute time course. It may be associated with periosteal reaction. Most commonly, however, the radiographs are normal or nonspecific.
- Dislocation of the polyethylene liner: Asymmetric position of the femoral head may also be seen with fracture or dislocation of the polyethylene liner but this would result in rapid change in position of the femoral head. It is not associated with lytic change.

### Essential Facts

- Small particle disease is one of the leading causes of failure of hip arthroplasty and leads to loosening of the prosthesis.
- Small particle disease is an inflammatory reaction to wear debris. Polyethylene is the main cause of small particle disease.
- Arthroplasties with ceramic articular surfaces have lower incidences of small particle disease.

• Small particle disease takes several years to develop and is rare within the first 3 years. It is often asymptomatic in its initial stages.

## Other Imaging Findings

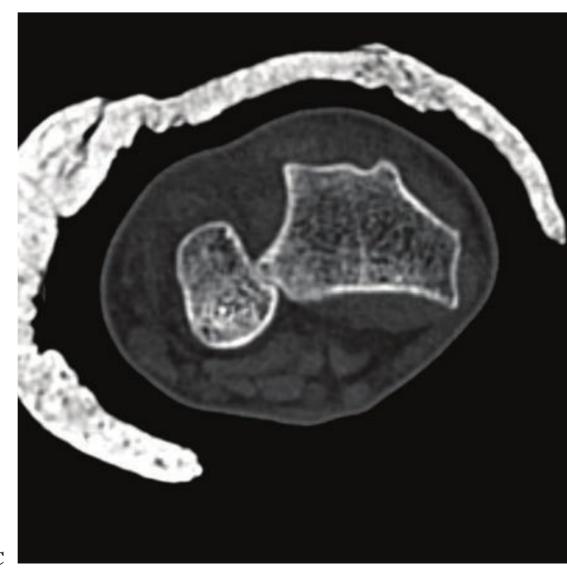
- Plain radiographs: Lobulated lucency with endosteal scalloping. In most cases, this progresses slowly. Mechanical loosening in comparison tends to produce more linear areas of lucency.
- Computed tomography (CT): Degree of periprosthetic bone loss can be accurately assessed on CT preoperative planning.
- Magnetic resonance imaging (MRI): MRI with metal artifact reduction sequences can also demonstrate the extent of periprosthetic bone loss as well as soft tissue extension of the inflammatory tissue. The inflammatory tissue is usually of mixed signal intensity and demonstrates heterogeneous enhancement.

- \* Imall particle disease is typically not associated with periosteal reaction in the absence of pathologic fracturing.
- \* Rapid development of periprosthetic lucency is unusual for small particle disease and should be viewed with suspicion. Infection would need to be excluded in such cases.





В



# Clinical Presentation

A 25-year-old man presents to the emergency room (ER) with wrist pain and stiffness after a friend landed directly on his wrist.







(A) Anteroposterior (AP) radiograph of the left wrist. Position of the ulnar styloid indicates the position of the wrist is not in neutral. The carpal, metacarpal, and phalanges are intact. (B) Lateral view of the wrist shows volar positioning of the ulna relative to the distal radius even allowing for the degree of obliquity. (C) Axial computed tomography (CT) with bone reconstruction shows the head of the ulna has displaced from the sigmoid notch of the radius to lie volarly.

## ■ Dif erential Diagnosis

- Distal radioulnar joint (DRUJ) volar dislocation: An uncommon isolated injury that results in volar displacement of the ulna relative to the radius. The mechanism typically involves a force on the wrist with hypersupination of the forearm.
- Galeazzi fracture-dislocation: A fracture of the radial diaphysis with dislocation of the DRUJ. This case shows no associated radius or ulnar fractures.
- Essex-Lopresti fracture-dislocation: Injury consisting of a comminuted fracture of the radial head associated with dislocation of the DRUJ and disruption of the interosseous membrane. The radius can migrate proximally. The radial head was intact in this case and there is no evidence of radial shortening.

#### Essential Facts

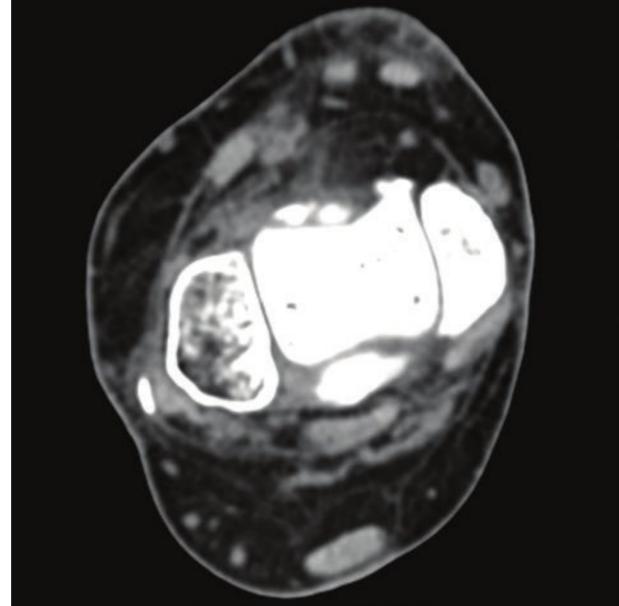
- Distal radioulnar joint stability is maintained through the bony structure, triangular fibrocartilaginous complex (mainly the dorsal and palmar radioulnar ligament components), pronator quadratus, and the interosseous membrane.
- Most DRUJ dislocations occur with the ulna located volar to the radius.
- Volar and dorsal dislocation result in limited pronation and supination, respectively.

### Other Imaging Findings

- AP view of the wrist in a volar dislocation can show overlap of the radius and ulna at the DRUJ in neutral position because of the convergent pull of pronator quadrates.
- Conversely, the AP view in a dorsal DRUJ dislocation can show widening of the joint.
- Ulnar styloid fracture
- In cases of DRUJ instability, CT scans of both wrists can be performed in pronation, neutral position, and supination to assess the radioulnar relationship through the range of motion

- ✓ Cadiographs in acute dislocation can be difficult to interpret, as a standard posteroanterior view may not be possible due to block to pronation/supination.
- determine reduction of a dislocation, a true lateral radiograph should be obtained. On a true lateral radiograph, the volar cortex of the pisiform overlies the central third of the interval between the volar cortices of the distal pole of the scaphoid and capitate.

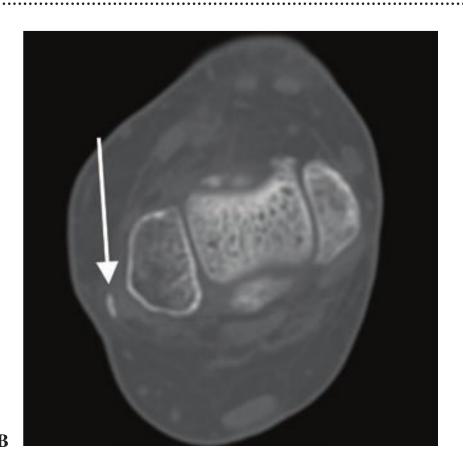




# Clinical Presentation

A 49-year-old woman with forced dorsiflexion injury of the ankle.







Anteroposterior (AP) view of the ankle (A) shows a small osseous fragment lateral to the lateral malleolus (arrow). The osseous density does not involve the fibular tip. The position of the fragment is confirmed on the axial computed tomography (CT) images with bone (B) and soft tissue (C) windows (arrow in B). There is soft tissue between the osseous fragment and the lateral malleolus (arrow in C). The peroneal tendons are not seen in their normal location in the retromalleolar groove.

### Dif erential Diagnosis

- Peroneal retinaculum avulsion with dislocation of the peroneal tendons: The position of the avulsion is very characteristic of the dislodgment of a fragment of fibular bone subsequent to the rupture of the peroneal retinaculum.
- Anterior talofibular avulsion fracture: Also causes an avulsion fracture of the distal fibula. The bony fragment is related to the tip of the lateral malleolus.
- Wagstaff-Lefort fracture: This is an avulsion fracture of the fibular attachment of the anterior inferior tibiofibular ligament. This is located along the anteromedial aspect of the fibula at the site of attachment of the ligament.

### Essential Facts

- May result from motor vehicle accidents, fall from height, or sport injuries. It may be seen with forced dorsiflexion and simultaneous contraction of the peroneals.
- The peroneal retinaculum extends from the distal lateral fibula to either the calcaneus or Achilles tendon (variable). This fibrous band creates the lateral border of the peroneal tunnel through which the peroneal tendons pass.
- Peroneal retinacular injuries are classified from I to IV. Type I: stripping injury from the lateral malleolus. Type II: tear at the fibular insertion. Type III: osseous avulsion. Type IV: tear of the posterior fibers.

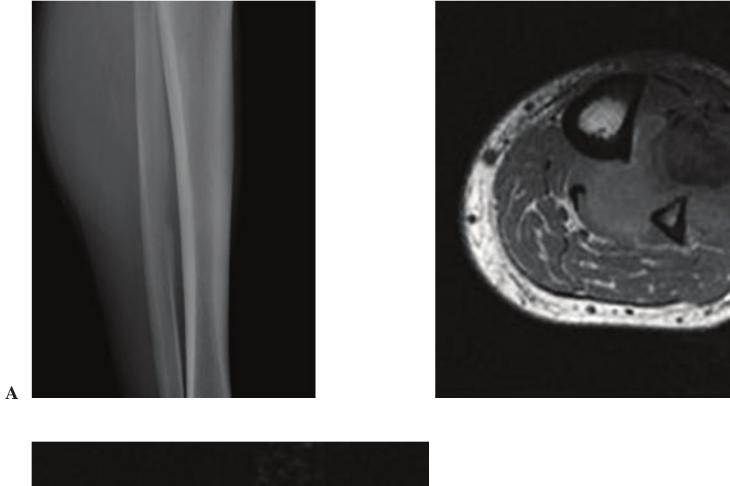
- Tears of the superior peroneal retinaculum may be associated with tendon dislocation.
- Peroneal retinacular avulsions are commonly associated with calcaneal fractures.

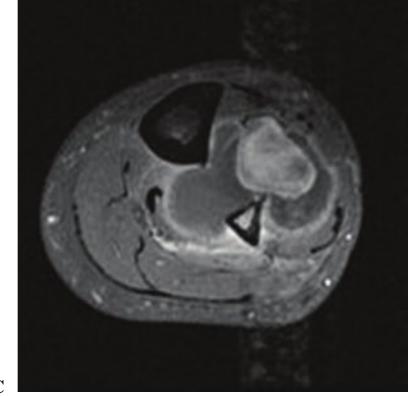
# Other Imaging Findings

- CT: Can assess the morphology of the peroneal groove. A convex posterior surface may predispose to tendon subluxation.
- Magnetic resonance imaging (MRI): Axial MRI is the imaging plane of choice. Can assess for tears of the retinaculum as well as avulsions. In stripping injuries, the retinaculum may be elevated from the fibular periosteum. Retinacular tears are seen as areas of ill definition and thickening. May be associated with peroneal tendon tears.
- Ultrasound: The peroneal retinaculum may be visualized on ultrasound. Dynamic examination may show subluxation of the peroneal tendons.

- ✓ Chronic subluxation may predispose to peroneal tendon tears.
- Etinacular tears are often clinically mistaken for lateral ligament tears.

Case 40

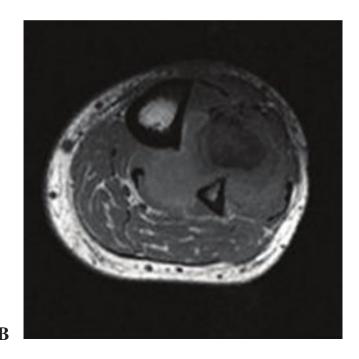


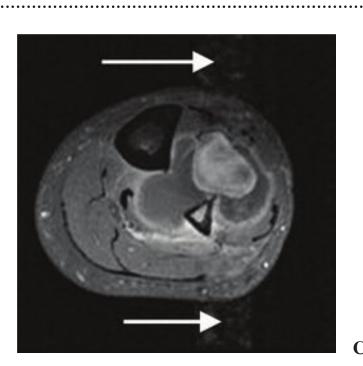


#### Clinical Presentation

A 50-year-old man with a 2-week history of pain in his left calf and recent history of cellulitis in his right leg.







Map 3
170dB/C 5
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LT LEG

LT LEG

(A) Lateral radiograph of the left leg shows an ill-defined cortical erosion of the mid-diaphysis of the fibula (arrow). (B, C) Axial T1-weighted and fat-suppressed T1-weighted postgadolinium magnetic resonance (MR) images through the midcalf demonstrate a mixed signal intensity lesion with central low T1 signal that demonstrates heterogeneous enhancement surrounded by a relatively T1 hyperintense area, which exhibits rim enhancement. The central enhancing region shows a pulsation artifact (arrows in C). There is signal change in the fibula. The lesion has breached through the interosseous membrane. (D) Power Doppler ultrasound image demonstrating evidence of arterial flow within the central component of the lesion.

#### ■ Dif erential Diagnosis

D

- Mycotic pseudoaneurysm: The heterogeneous enhancing central component and the striking pulsation artifact are in keeping with a vascular lesion. The surrounding fluid collection could represent hematoma or, as in this case, an abscess. Osseous erosion can either occur as a result of osteomyelitis or pressure erosion.
- Hematoma: Hematomas can have a variable appearance on magnetic resonance imaging (MRI) from completely cystic to more complex and heterogeneous signal characteristics depending on the age of the lesion. They should not exhibit pulsation artifact.
- Soft tissue sarcoma: Most soft tissue sarcomas have a somewhat nonspecific MRI appearance but the deep location, transcompartmental spread, and osseous erosion would be concerning. As with a hematoma, pulsation artifacts should not be seen with the lesion.

#### **■** Essential Facts

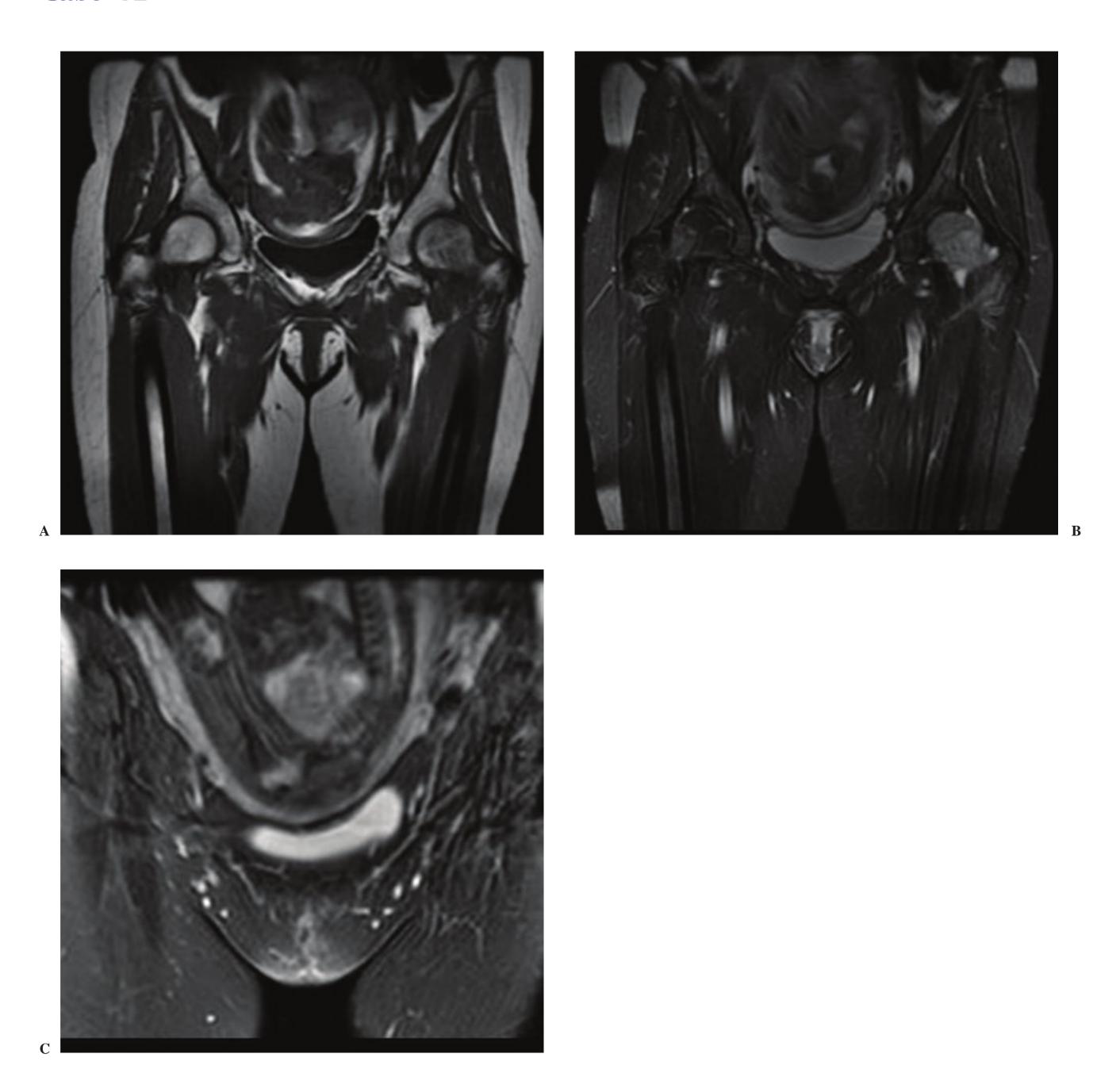
- Most common infectious agents are streptococci and staphylococci. Fungal infection is less common.
- There is weakening in the arterial wall due to the seeding of microorganisms. Communication remains with the

- vessel lumen. Seeding can occur as either direct trauma, contiguous spread, or embolic seeding.
- The most common cause of pseudoaneurysm in the lower limb is iatrogenic (femoral puncture for angiography).
- Septic aneurysms occurring in peripheral vessels may be seen with intravenous drug abuse.

### Other Imaging Findings

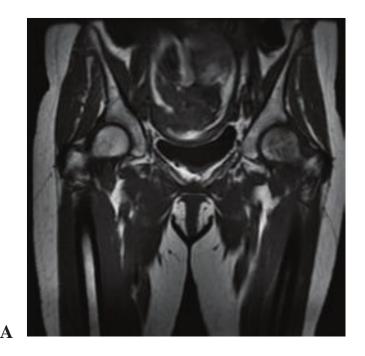
- Imaging appearances are dependent on whether the pseudoaneurysm is patent or thrombosed.
- Grayscale ultrasound: neck communicating with the artery, direct visualization of flow, layers of hematoma
- Doppler: bidirectional flow in the neck on color Doppler ultrasound (yin-yang sign), "to and fro" pulsed Doppler
- Mycotic pseudoaneurysms may demonstrate a thick wall.

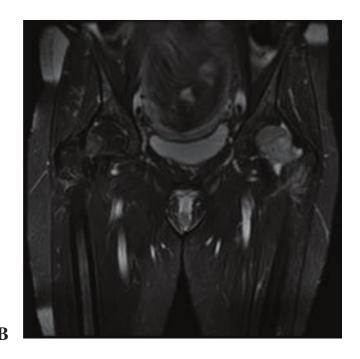
- ✓ Cinically, pulsations may not be evident due to surrounding hematoma.
- ✓ wer Doppler assessment should routinely be performed on any soft tissue mass prior to biopsy.

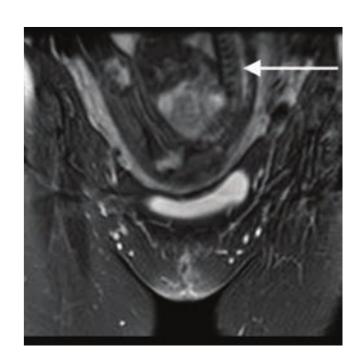


## Clinical Presentation

A 29-year-old woman with a 2-week history of severe pain in her left groin.







(A, B) Coronal T1 and fat-suppressed T2-weighted images showing diffuse low T1 signal and high T2 intensity affecting the left femoral head and neck. No evidence of fracture clefts, serpiginous areas, or focal lesions. (C) Coronal image showing evidence of a fetus in a gravid uterus (arrow).

### Dif erential Diagnosis

- Transient osteoporosis of the hip (TOH) in pregnancy: Characterized by bone marrow edema of the femoral head extending into the neck. TOH is characterized by unilateral groin pain.
- Avascular necrosis (AVN): In its early stages, AVN can present with diffuse edema, like TOH. Avascular necrosis typically involves the subarticular region and is more focal. Edema of the femoral neck may be seen especially if there is subchondral collapse.
- Subchondral fracture: This may accompany TOH or may be traumatic.

### Essential Facts

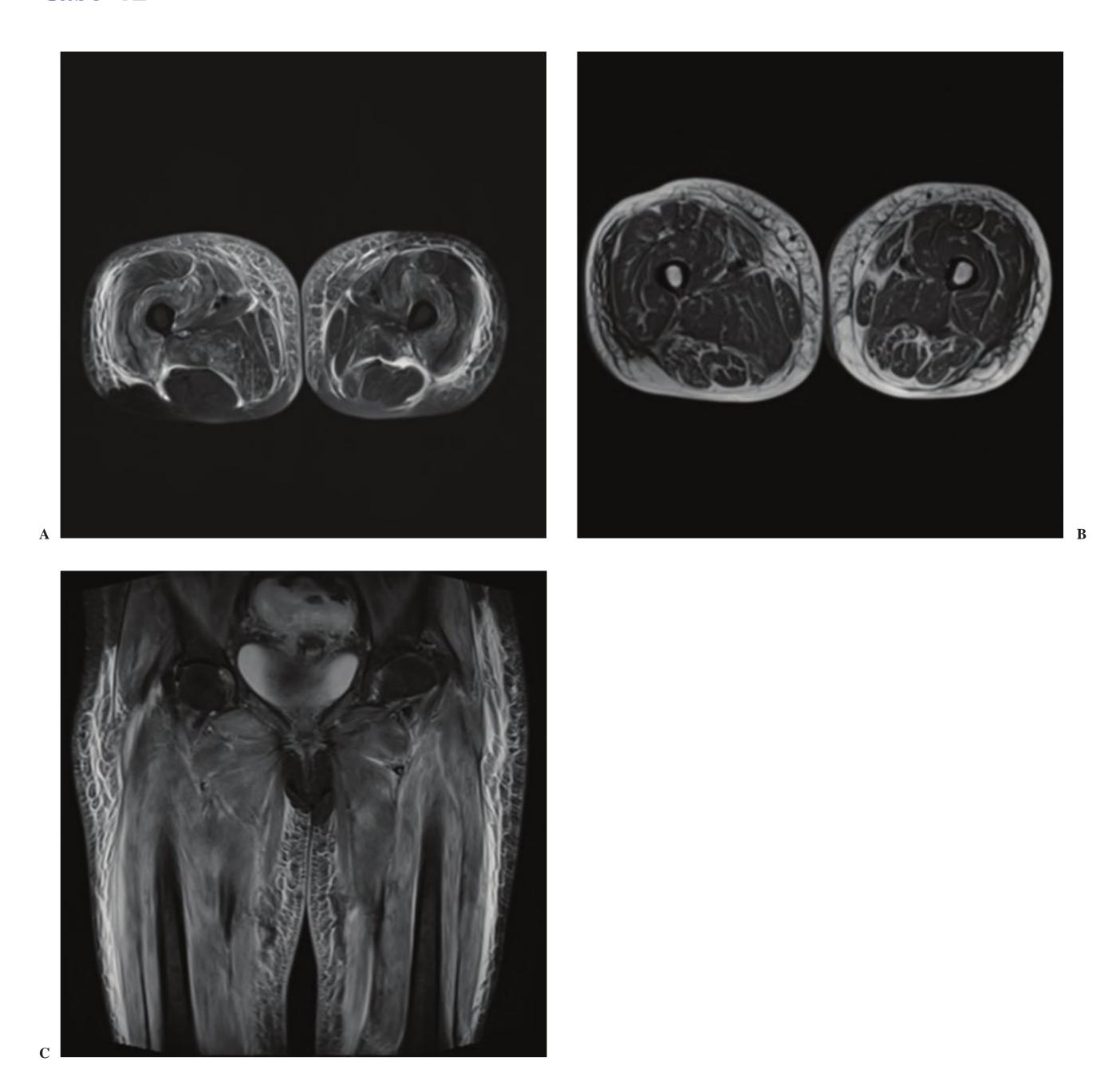
- Variably referred to as transient osteoporosis, regional migratory osteoporosis, and transient bone marrow edema syndrome depending on location, presence of osteopenia, time course, and number of joints involved
- Most cases occur in middle-aged men or women in their third trimester of pregnancy.
- There is controversy as to whether this represents an early reversible stage of AVN.
- Complications include recurrence, migration to other joints, and insufficiency fractures.

- Migration (regional migratory osteoporosis) usually occurs in the first year and extends from proximal to distal with the knee the most common secondary site followed by the ankle.
- Treatment is conservative. The condition typically resolves over 6 to 12 months.

### Other Imaging Findings

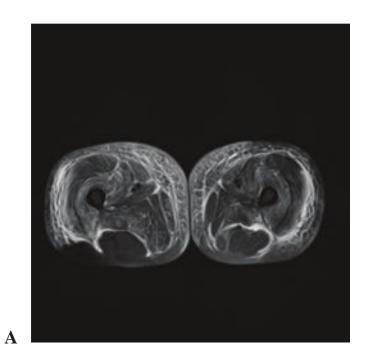
- Plain radiographs show diffuse unilateral osteopenia of the proximal femur in later stages and well-maintained joint space.
- Magnetic resonance imaging (MRI). Subchondral insufficiency fractures: linear low T1 and T2 signal paralleling the articular surface. With or without an effusion. Sparing of subchondral bone useful to distinguish from AVN.

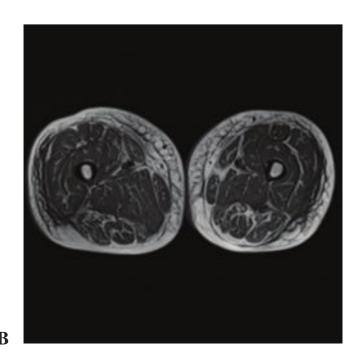
- ✓ widence of bone marrow edema can be detected on MRI within days of onset.
- bsence of osteopenia on plain radiographs does not exclude the diagnosis, as demineralization is often delayed.



# Clinical Presentation

A 56-year-old man brought into the emergency department was found unconscious. He has a known history of alcohol and drug abuse. He is found to have generalized weakness, renal impairment, and elevated creatine kinase (CK).







(A, B) Axial fat-suppressed T2-weighted and T1 magnetic resonance (MR) images of the thighs show patchy areas of signal abnormality in the deep muscle compartments of the anterior, posterior, and adductor compartments. The signal characteristics follow that of fluid/edema. Intercompartmental fluid signal particularly between the hamstrings and adductor muscles is also present. There is thickening and extensive reticular signal abnormality in the anteromedial and lateral aspects of the superficial subcutaneous layer consistent with edema. (C) Coronal short T1 inversion recovery (STIR) image shows the extent of patchy signal changes throughout all the muscles of the thigh and extent of subcutaneous edema and perifascial fluid.

### ■ Dif erential Diagnosis

- Rhabdomyolysis: This is muscle injury with disruption of the skeletal muscle cell membranes and release of myoglobin and toxic intracellular metabolites into the circulation. Affected individuals are at high risk of acute renal failure. It can occur with compartment syndrome, trauma, crush injury, excessive muscle activity, ischemia, drugs, toxins, and infection. Classically, there is a triad of weakness, muscle pain, and passage of dark brown urine. In this case, the CK levels were. 25,000.
- Inf ammatory myositis: Conditions such as polymyositis, dermatomyositis, and inclusion body myositis may present with muscle edema and, in some cases, subcutaneous edema. The hyperacute presentation would be unusual.
- Pyomyositis: Pyogenic or bacterial infection of skeletal muscle. Most common organism is Staphylococcus aureus. Risk factors include immunosuppression (including HIV), diabetes, and trauma. With suppuration, it can rapidly form an abscess. Focal muscle edema may be the earliest finding on fluid sensitive sequences. Bilateral changes that would be unusual for pyomyositis.

#### Essential Facts

• Serum CK level is a sensitive marker for muscle cell breakdown but its concentration is variable and does not necessarily correlate with the degree of muscle damage.

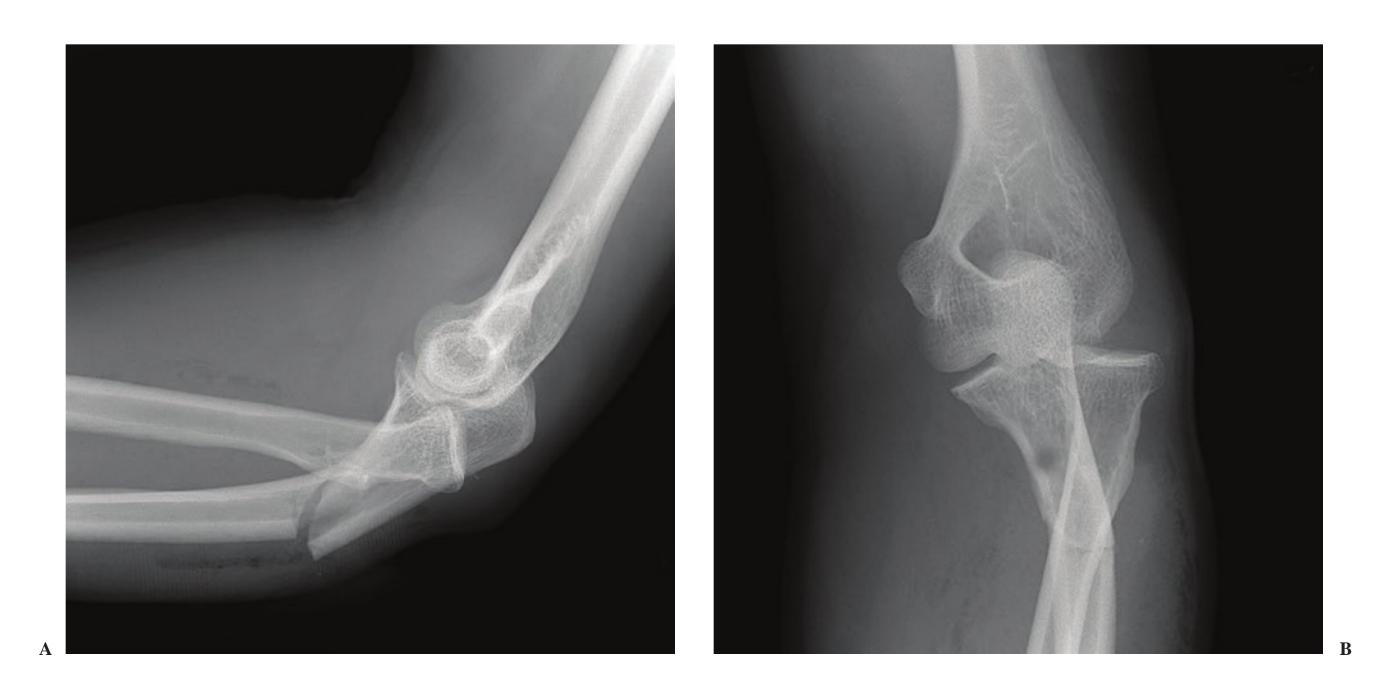
- Rhabdomyolysis is also associated with the detection of myoglobin in the urine.
- Early diagnosis is essential, as it can be a potentially lifethreatening condition due to hyperkalemia and metabolic acidosis that can develop.

#### Other Imaging Findings

- MR findings can be diffuse, symmetric, asymmetric, or unilateral. Magnetic resonance imaging is very sensitive but not specific and should be interpreted with clinical information.
- Nonintravenous (IV) contrast computed tomography (CT) imaging may demonstrate muscle enlargement and discrete fluid attenuation areas with established myonecrosis, but magnetic resonance imaging is more sensitive.

## ✓ Pearls & × Pitfalls

✓ IV contrast study should be avoided given the high risk of renal impairment with the condition.



## Clinical Presentation

A 45-year-old man with pain and swelling in the forearm after a fall.





(A) Lateral radiograph showing a transverse fracture through the proximal ulnar diametaphysis with slight angulation, apex posteriorly, and posterior dislocation of the radial head at the radiocapitellar joint and the proximal radioulnar joint. There is gas within the soft tissues consistent with an open fracture. (B) Anteroposterior view of the elbow showing lateral subluxation of the radial head with respect to the capitellum.

### Dif erential Diagnosis

• Monteggia fracture: Proximal ulnar fracture with dislocation of the radial head. A displaced fracture of the ulna leads to a dislocation of the radial head because the ulna and radius are bound by the interosseus membrane and ligaments resulting in a closed loop. In addition, the annular ligament is injured.

### Essential Facts

- A Monteggia fracture represents a fracture of the ulna (typically proximal to middle third) with dislocation of the radioulnar joint.
- This injury is usually as a result of fall on an outstretched hand with forced pronation or hyperextension.
- Monteggia fractures are classified into four types (Bado classification): (1) anterior dislocation of the radial head with apex anterior angulation of ulna, (2) posterior dislocation of the radial head with apex posterior angulation of ulna, (3) lateral dislocation of the radial head, and (4) anterior dislocation of the radial head with fractures of the proximal radius and ulna.
- The apex of the ulnar fracture usually points in the direction of the radial head dislocation.
- In children, an ulnar fracture may be a greenstick fracture.

- Anterior dislocation of the radial head accounts for 65% of all cases. Lateral dislocation is the second most common type.
- There may be a neuropraxia of the posterior interosseous branch of the radial nerve as it passes around the radial neck, particularly with type II fractures.
- Closed reduction of the radial head may fail due to interposition of the annular ligament at the proximal radioulnar joint, particularly with type III fractures.

## Other Imaging Findings

• Other modalities offer little additional information, which would potentially alter end point treatment in an acute setting.

- ✓ The radial head dislocation can be subtle and there needs to be a high index of suspicion with any ulnar fractures. To determine the presence of a radial head dislocation, a line paralleling the proximal radial diametaphysis should pass through the center of the capitellum on any view.
- ✓ **G** injuries of forearm bones, the elbow and wrist should be included in radiographs.



## Clinical Presentation

A 23-year-old who suffered an injury on the ski fields.







(A) Anteroposterior (AP) radiograph of the ankle demonstrates a fracture of the lateral aspect of the hindfoot involving the talus (arrow). (B) Lateral radiograph of the ankle demonstrates minimal deformity of the lateral process of the talus (arrow). (C) Coronal reformatted computed tomography (CT) of the ankle shows a minimally comminuted fracture through the lateral process of the talus (arrow).

### ■ Dif erential Diagnosis

- Lateral process of talus fracture: Careful attention to the cortex of each of the hindfoot bones reveals the cortical discontinuity is of the talus. This fracture is of the lateral process, which is a wedge-shaped projection of the lateral talar body. Commonly known as a *snowboarder's fracture*. The soft tissue swelling is typically more inframalleolar than seen with lateral malleolar fractures.
- Fracture lateral wall calcaneus: On the AP view of the ankle, fractures of the lateral cortex of the calcaneus may be seen in the inframalleolar region but are more inferior than lateral process talus fractures. These fractures are typically along the anterior calcaneus and may represent extensor digitorum brevis avulsions or may be along the lateral rim of the calcaneocuboid joint and be associated with cuboid and dorsal navicular fractures. A combination of AP and mortise views combined with AP view of the foot will show the correct localization of these lateral wall fractures.

#### **Essential Facts**

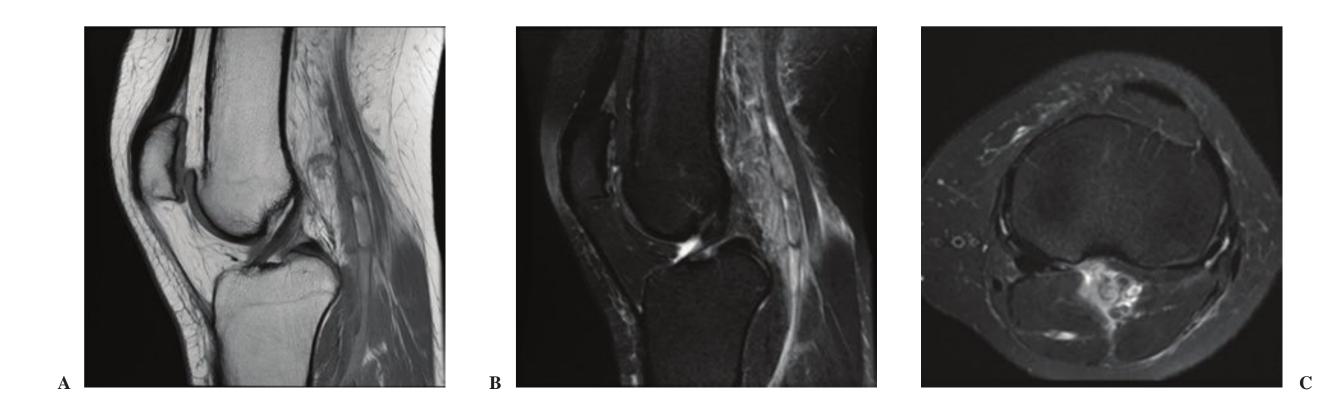
• The lateral process has a lateral articular surface, which articulates with the lateral malleolus, and an inferior articular surface, which forms part of the posterior facet of the subtalar joint.

- Snowboarder's fracture: Occurs when the foot is forcefully dorsiflexed and inverted/external rotation. Can also occur in a fall from height.
- The anterior talofibular ligament and several important talocalcaneal ligaments arise from the lateral process.
- Malunion or nonunion can result in malalignment and instability of the posterior subtalar joint, leading to persistent pain and rapidly progressive secondary osteoarthritis.
- Classified into three types: fractures through the tip, through the base, or comminuted fractures
- If the fragment is large and intra-articular, open reduction and internal fixation (ORIF) may be necessary.

## Other Imaging Findings

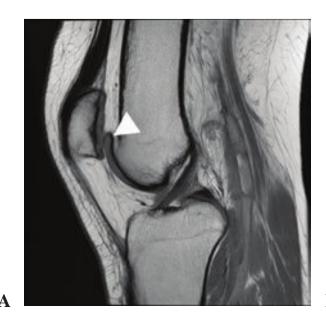
- Radiographs: fracture cleft, loss of visualization of lateral process on lateral
- CT scan is a valuable adjunct to define the size of the fracture, identify associated fractures, and evaluate for degree of comminution and intra-articular extension.

- framalleolar soft tissue swelling on AP view should raise concern for lateral process talus or anterior calcaneus fractures.
- \* Cadiographs often underestimate severity of the injury.

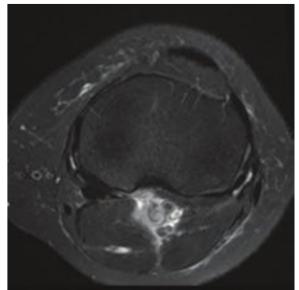


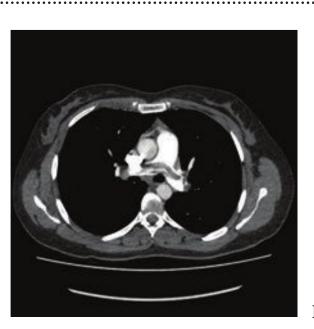
# Clinical Presentation

A 30-year-old woman in a motor vehicle accident (MVA) 1 month ago complaining of knee pain.









(A-C) Sagittal proton density, sagittal fat-suppressed T2-weighted, and axial fat-suppressed T2-weighted magnetic resonance (MR) images demonstrate diffuse intermuscular edema in the popliteal fossa. The edema has a predominantly perivascular distribution on the axial images. The sagittal images demonstrate focal distension of the popliteal vein with altered intraluminal signal changes through the region of expansion (arrowheads). No joint effusion, bone, or ligamentous injury is seen. (D) Subsequent axial computed tomography (CT) pulmonary angiogram demonstrated a saddle embolus.

### Dif erential Diagnosis

- Deep venous thrombosis (DVT) popliteal vein (with pulmonary embolism): The perivascular edema is suspicious for a vascular etiology and this is further supported by the venous distension and focal altered signal.
- Shearing injury through popliteal fossa: Intermuscular edema of the popliteal fossa is commonly encountered as part of a rotational knee injury such as a pivot shift injury. There are no supportive findings of such an injury, such as anterior cruciate ligament (ACL) tear or bone marrow contusions, in this case.
- Direct trauma to popliteal fossa with edema/hematoma: In cases of direct trauma, some intramuscular and subcutaneous changes would also be expected.

#### **Essential Facts**

• Magnetic resonance imaging (MRI) has been used for the detection of lower limb DVT with variable success. Overall sensitivities and specificities of >90% have been reported especially for above knee DVT. However, these results relate to dedicated magnetic resonance venography or direct thrombus imaging techniques.

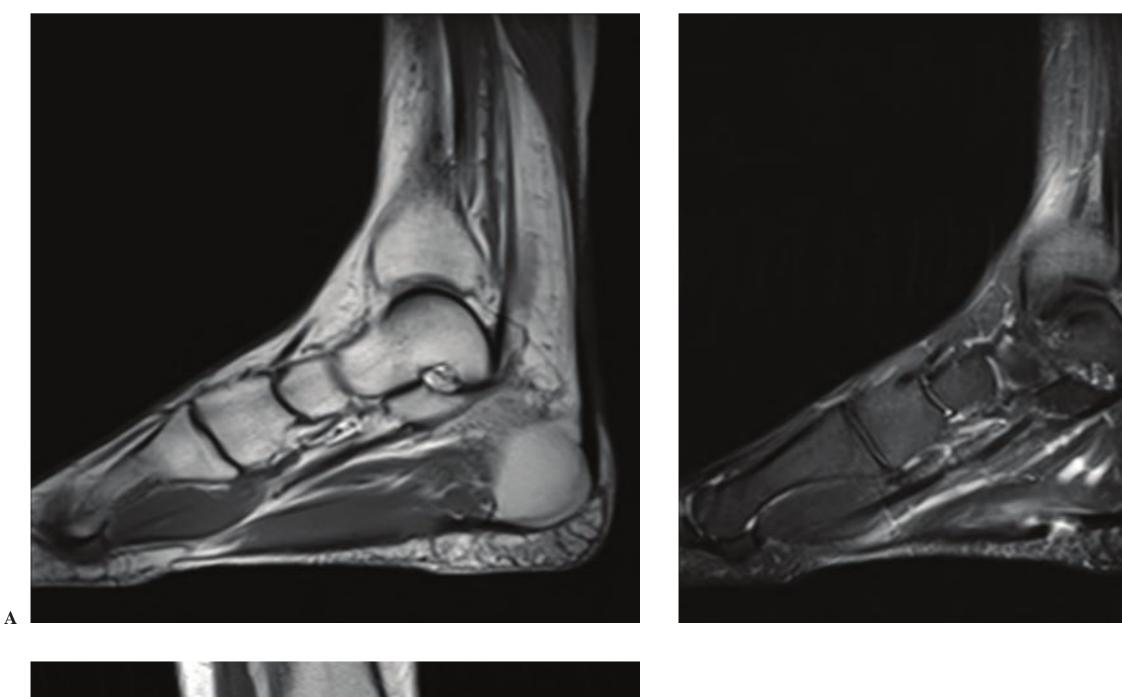
• The intravascular signal is highly variable on routine knee MR pulse sequences. Ancillary findings such as distension and edema should be evaluated for. The accuracy of routine knee pulse sequences for the detection of DVT is not known but is likely to be lower than magnetic resonance venography.

## Other Imaging Findings

• Doppler ultrasound (US): This is the most commonly utilized modality for assessment of DVT. Distension of the vein, lack of compressibility, altered intraluminal echogenicity, loss of normal augmentation, absent or decrease flow on Doppler US, and nonphasic flow.

### ✓ Pearls & ➤ Pitfalls

✓ Sessels should be carefully evaluated on knee MRI following trauma, particularly following knee dislocation.





# Clinical Presentation

A 28-year-old man with foot pain after running.







Sagittal T1-weighted magnetic resonance imaging (MRI) (A) demonstrates focal loss of the normal low signal intensity of the plantar fascia (arrow). Sagittal fat-suppressed T2-weighted MRI (B) shows focal discontinuity of the plantar fascia with intervening high T2 signal intensity (arrow) as well as edema within the adjacent f exor digitorum brevis. Coronal intermediate-weighted image (C) shows lack of the normal low signal intensity of the plantar fascia (arrowhead).

### Dif erential Diagnosis

- Rupture of the medial band of the plantar fascia: focal complete disruption of the plantar fascia
- Plantar fasciitis: Consists of microtears of the plantar fascia. It may be predisposed to by overuse, mechanical factors, or by inflammatory arthritides particularly seronegative arthropathies. This is usually seen as increased thickness of the plantar fascia with or without increased signal intensity but without discontinuity of the plantar fascia. Most commonly seen at the origin of the plantar fascia. May be associated with edema within the calcaneus.
- Plantar f brom atosis: Causes fusiform thickening of the plantar fascia typically of low T1 and T2 signal without discontinuity. More cellular and aggressive plantar fibromatosis may show increased T2 signal but this is not of fluid signal.

#### **■** Essential Facts

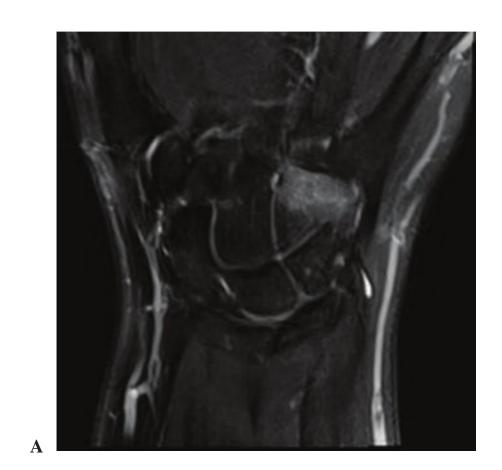
• The plantar fascia helps to support the longitudinal arch of the foot and consists of medial, central, and lateral bands and originates from the medial tuberosity of the calcaneus.

- The normal plantar fascia is of low signal intensity on all pulse sequences and measures up to 4 mm in thickness on MRI and ultrasound.
- Plantar fascia rupture is typically preceded by plantar fasciitis.

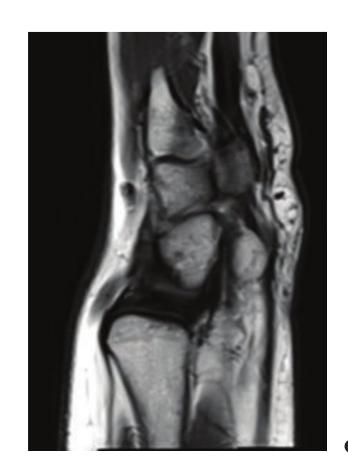
### Other Imaging Findings

- Ultrasound: Ultrasound may also be used for evaluation of the plantar fascia demonstrating thickening in cases of plantar fasciitis and discontinuity with variable hematoma, seen as hypoechoic changes, in cases of plantar fascia rupture.
- MRI: There may be an associated tear of flexor digitorum brevis.

- Heel spurs occur at the attachment of flexor digitorum brevis and are not the cause of plantar fasciitis.
- ✓ Mantar fascia rupture may be associated with local steroid injections.
- ✓ Thronic tears may be seen as areas of fusiform thickening of low signal intensity.

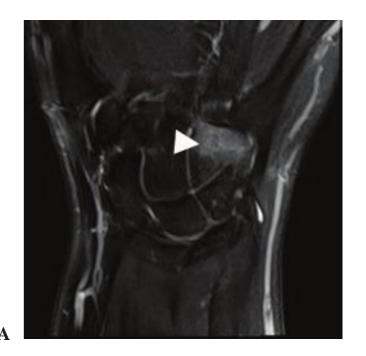


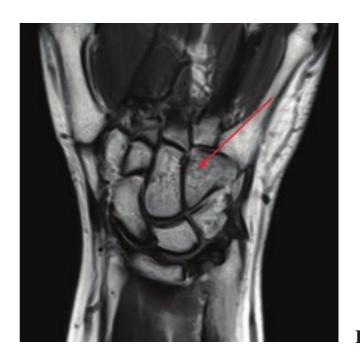




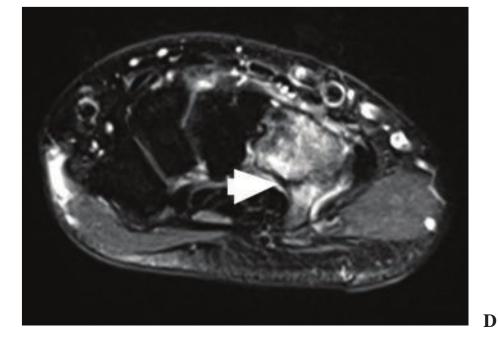
Clinical Presentation

A 41-year-old female recreational tennis player with wrist pain.









Coronal fat-suppressed T2-weighted image (A) demonstrates increased signal within the body of hamate (arrowhead). Corresponding coronal proton density image (B) demonstrates vague low signal intensity in the same area (arrow). Sagittal proton density image (C) shows a fracture cleft through the base of the hook of hamate (arrowhead). (D) Axial fat-suppressed T2-weighted image confirms diffuse edema of the body and hook of hamate and the undisplaced fracture cleft (arrowhead).

# ■ Dif erential Diagnosis

- Hook of hamate fracture: Diffuse edema in the hamate with a cleft at the base of the hook is consistent with a fracture. Commonly associated with racquet sports that cause chronic, repetitive injury such as tennis, baseball, and golf. Also occurs with fall on outstretched hand (FOOSH) injuries.
- Fracture of ham ate body: Less common. Usually demonstrates a dorsally displaced fragment. May be associated with fracture dislocations of the fourth and fifth carpometacarpal joints.
- Accessory ossicle (os hamulus proprium): May resemble a nonunited hook of hamate fracture; however, the margins tend to be smooth.

#### **■** Essential Facts

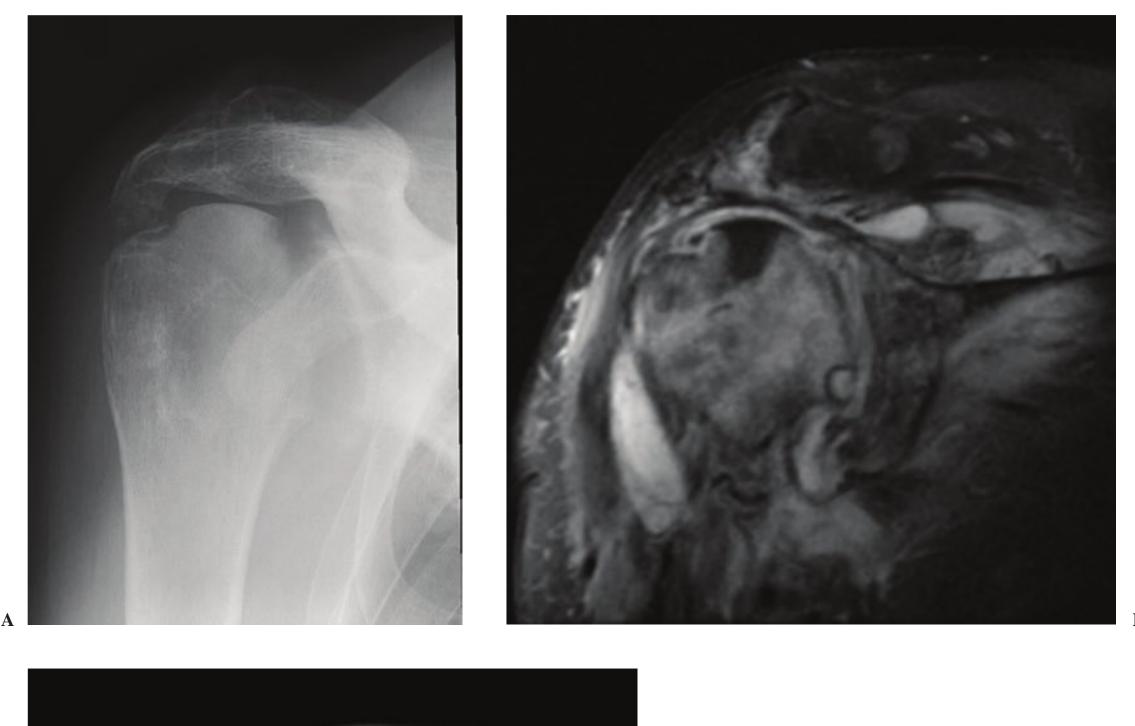
- Hamate fractures account for less than 2% of all of carpal fractures.
- More frequently involves the hook than the body
- Site of attachment of transverse carpal ligament
- The motor branch of the ulnar nerve passes along the ulnar margin of the hook of hamate, whereas the sensory branch passes more superficially.

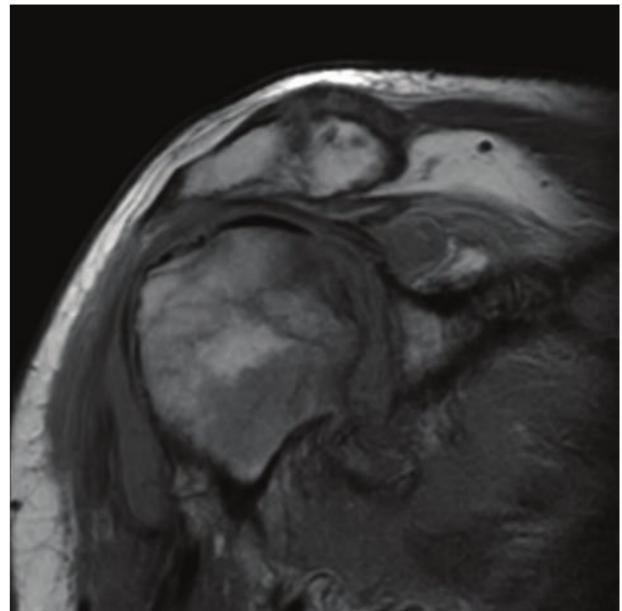
- Complications include nonunion, ulnar nerve palsy, carpal tunnel syndrome, and ulnar artery compromise.
- Nonunited fractures have been associated with tears of the third to fifth flexor tendons.
- Treatment options include cast immobilization, internal fixation, or excision of the hook.

### Other Imaging Findings

- Plain radiography: Difficult to visualize. Look for loss of cortical ring on anteroposterior (AP). Carpal tunnel views will demonstrate a hook fracture.
- Computed tomography (CT): imaging modality of choice for detection of fracture and assessment of union

- ✓ Cook of hamate has an intimate relation to the ulnar artery and nerve and also to the carpal tunnel. It is important to evaluate for their integrity.
- fracture nonunion may have to be treated by resection of the hook.

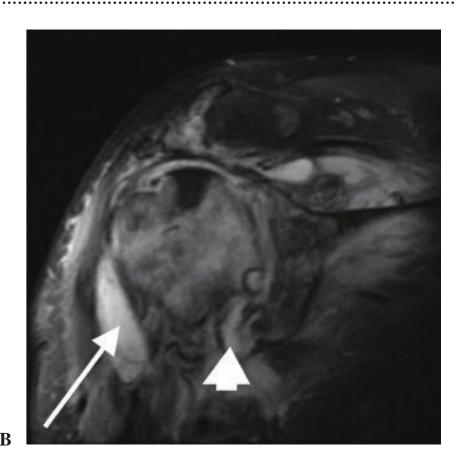


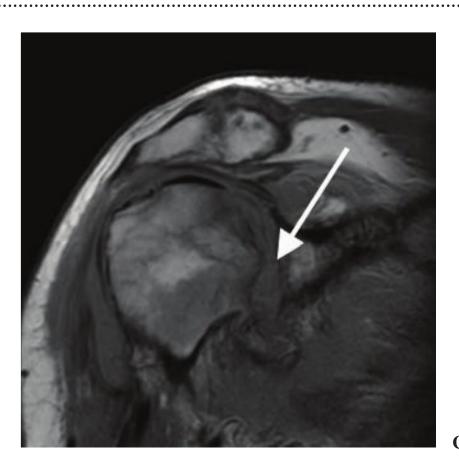


## Clinical Presentation

A 74-year-old man with a history of hepatocellular carcinoma presenting with a painful shoulder with decreased range of motion.







Anteroposterior radiograph of the shoulder (A) illustrates destruction of the humeral head and glenoid with widening of the glenohumeral joint space. Coronal oblique fat-suppressed T2 and proton density magnetic resonance (MR) images (B, C) demonstrate destruction of the articular surfaces of the glenoid and humeral head (arrow in C) with joint effusion and synovitis (arrowhead in B), extensive periarticular edema, and a fuid collection in the subacromial bursa (arrow in B). There is edema of the proximal humerus with low signal osseous changes on proton density images. The supraspinatus is torn.

### Dif erential Diagnosis

- Septic arthritis and osteomyelitis of the shoulder: Destructive changes involving both sides of the joint with effusion, synovitis, and periarticular inflammatory changes are consistent with infection.
- Crystal disease: Crystal deposition disease with calcium pyrophosphate dihydrate can have clinical similarities to septic arthritis and can produce destructive changes at the joint. However, the destructive changes of the humeral head are very ill defined and infection remains the diagnosis of exclusion.
- Active inf ammatory arthritis: Erosions and destructive changes with synovitis and periarticular inflammation may be seen. However, usually there is joint space loss and the destructive changes are not so confluent.

### Essential Facts

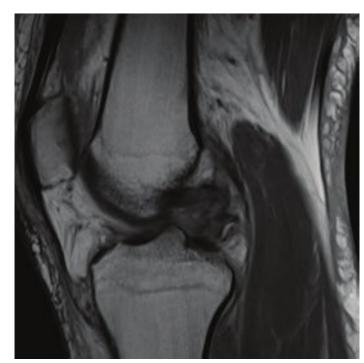
- Staphylococcus aureus and Neisseria gonorrhoeae are amongst the most common causative organisms of pyogenic infection.
- Risk factors: diabetes mellitus, immunosuppression, intravenous (IV) drug use, open fractures, orthopedic hardware, and sickle cell disease
- Septic arthritis is an emergency. Unchecked joint destruction can occur within 24 to 48 hours.
- Plain radiographs can be insensitive to early changes and normal radiographs do not exclude septic arthritis.

## Other Imaging Findings

- Soft tissue swelling and osteopenia are amongst the earliest radiographic findings.
- Ultrasound for detection of an effusion and aspiration
- Computed tomography (CT) and magnetic resonance imaging (MRI) are utilized if there is concern for an abscess, if there is no response to treatment, or for preoperative assessment. Increased T2 signal without corresponding T1 signal change in bone may be seen with osteitis. Low T1 signal changes add specificity for osteomyelitis. MRI will show areas of diffuse enhancement with abscesses exhibiting rim enhancement.
- Nuclear scintigraphy with bone and gallium or white cell scans will show increased activity and are very sensitive.

- ✓ Che loss of subchondral cortical bone/subarticular white line on a radiograph is indicative of septic arthritis until proven otherwise.
- Ever and an increased white cell count are both present in septic arthritis and crystal deposition disease.
- ✓ Gint aspirate should be sent for culture and sensitivity, cell count, and crystals.







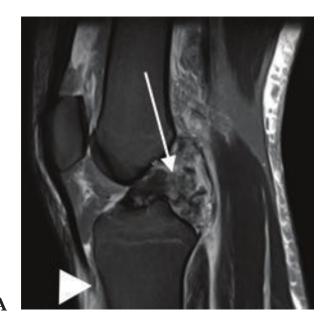
## Clinical Presentation

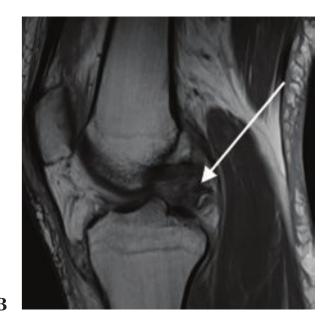
A 35-year-old with difficulty bearing weight following a twisting injury to the knee.

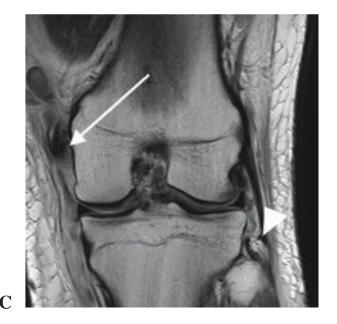
## **■** Further Work-up

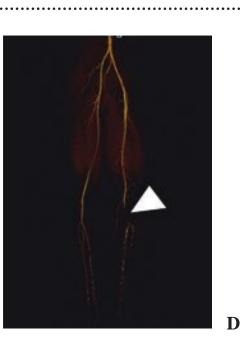


D









Sagittal fat-suppressed T2-weighted magnetic resonance imaging (MRI) (A) shows a complete tear of the proximal to mid anterior cruciate ligament (ACL) (arrow). There is also a tear of the distal insertion of the patellar tendon (arrowhead) as well as edema and focal discontinuity of the inferior aspect of the posterior capsule. (B) Sagittal proton density MRI demonstrates an osseous avulsion of the distal posterior cruciate ligament (PCL) (arrow). (C) Coronal intermediate-weighted image shows complete tears of the medial collateral ligament (MCL) (arrow) and distal f bular collateral ligament (arrowhead). (D) Image from a computed tomography (CT) arteriogram shows a popliteal artery injury with a segmental occlusion (arrowhead).

## ■ Dif erential Diagnosis

- Knee dislocation: Complete tears of the cruciates and collaterals as well as the patellar tendon with associated popliteal artery injury.
- O'Donoghue terrible triad: This consists of tears of the ACL, MCL, and medial meniscus. In this case, the PCL and fibular collateral ligament and the patellar tendon are also injured.

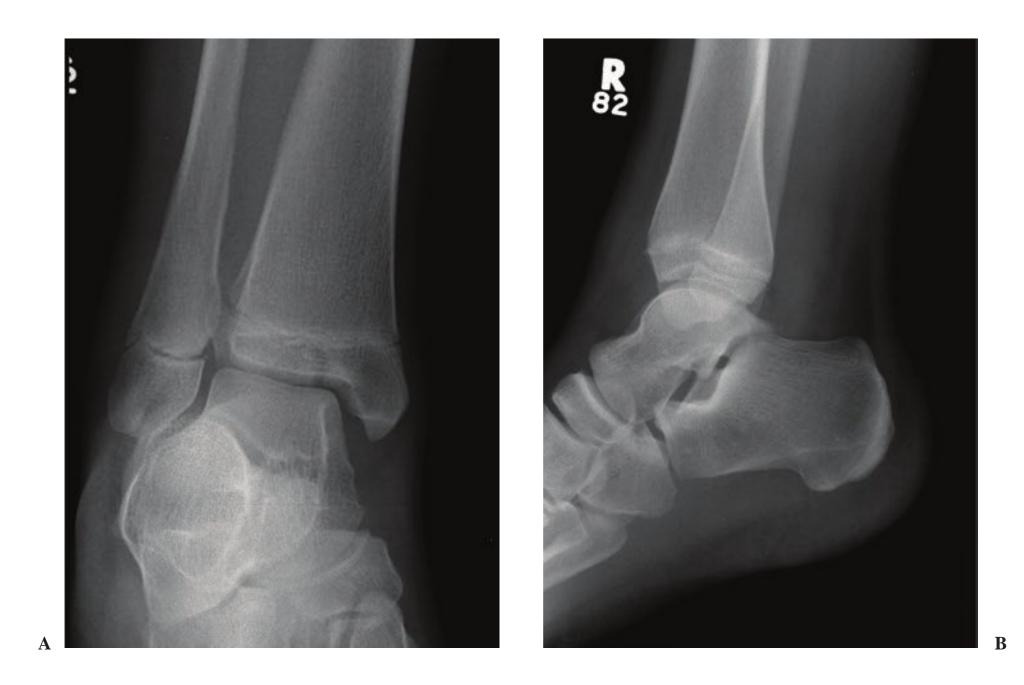
#### **■** Essential Facts

- Knee dislocations may be seen in the setting of sporting activities, a fall from height, or motor vehicle accident.
- Many knee dislocations may reduce spontaneously.
- The majority of patients with knee dislocations have tears of at least three ligaments. Some patients with knee dislocations may have tears of only two ligaments. These patients are more likely to have an associated fracture.
- ACL and PCL are torn in almost all cases. Patellar tendon injuries are relatively uncommon.
- Popliteal artery injuries may be seen in up to 40% of patients and common peroneal nerve injuries may be present in up to 33% of patients depending on the mechanism of injury. Most patients with common peroneal nerve injury have an injury of both cruciates and the fibular collateral ligament.

## Other Imaging Findings

- MRI: multiligamentous injuries, altered signal intensity in relation to the popliteal artery or the common peroneal nerve, capsular tears, meniscal tears, and biceps femoris and popliteus tears
- CT: fractures including arcuate fractures and cruciate avulsion fractures
- Conventional or computed tomography angiography: occluded popliteal artery

- ✓ Gue to the high incidence of neurovascular injuries, the neurovascular structures should be carefully evaluated.
- ✓ Eknee dislocation should be considered in all individuals with tears of three or more ligaments.

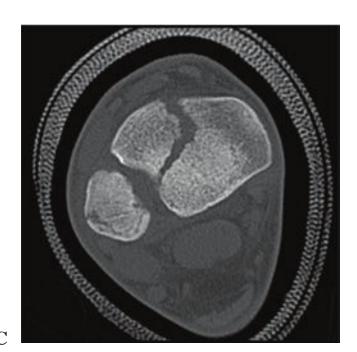


## Clinical Presentation

A 14-year-old boy presenting after ankle trauma.









(A, B) Anteroposterior (AP) and lateral radiographs of the ankle demonstrate a fracture through the distal tibial epiphysis in the sagittal plane (arrow). The physis remains open on these radiographs and the superior border of the fracture curves laterally along the physeal plate. (C, D) Axial and coronal computed tomographies (CT) of the ankle show an intra-articular fracture of the distal tibial epiphysis involving the anterolateral aspect of the articular surface. The fracture is vertically oriented in the epiphysis and has a transverse component through the physis. The coronal CT demonstrates some fusion across the medial aspect of the physis.

### ■ Dif erential Diagnosis

- Tillaux fracture (juvenile): The fracture has a vertical component through the epiphysis and a horizontal component through the physis representing a Salter-Harris III fracture.
- Triplanar fracture: The triplanar fracture is a fracture, which in addition to the vertical epiphyseal and transverse physeal fracture components of a juvenile Tillaux fracture, has a metaphyseal fracture best seen on the lateral view. There are several types representing either a Salter-Harris type IV fracture or a combination of type II and type III fractures.
- Pilon fracture: This is a more severe injury typically with a poorer outcome. These are fractures of the epiphysis (and physis in adolescents) that are typically comminuted with . 5 mm displacement and variable presence of talar and fibular fractures.

#### Essential Facts

• Usually occurs as a result of an external rotation injury. There is avulsion of the anterolateral tibial epiphysis by the anterior inferior tibiofibular ligament.

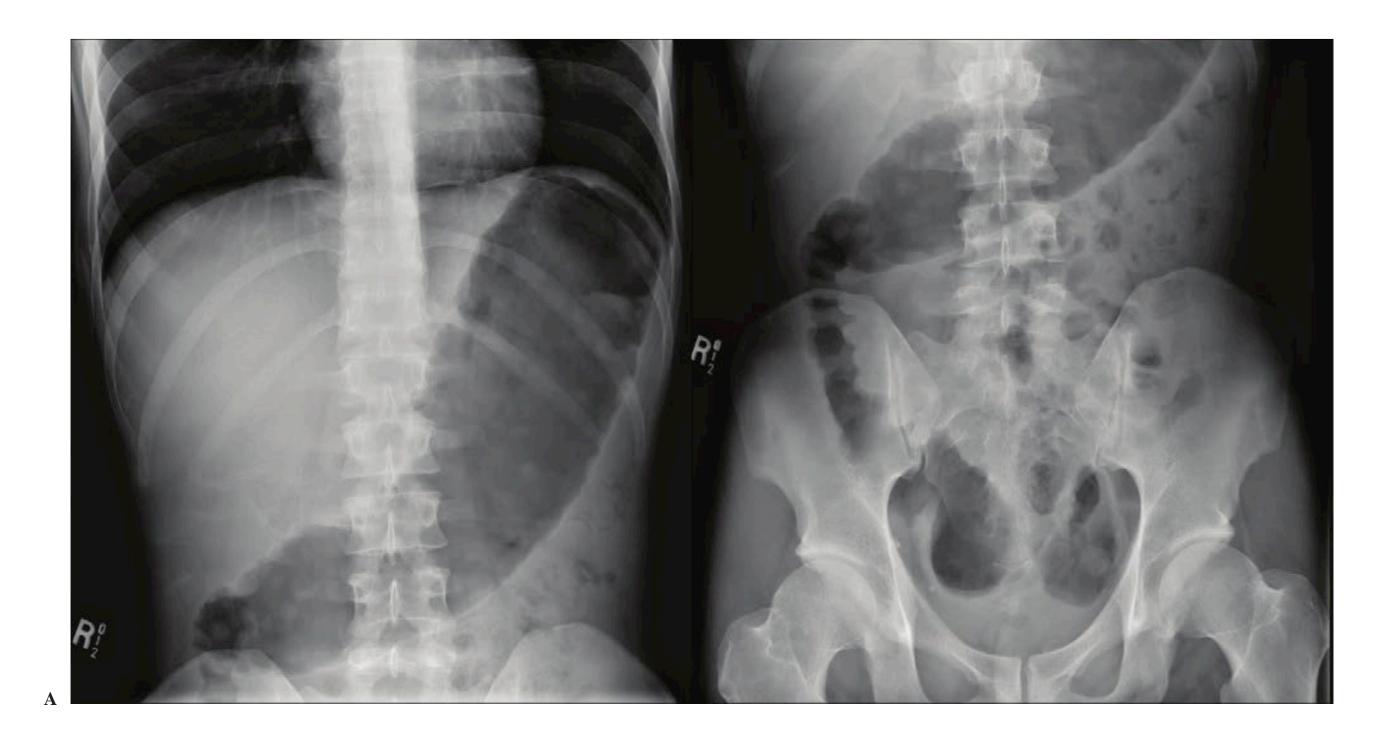
- The fracture commonly occurs in adolescents (11 to 15 years) after the central and medial parts of the physis have fused but before fusion of the lateral physis.
- As the fracture typically occurs once fusion of part of the physis has already commenced, the potential for deformity due to physeal injury is relatively minor.
- Although undisplaced fractures may be treated conservatively, displaced fractures (. 5 mm displacement and in some cases with 2 to 5 mm of displacement) are treated with internal fixation.
- The Tillaux fracture in adults represents a fracture of the distal tibial tubercle caused by the anterior inferior tibiofibular ligament.

### Other Imaging Findings

• CT: As in this case, CT demonstrates anterolateral rotation of the fracture fragment.

## ✓ Pearls & ➤ Pitfalls

✓ CΓ is the modality of choice for the detection of articular step deformity.



## Clinical Presentation

A 23-year-old man with 3-day history of diarrhea and 1-day history of fever and mild abdominal tenderness.



(A) Supine radiographs: dilated colon (10 cm) with thumbprinting (mucosal edema) of the colon, especially the ascending colon. Cecum measures 7 cm.

### Differential Diagnosis

- Acute ulcerative colitis: This inflammatory disease presents in most patients by the age of 30 years and can range from a proctitis to pancolitis. A plain abdominal X-ray can estimate disease extent and exclude toxic megacolon.
- Infectious diarrhea: Can occur in any age group and may be associated with recent travel or antibiotic use. Symptoms include watery or bloody diarrhea, abdominal cramps, weight loss, and fever. It is diagnosed by stool microscopy and cultures. The disease may be self-limiting.
- Diverticulitis: Prevalence of this disease is age dependent and more common in the elderly: 65% of patients have diverticulosis by age 80 years. Symptoms include abdominal tenderness, chronic constipation, diarrhea, and active bleeding. Computed tomography (CT) is the imaging of choice to assess severity and prognosis.

### Essential Facts

- A plain abdominal X-ray is essential.
- Daily abdominal X-rays should be performed in patients with megacolon until a management decision is made.

### Other Imaging Findings

- Flexible sigmoidoscopy would show the typical findings of colitis depending on the type. Ulcerative colitis: superficial ulceration; infectious colitis: ulcerative membranes.
- Colonic dimension (cecum. 9 cm, transverse colon. 7 cm) or progressive dilatation with toxic symptoms are ominous signs.
- CT can be used to diagnose and evaluate disease progression and assess complications such as perforation; also helpful in distinguishing ulcerative colitis from Crohn disease (especially if skip areas and small bowel [SB] involvement).

- ✓ ©gmoidoscopy may help evaluate the severity of an acute attack.
- ✓ ain films of the abdomen are essential in evaluating treatment effectiveness.
- ✓ SB becomes progressively dilated, then treatment is failing.
- **x** ectal contrast examination is contraindicated.

Case 52

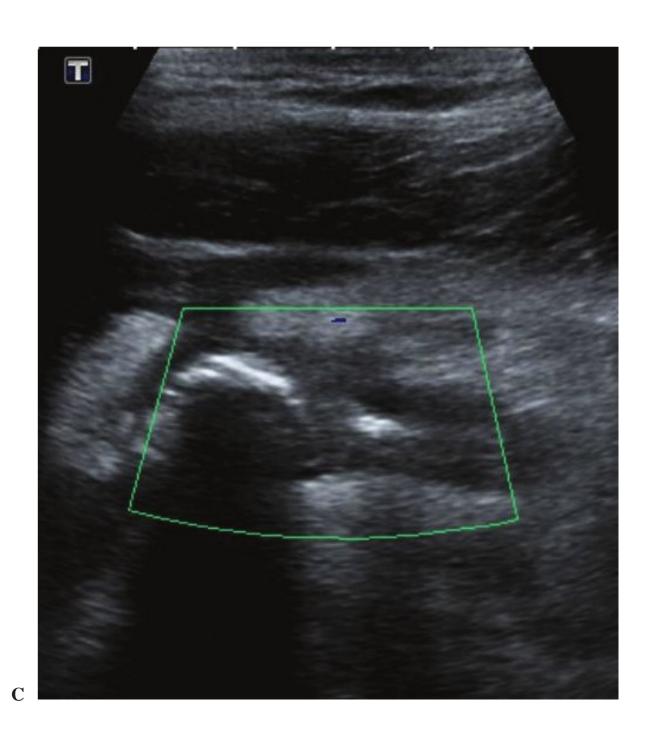


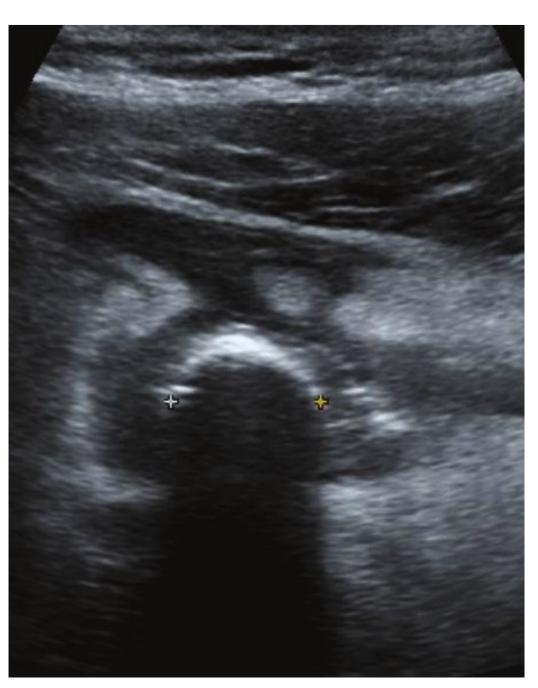


## Clinical Presentation

A 35-year-old man presents with right lower quadrant (RLQ) pain, nausea, and vomiting.

## **■** Further Work-up

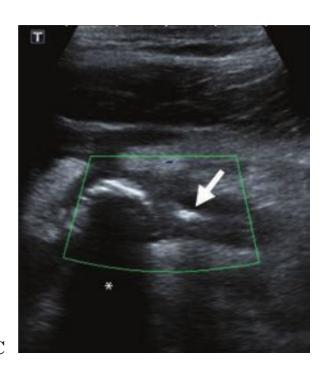




D









(A) A supine abdominal radiograph shows a well-circumscribed round rim calcification in right iliac fossa (arrow). (B) Supine film of the abdomen showing the immobile calcification in the right iliac fossa. (C) An ultrasound (US) scan of the RLQ shows the longitudinal view of a noncompressible, fluid-filled, blind-ending tubular structure (short arrow) representing a distended appendix measured 13 mm in diameter. (D) A transverse US scan through the tubular structure shown in (C), an echogenic foci (arrow) with acoustic shadowing (asterisk in images C and D), representing an appendicolith.

## ■ Dif erential Diagnosis

- Appendicitis with appendicolith: An appendicolith is a calcified deposit within the appendix. Although it is one cause of appendiceal lumen obstruction that can lead to acute appendicitis, the presence of an appendicolith in the absence of clinical symptoms or other signs of appendiceal inflammation is not diagnostic of acute appendicitis. An appendicolith can occasionally appear as a calcified mass in the right iliac fossa on abdominal X-ray. On US, it appears as an echogenic focus with acoustic shadowing.
- Mucocele of the appendix: This is a dilated appendiceal lumen secondary to abnormal accumulation of mucus. Mucocele of the appendix can appear as a round RLQ mass with curvilinear calcifications on abdominal X-ray. On US, mucoceles appear as elongated cyst-like masses with internal echoes and an indistinct wall.
- *Ureteral calculi:* An appendicolith that is close to the midline can mimic a ureteral calculi. Most ureteral calculi are impacted at the narrowest points of the ureter including the ureteropelvic junction, the ureterovesicular junction, and the crossing of the iliac vessels.

#### Essential Facts

- Thirty percent of patients with acute appendicitis demonstrate an appendicolith.
- Appendicolithiasis in association with abdominal pain is 90% specific for acute appendicitis.
- Appendicolithiasis is associated with a 50% greater risk of appendiceal perforation.
- The presence of an appendicolith has significant therapeutic considerations: dropped appendicoliths can result in the development of pelvic abscesses.

### Other Imaging Findings

- US: The maximal appendiceal diameter (outside wall diameter) is greater than 6 mm. A target appearance on transverse imaging is observed if fluid is present in the lumen. Other findings include pericecal/periappendiceal fluid, increased periappendiceal echogenicity, and enlarged mesenteric lymph nodes.
- Computed tomography (CT): Distended appendix greater than 7 mm in maximal diameter, appendiceal wall thickening and enhancement, appendicolithiasis, adjacent bowel wall thickening, pericecal fat stranding, intraperitoneal free fluid or abscess, and large mesenteric lymph nodes.

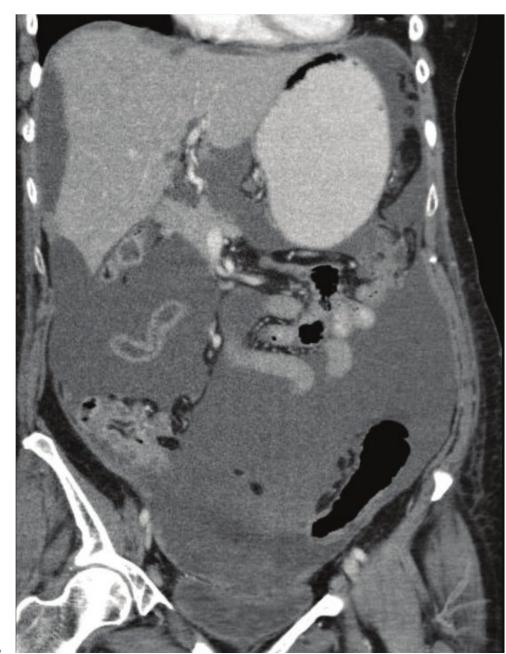
- ✓ Trim calcification in RLQ on plain abdominal films in the correct clinical setting suggests appendicolith with appendicitis.
- ✓ Craded-compression US and/or helical CT are the best imaging modalities to evaluate suspected appendicitis, as plain films are often unremarkable.
- is crucial to obtain a transvaginal US to visualize the appendix when it is not fully visualized transabdominally.
- x tot all calcification in the RLQ are appendicoliths.



## Clinical Presentation

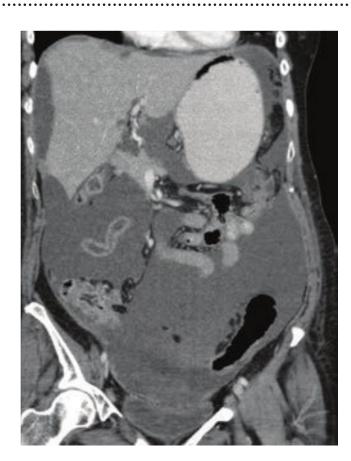
A 51-year-old woman presented with abdominal distension of several weeks duration. She drinks several bottles of wine per day.

## **■** Further Work-up



R





B

(A) Supine plain film shows ground-glass appearance of the abdomen. (B) Coronal computed tomography (CT) scan shows fluid in the paracolic gutters and around the liver and central peritoneal spaces.

### Differential Diagnosis

- Transudative ascites: Ascites is a pathologic collection of fluid in the peritoneal cavity. Patients present with abdominal distension and shifting dullness can be elicited on exam.
- Constipation: Abdominal X-ray will show fecal impaction, usually throughout the colon. Severe prolonged constipation can cause a "functional" small bowel obstruction.
- Bowel obstruction: Present with abdominal pain, vomiting, and failure to pass stool or gas. Plain abdominal X-ray may show air fluid levels and dilated intestinal loops.

### Essential Facts

- Common causes of ascites include cirrhosis (75 to 80%), malignancy (10%), heart failure, peritoneal tuberculosis, portal venous thrombosis, and pancreatitis.
- New-onset ascites:
- Urgent evaluation is required, including an abdominal ultrasound (US) and portal vein Doppler US.
- Diagnostic paracentesis should be done; fluid analysis should include cell count and differential, albumin, total protein, cultures, glucose, lactate dehydrogenase (LDH), amylase, and Gram stain.
- Fluid should be sent for cytology and culture to rule out malignancy and bacterial peritonitis.

### Other Imaging Findings

- Plain film: ground glass; central location of bowel loops, loss of posterior liver edge (Morrison pouch sign); colonic gutter fluid (colonic displacement from properitoneal fat, bulging flank sign); supravesicular fluid (Mickey Mouse ears sign)
- Abdominal US with Doppler: Confirms presence of ascites. Determines the patency of portal vein and presence of ovarian tumor or liver pathology.
- CT scan useful in cases of:
- Suspected serosal metastasis or malignancy (pancreatic, ovarian cancer)
- Suspected portal vein thrombosis (due to hepatocellular carcinoma; bland or septic thrombus)
- Patients with ruptured mucocele of the appendix (pseudomyxoma peritonei)

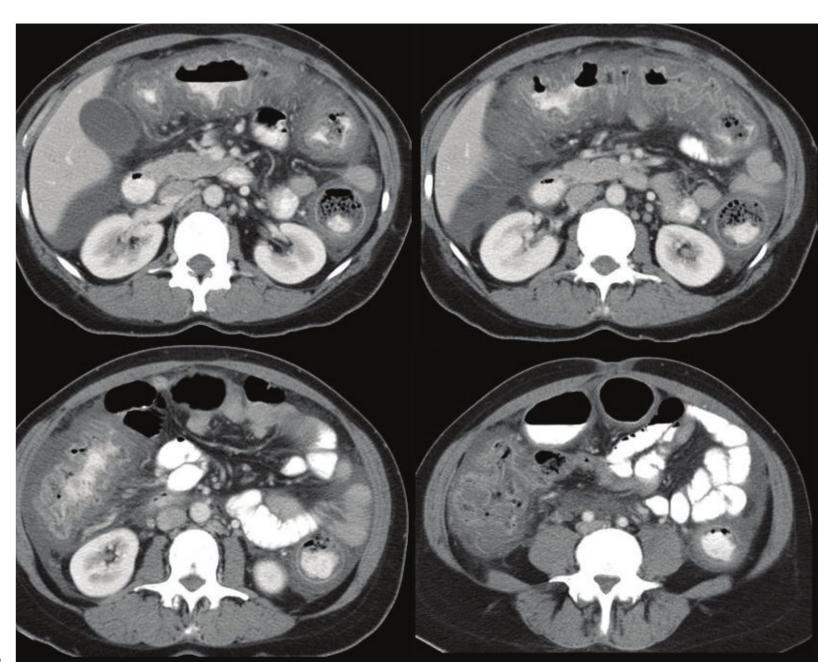
- ✓ anage refractory ascites with large volume paracentesis and albumin replacement.
- ✓ Contaneous bacterial peritonitis (SBP) is a medical emergency, with a mortality rate between 10 and 40%. Therefore, culture and sensitivity (C/S) of aspirated ascitic fluid is essential.
- maging characteristics of ascites are not always reliable.



## Clinical Presentation

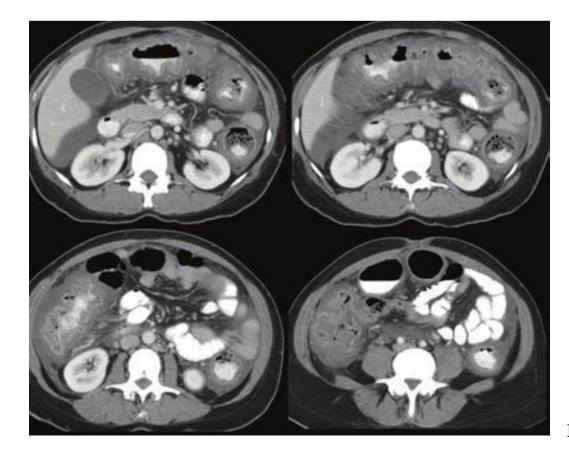
A 72-year-old patient presents with watery diarrhea, moderate abdominal cramping, low-grade fever, and leukocytosis on day 7 of their hospitalization and day 3 of clindamycin course.

## **■** Further Work-up



В





(A) A supine film of the abdomen shows a dilated transverse colon and thickened haustra "thumbprinting" from the cecum to the splenic flexure suggestive of edema. (B) The axial computed tomography (CT) scan of the abdomen shows pancolonic mural thickening and intense mucosal thickening (accordion sign) and ascites.

### Differential Diagnosis

- Clostridium difficile colitis: *C. difficile* colitis is a common nosocomial infection that often occurs in the elderly after antibiotic therapy. The main clues on plain film include polypoid mucosal thickening, colonic thumbprinting, or gaseous pancolonic distension (ileus).
- Ischemic colitis: Ischemic colitis has similar radiographic findings but confined to the "watershed" areas of the splenic flexure and rectosigmoid junction. Predisposing factors include elderly patients with vasculopathy, history of atrial fibrillation, or hypercoagulopathy.
- Acute ulcerative colitis: Presents with acute symptoms of bloody diarrhea; plain abdominal films show mural thickening and thumbprinting; colonic dilatation with clinical sepsis results in toxic megacolon, which may result in colectomy. Contrast studies of the colon are contraindicated in the acute setting.

## Essential Facts

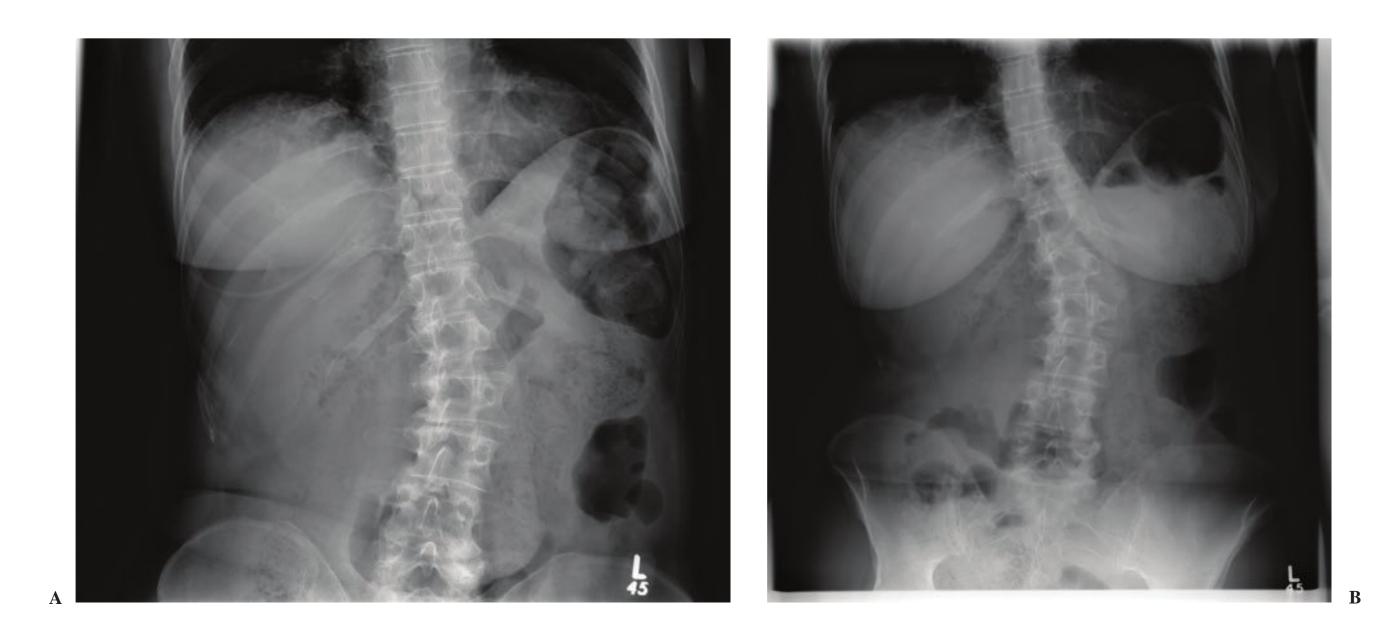
- The prevalence of *C. difficile* is 1.3 per 100 inpatients, a major cause of nosocomial infectious diarrhea. It is usually preceded by antibiotic use in elderly hospitalized patients.
- The typical clinical picture of *C. difficile* colitis includes watery diarrhea (up to 10 to 15 times daily), abdominal cramping, low-grade fever, and leukocytosis.
- The best diagnostic molecular test is polymerase chain reaction (PCR) performed with fresh diluted stool sample; result is obtained within 1 hour.

- Complications of *C. difficile* colitis include toxic megacolon, colonic perforation, and ileus. Systemic complications include dehydration, hypokalemia, renal failure, and gastrointestinal (GI) bleeding.
- Treatment includes supportive therapy and vancomycin or metronidazole to eradicate the *C. difficile*.

## Other Imaging Findings

- Abdominal plain film findings include thumbprinting and colonic dilatation; colonic wall thinning and small bowel ileus are ominous signs of treatment failure requiring urgent colectomy in the correct clinical setting of toxicity.
- Abdominal CT (with intravenous [IV] contrast):
- Demonstrates focal or pancolonic low-attenuation mural thickening, mucosal enhancement (accordion sign), pericolonic stranding, and peritoneal free fluid
- CT should not be the first-line imaging:
  - Efforts should be made to avoid unnecessary radiation exposure
  - Utilized when complications are suspected (localized peritonitis) or treatment fails

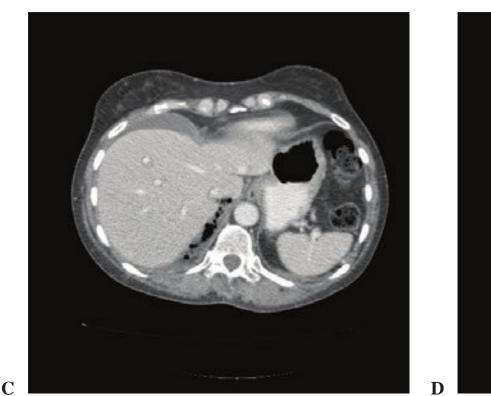
- ✓ Codominal plain films should be initial investigations.
- ✓ Cerial abdominal pain films are done to assess treatment.
- ✓ CT imaging of choice when treatment fails
- L'humbprinting and mucosal thickening are nonspecific signs of inflammation.

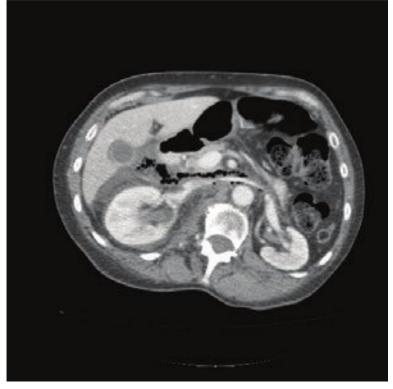


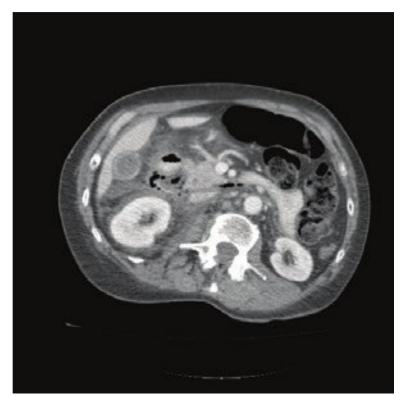
## Clinical Presentation

A 59-year-old woman presents with vomiting and epigastric pain.

## **■** Further Work-up



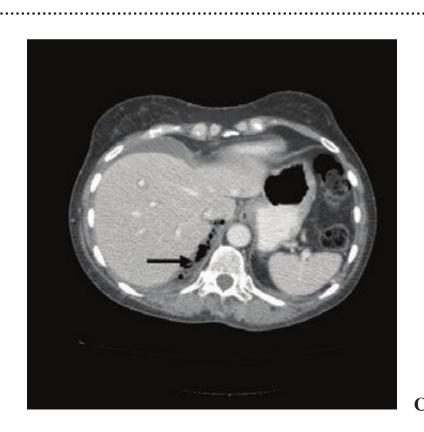


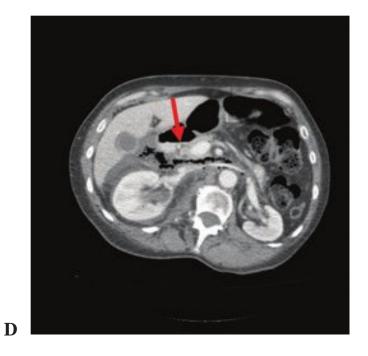


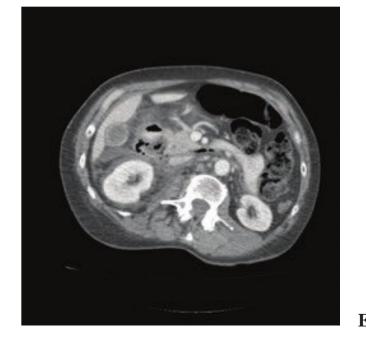
 $\mathbf{E}$ 











The upright (A) and supine (B) abdominal plain films show bubbles of gas outlining the top of the right kidney (arrow). (C) Computed tomography (CT) scan showing loculated bubbles of gas in the right anterior pararenal space (arrow). (D, E) CT scan showing oral contrast in duodenum (red arrow) with no leak into the retroperitoneum.

## Differential Diagnosis

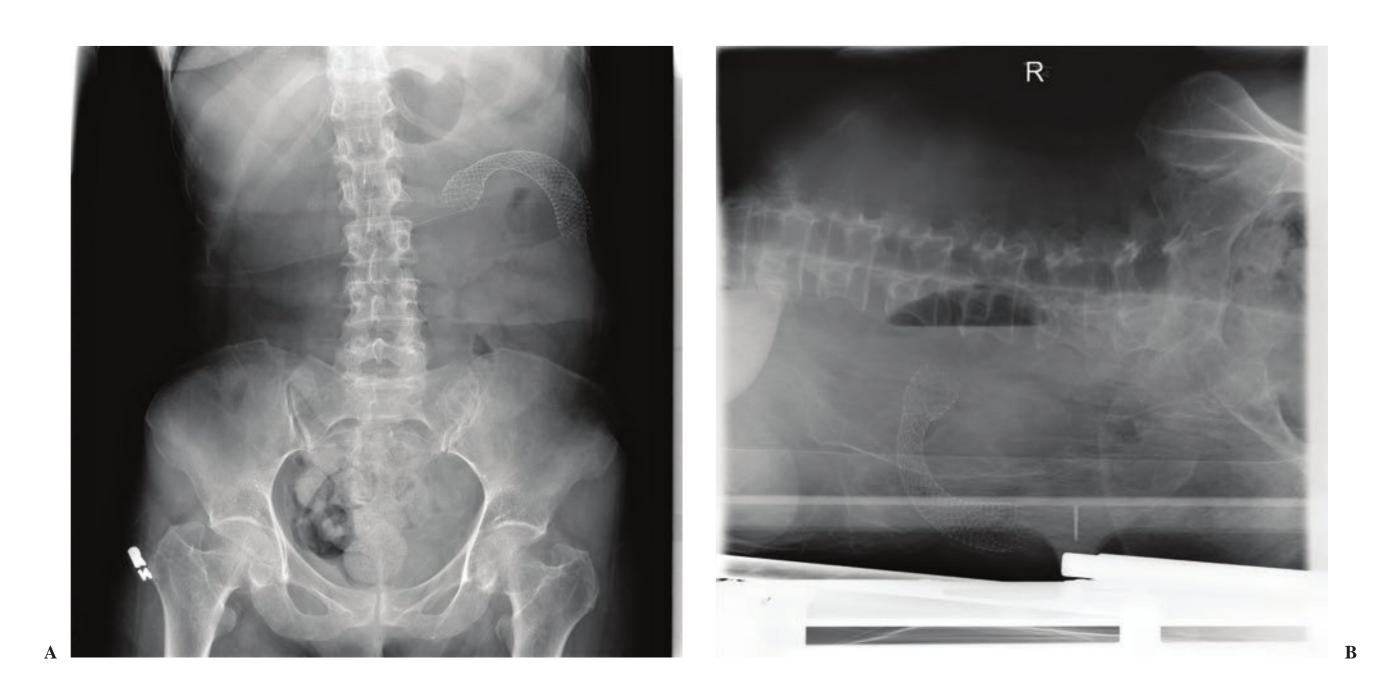
- Perforation of duodenal diverticulum: Duodenal perforation results in retroperitoneal free air seen on plain film images. The CT scan with oral contrast will show the contrast material leaking into the retroperitoneal space. Peptic ulcer disease is the most common cause of retroduodenal perforation.
- Carcinoma of hepatic flexure with perforation: Colorectal carcinoma is the third most common malignancy. As the hepatic flexure is part of the right colon, these malignancies can grow large with obstruction and may result in perforation.
- Postcolonoscopy perforation: The risk of a perforation after a colonoscopy is less than 1% and symptoms will usually show after the bowel contents have leaked into the peritoneum and have caused infection. The most likely location would be the retroperitoneal hepatic flexure.

#### Essential Facts

- A diverticulum is an outpouching of the gut wall, usually occurring where supplying arteries perforate the gut.
- Clinical features can be nonexistent but may consist of leukocytosis, raised serum amylase activity, and upper abdominal pain.

• The main clues to duodenal perforations are retroperitoneal collections of gas or contrast material and lack of continuity in the duodenal wall.

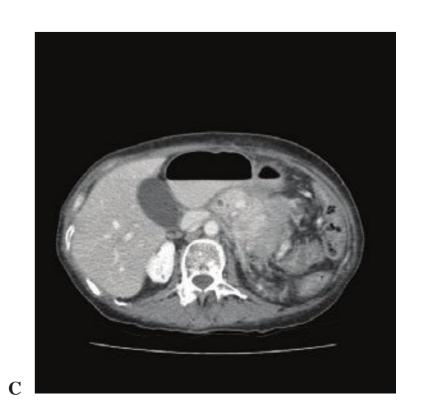
- ✓ is important to distinguish between duodenal contusions, duodenal hematomas, and duodenal perforations, as the treatments, whether surgical or not, will vary for each diagnosis.
- ✓ ceptic ulcer disease is the most common cause of retroduodenal perforation.
- CT scan will not always show the site of perforation (the perforation may seal off due to surrounding inflammation).



## Clinical Presentation

A 56-year-old female patient presents obstructive symptoms and a history of metastatic carcinoma.

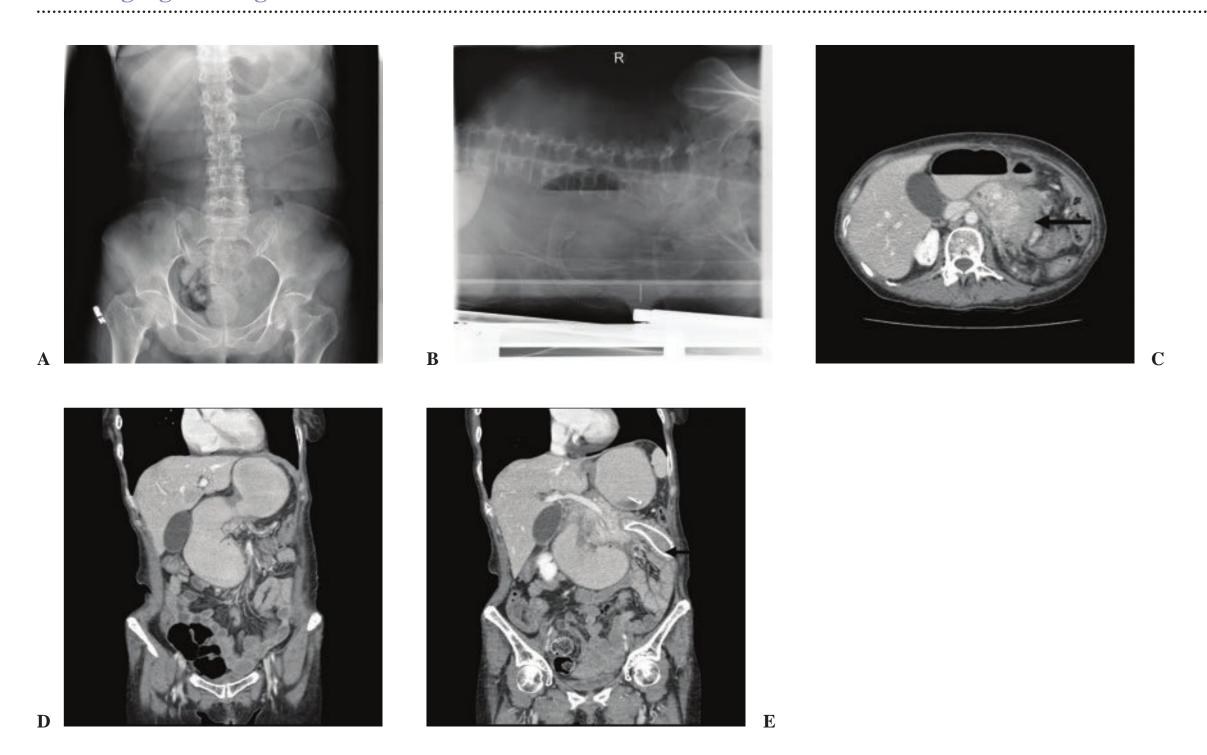
## **■** Further Work-up







E



Plain films supine (A) and upright (B) and ultrasound of right lower quadrant (C & D) are provided. (A) Plain film showing dilated stomach with metallic stent at the duodenojejunal (DJ) flexure. (B, C) Axial computed tomography (CT) showing dilated stomach with tumor around the DJ flexure (arrow). (D, E) Coronal images showing dilated stomach and obstruction at the DJ flexure where the stent is located (arrow).

### **Differential Diagnosis**

- Duodenojejunal obstruction: Small bowel obstruction due to metastatic carcinoma of the pancreas with subsequent dilatation of the proximal small bowel and stomach. Diagnosis of pancreatic cancer is usually done by a multidetector volumetric CT, with the tumor usually clearly seen against the pancreatic parenchyma. Ten percent of the tumor's attenuation is similar to the pancreatic parenchyma, and secondary signs such as pancreatic/biliary dilatation or vascular occlusion help with the diagnosis.
- Gastric outlet obstruction: Gastric outlet obstruction can occur due to hypertrophy of the pylorus or due to neoplasms obstructing the passage into the small intestine. It can be diagnosed radiologically using ultrasonography and upper gastric imaging.
- Gastroparesis: Gastroparesis refers to a form of gastric paralysis, with poor gastric motility and delayed gastric emptying. Scintigraphy, isotope breath tests, and ultrasonography are the methods to diagnose the disease.

#### **Essential Facts**

- Approximately 15 to 20% of patients will experience small bowel obstruction as a complication of pancreatic cancer. Bypass surgery and stent placement are two methods to help with this complication.
- Approximately 42,000 Americans develop pancreatic cancer each year, with surgical resection being the only curative treatment.

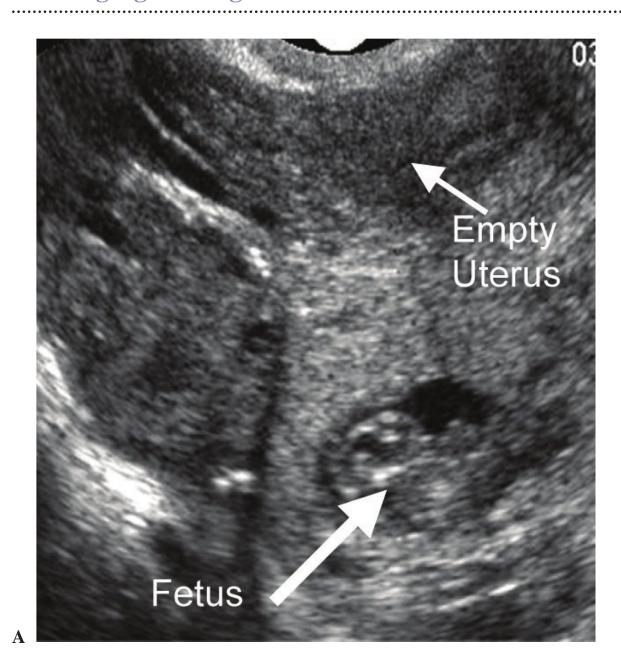
- ✓ Gue to the usual late presentation of the disease, only 15 to 20% of patients are candidates for a pancreatectomy.
- rate after a pancreaticoduodenectomy is only 25 to 30%.

Case 57



# Clinical Presentation

A 25-year-old woman with lower abdominal pain and 6 weeks of amenorrhea.



(A) Transverse image of the pelvis showing an empty uterus and fetus in the pelvis.

## **Differential Diagnosis**

- Ectopic pregnancy: Ectopic pregnancy occurs when the gestational sac implants outside the endometrium. Risk factors include pelvic inflammatory disease, previous ectopic pregnancy, and previous tubal surgery. The classic triad of symptoms is pelvic pain, vaginal bleeding, and a history of amenorrhea. Shoulder tip pain from diaphragmatic irritation is an indirect sign of a ruptured ectopic pregnancy. Initial evaluation should include serum beta human chorionic gonadotropin (b-HCG) and a transvaginal ultrasound (US).
- Appendicitis: Inflammation of the appendix classically presents with periumbilical abdominal pain localizing to the left iliac fossa and anorexia, nausea, and vomiting. Evaluation by US or computed tomography (CT) scan is useful to rule out gynecologic causes. US is 90 to 94% accurate but cannot rule out appendicitis.
- Ruptured ovarian cyst: Ovarian cysts are commonly found in premenopausal women. Rupture usually occurs with corpus luteum cysts; patients present with acute severe abdominal pain. Free fluid or hematoma may be seen on US.

### **Essential Facts**

- Four percent of maternal mortality in Canada is caused by ectopic pregnancies.
- Ectopic pregnancy is most commonly seen in the ampulla of the fallopian tube.
- Management can be conservative, medical, or surgical depending on the size and occurrence of free fluid or cardiac activity.

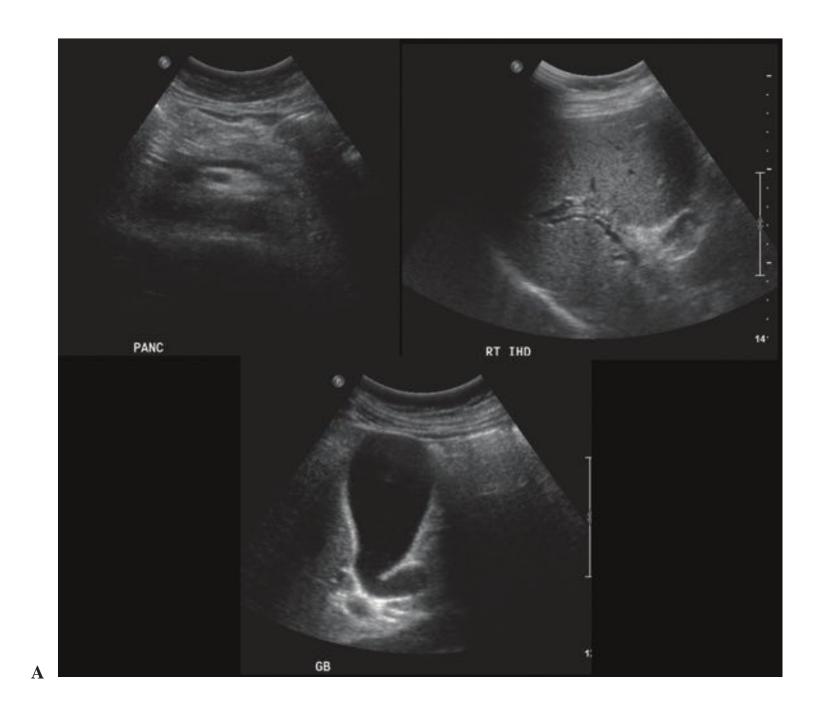
• If no intrauterine or ectopic pregnancy is visualized with b-HCG levels of . 2,000 m IU/m L, the patient must be monitored with regular US and b-HCG.

## **Other Imaging Findings**

- The most common finding of a tubal ectopic pregnancy is an adnexal mass separate from the ovary; if it is not separate, it is more likely a corpus luteum cyst.
- "Tubal ring sign" refers to a hyperechoic ring surrounding an extrauterine gestational sac.
- Extrauterine findings such as free fluid in the pelvis, hematosalpinx, and hematoperitoneum may be seen.
- If echogenic fluid is seen in the Morrison pouch and within the cul-de-sac, a ruptured ectopic pregnancy should be suspected.

- ✓ **©** a young female patient with abdominal pain and amenorrhea, an ectopic pregnancy must be ruled out first.
- \* an ectopic pregnancy may coexist with an intrauterine pregnancy.
- hirty percent of ectopics present before a period is missed.
- p to 50% of patients are asymptomatic or have nonspecific symptoms; therefore, a high index of suspicion is needed.

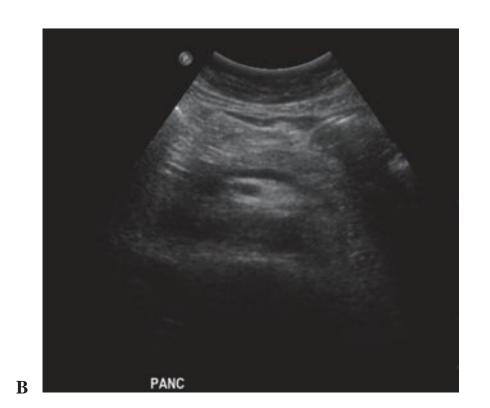
Case 58

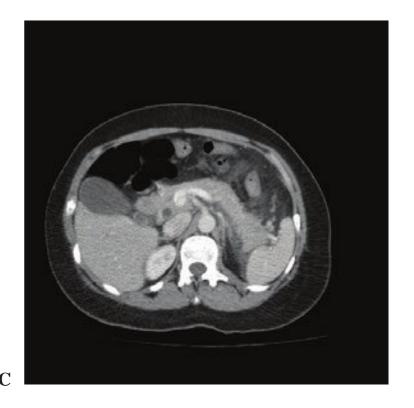


#### Clinical Presentation

A 51-year-old woman presents with right upper and epigastric pain. Alkaline phosphatase is elevated.

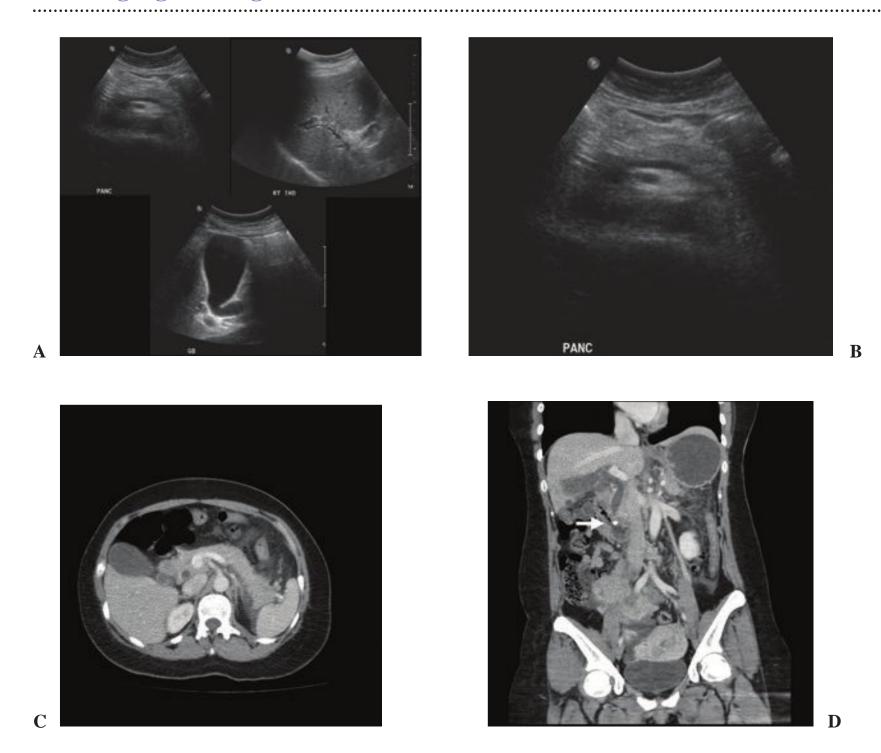
## **■ Further Work-up**







D



(A) Transverse view of the ultrasound showing mild decrease echogenicity suggesting pancreatitis. (B) Axial computed tomography (CT) showing fluid around the tail of the pancreas. (C) Axial CT scan shows peripancreatic fluid around the tail and dilated common bile duct. (D) Coronal CT showing dilated biliary tree and a small choledocholithiasis (arrow).

## Differential Diagnosis

- Choledocholithiasis/mild acute pancreatitis: The classic radiologic finding is bile duct dilatation greater than 8 mm, bile duct stone(s), and changes of pancreatitis.
- Acute cholecystitis: Is the second most common cause of right upper quadrant pain. A complication of acute cholecystitis is perforation of the gallbladder. The most common radiologic finding is the presence of cholecystolithiasis in combination with tenderness in a sonographically localized gallbladder (Murphy sign).
- Acute pyelonephritis: An uncomplicated ascending urinary tract infection can usually be diagnosed and treated without help of imaging. However, images are used for atypical cases or when complications have arose such as abscesses or obstructions. Findings can include renal enlargement, striated or delayed nephrograms, and dilatation of the collecting system.

## Essential Facts

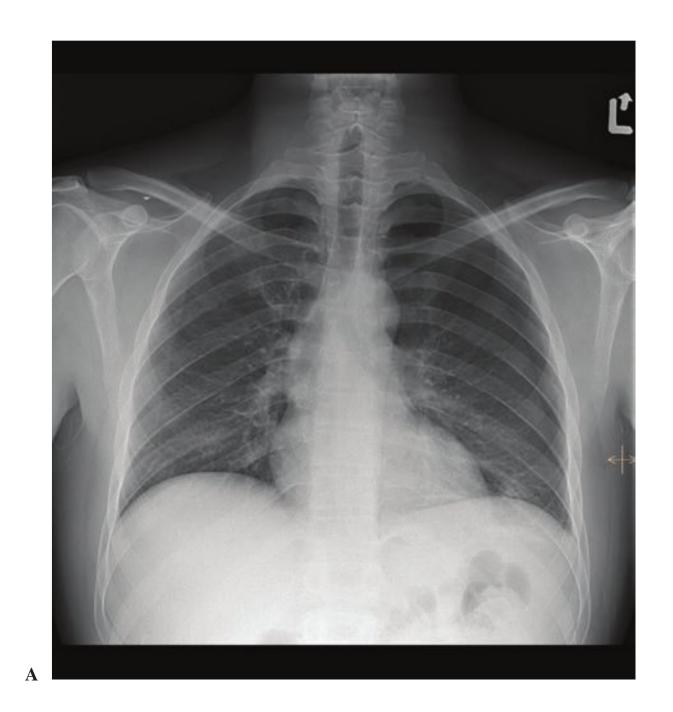
- Gallstones may be asymptomatic for many years.
- Five Fs risk factors: female, 40, fair skinned, fertile, fat
- Murphy sign, although positive in cholecystitis, is typically negative in choledocholithiasis.

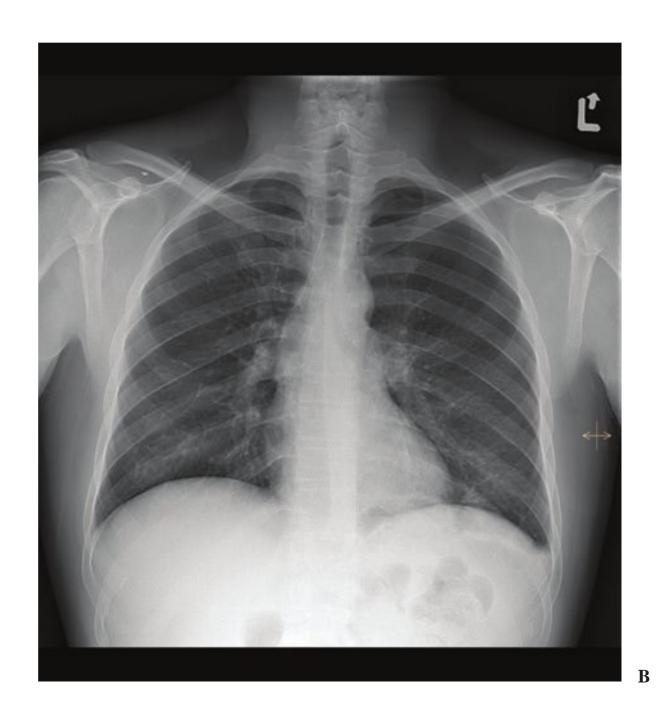
• Fifty percent of patients with pancreatitis have coexisting gallstones, as the gallstones obstruct the ampulla of Vater in the distal common bile duct.

### Other Imaging Findings

- Ultrasound: may or may not show bile duct stones
- Magnetic resonance cholangiopancreatography (MRCP): has been shown to have a high sensitivity and specificity for detection of bile duct abnormalities
- CT: may show choledocholithiasis and changes of secondary pancreatitis

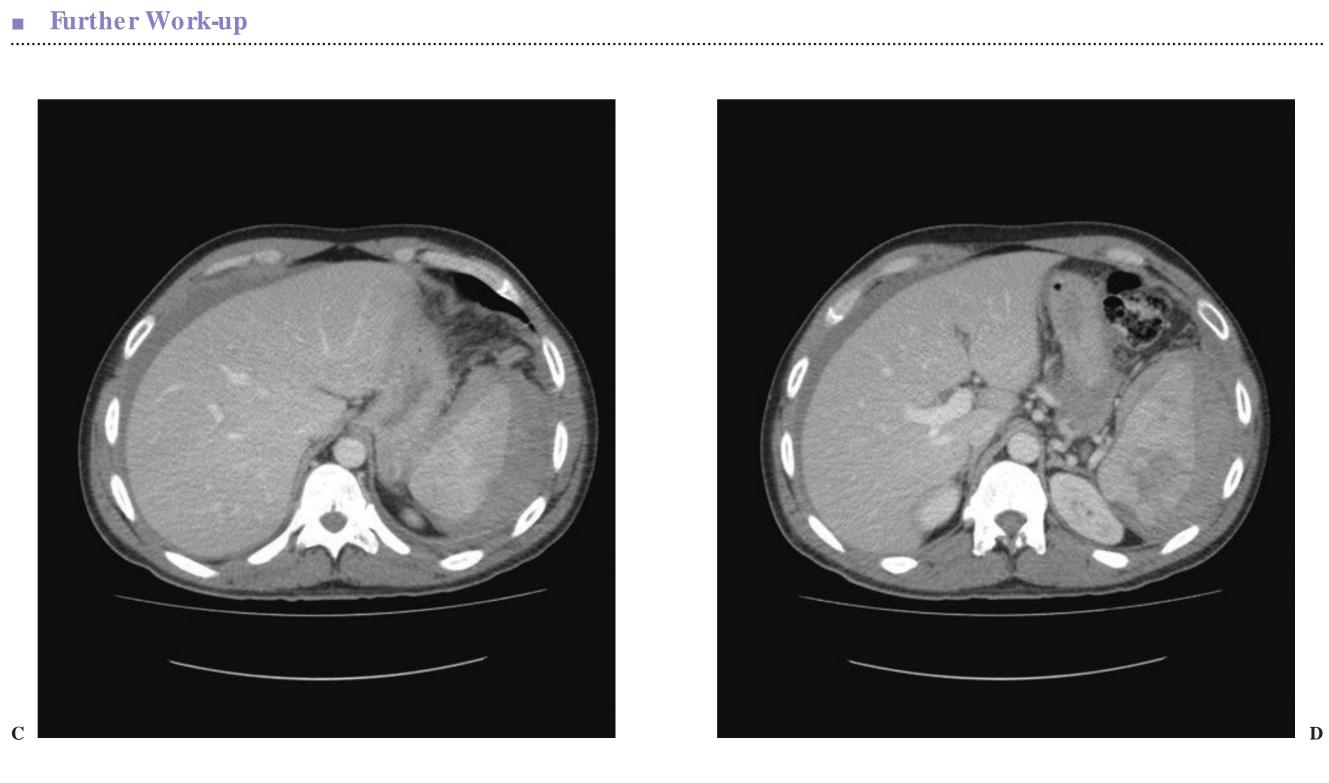
- ✓ Candoscopic retrograde cholangiopancreatography (ERCP) is used mostly as a therapeutic intervention for bile duct stone retrieval in a patient with gallstone pancreatitis.
- ✓ Catients with undetected bile duct stones can progress to severe pancreatitis.
- Ludge in the bile ducts can obscure the ultrasound findings for bile duct stones.



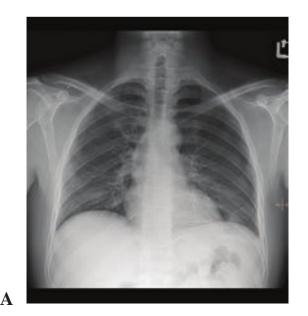


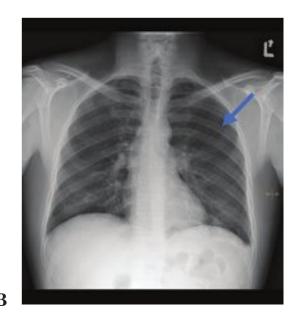
### **Clinical Presentation**

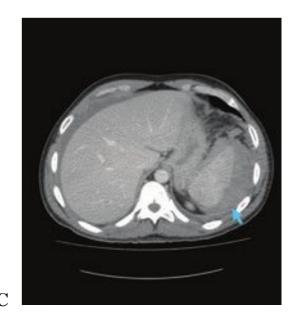
A 37-year-old male construction worker with a 1-hour history of shortness of breath and pleuritic chest pain after being struck in the left posterior hemithorax by a wood beam. A chest X-ray (CXR) was done (shown) in the emergency department.













(A, B) Posteroanterior (PA) CXR shows a left pneumothorax (arrow). (C, D) Computed tomography (CT) shows splenic rupture with subcapsular hematoma (short arrow) and laceration (long arrow) and intraperitoneal fluid (next to the liver).

## Differential Diagnosis

- Pneumothorax: A white visceral pleural line, separated from the parietal pleura by gas. Usually no pulmonary vessels are visible beyond the visceral pleural line (no vasculature in the gas collection). A pneumothorax can be identified on upright (gas in apicolateral space) and supine (deep sulcus sign: gas in subpulmonic spaces). In the trauma patient, pulmonary contusions may be seen both on CXR and CT scans as focal consolidation or atelectasis. Severe injuries and rib fractures can result in subcutaneous emphysema.
- Rib fracture: In most cases, rib fractures can be diagnosed based on plain radiographs and clinical findings (point tenderness over fractured ribs). If there is a strong clinical suspicion with no evidence of rib fracture on plain X-ray, a rib series with bone exposure and oblique views of the chest wall offers greater sensitivity. In trauma patients, if intrathoracic injury is suspected, a chest CT is warranted.
- Splenic injury: Due to the proximity of the spleen to the left hemithorax and the type of injury, imaging of such a patient should include ultrasound of spleen first and then CT scan (see image **D**).

### Essential Facts

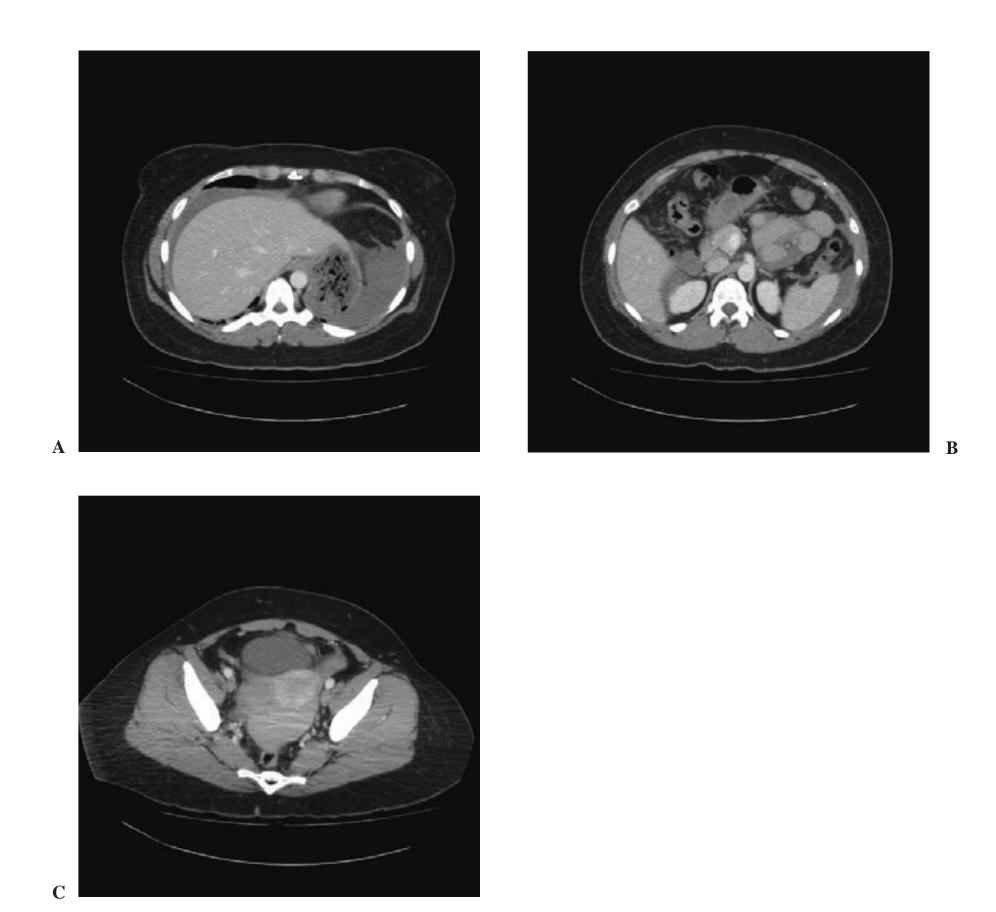
- The spleen is the most commonly injured intra-abdominal organ in blunt abdominal trauma.
- Fractured ribs, vertebrae, or pelvic fractures can lacerate intra-abdominal organs.
- A benign clinical presentation does not preclude significant intra-abdominal injury.

• A focused assessment with sonography in trauma (FAST) ultrasound of the abdomen should be used as a screening for organ injury (assess hemorrhagic ascites).

### Other Imaging Findings

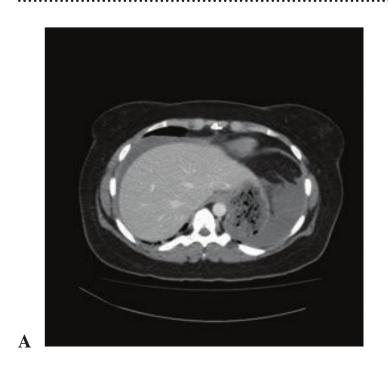
- CT scan imaging of choice:
- Subcapsular hematoma: regular, crescentic, hypoattenuating collections around the spleen
- Intraparenchymal hematoma: irregular, hyperattenuating collection within the spleen with mass effect and enlargement of the spleen
- Laceration: irregular hypodense area of nonenhancement with indistinct borders
- Active bleeding: extravasation of vascular contrast material from splenic parenchyma or the artery
- Fragmentation with autosplenectomy: separation of a fragment or entirety of the spleen from splenic hilum

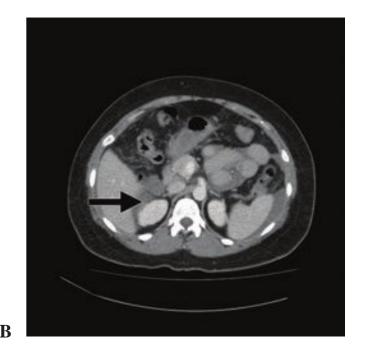
- ✓ Chrasound good screening imaging in patients with blunt trauma to detect unsuspected organ injury
- ✓ Selayed splenic rupture can occur days and even weeks after trauma.
- ✓ € actures causing splenic rupture are not always visible on radiographs.
- \*Associated injuries to solid organs should be considered with chest and abdominal trauma, liver on the right side, and kidneys with flank trauma.

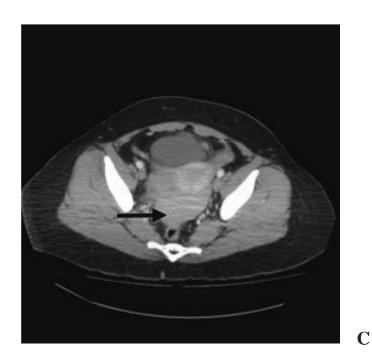


## Clinical Presentation

A 38-year-old woman presents with pain in both the right and left iliac regions with guarding and rebound tenderness in the right lower abdomen.







(A) Axial computed tomography (CT) scan on the upper abdomen shows ascites around the liver and the left hemidiaphragm. (B) Ascites in the Morrison pouch (arrow). (C) High-density ascites—hemoperitoneum in the rectovaginal space (arrow).

## Differential Diagnosis

- Hemoperitoneum: "Blood in the belly" can occur due to trauma, a tumor-associated hemorrhage, a gynecologic lesion, or an aortic aneurysm. Imaging such as biphasic arterial venous CT scan of the abdomen is essential in detecting the site and cause of the bleed.
- Ectopic pregnancy: An ectopic pregnancy accounts for , 2% of all pregnancies and occurs when the blastocyst implants itself outside of the endometrium. An ultrasound is the most specific and sensitive test to determine whether the pregnancy is ectopic, and the absence of the intrauterine gestational sac during the first trimester is a clue for ectopic pregnancy.

## Essential Facts

- Diagnosis in above images: ruptured ovarian cyst
- CT is important, as it differentiates between lowattenuation fluid (ascites) and higher attenuation blood (hemoperitoneum).
- The highest attenuation area of the CT is known as the sentinel clot and is the closest to the site of bleeding,

- whereas the lower attenuation unclotted blood is farther away from the source of bleeding.
- Splenic trauma, ruptured hepatocellular carcinoma, and a ruptured ovarian cyst are some of the causes of hemoperitoneum.

## Other Imaging Findings

- Ultrasound: the most sensitive test for detecting ascites (small quantity of fluid in the pelvis, paracolic gutter, and Morrison pouch)
- Plain films: the bulging flanks sign, hazy abdomen, and floating small bowel loops
- CT scan: Usually detects the etiology of the ascites. All signs in above imaging modalities can be found in the CT.

## ✓ Pearls & ➤ Pitfalls

✓ Cigh-attenuation ascites is suggestive of hemoperitoneum.

✓ Scites usually collect in the most dependent areas of the body—the hepatorenal recess (Morrison pouch) in the abdomen and the rectouterine/rectovesical space (cul-de-sac) in the pelvis.



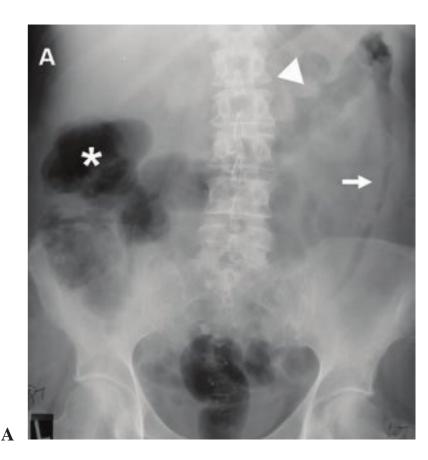
## Clinical Presentation

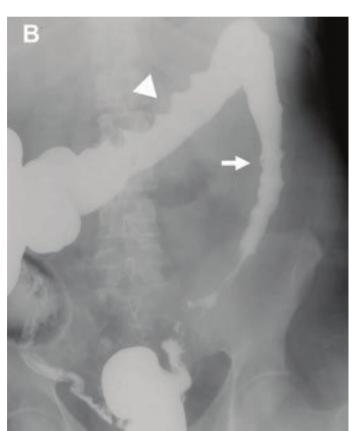
A 72-year-old man presents with sudden onset of mild abdominal pain and hematochezia.

## **■** Further Work-up



R





В

(A) Abdominal plain film shows dilatation of the hepatic flexure (asterisk), thumbprinting of the transverse colon wall (arrowhead), and narrowing of the lumen of the descending colon with thumbprinting (arrow). The rectum is normal. (B) A Hypaque (Amersham Health, Inc., Princeton, NJ) enema delineating thumbprinting of the transverse colonic wall (arrowhead) and the descending colon (arrow).

### Differential Diagnosis

- Large bowel ischemia: This occurs when there is decreased blood supply to the bowel, resulting in mucosal edema ("thumbprinting"), and leads to stricturing if untreated. These features can be seen on plain films.
- Inflammatory bowel disease: Both Crohn disease and ulcerative colitis can present with similar thumbprinting. Crohn disease can also cause stricturing but differs in that it can have fistulas, cobblestoning, and skipped lesions. Ulcerative colitis can present with pseudopolyps, a "lead pipe" colon (absent haustral markings), and only affects the large bowel.
- *Diverticulitis:* Along with mucosal thickening, diverticulitis can present with inflamed diverticula, fat stranding, abscesses, fistulas, and free air.

#### Essential Facts

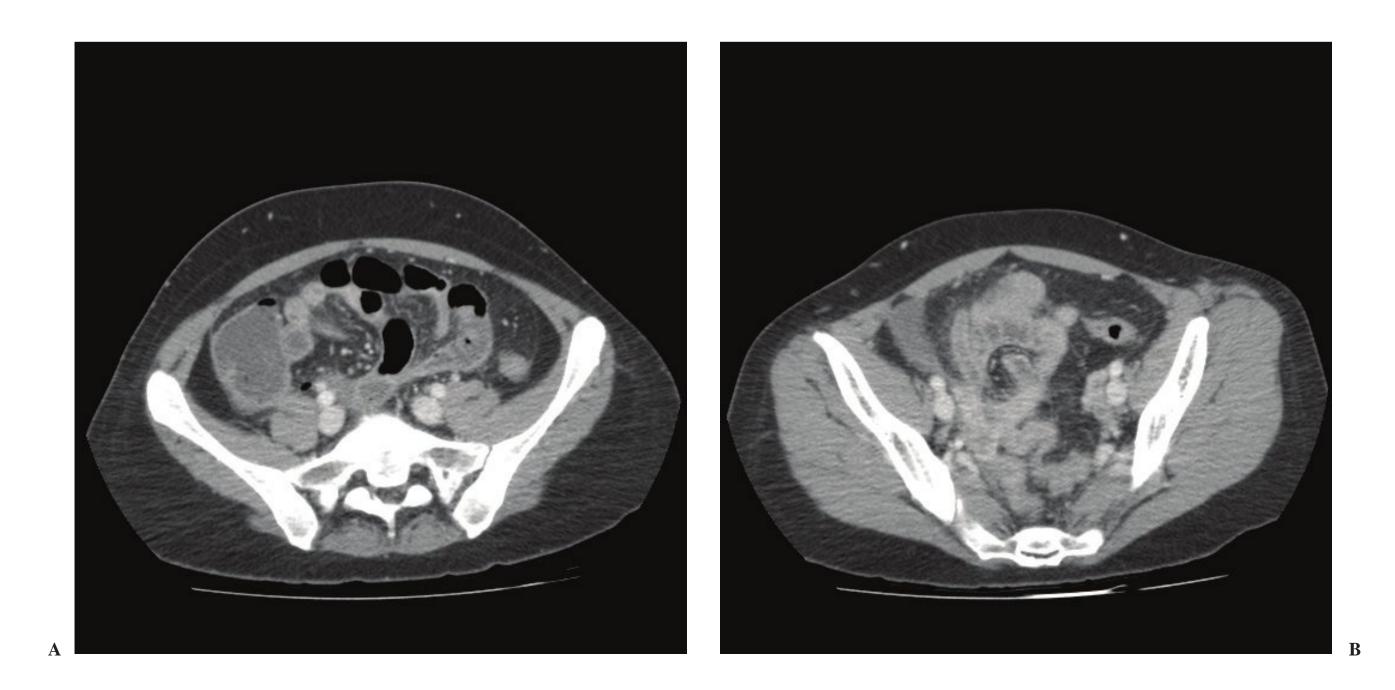
- Colonic ischemia is the most common type of intestinal ischemia and tends to occur in the elderly.
- It can lead to bowel necrosis and even death.
- The colon is supplied by superior and inferior mesenteric arteries (SMAs and IMAs) with many collaterals, which includes the arc of Riolan and the marginal artery of Drummond from the IMA and the middle colic artery from the SMA.

- Two "watershed" areas, the splenic flexure and rectosigmoid junction, are more vulnerable to ischemia due to poorer supply by the collaterals.
- Causes of colonic ischemia include systemic hypoperfusion, mesenteric venous thrombosis, small vessel disease, mechanical obstruction, and drugs.

## Other Imaging Findings

- Abdominal plain films: distension of bowel loops, thumbprinting along bowel walls, and linear air streaks in bowel walls suggesting pneumatosis
- Abdominal computed tomography (CT): thickening of the bowel walls
- Colonoscopy: Submucosal hemorrhages seen with ulcers on an erythematous mucosa. In early colonic ischemia, petechiae on pale mucosa with a positive "single-stripe" sign (single longitudinal ulcer) may be seen.

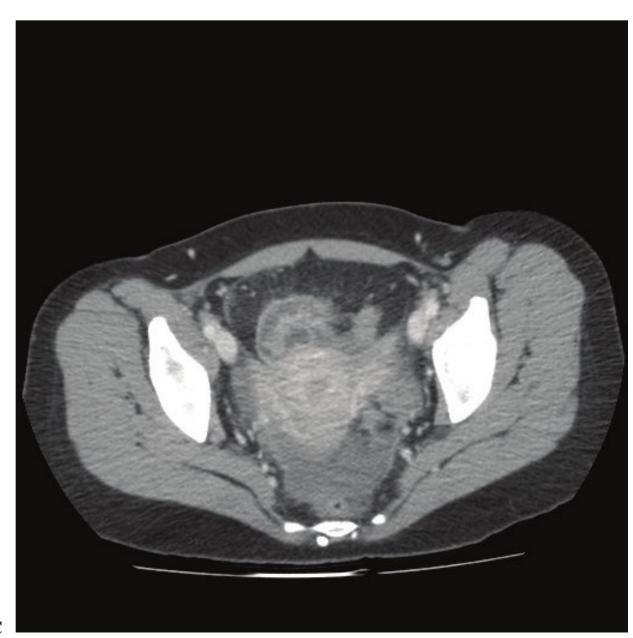
- ✓ Carge bowel ischemia most often affects the left colon; however, it tends to be more severe when it occurs in the right colon.
- \* Causes are often not identified.
- colonic ischemia is often transient; therefore, angiography has limited use.



## Clinical Presentation

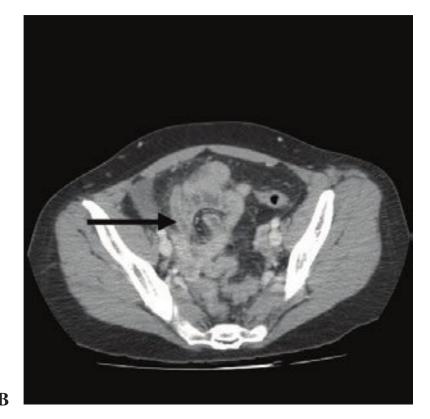
A 34-year-old patient presents with periumbilical pain radiating to the right lower quadrant.

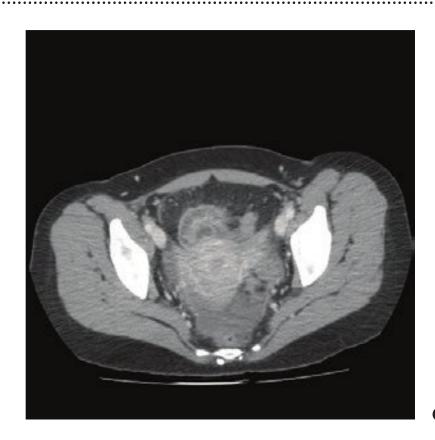
# ■ Further Work-up



C







(A) Extraluminal air anterior to the right psoas muscle (free air). (B) Tubular fluid appendix in the right lower quadrant (arrow). (C) Ascites in the cul-de-sac suggestive of perforation.

### Differential Diagnosis

- Acute appendicitis with localized perforation: Acute appendicitis is the most common surgical emergency with 50 to 80% of the cases associated with obstruction. Mucosal inflammation and ulceration may lead to perforation with peritonitis.
- Ectopic pregnancy: An ectopic pregnancy accounts for , 2% of all pregnancies. An ultrasound (US) is the most specific and sensitive test to determine whether the pregnancy is ectopic, which may present as a complex mass outside the uterine cavity with hemoperitoneum.
- Ruptured ovarian cyst: This may result in a significant hemorrhage. It may be life-threatening, as it is associated with hemoperitoneum and hypotension. A US and computed tomography (CT) scan are the primary radiologic modalities used and, if correctly diagnosed, patients usually require only supportive therapy.

### Essential Facts

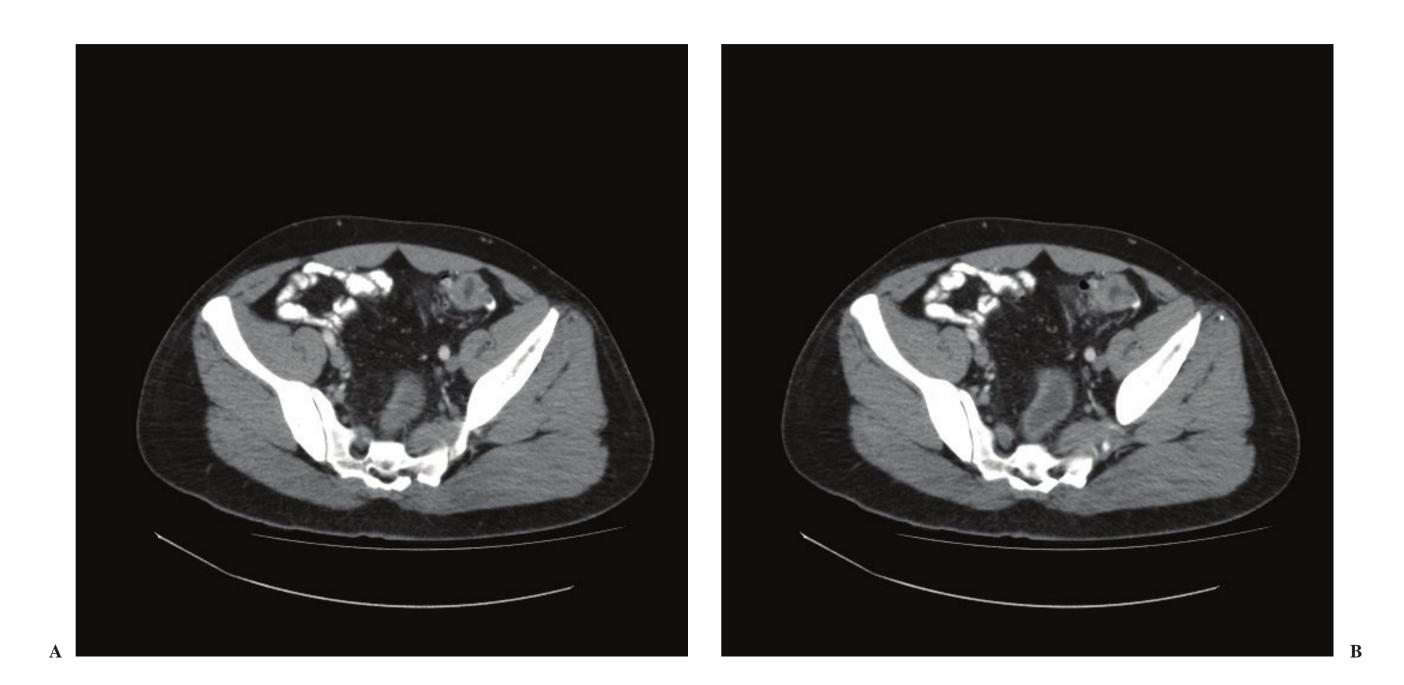
- Appendiceal obstruction can be caused by a fecalith, gallstones, tumors, foreign bodies, or diffuse lymphoid hyperplasia.
- Acute appendicitis can be graded into stages: acute focal, acute suppurative, gangrenous, and perforative.

• CT findings specific for appendicitis are an enlarged appendix and apical cecal changes showing a continuous inflammatory spread.

## Other Image Findings

- US is the imaging of choice in young children and women. The findings include dilated fluid-filled appendix greater than 6 mm, periappendiceal inflammation and abscess, and sometimes appendicolith.
- CT scan findings are similar to US except for more graphic changes of microperforation, abscesses, and appendicolith. Retrocecal and unusual locations of the appendix are best detected by the CT.

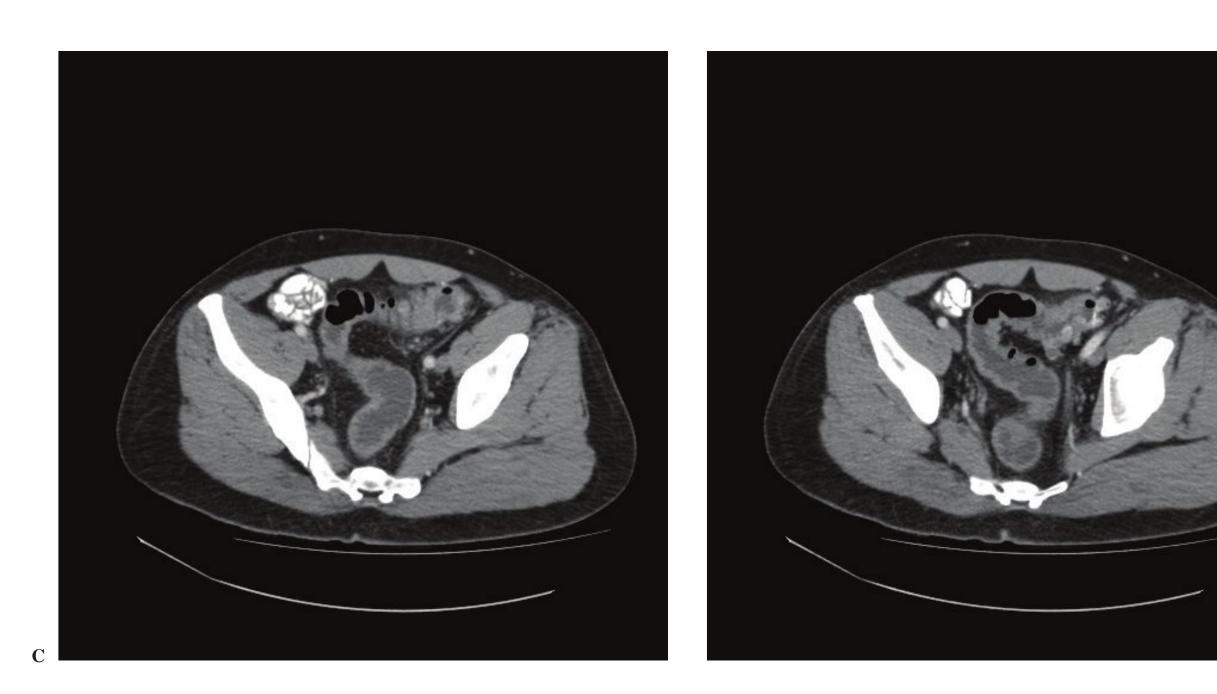
- ✓ S is the first imaging of choice for appendicitis.
- ✓ CT is useful in obese patients and in planning for percutaneous drainage of abscesses.
- Eetrocecal appendicitis may not present with the classic clinical signs.



## Clinical Presentation

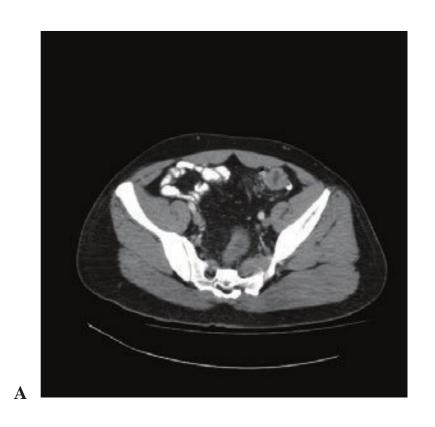
A 39-year-old patient presents with recurrent left lower quadrant pain along with fever and chills.

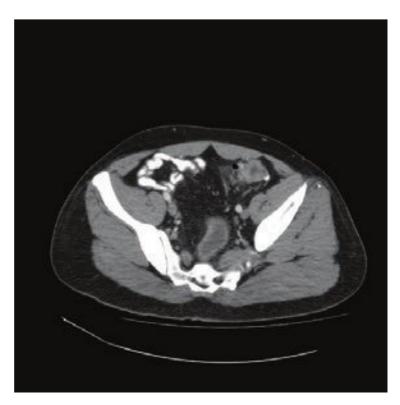
# ■ Further Work-up



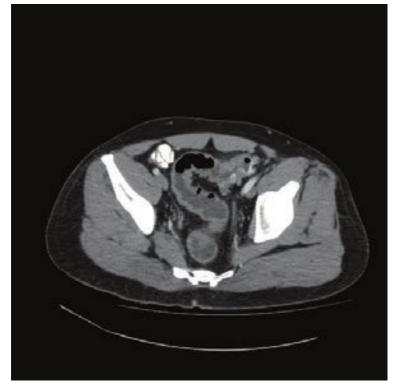
D

### ■ Image Findings









(A, B) X-ray image of sigmoid colon shows inflamed diverticulum with subtle mesenteric inflammation. (C, D) X-ray images of the rectosigmoid colon with negative contrast showing few diverticula but normal bowel.

### **■** Differential Diagnosis

- Sigmoid diverticulitis: A diverticulum is an outpouching of the gut, usually where mesenteric arteries perforate the gut wall. Diverticulitis refers to inflammation of a diverticulum. On a computed tomography (CT) scan, diverticulitis appears as a small air-filled outpouching with segmental wall thickening and inflammatory changes in the pericolic fat.
- Epiploic appendagitis: The epiploic appendices are small fat-filled pouches of the peritoneum that can become inflamed due to torsion or thrombosis. Radiologically, epiploic appendagitis can be mistaken for omental infarction and sclerosing mesenteritis. The CT scan shows an oval fat attenuation lesion less than 5 cm in diameter with a central dot representing the vessel with surrounding inflammatory changes.

## Essential Facts

- Diverticulitis is a common condition affecting 5 to 10% of the population older than 45 years and 80% of the population older than 85 years.
- CT is the imaging of choice with rectal contrast (either positive to check for fistula when clinically suspected or negative to assess mucosal detail and detect underlying neoplasm).

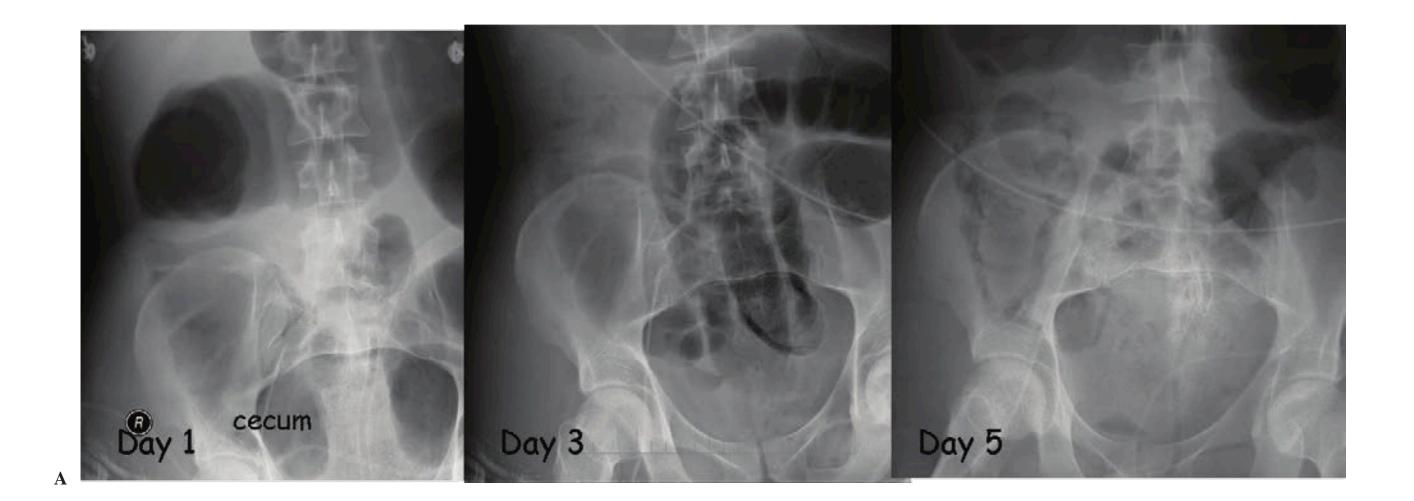
- CT can detect complications associated with diverticulitis such as diverticular abscesses, colovesicular fistula, and perforations.
- An underlying neoplasm can mimic or complicate diverticular or be obscured by severe diverticular disease (therefore, colonoscopy is performed after treatment).

### Other Imaging Findings

D

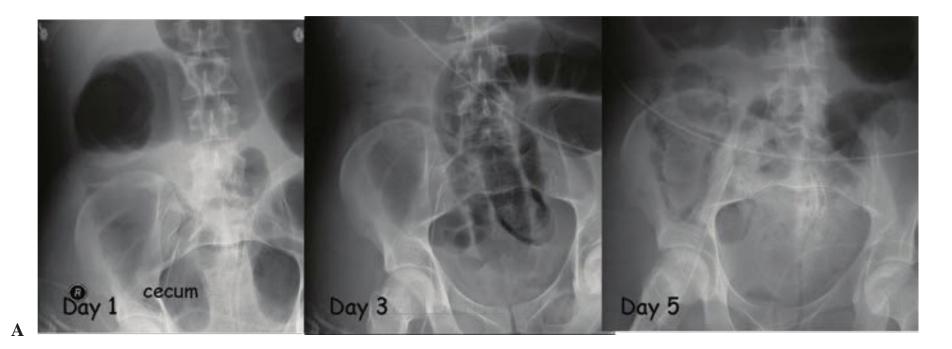
- Ultrasound: shows thickened bowel wall, mesenteric inflammation, and sometimes a diverticulum is identified
- CT scan: long segment of thickened colon with numerous adjacent diverticula with mesenteric inflammation, microperforation, abscesses, and fistula

- ✓ There usually is a diverticulum near the inflammatory changes.
- ✓ CΓ scan is the imaging of choice to assess for complications such as microperforations and abscesses, which can be drained radiologically.
- ight colonic diverticulitis may mimic appendicitis, and a careful search for the actual inflamed diverticula is required for an accurate diagnosis.



## Clinical Presentation

A 57-year-old male patient admitted to the intensive care unit (ICU) with acute respiratory distress syndrome (ARDS) secondary to pneumonia developed progressive abdominal distension over 5 days. Plain films were done as shown.



(A) Supine films of the abdomen performed over 5 days. Day 1: There is significant distension of the colon from cecum to the descending colon. Day 3: The cecum is less distended with sigmoid distension. Day 5: The cecum is less distended but there is now pneumatosis of cecal wall.

### Differential Diagnosis

- Ogilvie syndrome with cecal ischemia: Acute colonic pseudo-obstruction (no mechanical cause present) typically due to underlying medical or surgical condition. Pneumatosis is a major complication.
- Large bowel obstruction: Frequent causes include fecal impaction, obstructing malignancy, and volvulus. A partial obstructing intraluminal lesion is more likely to mimic pseudo-obstruction radiographically.
- Megacolon: Causes include medication, infection (Clostridium difficile), inflammation (ulcerative colitis), and systemic sepsis. In addition to colonic dilatation, thumbprinting and loss of haustral markings may be present.

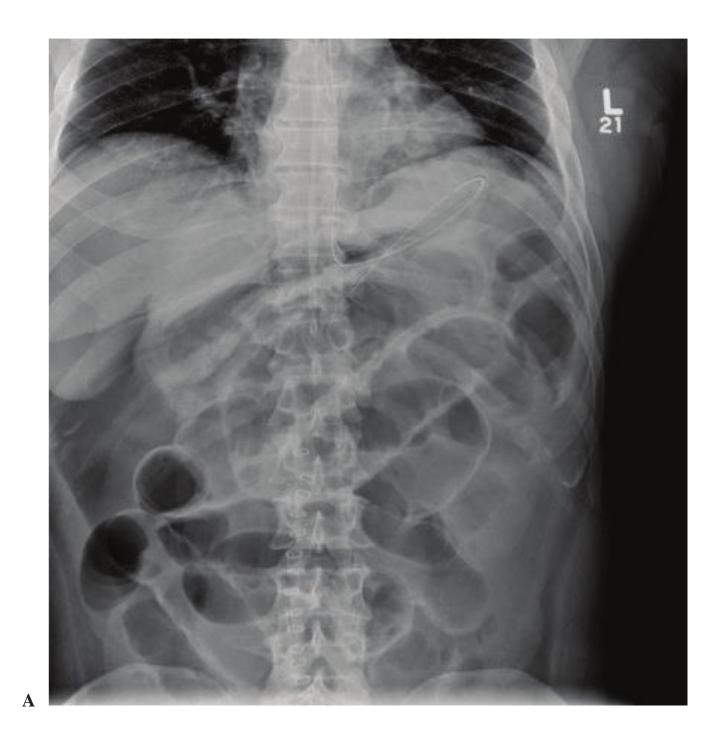
### Essential Facts

- Etiology: sympathetic and/or parasympathetic dysfunction
- Epidemiology: Ogilvie syndrome affects elderly patients (average age: 60 years) with underlying medical or surgical conditions.
- Clinical presentation: May present as abdominal pain and distension, nausea, vomiting, obstipation, and fever. Forty percent to 50% of patients continue to pass flatus (in contrast to patients with true obstruction).
- Complications: bowel ischemia and cecal perforation (prevalence of 1 to 3% and associated with a mortality rate of 50 to 70%)
- Treatment: Modes of treatment include supportive care, parasympathomimetic (i.e., neostigmine), endoscopy, and surgery (i.e., cecostomy).

### Other Imaging Findings

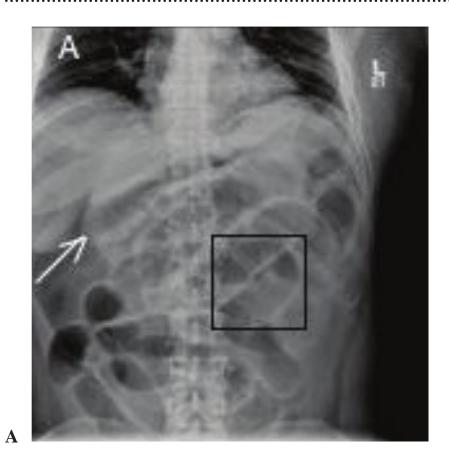
- Abdominal radiograph: Imaging modality of choice. Colonic dilatation with or the without the presence of air fluid levels. Pneumatosis is an ominous sign, which sometimes is missed.
- Computed tomography (CT): Demonstrates colonic dilatation in the absence of a transition point or obstructing lesion. CT is more sensitive in detecting early pneumatosis than plain film.

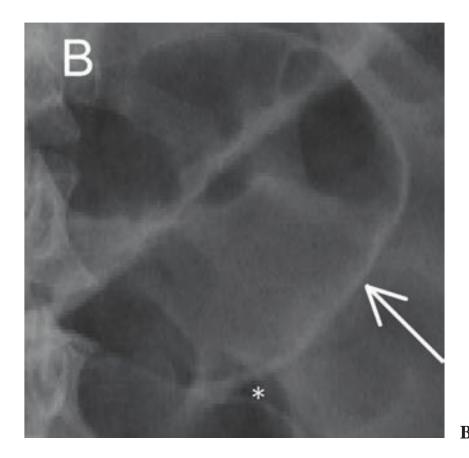
- ✓ ©gilvie syndrome is typically seen in ICU patients with sepsis.
- ✓ © transition point is seen on radiography.
- ✓ Conservative treatment is appropriate if cecal distension is, 12 cm.
- ✓ Cerial abdominal exams must be performed if conservative management is the treatment of choice, as increased colonic distension leading to perforation can be missed.
- contrast enema is contraindicated if megacolon is suspected.



## Clinical Presentation

A postoperative male patient complains of diffuse abdominal discomfort and distension.





(A) Supine abdominal radiograph demonstrating Rigler sign (black box) and visible gallbladder (arrow) consistent with pneumoperitoneum. A postoperative ileus is also seen (note that surgical staples are visualized in the midline). (B) A magnified image obtained from image A (within black box) demonstrating Rigler sign (arrow demonstrates visualization of mucosal and peritoneal bowel walls) and triangle sign (asterisk demonstrates free air between loops of bowel).

## Differential Diagnosis

- Pneumoperitoneum: Expected finding postoperatively. Other common causes include perforated viscus and trauma.
- Subhepatic abscess: A localized collection of free gas and fluid. Look for associated findings, which include localized ileus, air-fluid level, displacement of viscera, pleural effusion, and elevated hemidiaphragm. Important to correlate radiographic findings with clinical presentation (i.e., presence of fever and leukocytosis).
- Chilaiditi syndrome: Symptomatic hepatodiaphragmatic interposition of the intestine. Common causes include increased colonic mobility, reduced liver size, decreased tension of the suspensory ligament, phrenic nerve palsy, and obesity. Air within the bowel lumen can be mistaken for pneumoperitoneum.

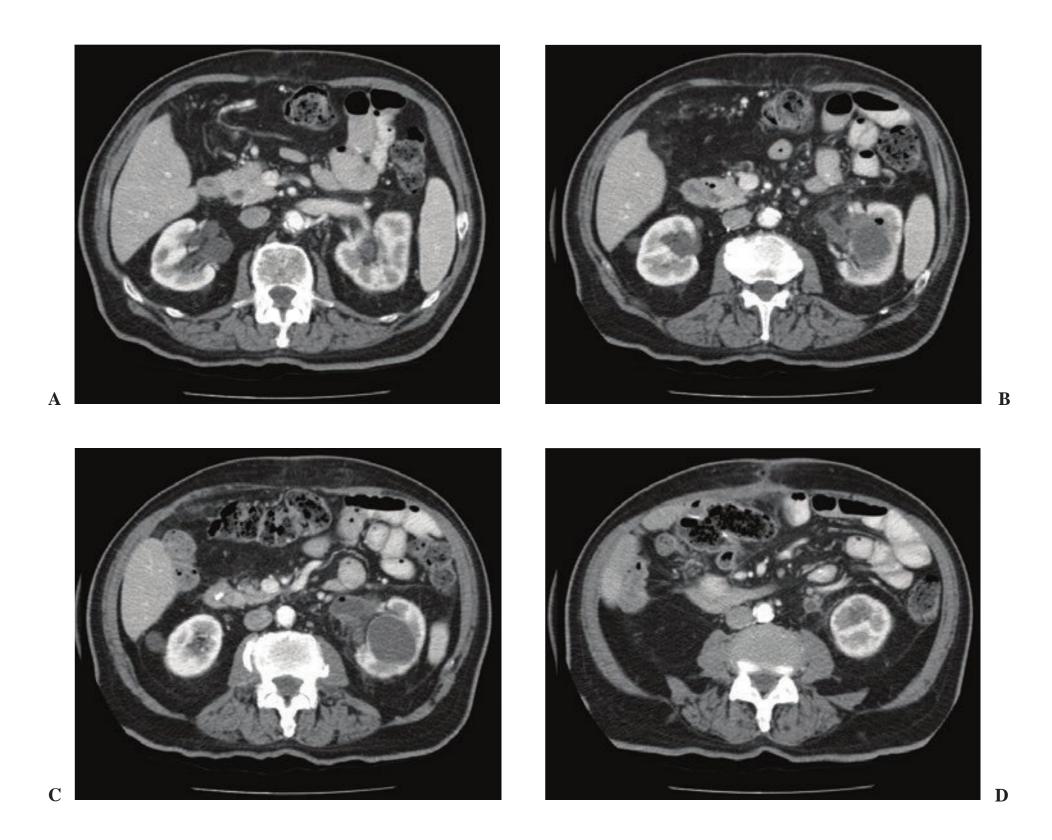
#### Essential Facts

- Prevalence: Peritoneal air is detected in over 50 and 90% of patients 3 days postoperatively by radiographs and computed tomography (CT), respectively.
- Common causes: iatrogenic (i.e., laparoscopy, diagnostic peritoneal lavage), perforated viscus, postoperative complication (i.e., infection, anastomotic leak), inflammation (i.e., perforated diverticulitis, appendicitis, and toxic megacolon), infection (i.e., perforated abscess), perforated neoplasm, Ogilvie syndrome, collagen vascular disease (i.e., scleroderma), and trauma.
- Clinical significance: Postsurgical pneumoperitoneum is typically benign and will resolve. Potential complications include hypercarbia (due to laparoscopic procedure), air embolism, cardiopulmonary compromise, and temporary hypotension.

## Other Imaging Findings

- Supine radiograph: Classic signs of free intraperitoneal air include Rigler/double-wall sign, triangle sign (air between two loops of bowel), football/dome sign (oval radiolucency in central abdomen, "football laces" represented by the falciform ligament), crescent sign (lucency of liver), visible gallbladder, falciform ligament sign, cupola sign (accumulation of free air beneath the central tendon; looks like an inverted cup), and inverted V sign.
- Upright radiograph: Free air under the diaphragm (seen on upright posteroanterior [PA] and lateral chest radiograph), continuous diaphragm sign (air below each diaphragm). Note the lateral radiograph is more sensitive to detect pneumoperitoneum versus PA.
- Left lateral decubitus radiograph: Free air is seen between the abdominal wall and liver.
- CT: Criterion standard to identify pneumoperitoneum but not always necessary due to cost and radiation burden. Intraperitoneal air is visualized as areas of low attenuation (i.e., Hounsfield units toward ] 1,000). CT can help identify origin of free air.
- Ultrasound (US): Typically first imaging modality in emergency situations. Enhancement of the peritoneal stripe with or without reflection artifacts is a sign of pneumoperitoneum.

- There are many radiographic signs of pneumoperitoneum. Familiarity with each sign will help to detect free air.
- ✓ wost signs of free air on supine radiographs are located in the right upper quadrant.
- ✓ Cateral film is more sensitive than PA to detect free air.
- with abnormal positioning of the bowel, intraluminal air can be mistaken for pneumoperitoneum.
- wo loops of bowel in contact with one another can be mistaken for pneumoperitoneum.

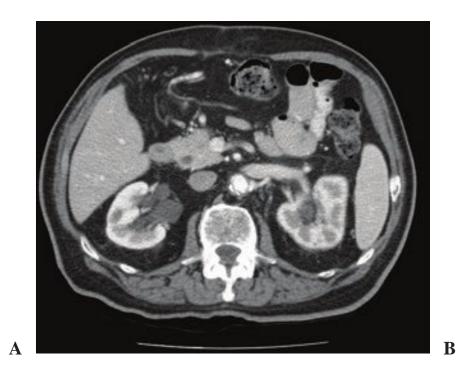


## Clinical Presentation

A 67-year-old female patient with a 4-day history of left flank pain and fever, now septic.

# ■ Further Work-up

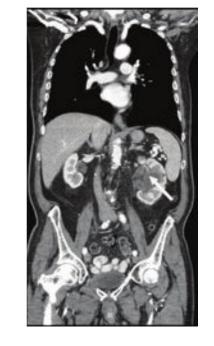












(A, B) Enhanced axial computed tomography (CT) images showing the left kidney with an air-fluid level within the calice (arrow). (C) Enhanced axial CT image showing thickening of the left perirenal septa and fascia (perirenal fatty stranding, arrow). (D, E) Enhanced coronal CT images showing increased left pelvic wall thickness (arrow), dilatation of the left collecting system, and left renal enlargement.

### Differential Diagnosis

- Pyonephrosis: infected purulent urine in an obstructed collecting system ("pus under pressure")
- *Hydronephrosis:* Important to recognize in the context of urinary tract infection (UTI), as it predisposes pyonephrosis. Similar findings on CT, with less pelvic wall thickening and perirenal fat changes.
- Renal abscess: Subcapsular or perinephric extension is accurately depicted by CT. Abscesses initially appear as peripheral cortical lesions and are small wedge or rounded areas of hypoattenuation on CT.

### Essential Facts

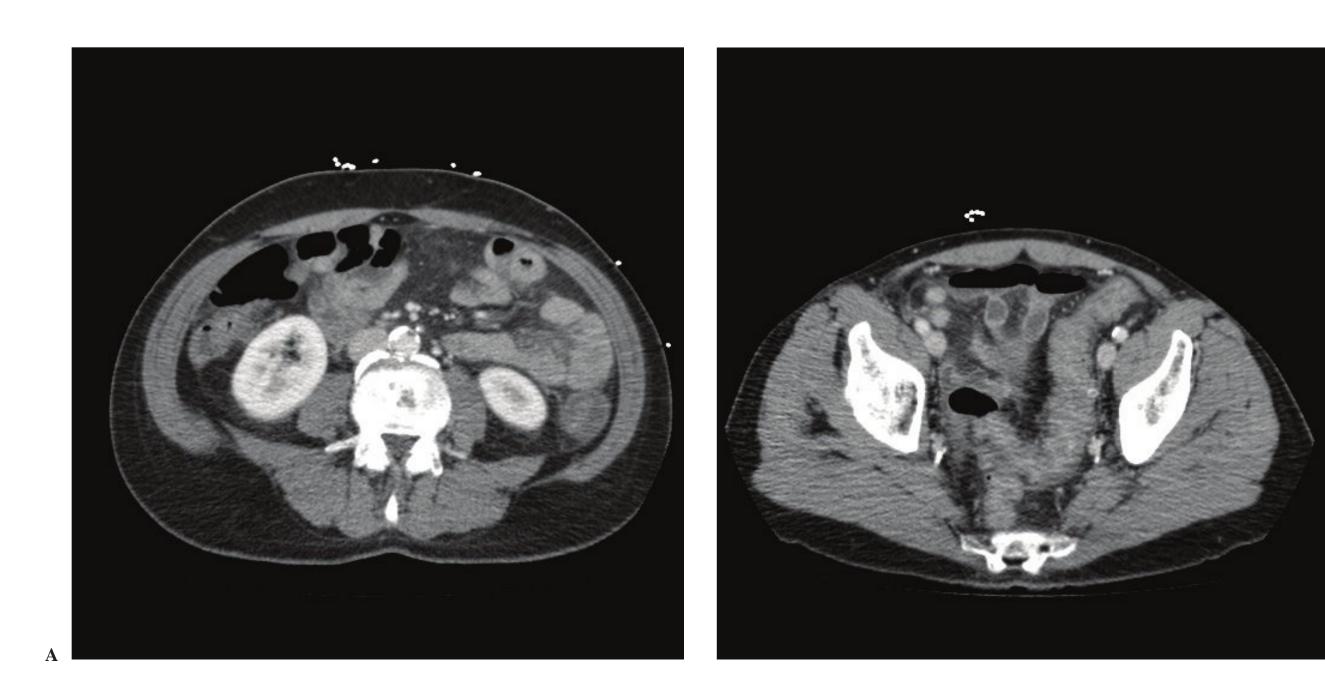
- If left untreated, a rapid and often irreversible renal failure may result. Septic shock may also develop.
- Patients may sometimes present with subtle clinical signs like weight loss and dull pain.
- Fifteen percent of cases are asymptomatic.
- Management includes immediate broad-spectrum antimicrobials and percutaneous drainage of the collecting system. It rarely requires nephrectomy.
- Once treated, additional imaging evaluation is required to identify the cause of the urinary obstruction.

### Other Imaging Findings

• CT: Pelvic wall thickening, perirenal fat changes, dilated collecting system. Fluid-fluid levels and gas within the collecting system may be seen. There is layering of urine,

- contrast and abscess fluid with pyonephrosis on the CT urogram studies. The cause of the obstruction may be identified.
- Ultrasound (US): Dilatation of the pelvic-caliceal system, echogenic collecting system debris, and fluid-fluid levels within the collecting system. US cannot easily show the normal ureter or ureteric calculi other than at the vesico-ureteric junction (VUJ).
- Magnetic resonance (MR): Offers little over CT. Findings include decreased signal intensity on T1 and increased signal intensity on T2, with dependent debris occasionally seen.
- Diffusion weighted MR: preliminary promising results to distinguish pyonephrosis from different renal diseases, like decreased diffusion in pyonephrosis compared with hydronephrosis

- ✓ CT is the imaging modality of choice in adult pyonephrosis.
- ✓ Cas in the collecting system on CT is the most accurate indicator of the presence of infected fluid.
- ✓ is crucial to recognize pyonephrosis, as a delay in treatment may result in irreversible renal failure and shock.
- yonephrosis is difficult to distinguish from uninfected hydronephrosis with CT imaging.
- car, MR has not shown a significant advantage over car for the diagnosis of pyonephrosis.



## Clinical Presentation

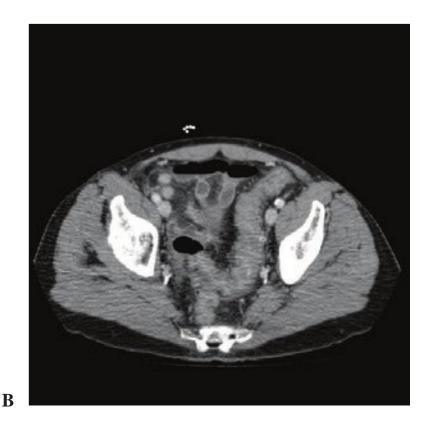
A 60-year-old female patient presents with acute onset of periumbilical pain with bright red bleeding per rectum.

# ■ Further Work-up



#### ■ Image Findings







(A) Axial scan of the descending colon shows mural edema. (B, C) Shows mural edema and mucosal enhancement.

## Differential Diagnosis

- Sigmoid ischemia: Ischemic bowel disease is caused by insufficient blood flow to the colon from various causes with the common ones being atherosclerotic stenosis of the inferior mesenteric artery (IMA) or hypovolemia. Regardless of cause, common computed tomography (CT) findings include bowel dilatation, bowel wall thickening, mucosal enhancement, and less commonly, occlusion of the IMA.
- Sigmoid diverticulitis: The incidence varies with the patient's age occurring predominately in elderly patients. The findings would include mural thickening, mesenteric edema, and numerous sigmoid diverticula, with the offending diverticulum showing the most mesenteric changes.
- Rectal/sigmoid cancer: Colorectal cancers can be polypoid, sessile, or annular constricting. They differ from the above two diagnoses with findings that are focal and may have regional adenopathy as a clue to the diagnosis.

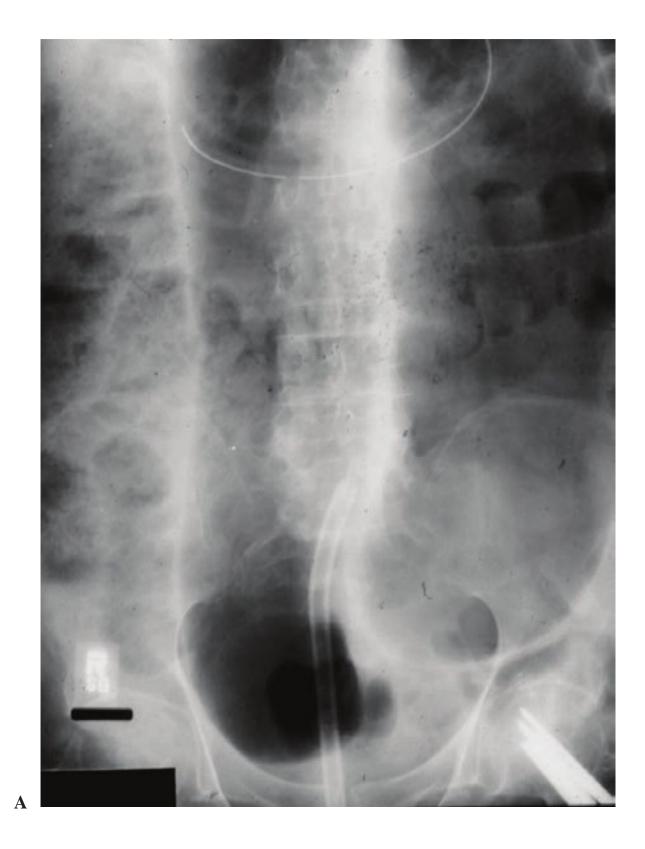
## Essential Facts

- The IMA has two collateral channels to the superior mesenteric artery (SMA) via the marginal artery of Drummond and arc of Riolan.
- In a small percentage of cases, the arc of Riolan is absent, which may result in sigmoid ischemia.

# Other Imaging Findings

- CT scan: intense or decreased mucosal enhancement, mural edema, mesenteric and vascular engorgement, pneumatosis, mesenteric and portal venous gas, occlusion of IMA, and ascites
- Plain film: distension of the left colon with thumbprinting suggesting mucosal edema and, less often, pneumatosis, free air, and portal venous gas

- ✓ The most common CT finding is bowel wall thickening due to submucosal edema or hemorrhage.
- The most common area of ischemia is at the watershed area at the splenic flexure.
- ✓ Ceneum atosis appearing as a streaky linear finding indicates bowel infarction in the correct clinical setting.
- Lain films are usually noncontributory in left colonic ischemia.



#### Clinical Presentation

A 75-year-old man from a nursing home with 8-month history of constipation presents with abdominal distension and pain. He has not had bowel movement in 2 days.



A supine film of the abdomen shows a dilated sigmoid colon with a central cleft of sigmoid mesentery. The colon proximally shows a large volume of stool. There is a rectal tube in place and a nasogastric (NG) tube for decompression.

### Differential Diagnosis

- Sigmoid volvulus: The rotation of the sigmoid colon along its mesenteric axis causing a closed-loop obstruction. A long sigmoid mesentery and chronic constipation are predisposing factors. Usually seen in patients who are elderly, from nursing homes, or from psychiatric facilities.
- Low rectal obstruction due to rectal cancer: About 15 to 20% of patients with colorectal cancer present with acute large bowel obstruction; some may present with progressive constipation, change in stool caliber, or rectal bleeding.

#### Essential Facts

- Accounts for 5 to 7% of large bowel obstruction
- Prior to reduction of the volvulus, patients should be fluid resuscitated.
- Decompression with sigmoidoscopy carries a risk of perforation.

## Other Imaging Findings

• Abdominal X-ray: Distended sigmoid colon with the loop pointing toward the upper right quadrant, which often lacks haustral markings. The "coffee bean" sign describes the dilated and apposed loops of bowel with a central cleft representing the sigmoid mesentery.

- Computed tomography (CT) can rule out ischemia, an infrequent complication, and other causes of obstruction. Whirl sign on CT represents twisted mesenteric vessels.
- Contrast enema: Bird's beak sign is seen when the barium column stops at the site of the twist resulting in a point resembling a bird's beak.

- ✓ gmoidoscopy with insertion of rectal tube comprises definitive management.
- ✓ Coffee bean sign is the classic plain film diagnosis for sigmoid volvulus.
- expectant management is not recommended: Spontaneous reduction only occurs in 2% of patients.
- contrast enema reduces 5% of cases but is not definitive management: Recurrence of volvulus is 80 to 90%.



## Clinical Presentation

A 70-year-old patient presents with nausea, vomiting, and abdominal pain. Patient has had an ileostomy and colectomy with a past history of ulcerative colitis.

# **■** Further Work-up



В

#### ■ Image Findings





(A) Upright plain film shows markedly dilated small bowel (SB) with differential air—fluid levels and minimal gas distally near the stoma. (B) Supine plain film shows dilated SB>3 cm.

### Differential Diagnosis

- Small bowel obstruction (SBO): Presents with dilated SB, multiple differential air-fluid levels, and minimal or no air beyond obstructed segment. In the elderly patient, look for Rigler triad—gallstone, SO, and bile duct air—as the cause.
- *Ileus:* Most often during postoperative period, the findings defer from classic SBO, air throughout the gastrointestinal (GI) tract with normal air-fluid levels, and nondilated SB.

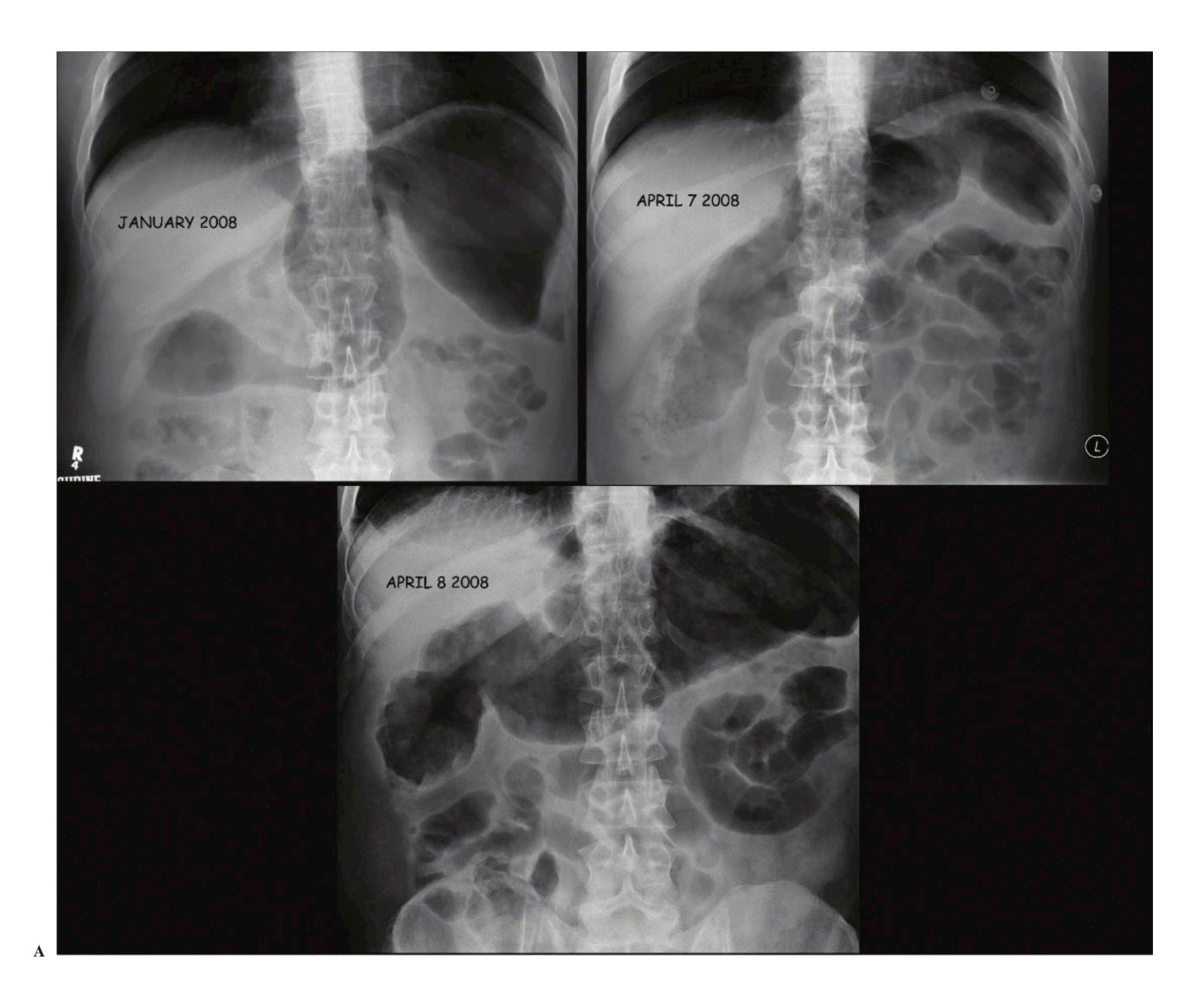
#### Essential Facts

- Etiology of SBO is adhesions; other causes include distal SB lesions (tumor, inflammatory bowel disease, appendicitis with abscess).
- There are two types of bowel obstructions.
- High-grade SBO: imaging findings
- Include dilatation . 3 cm; differential air-fluid levels, string of pearls sign (bubbles of gas trapped at corners of plicae semicircularis), and minimal or no gas beyond the obstructed point

## Other Imaging Findings

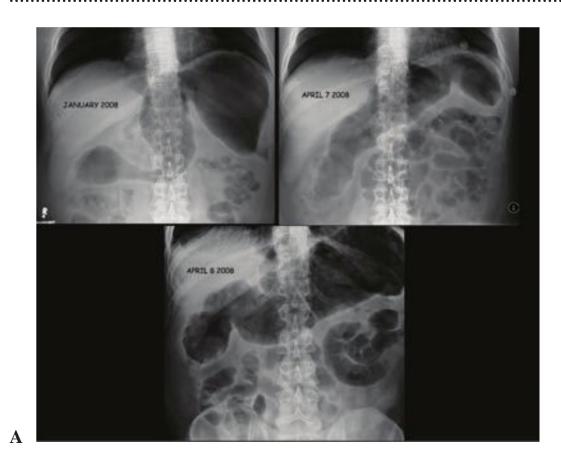
• Mimic ileus, normal or slightly dilated SB, bowel gas seen beyond the obstructed point, air-fluid levels at same level, clinical history, and physical examination of SBO are more important.

- ✓ €iology of SBO are not detected on plain films except in gallstone ileus (Rigler triad) and inguinal hernias.
- ✓ Cequire computed tomography (CT) imaging for a definitive diagnosis of etiology of SBO.
- ✓ Conresolving SBO with conservative prescription (Rx) requires further imaging to rule out ominous diagnosis of strangulation.
- \*Casless abdomen (fluid-filled loops of bowel), a rare sign of SBO, can be misleading (usually interpreted as normal study).



## Clinical Presentation

A 35-year-old male patient with long history of ulcerative colitis (UC) presented with abdominal pain, bloody diarrhea, dehydration, and fever with leukocytosis. Plain films were done for 2 consecutive days (a previous abdominal film done few months before is also shown).



(A) Supine abdominal radiographs on three separate times demonstrating distension of transverse colon and thumbprinting of the haustra. One day later, the transverse colon is further dilated, measuring 12 cm. The radiograph done in January is shown.

## Dif erential Diagnosis

- Toxic megacolon: Causes include inflammatory bowel disease (IBD) (UC more than Crohn) and infectious colitis (typically *Clostridium dif cile*). In addition to colonic dilatation, thumbprinting and loss of haustral markings are usually present.
- Ogilvie syndrome: acute colonic pseudo-obstruction (no mechanical cause present) typically due to underlying medical or surgical condition
- Large bowel obstruction: Frequent causes include fecal impaction, obstructing malignancy, and volvulus. Intraluminal gas distal to the site of obstruction is not seen in complete obstruction. A partial obstructing intraluminal lesion is more likely to mimic pseudo-obstruction radiographically.

#### Essential Facts

- Etiology: transmural inflammation more commonly in patients with UC
- Clinical presentation: Presents with bloody diarrhea, abdominal pain, fever, and electrolyte imbalance. Toxic megacolon is a combination of dilated inflamed colon with constitutional symptoms of sepsis.
- Imaging:
- Abdominal radiograph: Three views of the abdomen is the imaging of choice. Serial follow up abdominal films every 24 hours to assess colonic changes as response of treatment. If clinical state changes (i.e., more septic) or localized peritonitis or treatment fails, repeat abdominal films are done more frequently.
- Computed tomography (CT): may be done in relatively stable patients who have developed severe

- complications undetected clinically or on plain abdominal films
- Complications: Pancolonic inflammation and dilatation with prominence of cecum and/or transverse colon; colonic distension leads to vascular comprise and ischemia ultimately with pneumatosis and perforation.
- Treatment: Toxic megacolon if not amenable to medical therapy (steroids etc.) then surgery is mandated to prevent catastrophic complications such as perforation and death.

#### Other Imaging Findings

- Abdominal plain films: colonic dilatation (cecum. 9 cm, transverse colon. 7 cm), thumbprinting, and pneumatosis
- Contrast-enhanced CT: all of the above and pericolonic inflammation, ascites, and small bowel (SB) ileus

- ✓ tic megacolon is typically seen in patients with UC and rarely in Crohn.
- ✓ can be the first presentation of IBD in a young patient.
- ✓ ain films are the best imaging for both diagnosis and assessment for complications and treatment response.
- ✓ Crogressive colonic distension and SB ileus are ominous signs that may require surgery (urgent pancolectomy) in the correct clinical context.
- contrast enema is contraindicated if megacolon is suspected.
- T is not always necessary to detect complications (worsening of clinical and abdominal plain film changes are more important).



### Clinical Presentation

A 45-year-old male patient with 4-day history of bloody diarrhea, sudden-onset abdominal pain, and distension, with guarding, fever, orthostatic hypotension, and tachycardia.



(A) Left lateral decubitus abdominal film shows dilated transverse colon 15 cm with thumbprinting and an air—fluid level; a large amount of intraperitoneal air (free air) is seen near the right hemidiaphragm outlining the liver.

#### Differential Diagnosis

- Toxic megacolon with perforation: Colonic dilatation, thumbprinting, transmural inflammation, and loss of haustral markings are common plain film findings, along with free intraperitoneal air.
- Large bowel obstruction with perforation: Perforation when obstruction progresses with a competent ileocecal valve leading to colonic dilatation and ischemia. Colonic distension is seen proximal to obstruction with collapsed colon distally.
- Infectious colitis with perforation: Colitis caused by Shigella, rotavirus, Salmonella, Campylobacter, and other infectious species. Perforation is rare only when treatment fails.

#### **■** Essential Facts

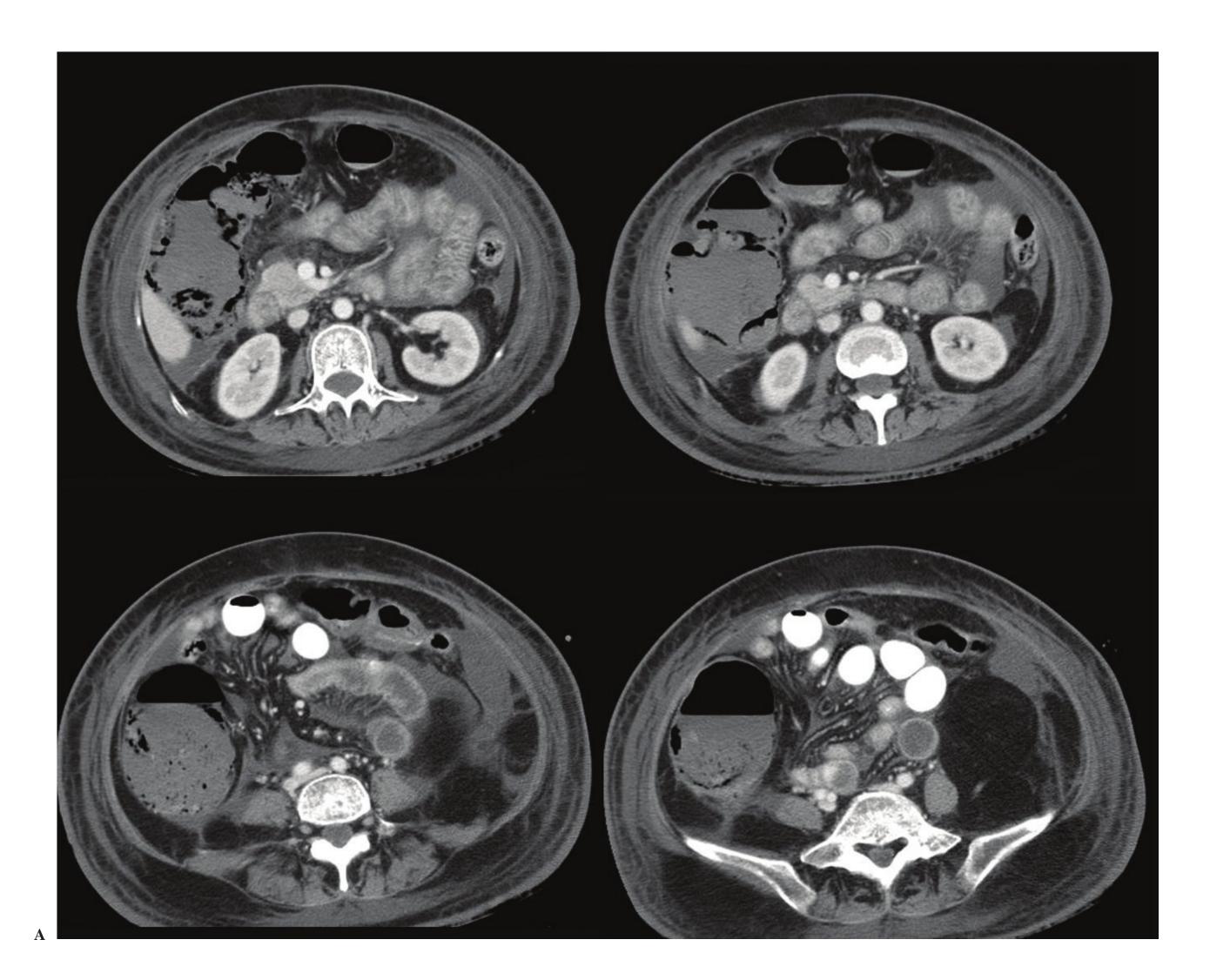
- Toxic megacolon is a common manifestation of inflammatory bowel disease (IBD) or ulcerative colitis, preceding history of bloody diarrhea.
- Severe transmural inflammation paralyzes colonic smooth muscle, causing dilatation. A competent ileocecal valve is a risk factor for perforation.
- Patients will present with clinical signs of sepsis along with peritoneal signs indicative of perforation.
- Daily abdominal X-rays should be performed in patients with megacolon to assess if colon is dilating or not.

• Perforation is an absolute indication for surgery, as mortality increases fivefold after perforation. The surgery of choice is subtotal colectomy with end ileostomy.

# Other Imaging Findings

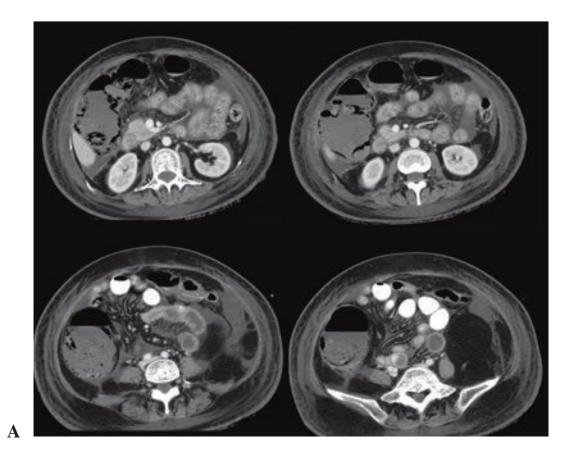
- Flexible sigmoidoscopy would show the typical findings of colitis depending on the type. Ulcerative colitis—superficial ulceration; infectious colitis—ulcerative membranes.
- Colonic dimension (cecum . 9 cm, transverse colon . 7 cm) or progressive dilatation with toxic symptoms and a competent ileocecal valve are ominous signs for perforation.
- Computed tomography (CT) can be used to diagnose and evaluate disease progression and assess complications such as perforation and is also helpful in distinguishing ulcerative colitis from Crohn.

- ✓ ain films of the abdomen are essential in evaluating treatment effectiveness.
- ✓ ©erforation is an absolute indication for surgery.
- \*Indoscopic evaluation may complicate the course of disease if colonic distension is performed.



## Clinical Presentation

An elderly patient was admitted to the emergency department with fever and right lower quadrant pain. He had been on chemotherapy for lung cancer. Plain film of the abdomen was noncontributory. A computed tomography (CT) scan of the abdomen with oral and intravenous (IV) contrast was given. What are your findings and diagnosis?



(A) The CT scan shows pneumatosis of the cecum with pericolonic inflammation. There is also small-volume ascites in Morrison pouch and left upper paracolic peritoneal space.

## Differential Diagnosis

- Typhlitis (neutropenic enterocolitis): characterized by edema and inflammation of the cecum, the ascending colon, and sometimes the terminal ileum; may result in transmural necrosis, perforation, and death
- Ogilvie syndrome with cecal ischemia: Acute colonic pseudo-obstruction (no mechanical cause present) typically due to underlying medical or surgical condition. Pneumatosis is a major complication.
- Megacolon: Causes include infection (Clostridium difficile), inflammation (ulcerative colitis), and systemic sepsis. In addition to colonic dilatation, thumbprinting and loss of haustral markings may be present.

#### **Essential Facts**

- Etiology: occurs in neutropenic patients undergoing treatment for malignancy (acute leukemia, aplastic anemia, or lymphoma), AIDS, or kidney transplantation
- Clinical presentation: presents with fever, watery or bloody diarrhea, and abdominal pain localized to the right lower quadrant
- Pathophysiology:
- Changes due to a combination of ischemia, infection (especially with cytomegalovirus), mucosal hemorrhage, and transmural tumoral infiltration
- Colonic changes include edema and inflammation of cecum and ascending colon.
- Transmural necrosis, perforation, and death can result if diagnosis is not suspected clinically or diagnosed early on imaging.

#### • Treatment:

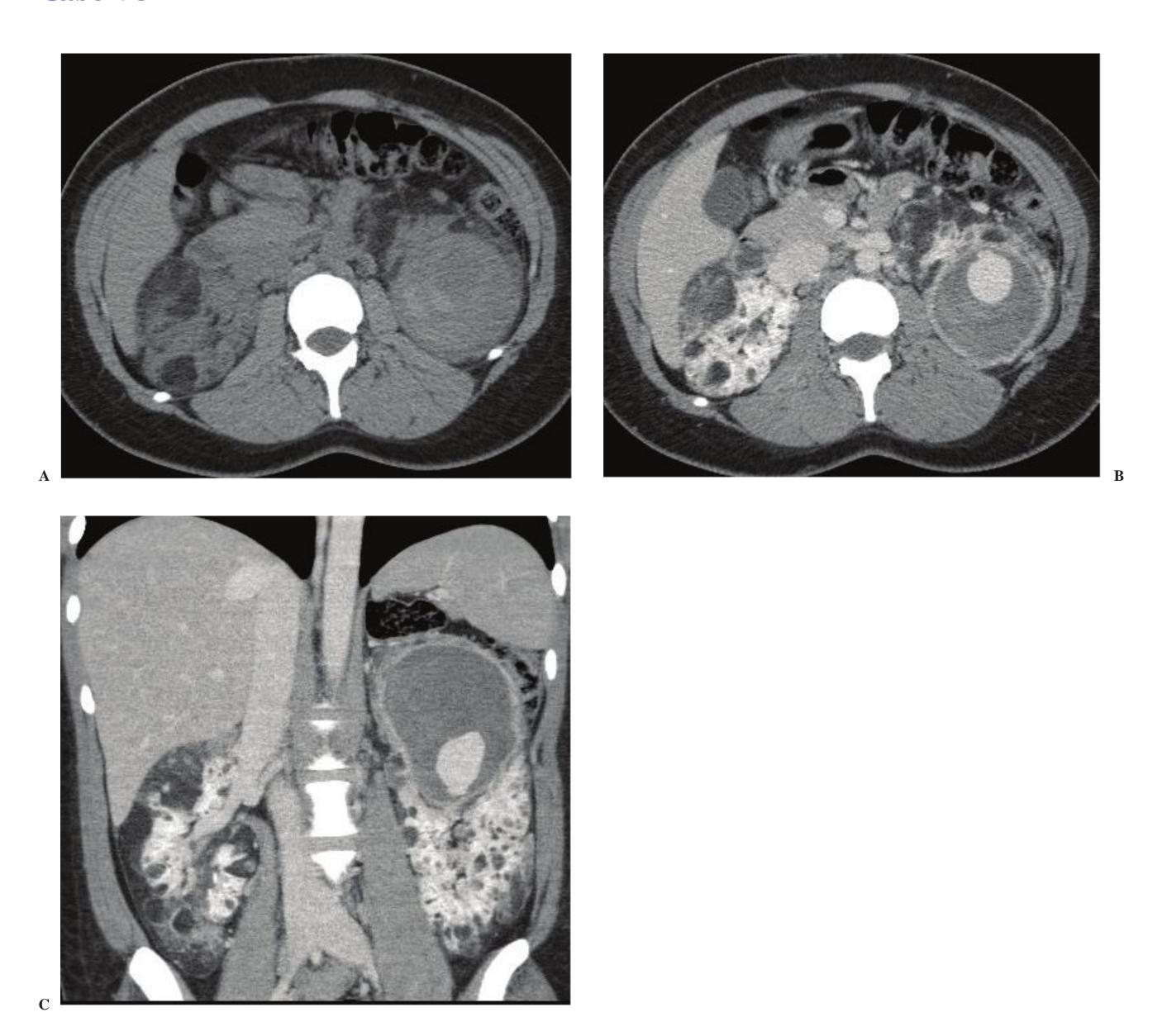
- Medical: consists of bowel rest, total parenteral nutrition, antibiotics, and aggressive fluid and electrolyte replacement
- Surgery is indicated in patients with uncontrollable gastrointestinal bleeding, abscess, transmural necrosis, free intramural perforation, or uncontrolled sepsis.

#### Other Imaging Findings

- Abdominal radiograph: Imaging study performed initially. Right colonic ileus; thumbprinting and pneumatosis usually of the cecum and or right colon.
- CT: Imaging of choice. Cecal distension and circumferential thickening (low attenuation due to edema). Inflammatory stranding of the adjacent mesenteric fat, ascites, and secondary inflammation of adjacent small bowel.
- Complications include pneumatosis, pneumoperitoneum, and pericolic fluid collections.

- ✓ CT is the imaging of choice to detect early changes before ischemia and perforation ensues.
- ✓ Cansmural thickening, pneumatosis, and mesenteric inflammation are important imaging findings.
- ✓ the correct clinical context, imaging findings of typhlitis are important indicators for surgical intervention.
- imilar changes are seen in appendicitis, Crohn, and vascular ischemia.

**Case 73** 

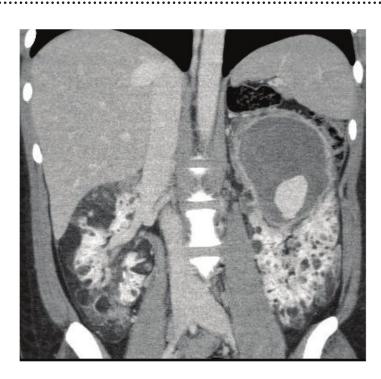


# Clinical Presentation

A 27-year-old woman with a long history of a seizure disorder presents with sudden-onset left flank pain.







(A) Axial noncontrast computed tomography (CT) shows a heterogeneous left renal mass with areas of high attenuation and bilateral fat-containing renal masses. (B, C) Axial and coronal contrast-enhanced CT shows an aneurysm with surrounding hematoma in the left kidney and bilateral fat-containing renal masses.

### Differential Diagnosis

- Ruptured aneurysm from a renal angiomyolipoma (AML) in a patient with tuberous sclerosis (TS): There are multiple fat-containing lesions in both kidneys diagnostic of AMLs. The dominant abnormality in the upper pole of the left kidney has a focal homogeneous area of enhancement, similar to the aorta representing the aneurysm with surrounding lower attenuation hematoma.
- Enhancing renal mass such as renal cell cancer: Renal cell cancers tend to be more heterogeneous.

# Essential Facts

- TS is a rare genetic disorder characterized by hamartomas involving multiple organs including the central nervous system (CNS), kidneys, and skin.
- Manifestations of TS in the abdomen/pelvis may include renal AMLs and cysts, liver AMLs, lymphangioleiomyomas, and rectal polyps.
- Renal AMLs are hamartom as composed of abnormal blood vessels, smooth muscle, and fat.

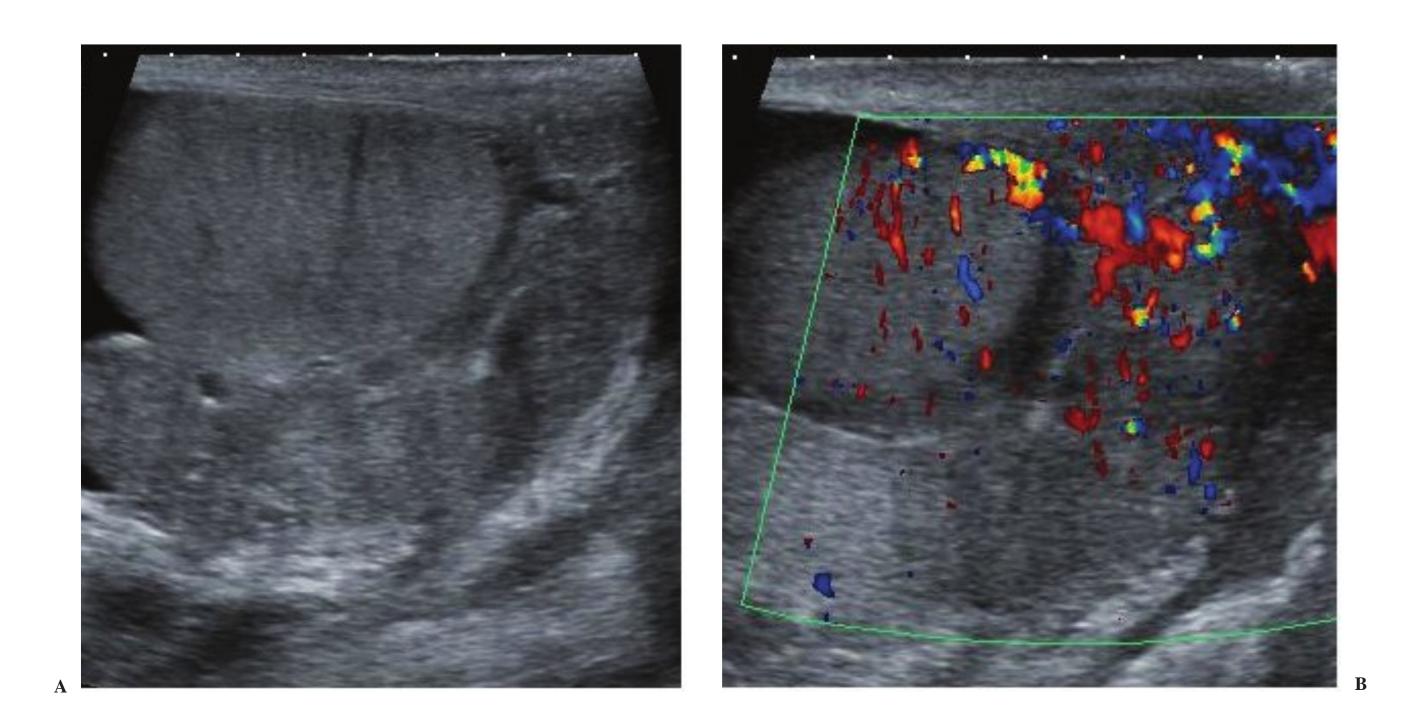
- Multiple, bilateral renal AMLs are present in the majority of patients with TS.
- Complications from renal AMLs in TS include hemorrhage and renal failure.

### Other Imaging Findings

- Ultrasound (US) can be used to monitor the size of renal AMLs in TS.
- The presence of macroscopic fat in a renal mass is diagnostic of AML.

- ✓ Qultiple bilateral AMLs are common in TS.
- ✓ The larger the AML, the more likely it is to bleed.
- ✓ Carger AMLs (. 4 cm) or ruptured AMLs can be treated with percutaneous selective renal artery embolization.
- concontrast CT alone will not be able to diagnose the aneurysm within a large AML.

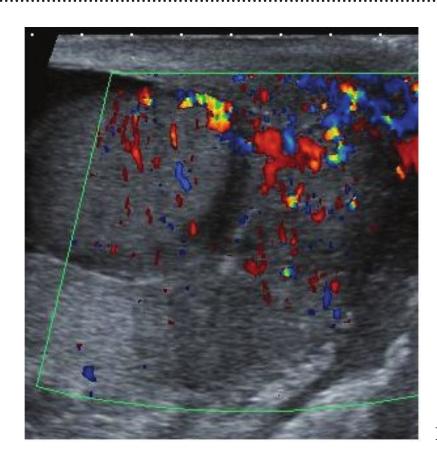
Case 74



# Clinical Presentation

A 66-year-old man presents with a 5-day history of scrotal swelling, right testicular pain, and fever.





(A, B) Ultrasound (US) images show a thickened, heterogeneous right epididymis. Color Doppler US shows increased flow to the right epididymis.

#### Differential Diagnosis

• Epididymitis, testicular torsion, and testicular neoplasm: The short clinical course and presence of fever makes infection or possibly torsion more likely than testicular neoplasm. US shows that the abnormality is within the epididymis, there is no testicular mass (excluding testicular neoplasm), and there is flow in the testis (excluding testicular torsion).

#### Essential Facts

- Epididymitis is the most common cause of acute scrotal pain.
- In younger men, the most common organisms are Neisseria gonorrhoeae and Chlamydia trachomatis; in older men, Escherichia coli is more common.
- Testicular US is the primary imaging modality for the investigation of scrotal disorders.
- US allows classification of scrotal disorders as testicular or extratesticular.

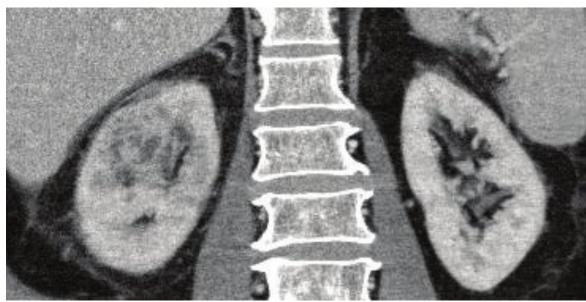
• Color Doppler US can be used to assess the vascular supply to the testis, important in the evaluation of suspected testicular torsion, and to the epididymis, helpful in the diagnosis of epididymitis.

### Other Imaging Findings

• Epididymitis may be accompanied by orchitis—usually seen as increased flow to the testis.

- S is the modality of choice for the investigation of scrotal disorders.
- ✓ Comparison with Doppler US of the contralateral testis and epididymis can be helpful to assess blood flow when there is a question of testicular torsion.
- Elinically, testicular tumors may occasionally be mistaken for epididymitis/orchitis.

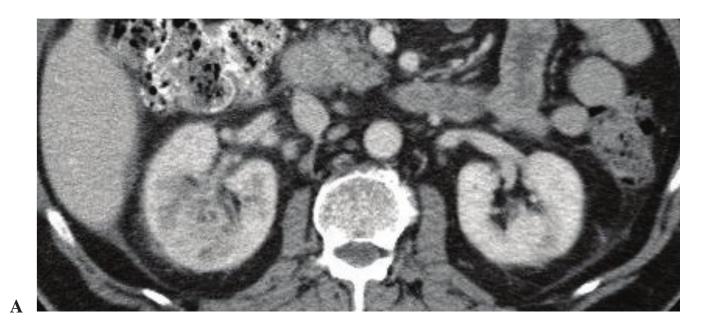




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# Clinical Presentation

A 64-year-old man with 3-day history of right flank pain and fever.





(A, B) Axial and coronal contrast-enhanced computed tomography (CT) shows a focal heterogeneous area in the right kidney with ill-defined borders and stranding of the surrounding fat.

#### Differential Diagnosis

- Focal pyelonephritis: occurs as a complication of urinary tract infection (UTI)
- Renal abscess: The majority of the lesion is usually more liquefactive than in this case.
- Renal cell carcinoma: The borders are usually more well-defined and there is usually no stranding of the perinephric fat. Most renal cell carcinomas are asymptomatic and discovered as incidental findings on imaging. When symptomatic, they can cause pain and/or hematuria.

#### Essential Facts

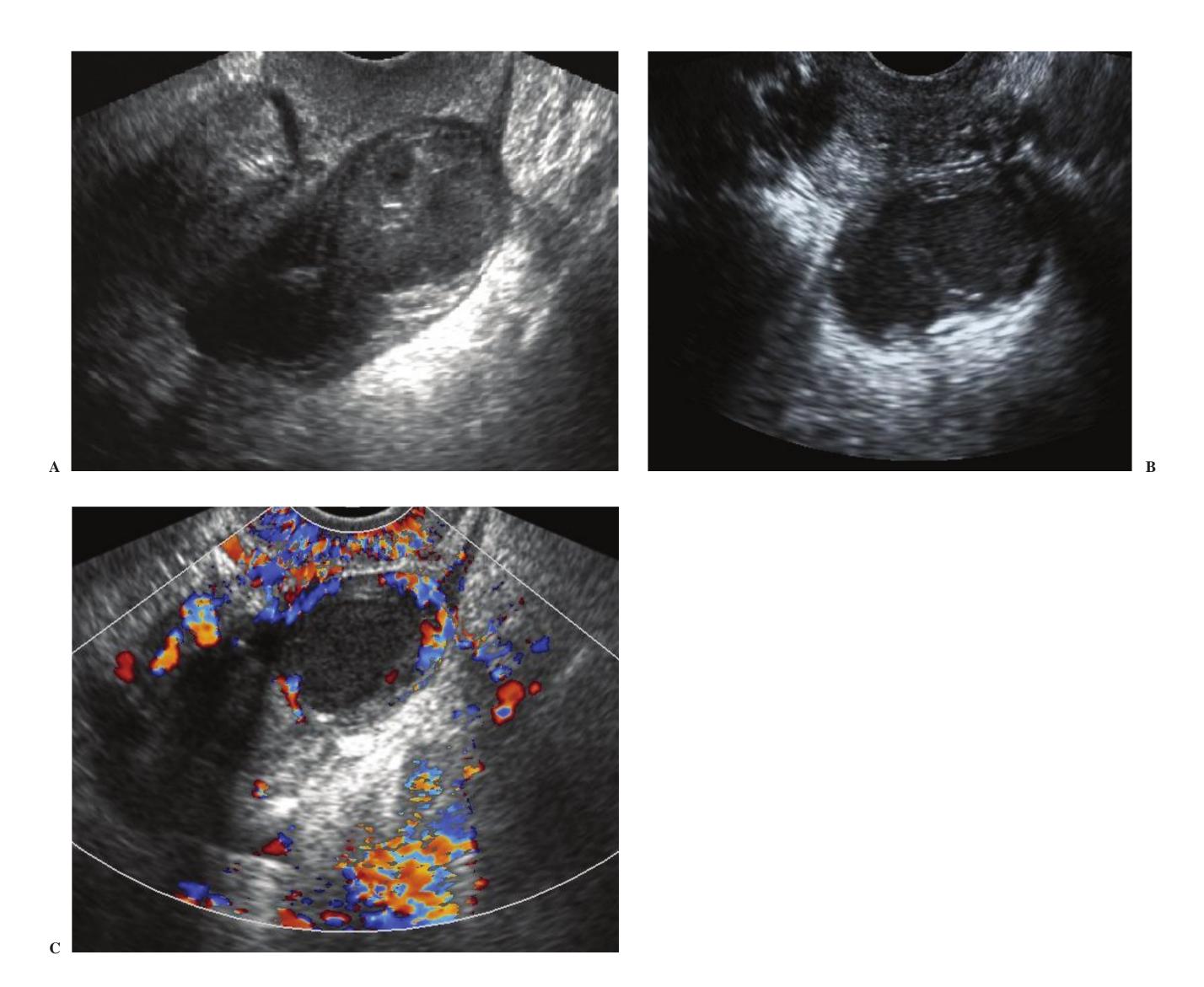
- Pyelonephritis does not usually require imaging for diagnosis.
- Imaging may be used to confirm the diagnosis or to assess for complications such as progression to a renal abscess.
- Ultrasound (US) is not sensitive for the diagnosis of pyelonephritis.
- When imaging is indicated, CT is the modality of choice.

## Other Imaging Findings

• On CT, focal pyelonephritis may show renal enlargement, striated nephrogram, and/or perinephric stranding or fluid.

- ✓ aging is not usually indicated for the diagnosis of uncomplicated UTI.
- ✓ Canaging is reserved for patients with UTI that does not respond to therapy and to evaluate for complications from UTI.
- ✓ © cal pyelonephritis may progress to renal abscess.
- is important not to misinterpret focal pyelonephritis as a renal tumor; the combination of clinical and imaging findings should lead to the correct diagnosis.

**Case 76** 

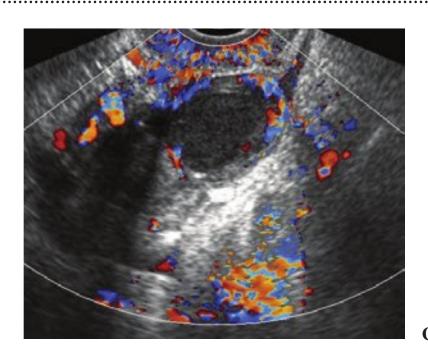


# Clinical Presentation

A 25-year-old woman presents with a 3-day history of left lower quadrant pain and fever. Her white cell count is elevated and human chorionic gonadotropin (HCG) is negative.







(A, B) Longitudinal and transverse ultrasound (US) images show a 6.4-cm dilated tubular structure in the left adnexa with a thick wall and low-level echoes in the lumen. (C) The wall and surrounding tissues are vascular and the patient was focally tender in this area with the US probe. The left ovary was not seen separately from the mass. The right ovary and uterus were normal (not shown).

## Differential Diagnosis

- Tubo-ovarian abscess (TOA): The patient was started on intravenous (IV) antibiotics. Using transvaginal ultrasound guidance, an 18-gauge needle was inserted into the left fallopian tube and ~20 mL of pus was aspirated.
- Endometriosis: involving the fallopian tube and ovary—the acute presentation, fever, and elevated white cell count make this less likely
- Ovarian neoplasm: the tubular shape of the structure; acute presentation, fever, and elevated white cell count make this less likely

#### Essential Facts

- Pelvic US is the imaging modality of choice for the investigation of suspected pelvic inflammatory disease (PID) including TOA.
- Risk factors for the development of PID and TOA include young age, multiple sexual partners, and intrauterine devices (IUD).
- TOAs are most commonly the result of infection from *Chlamydia trachomatis* and *Neisseria gonorrhoeae*.

• TOA can be managed with antibiotics, percutaneous image-guided drainage, or surgery, depending on severity.

#### Other Imaging Findings

- The ipsilateral ovary may not be seen separately from the dilated fallopian tube (tubo-ovarian complex).
- Alternatively, the ipsilateral ovary may be enlarged with increased vascularity.

- ✓ tis important to correlate US findings with HCG to exclude an ectopic pregnancy.
- ✓ Callopian tubes are not usually seen with US unless they are abnormal.
- ✓ ♠ A is associated with a higher risk of infertility and ectopic pregnancy.
- he presence of fever and elevated white cell count makes TOA a more likely diagnosis than endometriosis or ovarian neoplasm.





### Clinical Presentation

A 66-year-old man with a history of chronic renal insufficiency presents with acute left flank pain and hematuria. (A) Axial noncontrast CT through the kidneys was obtained. (B) Axial noncontrast CT from 2 months earlier is provided for comparison.





(A) Axial noncontrast computed tomography (CT) shows a heterogeneous left renal mass with areas of high attenuation. There are also multiple bilateral renal cysts. (B) Axial noncontrast CT from 2 months earlier is provided for comparison.

### Differential Diagnosis

- Hemorrhage into a renal cyst in a patient with autosomal dominant polycystic kidney disease (ADPKD): The high attenuation within the renal cyst is typical of acute hemorrhage.
- Renal cell cancer: Although renal cell cancer may present with flank pain and hematuria, the presence of a simple cyst in the same location 2 months earlier makes this diagnosis unlikely.

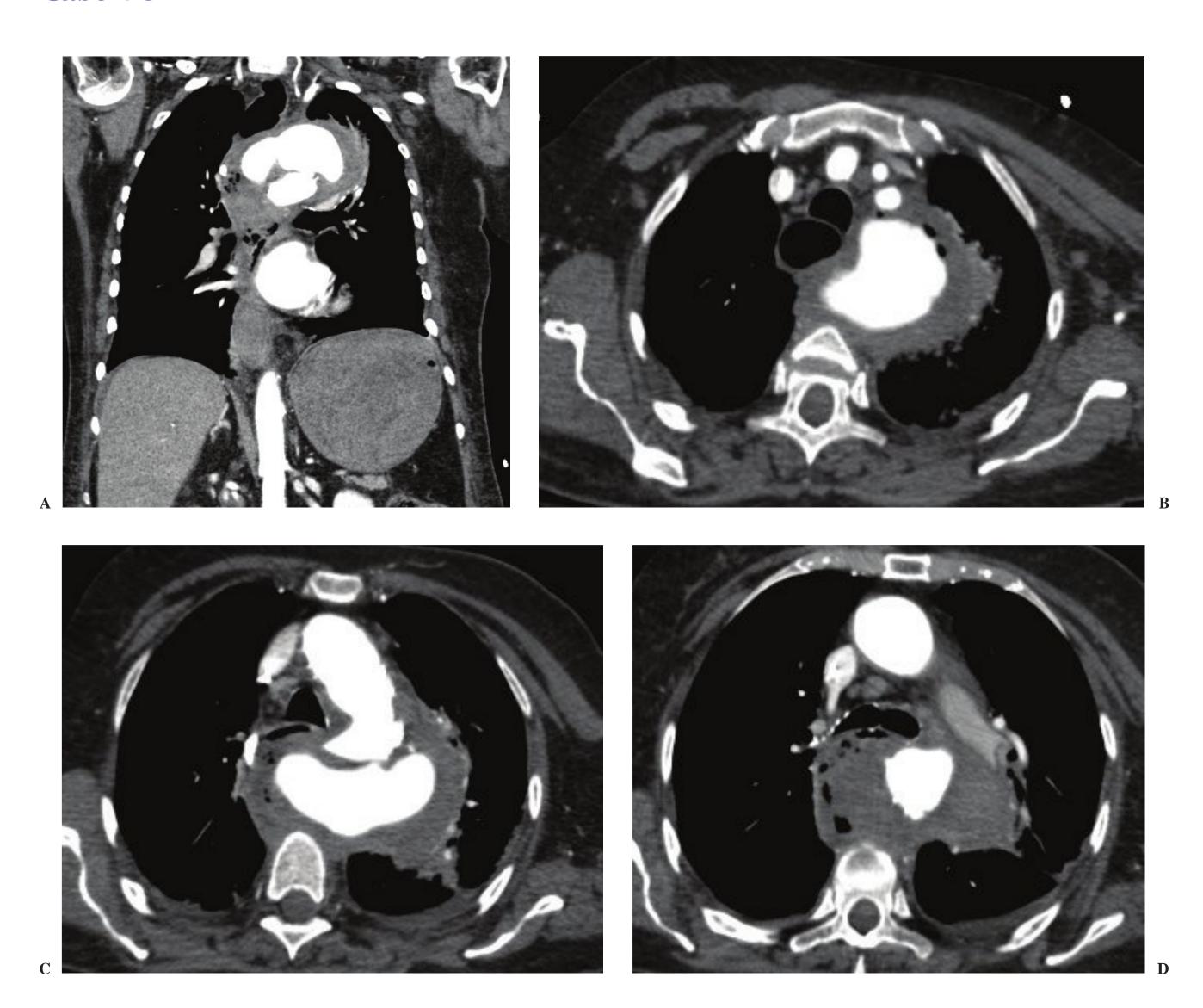
#### Essential Facts

- Renal cysts are very common in the general population but bleeding into a cyst is uncommon.
- In patients with ADPKD, symptomatic bleeding into a renal cyst is more common than in the general population.
- Adult polycystic kidney disease (APCKD) usually presents with progressive renal insufficiency and hypertension.
- Symptoms do not usually appear until middle age.
- Approximately 50% of patients with APCKD will develop end-stage kidney disease.
- In APCKD, other abdominal organs may also contain cysts such as the liver, pancreas, and spleen.
- APCKD is associated with cerebral artery aneurysms.

### Other Imaging Findings

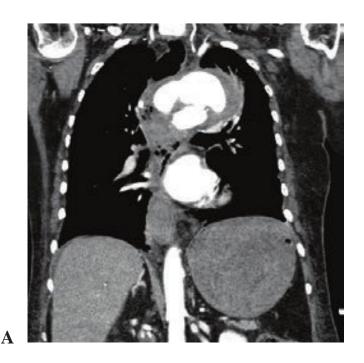
- Ultrasound (US) is the modality of choice to screen family members of patients with APCKD for renal cysts.
- On CT, blood is high-attenuated due to the protein content in hemoglobin.

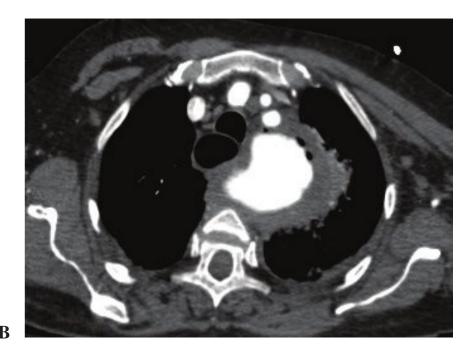
- ✓ Giffuse enlargement of both kidneys with multiple cysts is typical of ADPKD.
- ✓ Cemorrhage into a renal cyst is a known complication of APCKD.
- ✓ Cyst hemorrhage is usually self-limiting but selective renal artery embolization may be required to control bleeding.
- be helpful to confirm the acute findings.

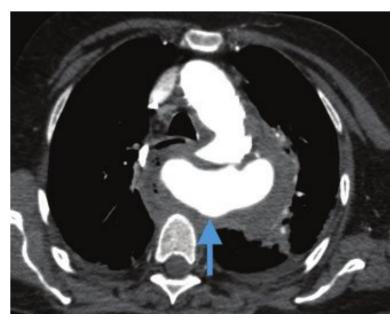


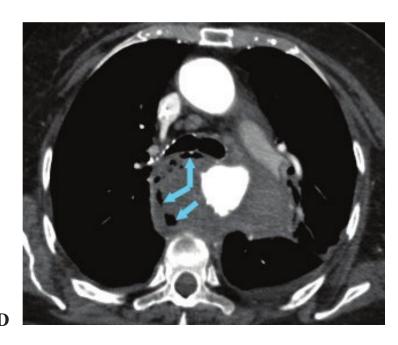
# Clinical Presentation

A 60-year-old woman has acute onset of chest pain and massive hematemesis.









(A-D) Coronal and axial computed tomography (CT) images show a large pseudoaneurysm (large arrow), which contains air (small arrows). High-density material with distension of the stomach is consistent with blood.

#### ■ Dif erential Diagnosis

- Aortoesophageal f stula: Most commonly relates to an aortic aneurysm, which erodes into the esophagus. CT will show an aortic aneurysm abutting the esophagus, which is nonspecific but air outside the esophagus and in the aorta makes the diagnosis. An esophageal abnormality such as an esophageal foreign body that perforates the aorta can also cause a fistula. In this presentation, CT will show evidence of esophageal perforation and looks for any irregularity of aorta for site of fistula.
- Esophageal rupture: can have air in mediastinum adjacent to but not in the aorta
- Traumatic pseudoaneurysm: can have aortic abnormality as well as air in the mediastinum due to trauma but is in a different clinical presentation

### Essential Facts

- Aortoesophageal fistula is a rare life-threatening condition that can lead to massive bleeding and exsanguination.
- It has higher risk with prior aortic reconstructions or esophageal surgery.
- Treatment is surgical with allograft of aorta and esophagectomy but high mortality.

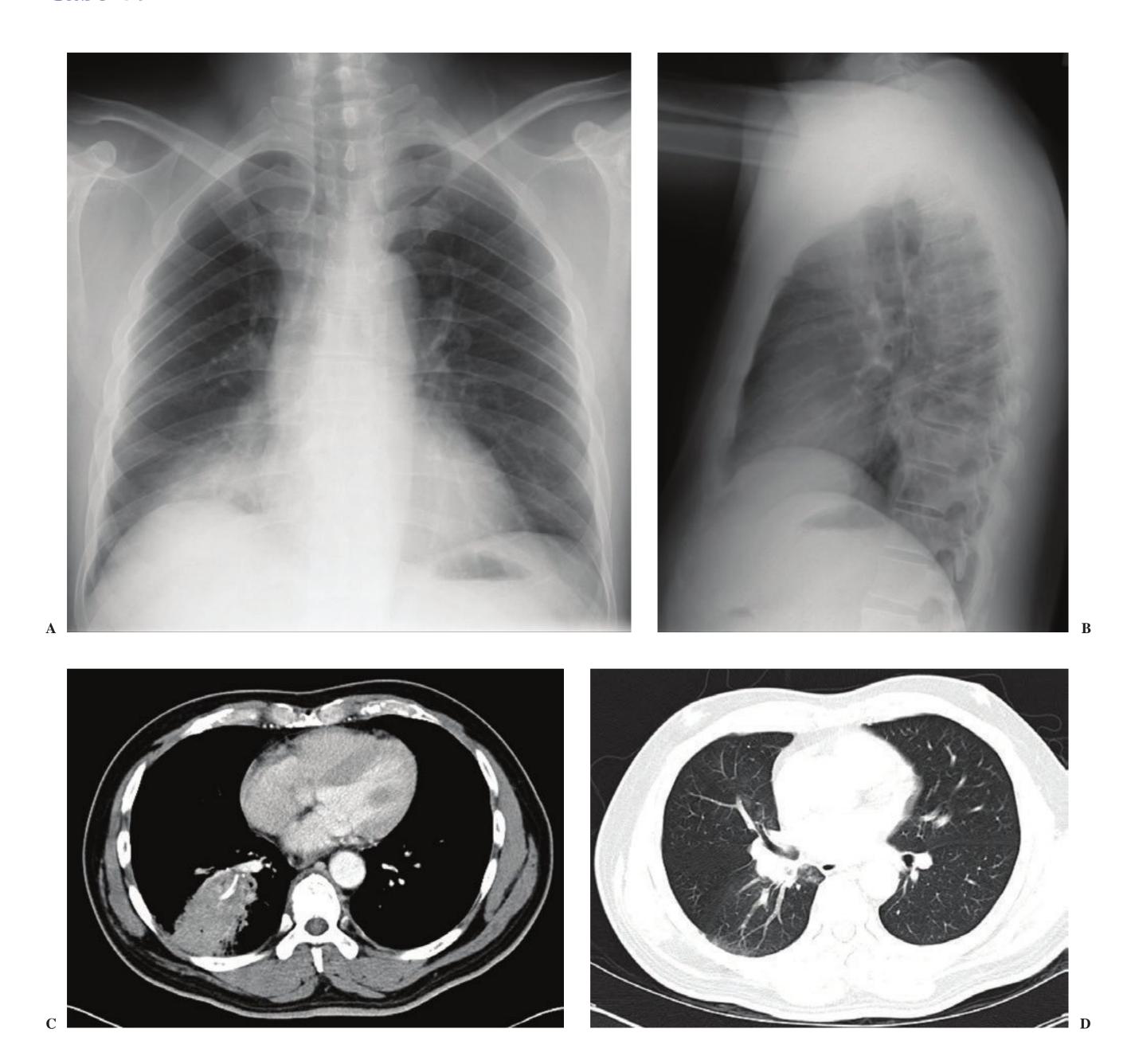
- Endovascular repair has been done as a temporary alternative but surgery is usually still needed and surgical esophageal repair would still have to be done.
- Patients are prone to infection and sepsis.

# Other Imaging Findings

- Esophagram can find esophageal abnormality at site of fistula.
- Angiography can assess for fistula if there is active bleeding.
- Red blood cell (RBC) scan can also assess for slower bleeding.

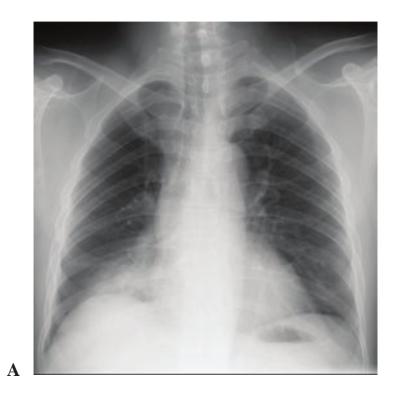
- ✓ This is a surgical emergency with high mortality that needs immediate treatment.
- ✓ Cansient self-limited bleeds may precede massive bleed/hematemesis.
- ✓ Catients are prone to infection and sepsis given contamination of aorta by esophagus.
- is often not diagnosed with mostly postmortem diagnosis.

**Case 79** 

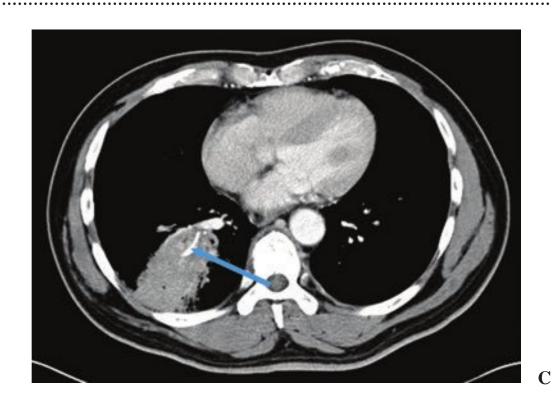


# Clinical Presentation

A 50-year-old man presents with dyspnea and hemoptysis.









(A, B) Posteroanterior (PA) and lateral view shows right lower lobe (RLL) consolidation. (C, D) Computed tomography (CT) scan shows obstruction of the RLL bronchus and a radiopaque density (arrow) within the RLL, which represents an aspirated chicken bone.

#### Differential Diagnosis

- Foreign body aspiration (FBA): FBA into the airways and lungs may cause a variety of pulmonary appearances. Characteristic imaging findings depend on the density of the aspirated object and the duration of symptoms. Chest radiographs can be used to visualize characteristic radio-opaque materials such as coins, toys, bones, and teeth. Often, chest radiographic findings are nonspecific and include obstructive lobar or segmental overinflation or atelectasis. Pneumonia, air trapping, and pneumomediastinum may also suggest FBA when no radio-opaque object is seen. Less commonly, a foreign body can also manifest as a centrally located mass with lobar or segmental collapse on chest radiograph and CT scan.
- Neoplasm: Endobronchial tumors such as carcinoid tumors can resemble non-radio-opaque foreign bodies. Obstructive neoplasm such as carcinoid and bronchogenic carcinoma can simulate non-radio-opaque obstructing foreign bodies with postobstructive changes.

#### Essential Facts

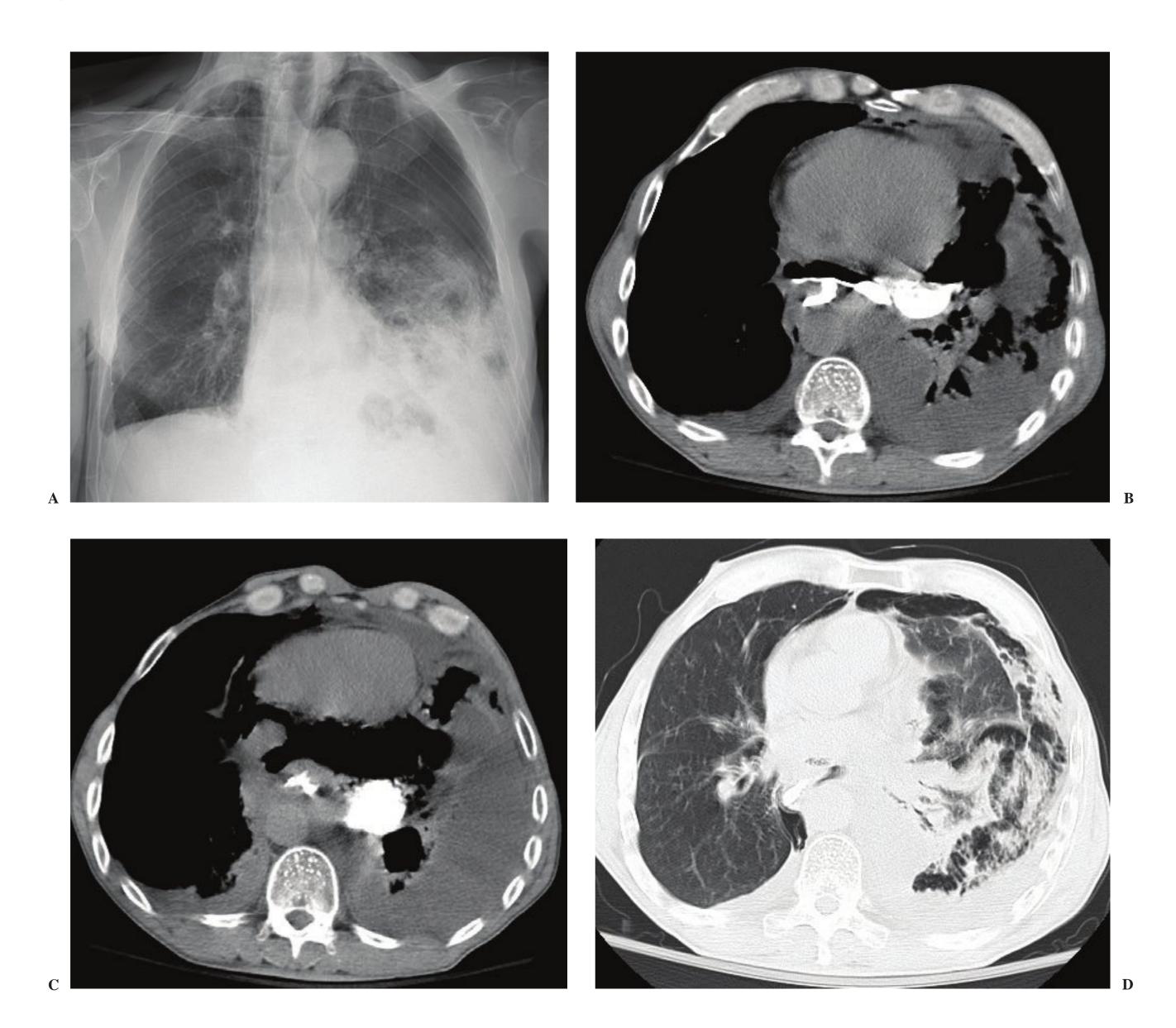
- Foreign body aspiration is more common in children than in adults, with the majority of cases occurring in patients younger than 15 years of age.
- It is often clinically silent in adult patients because the foreign body usually is wedged distally in lower lobe bronchi or the bronchus intermedius.
- Unilateral hyperinflation may be noted, but this finding is more commonly associated with pediatric FBA.

- It may become a chronic condition with volume loss of affected lobe, recurrent pneumonia, and the formation of an intrabronchial mass.
- The most commonly inhaled foreign bodies are food and broken fragments of teeth, which frequently lodge in a main or lobar bronchus.

#### Other Imaging Findings

- Chest X-ray (CXR) and CT: Secondary radiographic signs, such as obstructive emphysema, atelectasis, pneumonia, and a mediastinal shift, help in diagnosing FBA.
- For definitive diagnosis and treatment, all patients in whom the clinical suspicion for FBA is high should undergo endoscopy due to the limitations of radiographic studies.

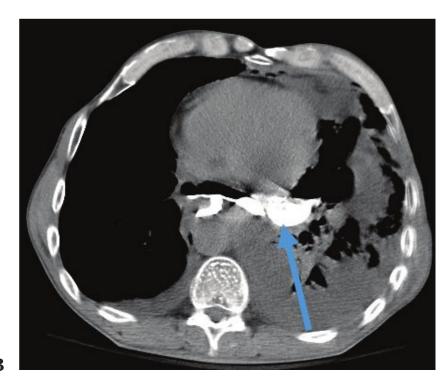
- \* Adult patients do not always volunteer or recall a history of choking, making FBA difficult to diagnose in this patient population and the diagnosis is frequently overlooked without proper history and mistaken for other diagnosis such as malignancy.
- ✓ T is far more sensitive than chest radiography in demonstrating radiolucent foreign bodies. In some instances, CT may provide additional diagnostic information by demonstrating subtle low-attenuation intrabronchial material, which is often the only finding that can help suggest the diagnosis.

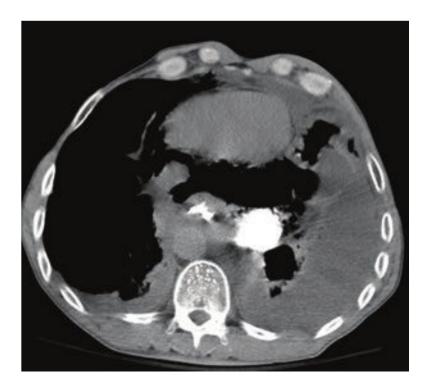


# Clinical Presentation

A 56-year-old man presents to the emergency room (ER) with shortness of breath (SOB), with severe retching and vomiting followed by excruciating retrosternal chest and upper abdominal pain. He had an elevated white blood cell (WBC) count.







(A) Chest X-ray (CXR) shows subcutaneous emphysema with linear streaks in the mediastinum consistent with pneumomediastinum. Opacity is seen in the left lower lung. Also evident is a moderate-sized left-sided pleural effusion and small left apical pneumothorax. (B–D) Computed tomography (CT) scan with oral contrast shows an extraluminal collection (arrow) of contrast anterior and to the left of esophagus consistent with perforation with evidence of a moderate left and small right pleural effusion with concomitant pneumomediastinum and small left pneumothorax.

# Differential Diagnosis

- Boerhaave syndrome: The spontaneous transmural perforation of the esophagus. In most cases of Boerhaave syndrome, the tear occurs at the left posterolateral aspect of the distal esophagus and extends for several centimeters, with the most common radiologic finding being a pneumomediastinum and left-sided effusion. CT will show a mediastinal fluid and extravasation of contrast.
- Spontaneous pneumomediastinum: Due to rupture of alveoli, which dissects back into the mediastinum. Air is seen within the mediastinum but without the pleural fluid or collections seen in Boerhaave.

### Essential Facts

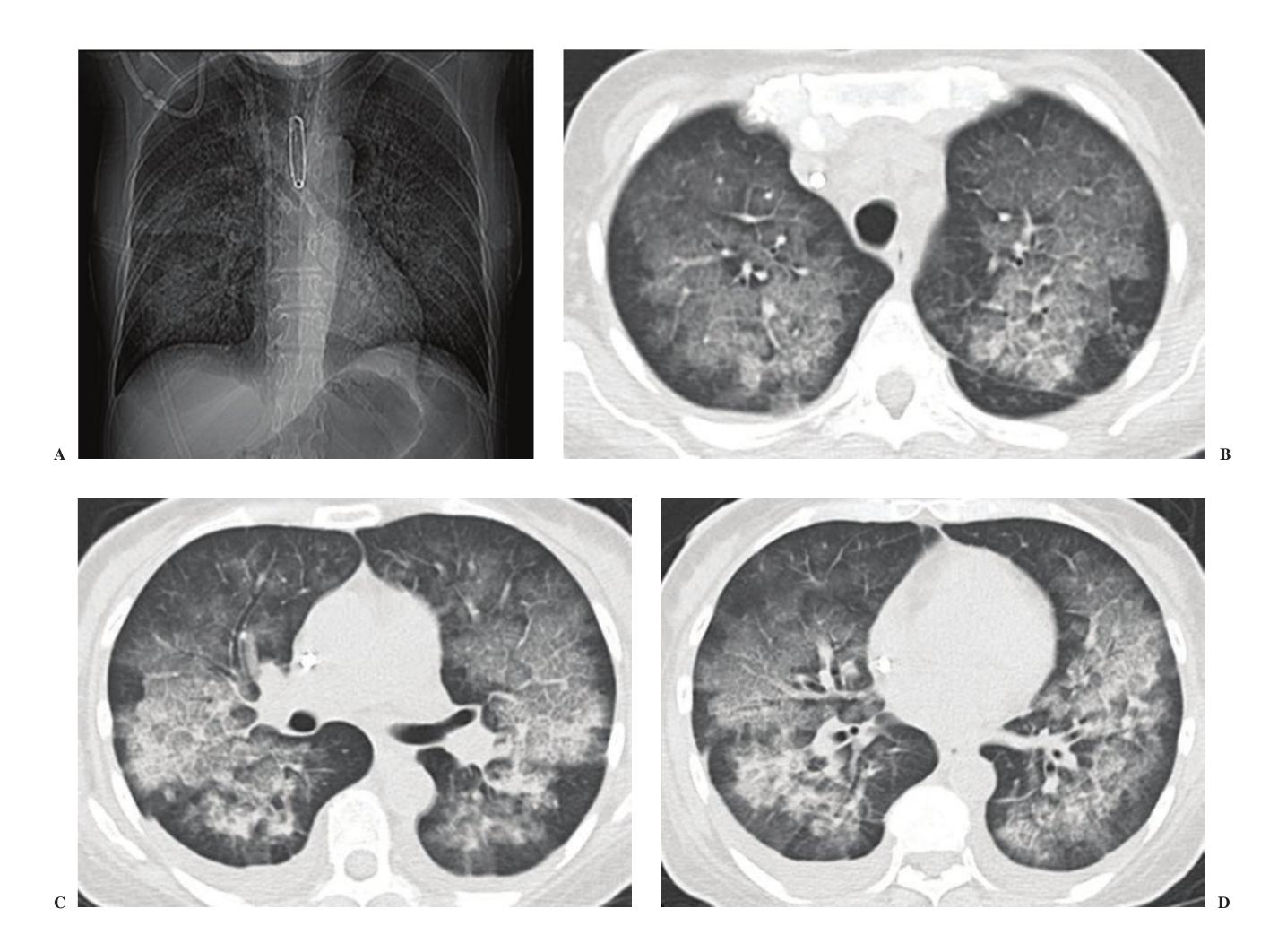
- Boerhaave syndrome is often caused by straining or vomiting resulting in a sudden increase in intraesophageal pressure combined with negative intrathoracic pressure leading to esophageal rupture.
- Usually in men, although neonatal esophageal rupture occurs primarily in girls
- Tears are most commonly vertically oriented, ranging from 1 to 4 cm in length.
- Almost all (90%) occur along the left posterolateral wall of the distal esophagus.
- Boerhaave syndrome may be commonly misdiagnosed as a myocardial infarction, pancreatitis, lung abscess, pericarditis, or spontaneous pneumothorax.

• Boerhaave syndrome is associated with high morbidity and mortality and is fatal in the absence of therapy.

## Other Imaging Findings

• The diagnosis of esophageal perforation can also be confirmed by performing a water-soluble contrast esophagram study to show extravasation of contrast into the pleural cavity outlining the length of the perforation and its location. However, the sensitivity of contrast studies depends on the size and location of the perforation and the technique used for the study.

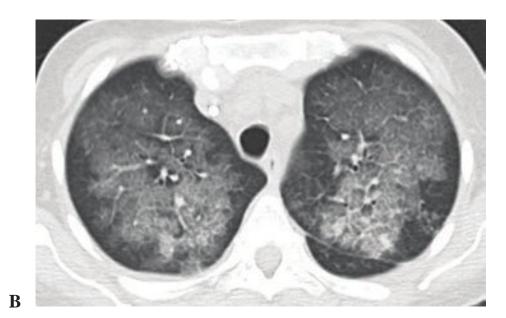
- ✓ The diagnosis of Boerhaave syndrome is suggested on the plain chest radiography and confirmed by a CT scan of the chest. The initial plain chest radiograph is almost always abnormal in patients with Boerhaave syndrome and usually reveals mediastinal or free peritoneal air as the initial radiologic manifestation.
- ✓ cesophageal perforation is suspected, even in the absence of physical findings, contrast radiographic studies of the esophagus and a CT scan should be obtained promptly.
- he occasionally nonspecific nature of the symptoms may contribute to a delay in diagnosis and a poor outcome.

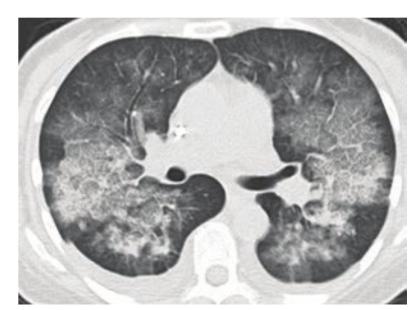


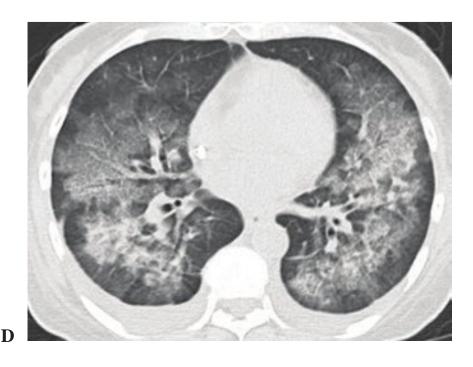
## Clinical Presentation

A 51-year-old woman with relapsed chronic myelogenous leukemia (CML), post-bone marrow transplantation (BMT), develops graft-versus-host disease of the skin and gastrointestinal tract and presents with fever, dyspnea, and cough.









(A) Scout image has diffuse bilateral air-space opacity. (B–D) Computed tomography (CT) scan of the chest shows bilateral diffuse central ground-glass opacities with thickened interlobular septum ("crazy-paving" pattern).

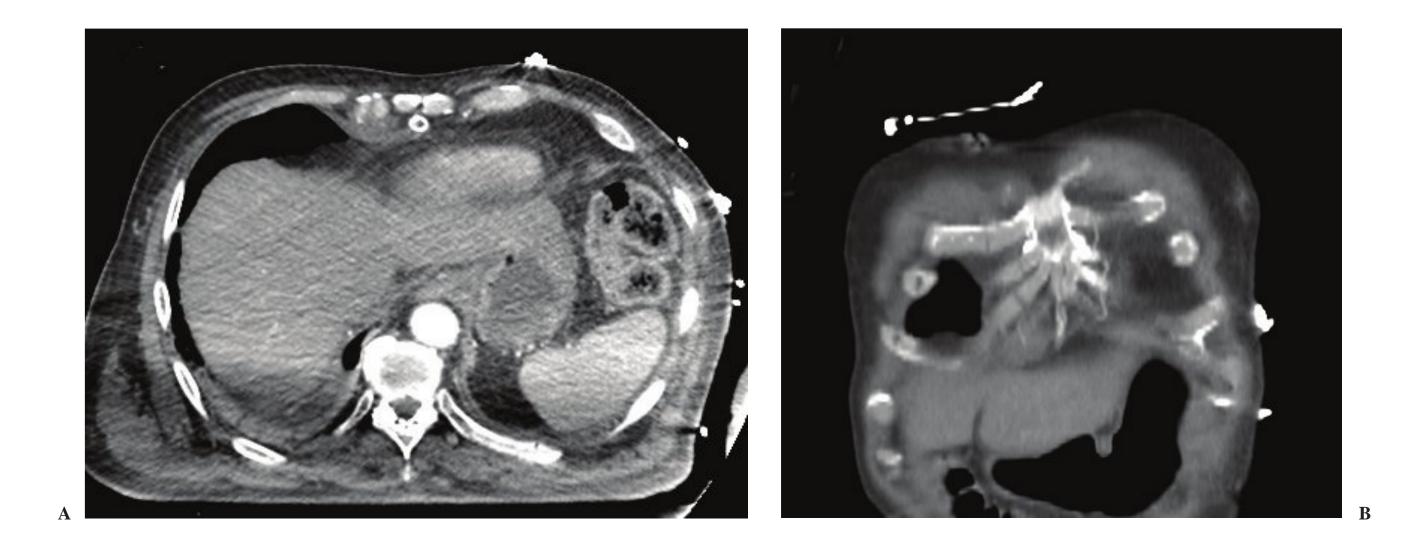
#### Differential Diagnosis

- Cytomegalovirus (CMV) pneumonia: Chest radiograph findings are often nonspecific and commonly include mixed interstitial and air-space opacities. On CT, bilateral lobar consolidation, diffuse and focal ground-glass opacities, irregular reticular opacities, and poorly defined centrilobular small nodules can be seen. Interlobular septal thickening and pleural effusion are frequently associated.
- Pneumocystis carinii pneumonia (PCP): An atypical bacterial pneumonia typically affecting immunocompromised patients, with fine reticular interstitial pulmonary pattern, often with a perihilar distribution similar in radiographic appearance to CMV. Pleural effusions are normally not a feature. High-resolution computed tomography (HRCT) features differing from CMV pneumonia include pneumatoceles, which are seen in up to 30% of cases.
- Pulmonary hemorrhage: Like CMV pneumonia, it may be seen in post-BMT patients. On chest radiograph, it may appear similar to CMV pneumonia with evidence of bilateral diffuse, patchy, or focal infiltrates. In the acute phase, CT scans show consolidation or ground-glass opacification, with nodules that are distributed in a uniform fashion. In later stage, there may also be evidence of interlobular septal thickening.

#### Essential Facts

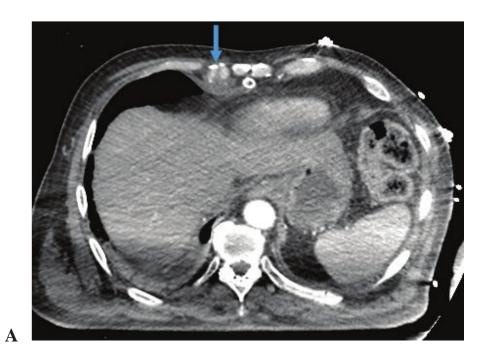
- DNA virus that is a member of the Herpesviridae family, CMV is able to become latent in the human host, with the potential for reactivation.
- CMV commonly produces pulmonary disease in those with deficient immune systems.
- It is a major cause of morbidity and mortality following transplantations and in patients with AIDS in whom CD4 cells are, 100 cells per cubic millimeter.
- CMV pneumonia is one of the most common pulmonary complications after BMT, occurring in up to 70% of BMT recipients, with approximately one-third developing CMV pneumonia.
- Treatment of CMV is recommended in the presence of symptomatic pulmonary disease, evidence of CMV in the lung, and the absence of other treatable pulmonary infections.

- ✓ fectious pneumonia of any cause (e.g., bacterial, viral, mycobacterial, fungal, and parasitic) can cause some ground-glass opacification to appear on HRCT scans, but a diffuse pattern of predominately ground-glass opacification in the absence of associated CT scan findings is a characteristic presentation for CMV pneumonia and PCP.
- T is currently the imaging modality of choice for the evaluation of pulmonary viral infections.



# Clinical Presentation

A 75-year-old man was admitted to the hospital following chest trauma with anterior chest pain.





(A) Axial computed tomography (CT) image shows a linear defect (arrow) in the right costicartilage with associated soft tissue consistent with a hematoma. (B) Coronal reconstructions show multiple costicartilage fractures (arrows).

## Differential Diagnosis

- Costal cartilage fracture: On CT, a fracture appears as a focal discontinuity of the costal cartilage, with surrounding calcifications present near old fractures. A significant displacement of the adjacent segments and swelling of the neighboring soft tissues may also be seen. In some cases, a thin area with gas density may be present within the cartilaginous cleft.
- Costochondritis: inflammation of the costicartilage, which can cause pain and tenderness but no swelling
- Tietze syndrome: Inflammation of the costal cartilage with pain and tenderness. Differentiated from costochondritis by swelling and can have redness and warmth.

#### Essential Facts

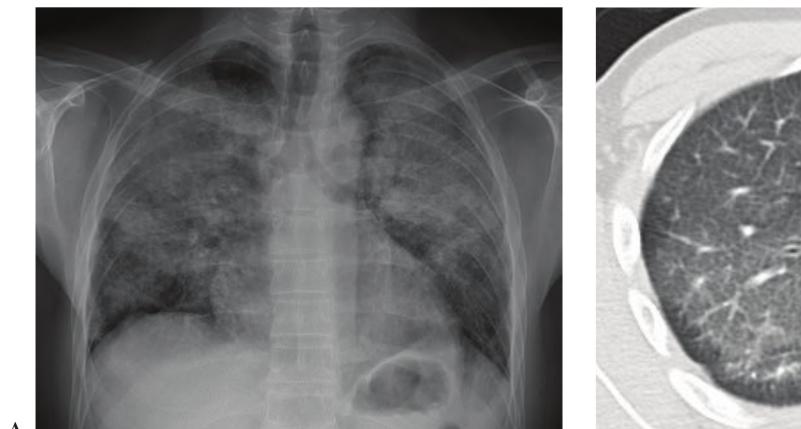
- Rib fractures are common, occurring in about half of all patients who have major blunt chest trauma.
- They are usually related to the osseous rib component, with costal cartilage fractures being very rare.
- Costal cartilages are generally not visible on plain radiographs, with the exception of irregular ossification foci that appear during adulthood; thus, fractures involving the costal cartilage are best shown by CT.
- Costal cartilage injuries are often located in the junctional regions, either sternochondral or costochondral.

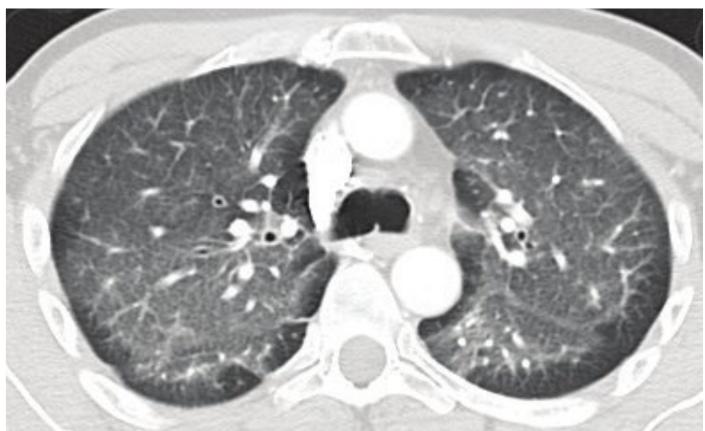
• These injuries typically occur in young patients as a result of significant trauma that is often associated with contact sports.

### Other Imaging Findings

- Sonography: The cartilage fracture appears as a focal interruption in the linear echogenic anterior margin of the hypoechogenic cartilages.
- Magnetic resonance imaging (MRI): a high T2 signal, at the site of the fracture, from the surrounding edema

- ✓ Costal cartilage fractures are not visible on radiographs unless the fracture involves a strongly calcified cartilage.
- costal cartilage fractures probably occur more frequently than is currently recognized because of underdiagnosis.





# Clinical Presentation

A 35-year-old man presents to the emergency room (ER) with acute onset of chest pain and shortness of breath after crack cocaine inhalation.





(A) Posteroanterior (PA) view shows dif use bilateral air-space opacities best seen in the mid to upper lungs. (B) Computed tomography (CT) scan shows dif use ground glass with some interstitial thickening.

# Dif erential Diagnosis

- "Crack lung": refers to an acute lung injury with symptoms of fever, hypoxemia, and hemoptysis with often associated diffuse nonspecific pulmonary opacities of consolidation and ground glass
- Pulmonary edema: Cocaine can cause edema but septal thickening and pleural effusion would be expected if cardiogenic. Noncardiogenic edema can look very similar to crack lung.
- Pulmonary hemorrhage: can occur in cocaine user and can also look quite similar with diffuse lung opacity

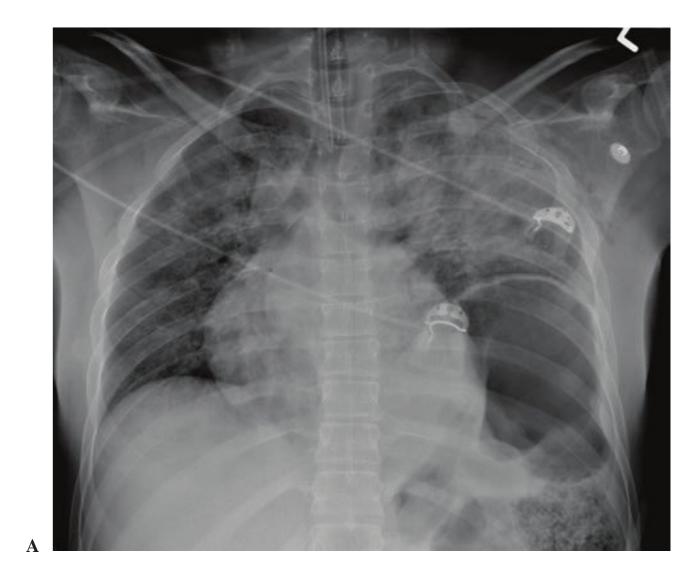
#### **■** Essential Facts

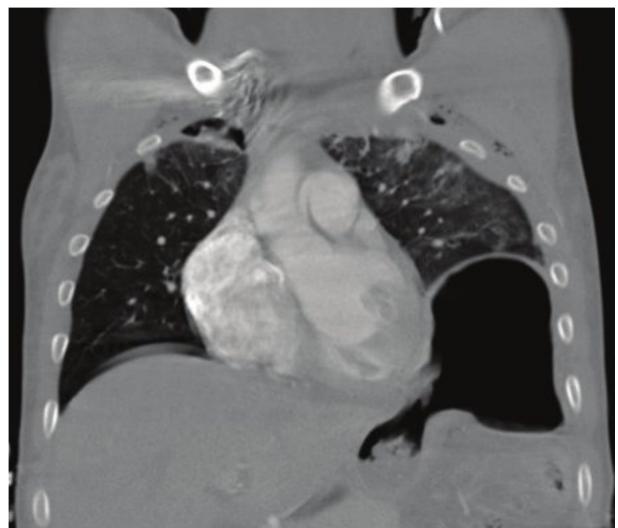
- Pathologically, there is diffuse alveolar damage and hemorrhage and often associated with eosinophilia.
- There are many forms of cocaine but crack cocaine is heated and is inhaled/smoked.
- Cocaine is the most common illegal drug to cause pulmonary symptoms that require hospital visit.
- Cocaine acts as a sympathomimetic agent.
- Crack users inhale a large amount of particulate matter.

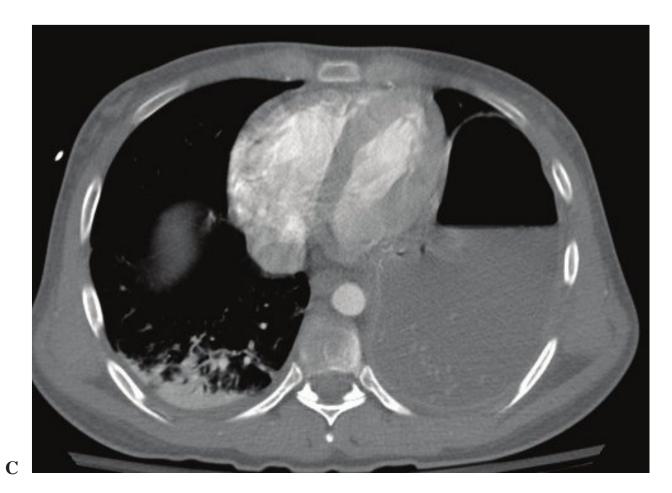
## Other Imaging Findings

- Neuro CT or magnetic resonance imaging (MRI): Cocaine can be associated with neurologic complications of which the most common are hemorrhage and ischemia.
- Peripheral CT or ultrasound (US): can develop abscesses or septic arthritis in intravenous (IV) drug users
- CT: Chronic cardiopulmonary findings include interstitial lung disease, pulmonary hypertension, and cardiomyopathy.

- ✓ Cocaine can be associated with numerous other acute injuries such as myocardial infarction, pneumothorax, pneumomediastinum, and dissections.
- presents with chest pain or myocardial infarction.
- ✓ Complications can relate to adulterants, for example, talc.
- ✓ Chest pain is common after crack cocaine smoking.





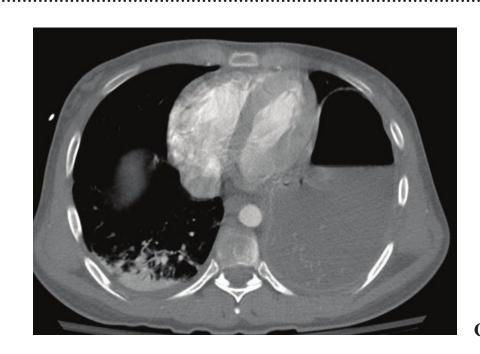


# Clinical Presentation

A 35-year-old in a motor vehicle accident (MVA) was brought to the emergency room (ER) unconscious.







(A) Chest X-ray (CXR) shows marked apparent elevation of the left diaphragm with distended stomach bubble. Consolidation throughout the left lung is seen and some subcutaneous emphysema on the left. (B, C) Computed tomography (CT) shows the stomach herniating above the diaphragm (arrow) and small apical pneumothoraces.

## Differential Diagnosis

- Diaphragmatic rupture: A tear in the diaphragm most commonly from blunt or penetrating trauma. With penetrating trauma, presentation can be delayed. CXR can show herniation of the stomach or bowel into the lower thorax and the mediastinum can be shifted. A nasogastric (NG) tube within the stomach above the diaphragm is specific but not reliable sign. CT can detect discontinuity of the diaphragm.
- *Diaphragmatic eventration*: a broad-based bulge of the diaphragm
- Paralyzed diaphragm: can cause elevation of the diaphragm but stomach remains below the diaphragm

#### Essential Facts

- Most ruptures occur on the left and most common etiology is motor vehicle accident.
- Thoracoscopy is the most reliable investigation.
- Surgery is needed to treat ruptures.
- Herniated contents can strangulate.

#### Other Imaging Findings

• CT is the most common investigation for diaphragmatic injury, as CT will often be done to assess for other injuries.

- Gastrointestinal (GI) series can determine location of stomach and identify hernia.
- Ultrasound can detect rupture of right diaphragm but normally poorly visualizes the left diaphragm due to bowel gas.

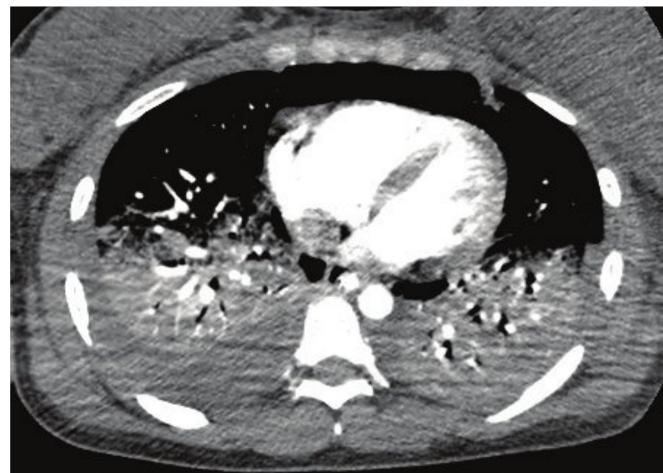
#### ✓ Pearls & × Pitfalls

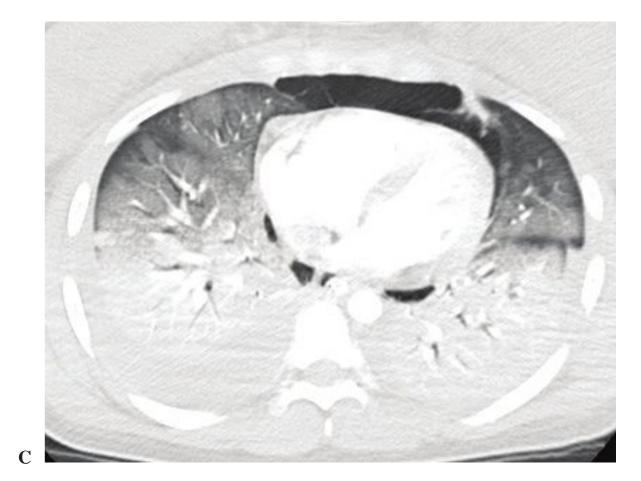
- iaphragmatic ruptures are diagnosed preoperatively in less than half the cases and sometimes delayed.
- ✓ Merniated contents can strangulate.
- ✓ Fenetrating trauma can present years later with herniation.
- \* Vatients with diaphragmatic rupture commonly have other injuries, which can mask the diaphragmatic rupture.
- \* Focal small defects of the diaphragm can be seen in healthy patients particularly in older patients.

## Acknowledgments

Images courtesy of H. Shulman, Sunnybrook Hospital, University of Toronto.



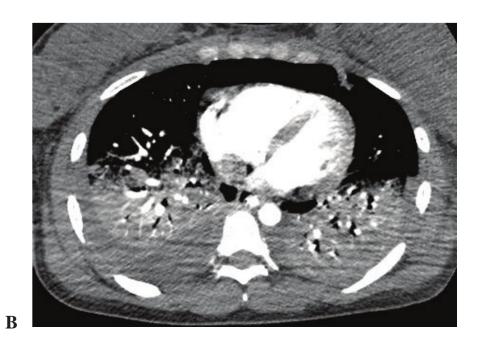


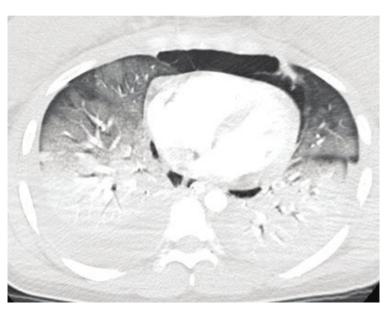


# Clinical Presentation

A 19-year-old woman was resuscitated after suffering a ventricular fibrillation arrest in a swimming pool.







(A) Anteroposterior (AP) chest radiograph shows bilateral diffuse consolidation. (B, C) Computed tomography (CT) of the thorax shows small bilateral pleural effusions and extensive lung parenchymal consolidation and ground glass. Apneumomediastinum and small pleural effusions are present.

# Differential Diagnosis

- Near drowning: Results in primary respiratory impairment from water inhalation due to submersion in a liquid medium. On chest radiograph, direct lung injuries such as submersion injuries often result in acute respiratory distress syndrome (ARDS). Chest radiographic findings of ARDS are generally nonspecific and resemble those of pulmonary edema or hemorrhage. Bilateral patchy alveolar infiltrates may be seen after 12 to 24 hours, which may progress to massive bilateral air-space consolidation after 24 to 48 hours post—lung injury. On CT scans, asymmetrical areas of mixed consolidation and ground-glass opacification are typically seen.
- Pulmonary hemorrhage: Like near drowning, it is a direct lung injury that often presents as ARDS. On chest radiograph, bilateral diffuse, patchy, or focal infiltrates in the acute phase may be seen with relative apical sparing. CT scans often show consolidation mixed with ground-glass opacification.
- Pulmonary edema: can be cardiogenic or noncardiogenic and presents with diffuse bilateral air-space disease

#### Essential Facts

- Drowning is the fourth most common injury after road traffic accidents, self-inflicted injuries, and violence and is an important cause of childhood fatalities worldwide.
- Typically, cases of drowning involve children younger than 5 years of age and males between 15 and 25 years old.
- Causes of near drowning tend to vary with age and may be a primary event or may be secondary to events such

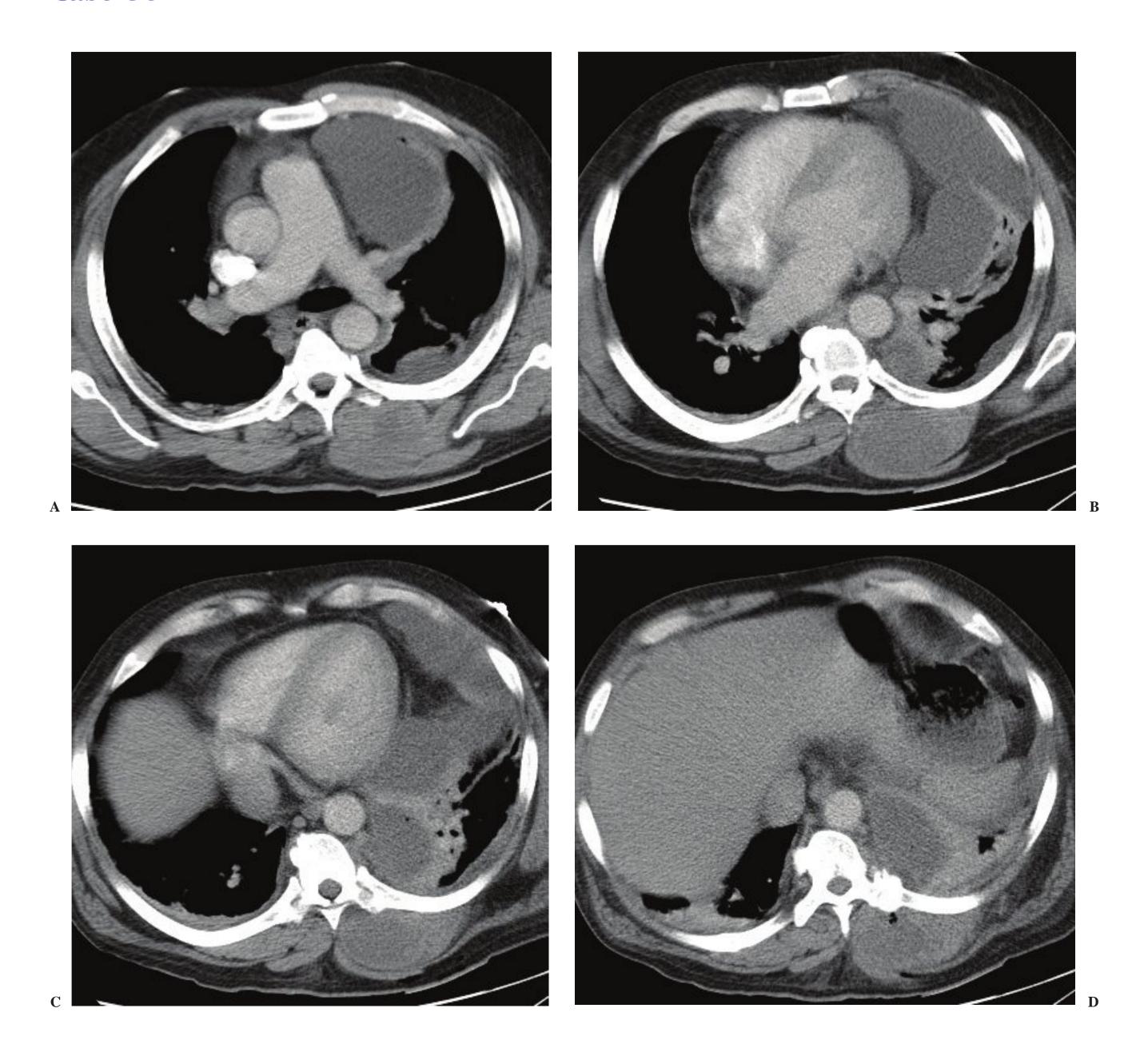
- as seizures, head or spine trauma, cardiac arrhythmias, hypothermia, or alcohol and drug ingestion.
- Most toddlers drown in swimming pools and bathtubs, whereas most adolescents drown in natural bodies of water.
- Approximately 75% of near-drowning victims survive. Of these,, 6% suffer a residual neurologic deficit.
- Near drowning results in varying degrees of hypoxemia due to the aspiration of water, which washes out surfactant in the lungs, often producing noncardiogenic pulmonary edema and ARDS.
- Rescue and immediate resuscitation by bystanders improves the outcome of near-drowning victims.

# Other Imaging Findings

- CT and magnetic resonance imaging (MRI) of brain can be done for associated neurologic deficit, as ischemic strokes can be associated.
- X-rays and CT for associated injuries if there was a fall or shallow water injuries, for example, C-spine

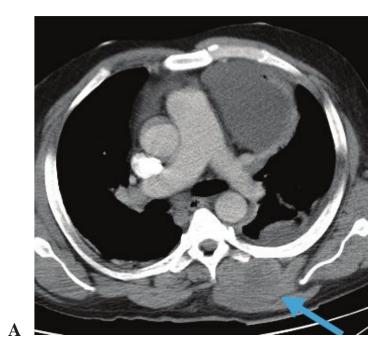
- ✓ Caryngospasm is often seen in drowning victims and can prevent water from entering the lungs.
- arrhythmia, or stroke.
- and can have atypical organisms.

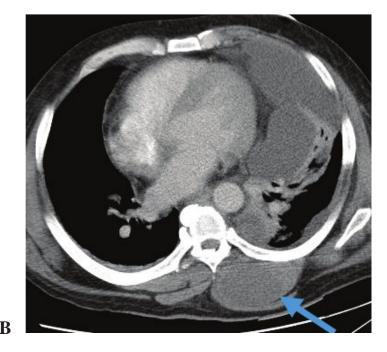
Case 86

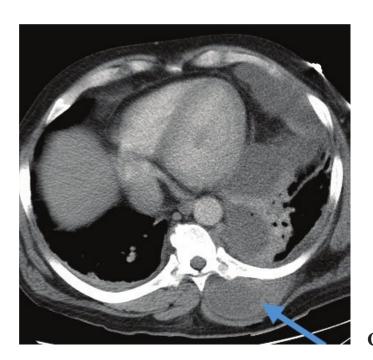


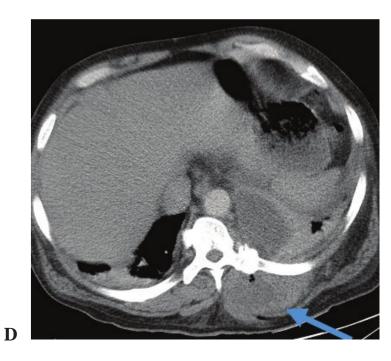
# Clinical Presentation

A 61-year-old man who has previously been treated with antibiotics for pneumonia by his family doctor now presents with left-sided discomfort and fever.









(A–D) Computed tomography (CT) shows loculated left pleural effusion consistent with an empyema. There is contiguous fluid collection with some air in the left posterior chest wall consistent with chest wall abscess (arrows).

## Differential Diagnosis

- Empyema necessitans: Empyema necessitans is infection of the pleural space, which has extended beyond the parietal pleura into the surrounding chest wall, mediastinum, neck, or abdomen. CT will best assess both the empyema and direct chest wall extension.
- Septic emboli: A patient with a source of sepsis can lead to multiple sites of infections including the chest wall.
- Malignancy: Pleural malignancy that could be primary, for example, mesothelioma or metastases, can spread to the chest wall but usually higher density and enhancing tumor rather than fluid collections.

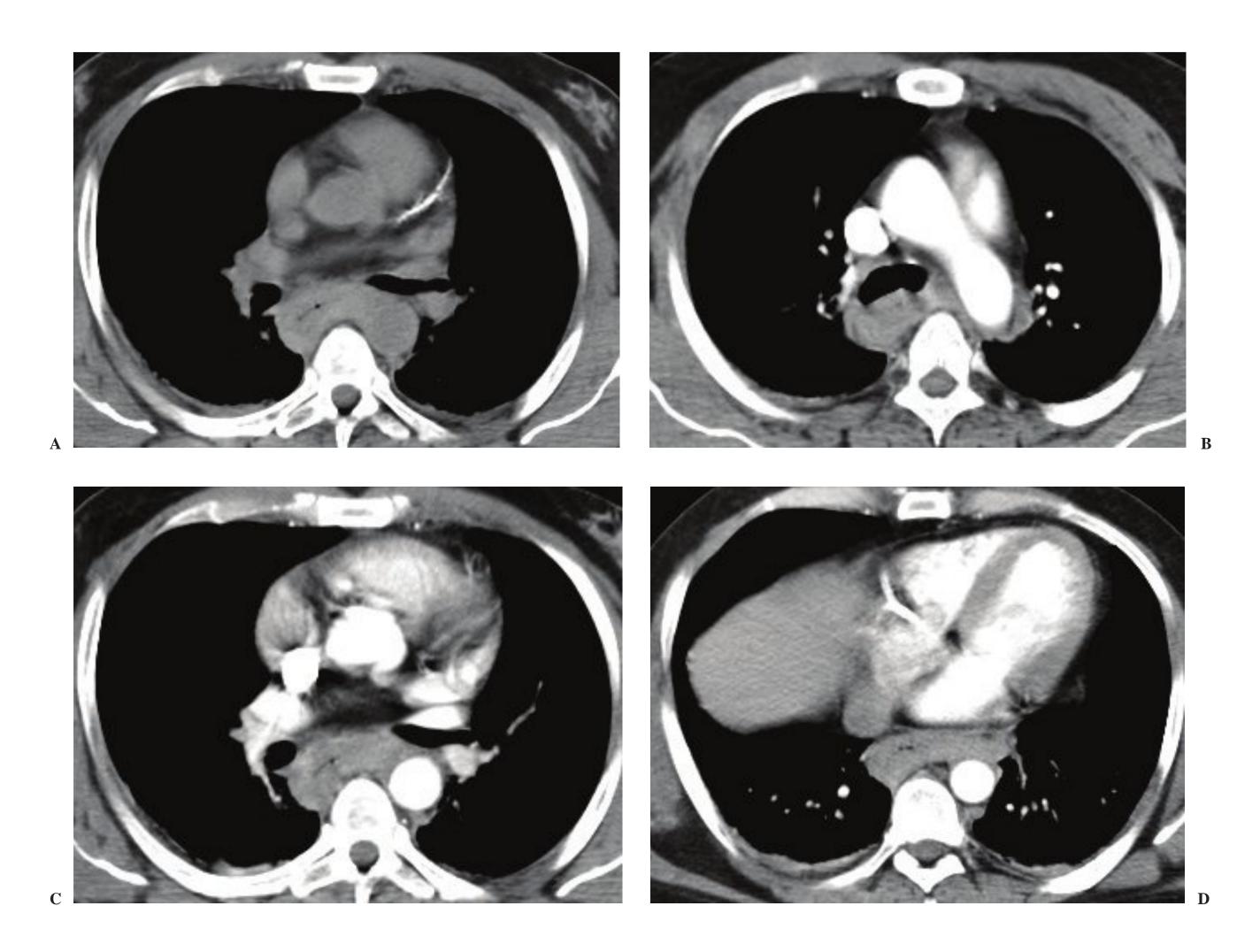
#### Essential Facts

- Rare diagnosis in the antibiotic era
- Most common organisms are Mycobacterium tuberculosis and Actinomyces. Aspergillus, Mucormycosis, Mycobacterium avium-intracellulare (MAI), Streptococcus, and Staphylococcus are other causal organisms.
- Can spontaneously form sinus tract to skin
- Treatment is antibiotics and drainage by either interventional radiology or surgery.

## Other Imaging Findings

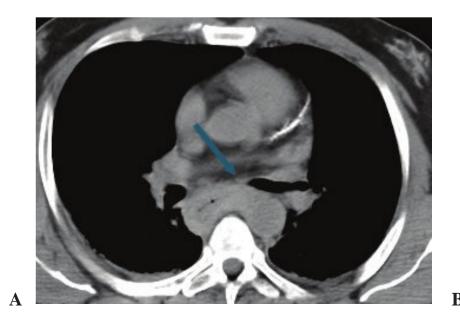
- CT is the investigation of choice but ultrasound can help assess palpable collections.
- Magnetic resonance imaging (MRI) will better assess potential bony involvement.

- ✓ Geed to consider diagnosis in patient with empyema who develop superficial masses
- rainage of superficial collection can lead to sinus formation.
- ✓ ☑. tuberculosis and Actinomyces can have a slow prolonged course.
- \* anaerobes can be difficult to culture.

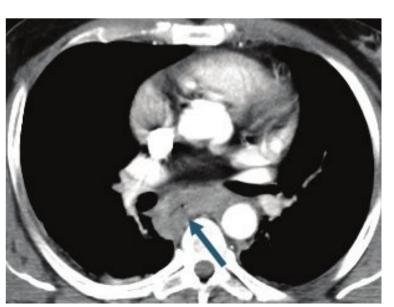


# Clinical Presentation

A 40-year-old man presents with vomiting and chest pain postangiography. A computed tomography (CT) scan with noncontrast and contrast images were performed to rule out aortic dissection.







C



(A–D) CT shows thickening (arrows) surrounding the esophagus, which on noncontrast images is hyperdense compared with blood. No evidence of pneumomediastinum or abnormal density outside the esophagus. No pleural effusion.

# Differential Diagnosis

- Esophageal hematoma: accumulation of blood in the wall of the esophagus; presents as high density (blood) in the wall of the esophagus
- Esophagitis: It can cause diffuse thickening related to infection, radiation, or reflux. It would usually have smoother thickening.
- Esophageal cancer: Malignancy of the esophagus usually will present as a more focal and eccentric thickening and different clinical presentation.

#### **■** Essential Facts

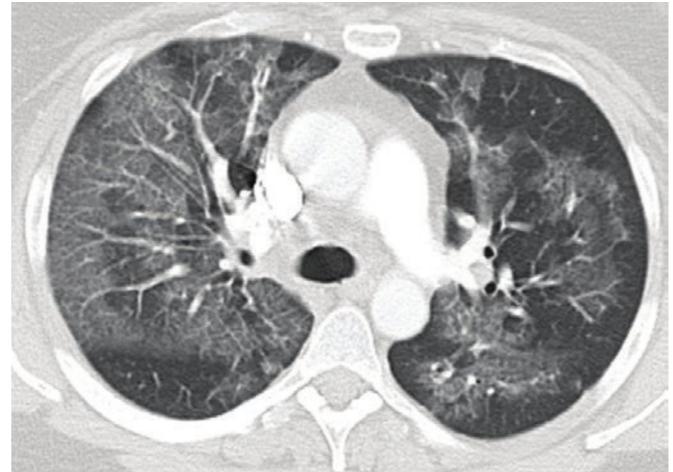
- Can be spontaneous often with emesis
- Predisposing factors include anticoagulation or bleeding disorders, instrumentation, foreign body ingestion, trauma, and vomiting.
- Can present with only hematoma or part of esophageal perforation
- Presents with severe pain and dysphagia, or odynophagia
- Eighty percent occurs in female.
- Usually resolves with conservative therapy

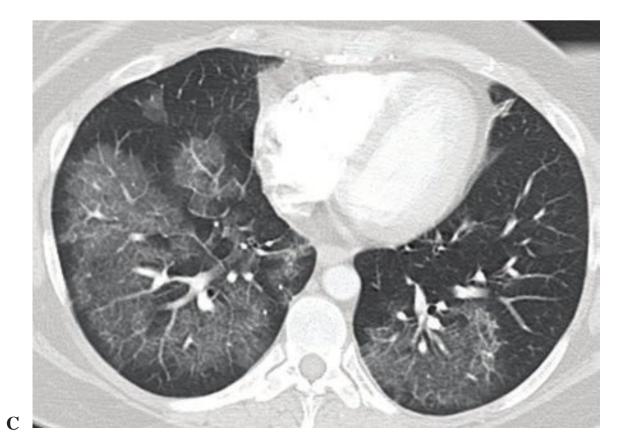
# Other Imaging Findings

• Esophagram: To exclude esophageal rupture. Initially, give water-soluble contrast and if no gross extravasation, give barium, which will better assess for small perforation.

- \* Symptoms and presentation can mimic other conditions such as a ortic dissection or myocardial infarction and often CT will be done to assess for other conditions.
- Must distinguish from myocardial infarction, as anticoagulation would be contraindicated
- ✓ Must distinguish isolated esophageal hematoma from ruptured esophagus (Boerhaave)





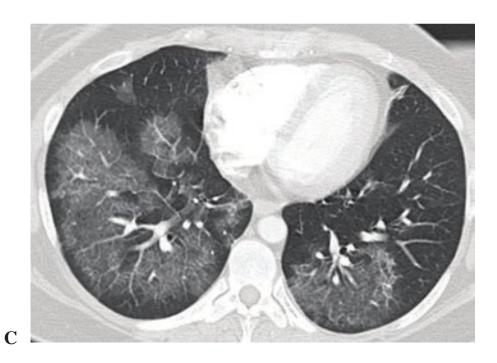


# Clinical Presentation

A 49-year-old woman with osteoarthritis, postoperative right total hip arthroplasty, now has confusion, dyspnea, and tachycardia and is desaturating to 70% on room air. A petechial rash is noted on her chest.







(A) Scout shows diffuse bilateral air-space opacities. (B, C) Computed tomography (CT) of the chest shows patchy bilateral areas of ground-glass opacities with mild septal thickening involving all lobes.

# Differential Diagnosis

- Fat embolism: Chest radiographs are normal in the majority of patients. A minority of chest radiographs reveal air-space disease due to edema or alveolar hemorrhage, which tends to be most prominent in the periphery and bases. CT of the chest generally shows focal areas of ground-glass opacification with interlobular septal thickening.
- Acute respiratory distress syndrome (ARDS): Chest radiographic findings are nonspecific and can resemble those of typical pulmonary edema, pulmonary hemorrhage, and pulmonary fat embolism. Findings include diffuse bilateral coalescent consolidation and widespread homogeneous and heterogeneous areas of increased opacity.

#### Essential Facts

- It is most commonly associated with long bone and pelvic fractures.
- Fat embolism syndrome (FES) typically manifests 24 to 72 hours after the initial insult but may rarely occur as early as 12 hours or as late as 2 weeks after the inciting event.

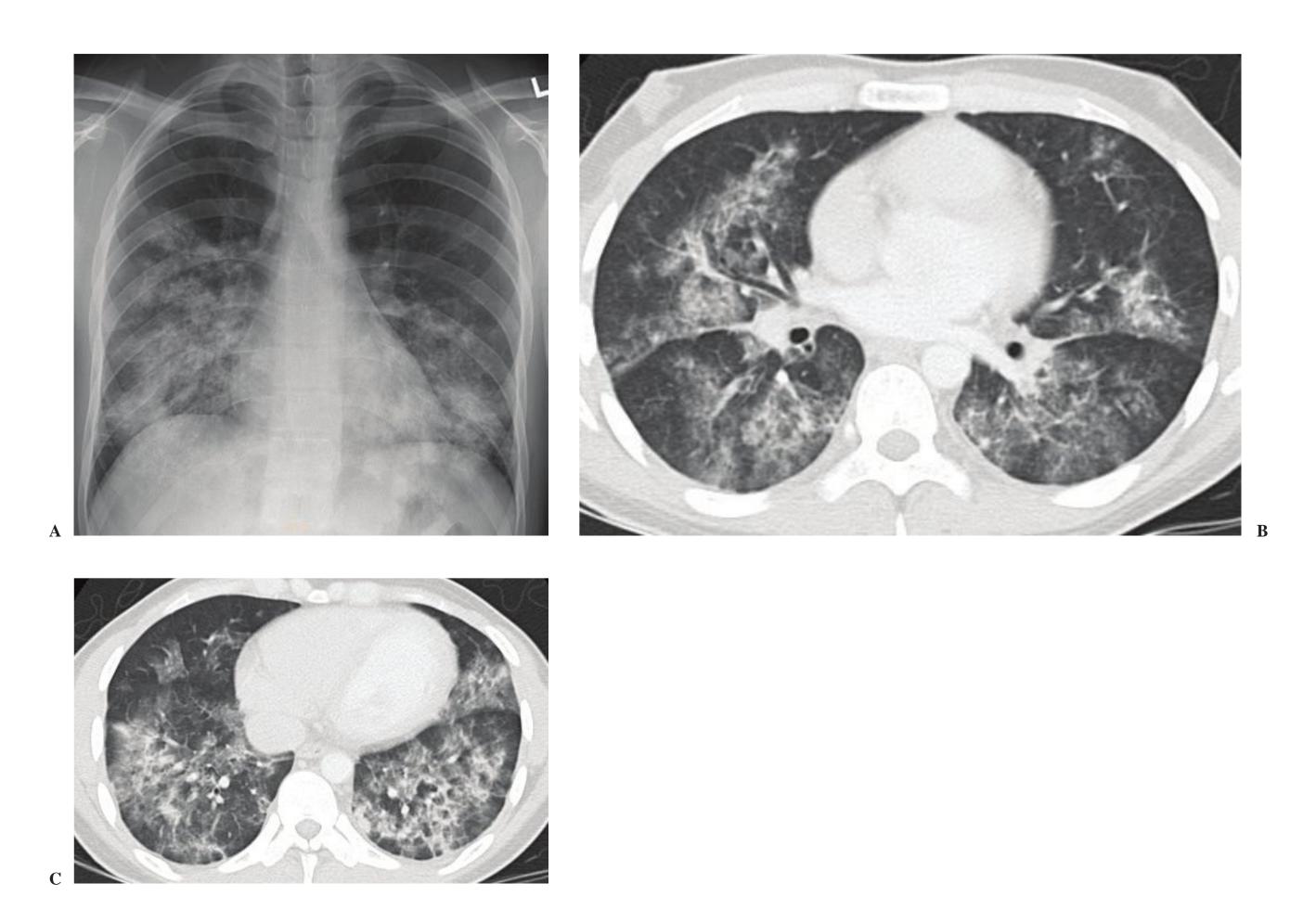
- Early immobilization of fractures reduces the incidence of FES.
- Patients with increased age, multiple underlying medical problems, and/or decreased physiologic reserves have worse outcomes than other patients.
- Supportive care is the mainstay of therapy for clinically apparent FES.
- Obstruction of pulmonary vessels by fat globules followed by chemical pneumonitis from unsaturated plasma fatty acids produce hemorrhage/edema.

### Other Imaging Findings

• Ventilation/perfusion scans can be used and may demonstrate a mottled pattern of subsegmental perfusion defects with a normal ventilatory pattern.

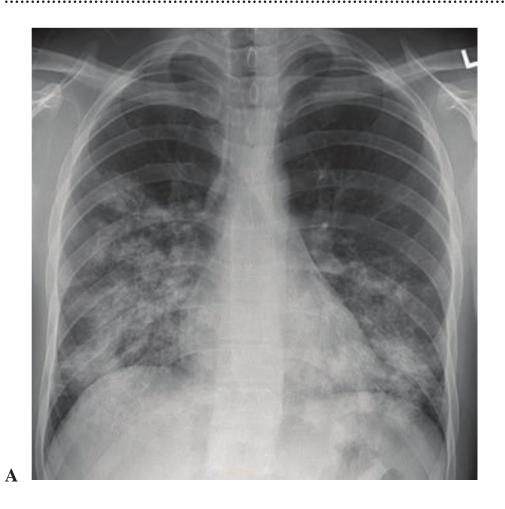
- ✓ Effected patients develop a classic triad—hypoxemia, neurologic abnormalities, and a petechial rash.
- here is no diagnostic test that is sufficiently sensitive or specific to be useful for confirming or excluding FES.

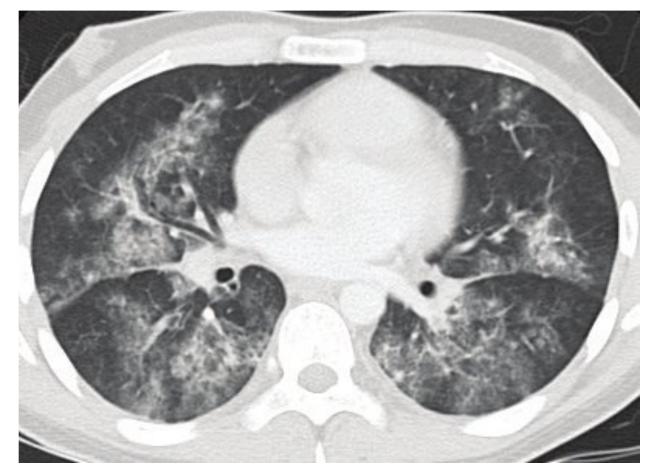
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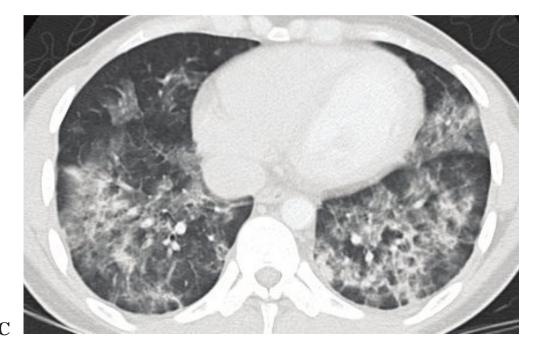


# Clinical Presentation

A 24-year-old man presents with renal disease and exertional dyspnea with hemoptysis.







(A) Chest X-ray (CXR) shows bilateral air-space opacities best seen within the mid to lower lungs. (B, C) Computed tomography (CT) shows bilateral areas of ground glass with interstitial thickening and consolidation.

## Differential Diagnosis

- Goodpasture syndrome: This is a rare autoimmune disorder characterized by the presence of circulating anti-basement membrane (anti-GBM) antibodies. Chest radiograph shows extensive bilateral air-space consolidation. The opacities are typically widespread but may be more prominent in the perihilar areas and in the mid and lower lung zones. The consolidation usually resolves within 2 or 3 days and is replaced by a reticulonodular pattern in a similar distribution. Complete radiographic resolution is usually seen ~10 to 12 days after the original episode. However, with repeated episodes of hemorrhage, progressive fibrosis can be seen. CT findings consist predominantly of areas of ground-glass attenuation or consolidation, involving mainly the dependent lung regions.
- *Idiopathic pulmonary hemorrhage:* This is radiographically indistinguishable from Goodpasture syndrome. In contrast to Goodpasture syndrome, it most commonly occurs in children, usually younger than 10 years.

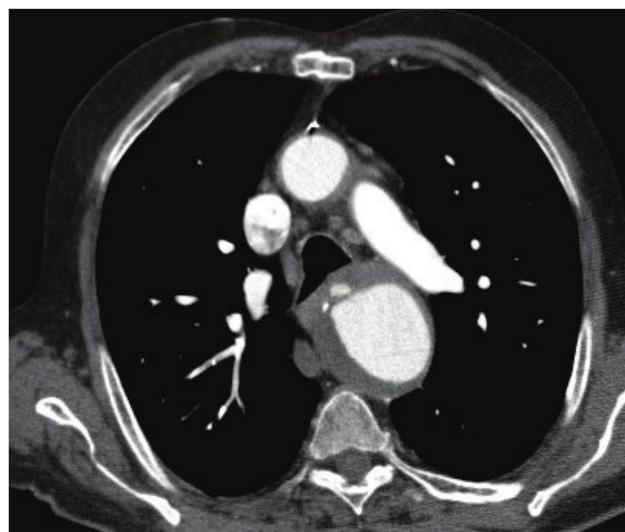
#### Essential Facts

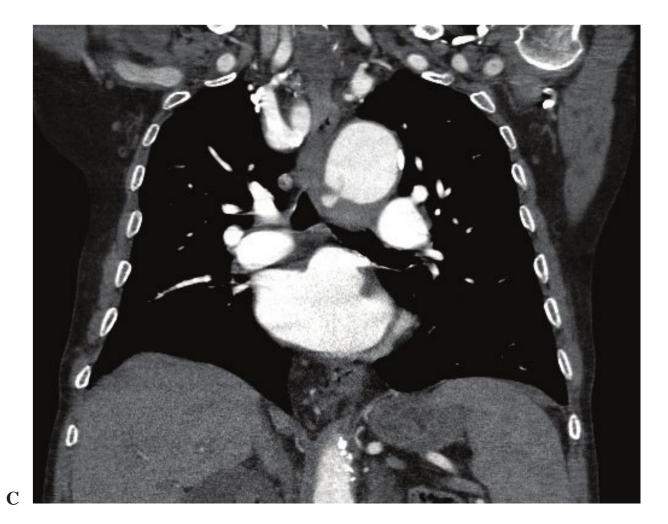
• Goodpasture syndrome is characterized by diffuse pulmonary hemorrhage and acute or rapidly progressive glomerulonephritis.

- It is primarily a disease of young adults older than 16 years, but elderly people can also be affected.
- It occurs twice as common in men as in women.
- Hemoptysis is the most common presenting symptom, occurring in ~80 to 95% of those affected.
- Treatment is with plasmapheresis, steroids, and immunosuppressive agents.
- Serologic assays for anti-GBM antibodies are valuable for confirming the diagnosis and monitoring the adequacy of therapy.

- The chest radiograph may be normal, in as many as 18% of patients, despite the presence of diffuse pulmonary hemorrhage and CT may show parenchymal abnormalities in patients who have normal or questionable radiographic findings.
- The lung apices and costophrenic angles almost invariably are spared.
- Tappearances cannot be distinguished from other cause of diffuse pulmonary hemorrhage.

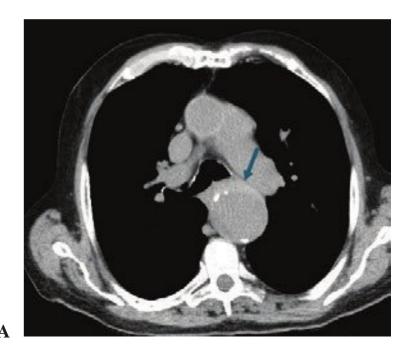




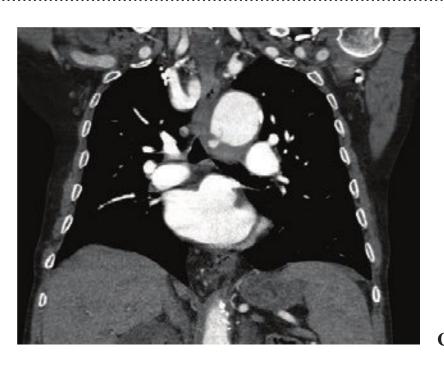


# Clinical Presentation

An 84-year-old man presents with acute tearing chest pain.







(A, B) Noncontrast computed tomography (CT) images show a crescentic area of high density (arrow) peripheral to intimal calcification consistent with an intramural hematoma. (C) Contrast images show an outpouching of contrast into the intramural hematoma consistent beyond intimal calcification consistent with a penetrating ulcer.

# Differential Diagnosis

- Intramural hematoma with penetrating atherosclerotic ulcer (IMH with PAU): Intramural hematoma is hemorrhage in the wall of the aorta. Penetrating atherosclerotic ulcer is a deep ulcerated lesion of an atheromatous plaque that has eroded the inner elastic layer of the aortic wall. Characteristic CT findings of an IMH with PAU include focal contrast-filled, pouch-like collection protruding beyond the aortic lumen and aortic wall thickening or enhancement.
- Nonpenetrating ulcer: Atherosclerotic thrombus can have ulceration, which can be seen as focal contrast but the difference from penetrating ulcer is that it does not extend beyond the intima of the aorta.
- Intraluminal atherosclerotic thrombus: can be mistaken for IMH but characteristically is hypodense on noncontrast images

# Essential Facts

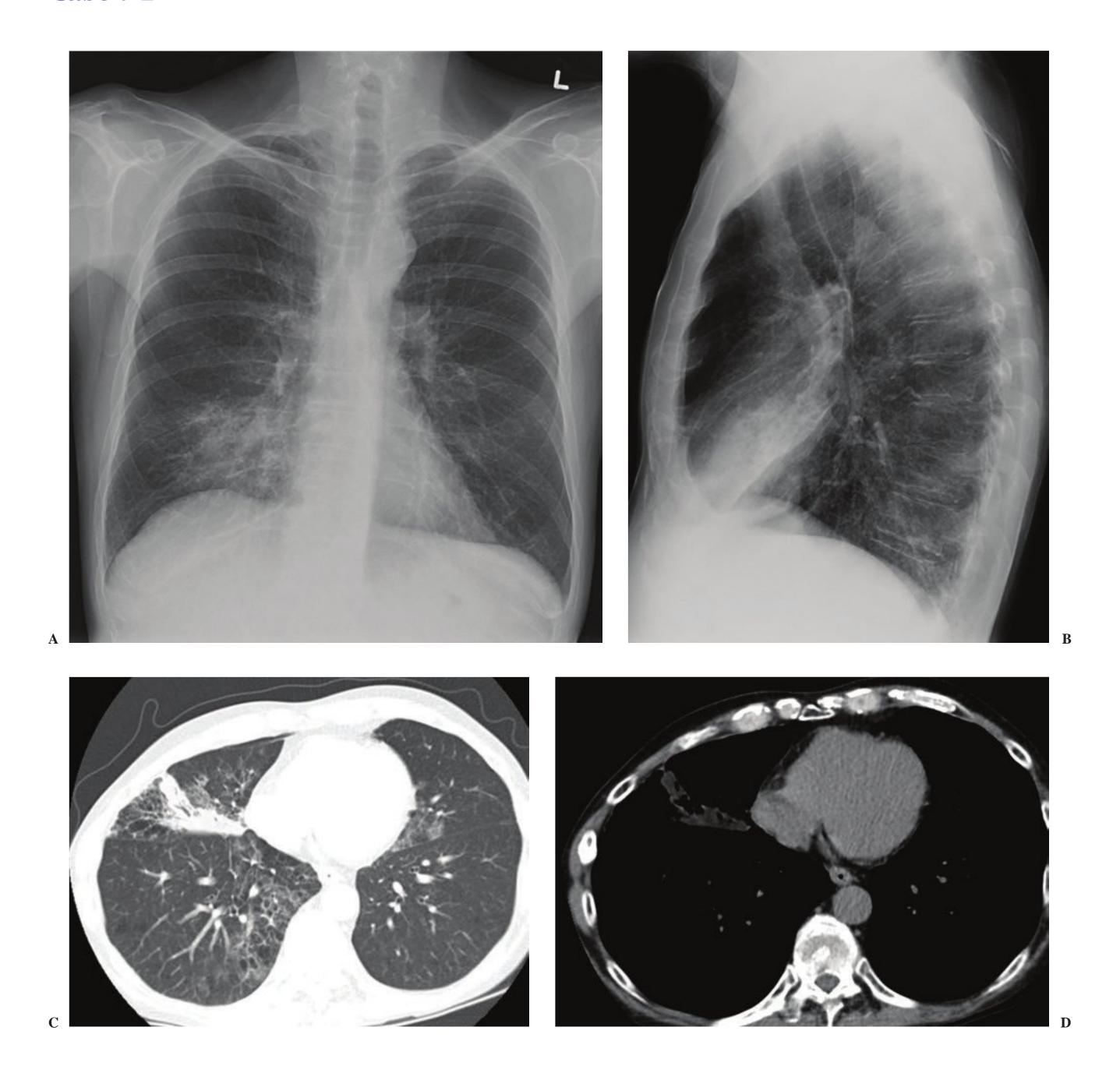
- IMH with PAU is commonly seen in the elderly population, which has a history of severe atherosclerosis, hypertension, and hyperlipidemia. It is more common in males.
- Eighty percent of PAU is associated with an intramural hematoma.
- Saccular aneurysm formation, dissections, compression of nearby structures, and rupture are common complications of IMH with PAU.
- IMH with PAU can resolve completely or stay stable; however, surgical intervention is required for PAU that show evidence of an expanding hematoma, impending rupture, and/or an inability to control the patient's blood pressure.

• Aggressive management with antihypertensive medication and radiographic follow-up is the first-line therapy for ulcers of the descending aorta to prevent and monitor for disease progression.

# Other Imaging Findings

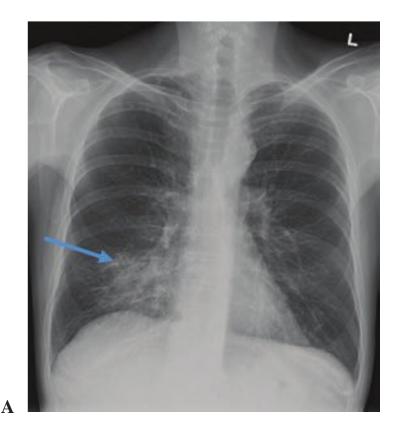
- Magnetic resonance imaging (MRI) can be helpful in distinguishing IMH from atherosclerotic thickening.
- Transesophageal echocardiography (TEE) of a PAU includes a craterlike or focal protrusion in the atherosclerotic portion of the aortic lumen. Atherosclerosis may also be evident in sites other than the area of ulceration.

- Linical presentation is similar to dissection.
- ✓ Vatients with IMH with PAU must be followed up, particularly during the first month after onset to monitor for life-threatening complications.
- ✓ MAU of the ascending aorta is rare and is more likely to rupture and therefore require emergent surgical repair, unlike PAU of the descending aorta.

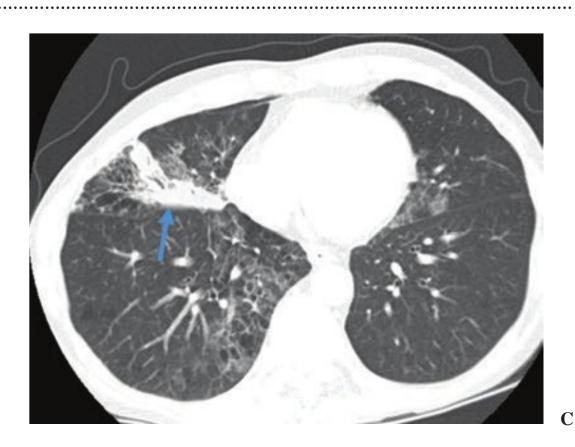


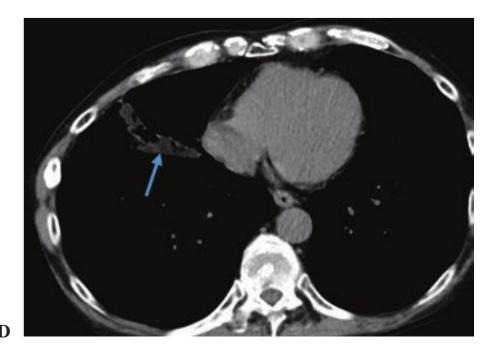
# Clinical Presentation

A 74-year-old man presents with cough, dyspnea, and low-grade fever.









(A, B) Posteroanterior (PA) and lateral radiographs show right middle lobe consolidation (arrows). (C, D) Computed tomography (CT) shows low-density consolidation in the right middle lobe, which measures close to fat density (arrows).

## ■ Dif erential Diagnosis

- Lipoid pneumonia: An uncommon form of pneumonia caused by the aspiration or absorption of oil-based substances into the lungs, which typically manifests as an adipose-containing mass. Chest radiographic features may range from consolidation to irregular mass-like lesions to a reticulonodular pattern. Commonly seen are homogeneous segmental air-space consolidation and ill-defined nodular areas of increased radiopacity. On CT scan, lipoid pneumonia often appears as bilateral, segmental, alveolar consolidations of low attenuation values in the dependent portions of the lungs.
- Pulmonary hamartoma: A benign neoplasm commonly composed of fat amongst other tissue types. Chest radiographic findings may be nonspecific, including well-circumscribed mass with either smooth or lobulated margins. Some but not all hamartomas have macroscopic fat and will typically have a Hounsfield measurement of 2 40 to 2 120 HU, similar to that seen in lipoid pneumonia.

#### Essential Facts

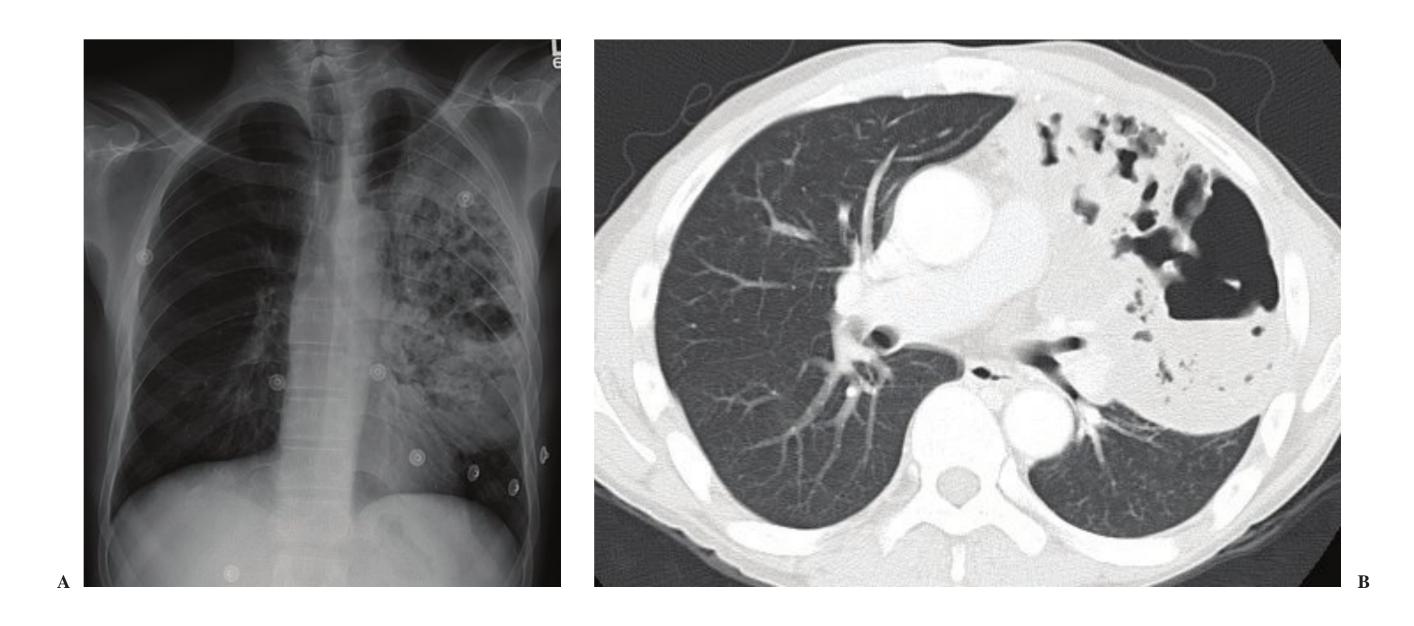
- Lipoid pneumonia is uncommon and due to the accumulation of lipids in the alveoli from either an exogenous or endogenous source.
- Most common etiology is aspiration of mineral oil used for constipation.
- Other causes include fire eaters and accidental poisoning
- Exogenous usually occurs following the aspiration or inhalation of animal fat or vegetable or mineral oil

- leading to a chronic foreign body reaction to the inhaled exogenous lipid droplets.
- Endogenous lipoid pneumonia is usually associated with bronchial obstruction, chronic pulmonary infection, pulmonary alveolar proteinosis, or fat storage diseases and is a secondary phenomenon caused by the release of cholesterol and other lipids from tissue breakdown distal to an obstructed airway.
- Treatment is often supportive, as most cases will resolve spontaneously with discontinued exposure.

## Other Imaging Findings

• CT: Lipoid pneumonia can present as areas of ground glass and presents with a "crazy-paving" appearance.

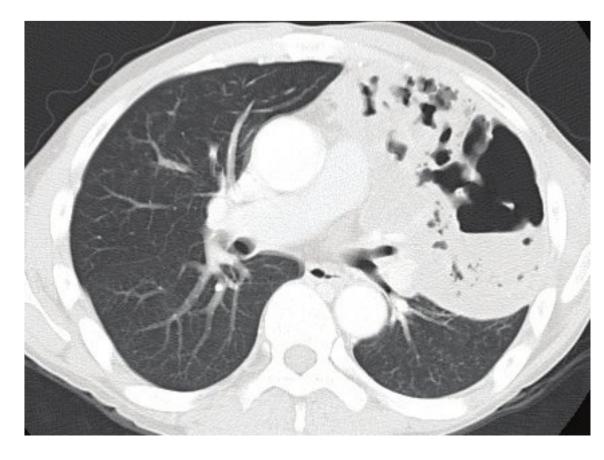
- Tcan reveal areas of fat attenuation as low as 2 30 HU within the consolidative opacities and nodules, a finding diagnostic of lipoid pneumonia but often overlooked. When measuring, it is crucial to measure an area that is densely consolidated. Measuring an area of ground glass will give a false-low density.
- ✓ The radiologic manifestations of chronic exogenous lipoid pneumonia can improve slowly over time but typically remain stable even if the exposure to lipid source is discontinued for many years.
- Siven the nonimproving nature of consolidation, lipoid pneumonia can be mistaken for malignancy.



# Clinical Presentation

A 50-year-old man presents with fever and cough, which has persisted for 2 weeks.





(A) Posteroanterior (PA) view shows a large opacity with cavitation within the left lung. (B) Computed tomography (CT) of the lung shows extensive opacity of the left upper lobe with cavitation.

# Dif erential Diagnosis

- Lung abscess: Formation of cavities containing necrotic debris or fluid caused by microbial infection. On chest radiography, it is a rounded, irregularly shaped cavity with an air-fluid level inside. On CT scans, an abscess is often round and can have a thick wall and ill-defined irregular margins.
- Empyema: An accumulation of pus in the pleural space. Radiologic findings show loculated lenticular pleural effusions often with pleural thickening, which forms the "split pleura" sign (pleural fluid between enhancing thickened parietal and visceral pleura). It has a smooth border with the adjacent lung and causes some adjacent atelectasis.
- Lung carcinoma: It can present with cavity, often thickwalled.

## Essential Facts

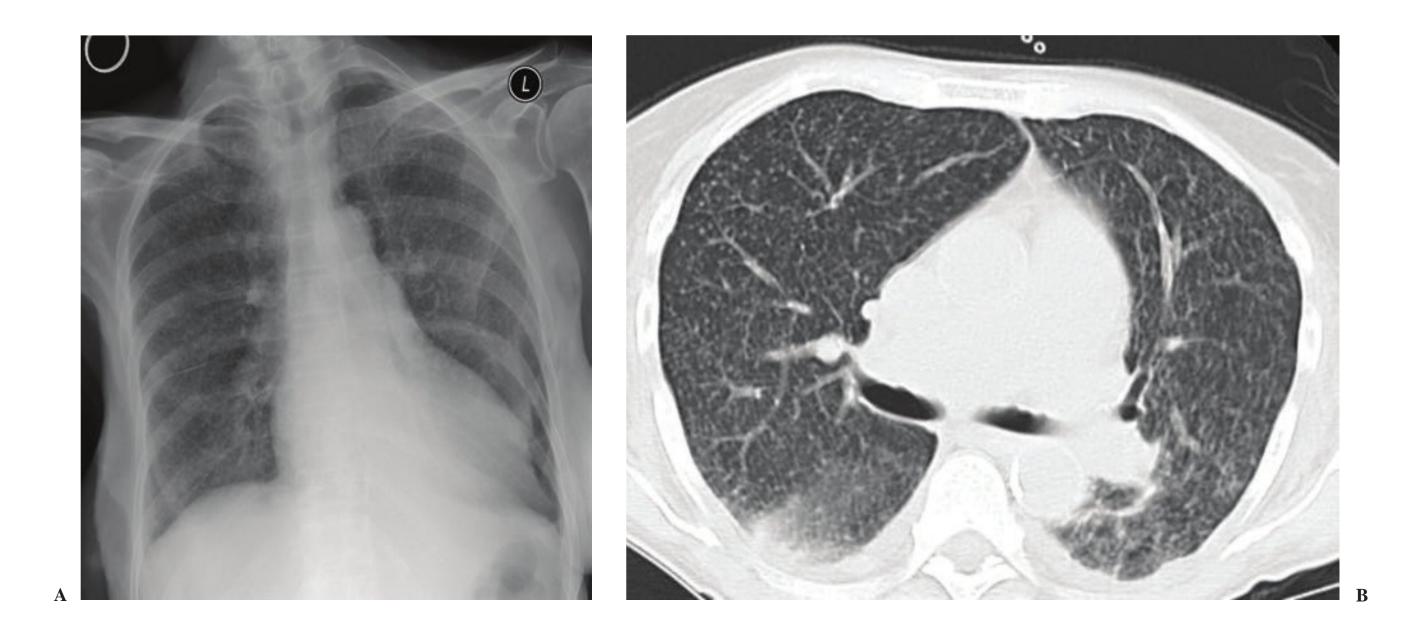
- It can result from aspiration or pneumonia. Preexisting periodontal disease is a common source.
- Alcoholics, those with seizure disorders, and immunocompromised patients are at higher risk.
- Anaerobes are most frequent cause but often polymicrobial.

- Usually treated with antibiotics with drainage percutaneously or surgery for refractory cases
- Nosocomial lung abscesses have higher mortality.

# Other Imaging Findings

- CT is the main imaging study to distinguish lung abscess from empyema, and helpful features include:
- Shape: Abscess tends to be round, whereas empyema are lenticular.
- Margins: Abscess tends to be irregular-walled, whereas empyema is smoother.
- Displacement (atelectasis) of adjacent lung: absent in abscess, present in empyema
- Pulmonary vessels: interrupted by lung abscess but displaced by empyema

- Fronchial obstruction such as carcinoma will increase risk of abscess and can be coexisting.
- ✓ Meed to differentiate lung abscess from empyema due to difference in treatment and usually CT can differentiate but some cases are indistinguishable
- ✓ Ying abscess if peripheral can lead to empyema with a bronchopleural fistula.



# Clinical Presentation

A 75-year-old woman presents with a 10-week history of fatigue, weakness, and a low-grade fever.





(A) Posteroanterior (PA) view shows diffuse fine nodules throughout the lungs. (B) Computed tomography (CT) scan of the thorax shows diffuse fine nodularity of the lungs in a random/miliary pattern.

# ■ Dif erential Diagnosis

- Miliary tuberculosis (TB): This is the widespread hematogenous dissemination of *Mycobacterium tuberculosis*. On chest radiography, millet-like (mean, 2 mm; range, 1 to 5 mm) nodules. On CT, these nodules are in a random pattern sometimes with a basilar predominance.
- Fungal diseases: Histoplasmosis, coccidioidomycosis, and cryptococcosis can present in an identical appearance.
- Metastatic disease: From thyroid and renal cell, it can also cause a miliary pattern.

## Essential Facts

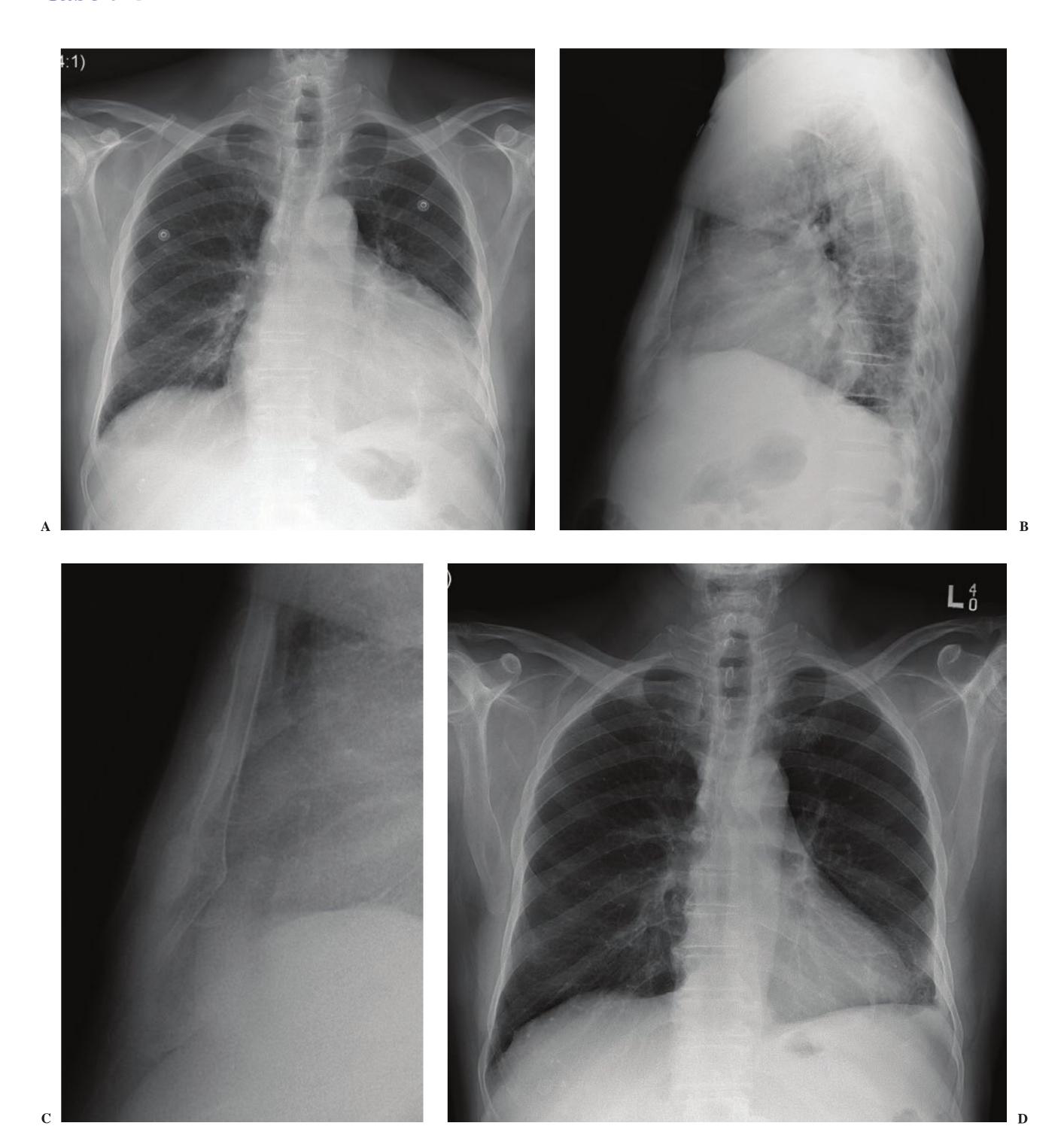
- It can present with nonspecific symptoms such as weakness and weight loss.
- Miliary TB can arise as a result of progressive primary infection or via reactivation of a latent focus with subsequent spread.
- Miliary TB may infect any number of organs, including the lungs, liver, and spleen.
- Risk factors for miliary TB involve immunosuppression such as AIDS, hematopoietic disease, and immunosuppressive drugs including steroids.

- Sputum has low sensitivity.
- Empiric treatment should be immediate if suspected.

# Other Imaging Findings

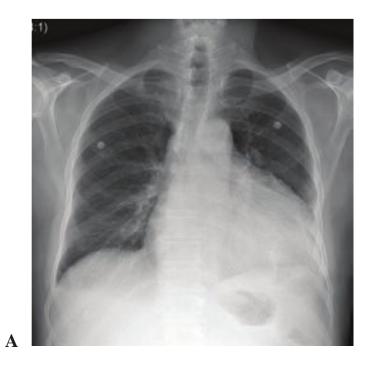
- Magnetic resonance imaging (MRI) will better assess brain and spinal involvement.
- CT or ultrasound (US) will assess abdominal disease.
- Nuclear medicine positron emission tomography (PET), gallium, and white blood cell (WBC) scan can detect sites of infection but does not differentiate etiology.

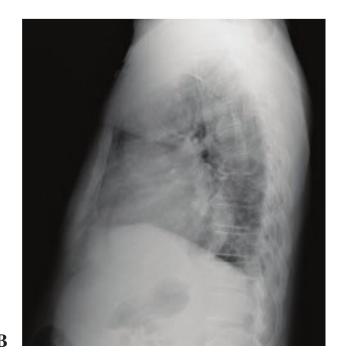
- The interval between dissemination and the development of radiographically discernible miliary TB is, 6 weeks or more.
- ✓ €mmunosuppressed patients have higher risk of extrapulmonary features of TB.

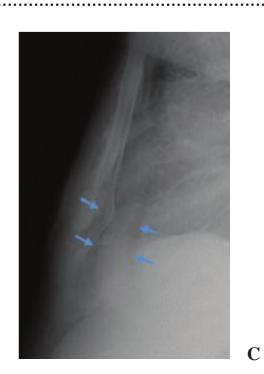


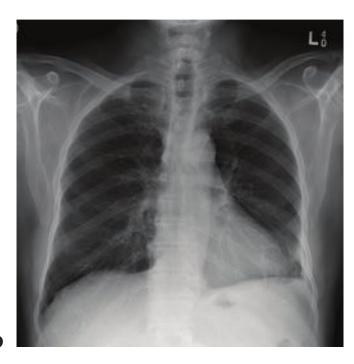
# Clinical Presentation

A 72-year-old man presents with fever, chills, and a productive cough. He is currently being treated with chemotherapy. He has a history of left pleural effusion. At the bottom is the patient's chest X-ray (CXR) from 1 month ago.









(A–D) Posteroanterior (PA) and lateral chest radiography shows a markedly enlarged cardiac silhouette with a globular contour, new from his baseline CXR. On the lateral view is a "stripe" sign of pericardial fluid between epicardial and pericardial fat (arrows).

## ■ Dif erential Diagnosis

- Pericardial ef usion: The presence of an abnormal accumulation of and/or an abnormal character to fluid in the pericardial space. On chest radiography, a globular enlarged cardiac shadow, so-called "water-bottle" heart, and a pericardial fat stripe may be seen. The fat stripe sign is best seen on lateral view chest radiography showing the pericardial fluid between two lucent stripes representing the epicardial and pericardial fat.
- Hemopericardium: The accumulation of blood in the pericardial sac. On computed tomography (CT) scan, a higher attenuation is seen compared with a pericardial effusion indicating the presence of blood in the pericardial sac.
- Cardiomegaly: It refers to the enlargement of the heart and can sometimes mimic a pericardial effusion on CXR.

#### Essential Fact

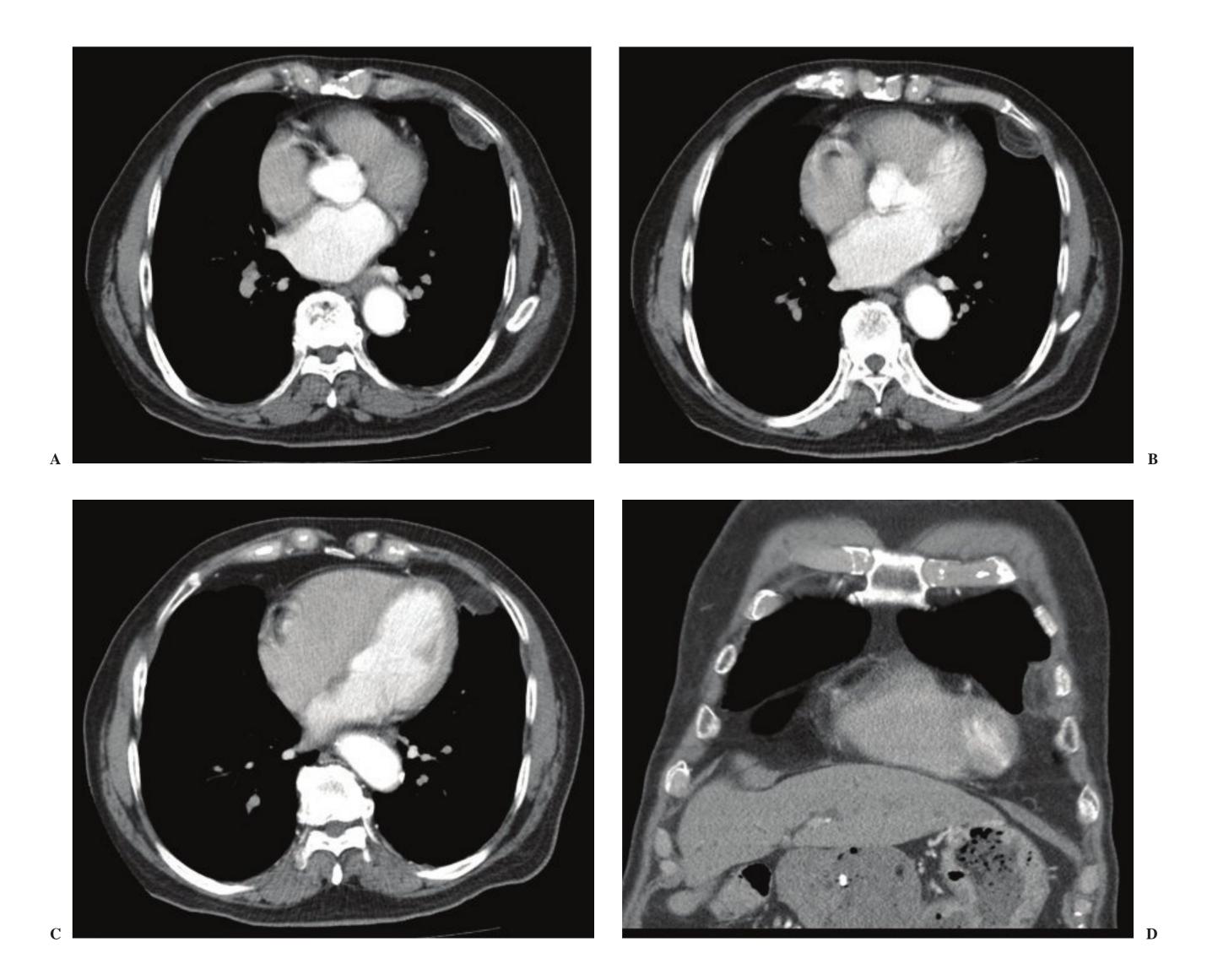
- Most commonly, pericardial effusions result secondary to injury or insult to the pericardium, such as seen with pericarditis.
- Transudative pericardial effusions commonly arise due to obstruction of fluid drainage, which occurs through lymphatic channels.
- Exudative pericardial effusions often occur secondary to inflammatory, infectious, malignant, or autoimmune processes within the pericardium.
- Treatment varies and is directed at alleviating the underlying cause and symptom management. Removal of

- the pericardial fluid through pericardiocentesis can be performed for large symptomatic effusions.
- Cardiac tamponade is a serious complication of pericardial effusion.

# Other Imaging Findings

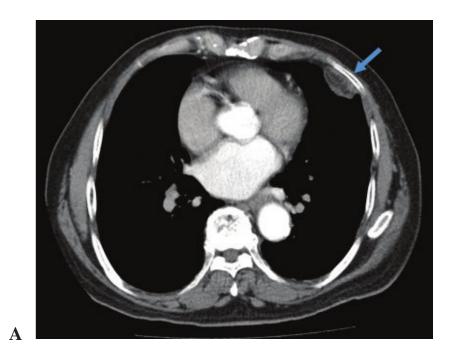
- Echocardiography is both specific and sensitive for pericardial effusion. Pericardial fluid appears as an echolucent space between the pericardium and the epicardium. Echocardiography is the method of choice to confirm the diagnosis, estimate the volume of fluid, and assess the hemodynamic impact of the effusion.
- CT and magnetic resonance imaging (MRI) can also detect small pericardial effusions and differentiate between cardiomegaly and pericardial effusion.

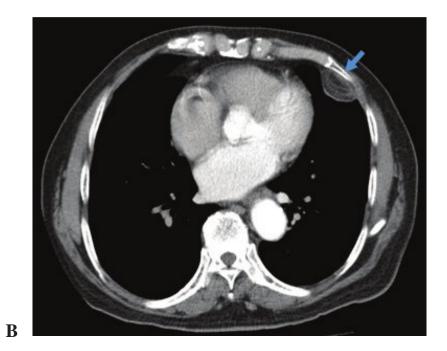
- ✓ Cinical evaluation and electrocardiographic (ECG) findings may suggest the presence of a pericardial effusion, but imaging, usually echocardiography, is required to establish the diagnosis.
- hemodynamically unstable patients with a definitive diagnosis of pericardial effusion consistent with cardiac tamponade, urgent drainage of the pericardial effusion should be performed.

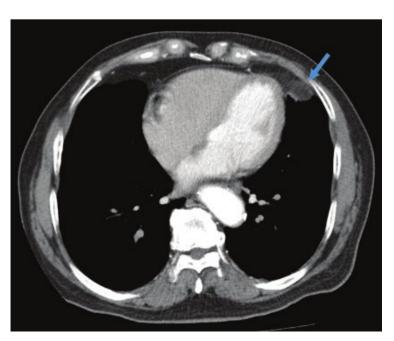


# Clinical Presentation

An 82-year-old man with acute pleuritic chest pain.







(A–D) Axial coronal computed tomography (CT) images show a fat-density lesion (arrows) contiguous with pericardial fat but having streaks of higher soft tissue density.

# ■ Dif erential Diagnosis

- Pericardial fat necrosis: An uncommon, benign condition often presenting with an acute onset of pleuritic chest pain. Associated findings on chest radiograph include an anteriorly located mass in or near the cardiophrenic angle on the side of the chest pain. The mass is also almost always contiguous with the cardiac silhouette. A paracardiac area of increased opacity occurring predominantly on the left side is usually seen on a posteroanterior (PA) chest radiograph. CT scan can be used to determine the nature and location of the mass. An encapsulated fatty lesion with inflammatory changes such as dense strands and thickening of the adjacent pericardium with associated pericardial thickening are often seen on CT scan. Spontaneous improvement or resolution of radiologic findings often appears in follow-up studies.
- Pericardial neoplasms: Such as lipoma and liposarcoma, these are uncommon tumors in the cardiophrenic space and present as focal fatty masses.
- Diaphragmatic hernia (Morgagni hernias): By omental fat and other abdominal structures, this can occupy the cardiophrenic space imitating a tumor on radiographic studies.

# Essential Facts

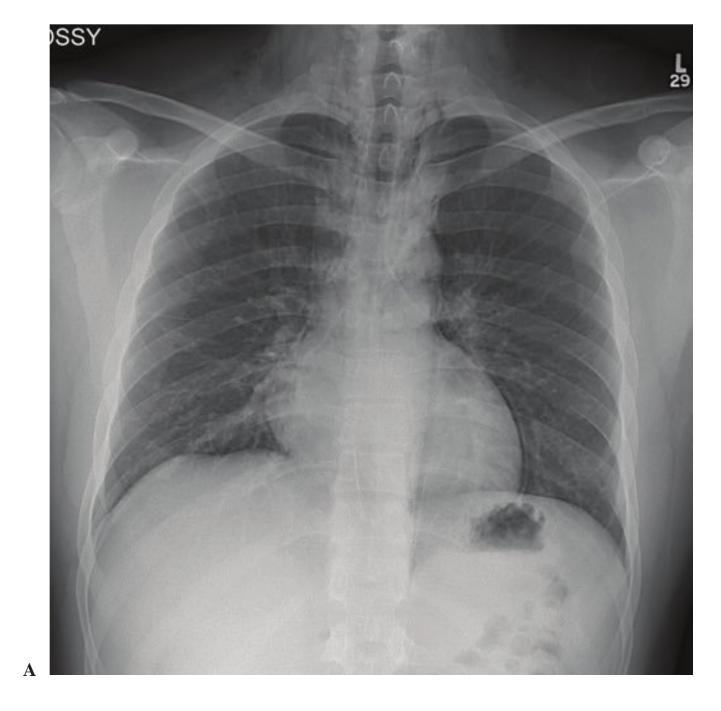
• Pericardial fat necrosis is an uncommon benign condition that can be diagnosed on the basis of its characteristic CT findings.

- Pericardial fat necrosis classically strikes suddenly as excruciating, low anterior pleuritic chest pain without fever or cough.
- In patients presenting with an acute onset of pleuritic chest pain with no abnormal laboratory test or echocardiography, a diagnosis of pericardial fat necrosis should be considered.
- Treatment is often supportive due to its benign, selflimiting nature, unless symptoms are unmanageable and the diagnosis is not confirmed, in which case a thoracotomy may be necessary.

## Other Imaging Findings

• Magnetic resonance imaging can also show the CT findings of fat with stranding.

- \* It is not uncommon to see an abnormal amount of pericardial fat, especially if the patient is obese or is on steroid therapy or has Cushing syndrome. The acute presentation and the thickening and stranding in the fat separate pericardial fat necrosis from normal pericardial fat.
- ✓ **W** is similar to epiploic appendagitis in the abdomen.

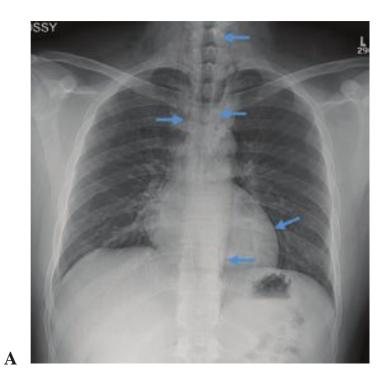


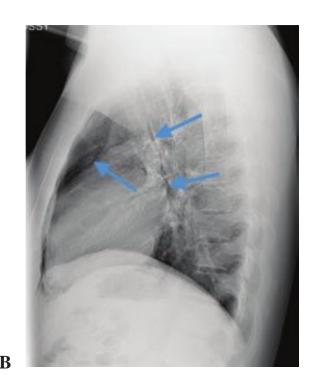


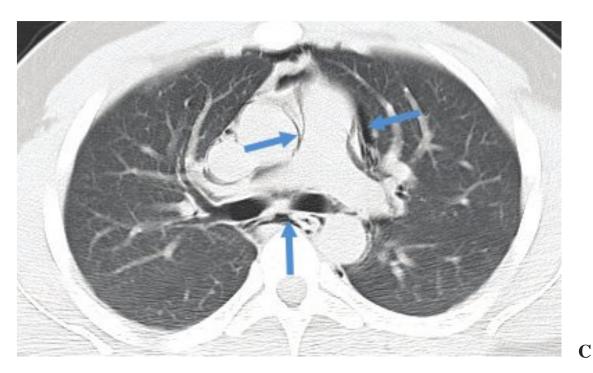


# Clinical Presentation

A 25-year-old man presents to the emergency room (ER) 1 day postinhalation of cocaine with retrosternal chest pain.







(A, B) Posteroanterior (PA) and lateral radiographs show abnormal linear collections of air throughout the mediastinum extending into the neck with some subcutaneous air within the neck consistent with a pneumomediastinum (arrows). (C) Computed tomography (CT) of the chest shows streaks of air throughout the mediastinum (arrows).

# Dif erential Diagnosis

- Spontaneous pneumomediastinum: Defined as the presence of free air or gas within the mediastinal space. It is spontaneous in origin related to rupture of alveolus as a result of increased intraparenchymal pressure. The air causes lucent streaks, which may outline mediastinal structures such as the ascending aorta and its branches, pulmonary artery, airways, and esophagus. The gas may also extend into the neck and chest wall.
- Spontaneous esophageal perforation (Boerhaave syndrome): A swallow study is indicated for any case of suspected pneumomediastinum presenting with emesis to rule out Boerhaave syndrome. It is classically associated with left-sided pleural effusions.

# **Essential Facts**

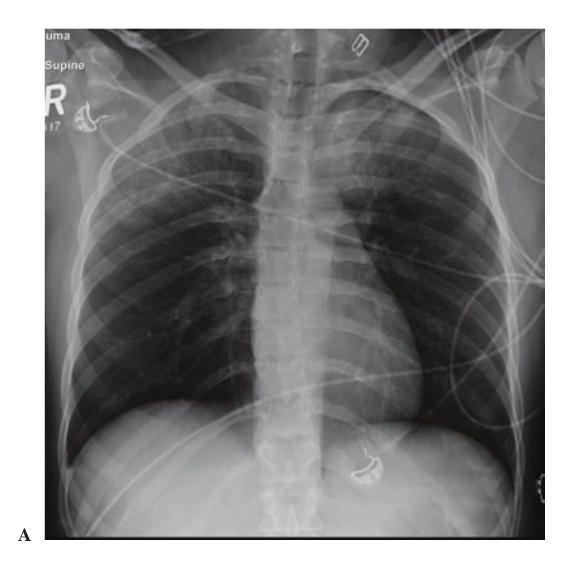
- Pneumomediastinum is generally a self-limiting condition requiring supportive treatment only.
- Most common in infants, rare in adults, and more commonly spontaneous in etiology
- Inhalation of toxic agents or illicit drugs (e.g., cocaine) or asthma resulting in bronchial constriction may lead to the development of a spontaneous pneumomediastinum, especially in children and young adults, whereas

- mechanical ventilation, vomiting, or Valsalva maneuver may result in barotraumas resulting in spontaneous pneumomediastinum.
- Up to 10% of patients who have sustained blunt cervical or thoracic trauma may develop a pneumomediastinum.

### Other Imaging Findings

- Esophagram if history suggests esophageal perforation
- Chest X-ray (CXR): "Ring around the artery" sign is the accumulation of air (lucency) around the aorta or pulmonary artery. "Continuous diaphragm" sign is the presence of air outlining the central portion or sternal attachments of the diaphragm.

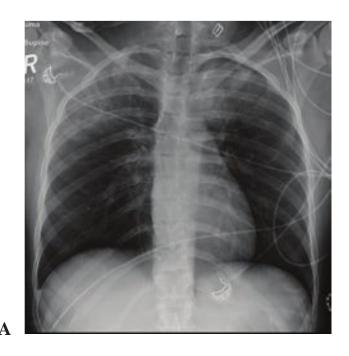
- ✓ ⊈pneumomediastinum may progress to the development of a pneumothorax or pneumopericardium, especially in those infants with respiratory distress syndrome or aspiration pneumonitis.
- neumomediastinum is frequently overinvestigated and overtreated due to concern for missing an esophageal injury.

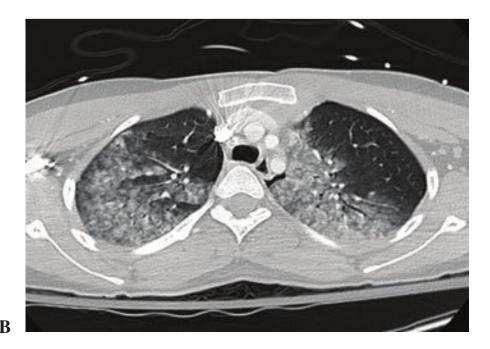




# **Clinical Presentation**

A 26-year-old man with hemoptysis fell from 15 feet.







(A) Chest X-ray (CXR) shows bilateral upper lung air-space opacity. (B, C) Computed tomography (CT) shows bilateral apical air-space opacity and left lower lobe air-space opacity with focal collection of air and fluid (arrow).

# Dif erential Diagnosis

- Pulmonary contusion and laceration: Pulmonary contusion presents as pulmonary air-space opacity. On CT, this will appear as ground glass and consolidation. A pulmonary laceration will appear as a rounded density, which can be completely opacified appearing nodular, have an air-fluid level, or be air filled.
- Air-space simulating pulmonary contusion: It can be seen with pneumonia, aspiration, and atelectasis as well as edema. In patients with fractures, fat embolism is a potential cause.
- Nodules/cavities simulating laceration: Include preexisting bulla or cavity such as related to tumor, vasculitis, and infection. Acute localized pneumothorax can simulate peripheral lung laceration.

## Essential Facts

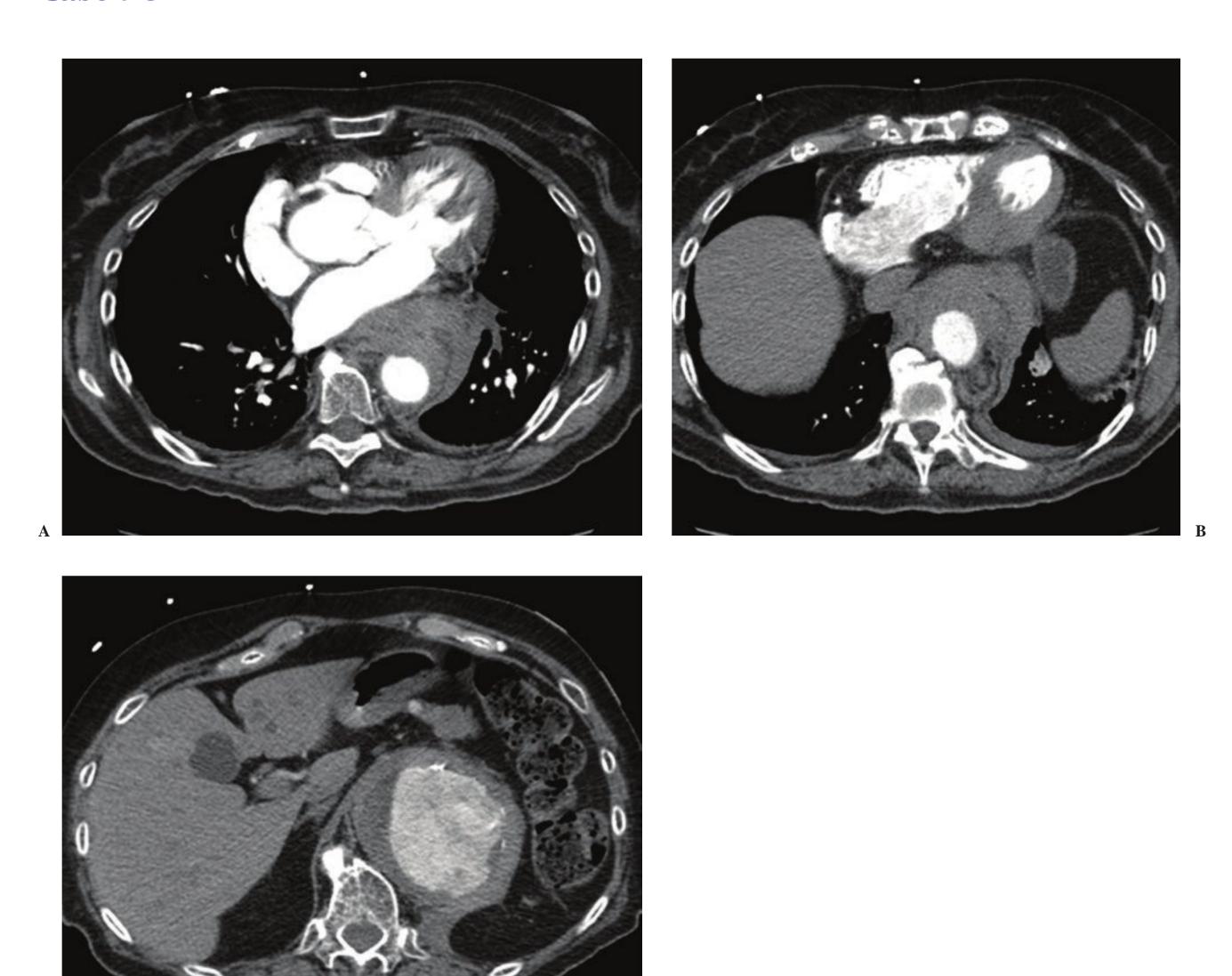
- Pulmonary contusion is the most common lung injury from blunt trauma.
- Fifty percent to 60% of patients with significant pulmonary contusions will develop bilateral acute respiratory distress syndrome (ARDS). Other complications include respiratory failure, atelectasis, and pneumonia.
- Contusion is located posteriorly in lungs in most cases (60%). It is usually at the site of direct impact but may occur on side opposite the impact (contrecoup injury).
- Pain control and supportive therapy are the mainstays of treatment while the pulmonary contusion resolves (3 to 10 days).

- Laceration is usually surrounded by contusion.
- Four types of laceration: compression rupture (most common in deep portion of lung), compression shear (paraspinal), rib penetration tear, and adhesion tear (pre-existing pleuroparenchymal disease)
- Laceration takes much longer to heal than contusion and may take weeks.
- Conservatively treated but occasionally need surgical repair or resection.

# Other Imaging Findings

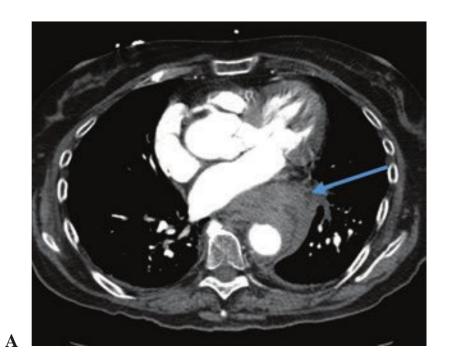
• CT is much more sensitive than CXR in detecting contusion or laceration and better assesses the extent of findings. It is often performed to assess other areas of trauma and main imaging investigation for contusion and laceration.

- ✓ CΓ will often see contusion immediately after injury, whereas CXR may lag and progress up to 24 hours after injury.
- wupine CXR that is commonly done in trauma will not easily detect the air-fluid levels in pulmonary laceration.

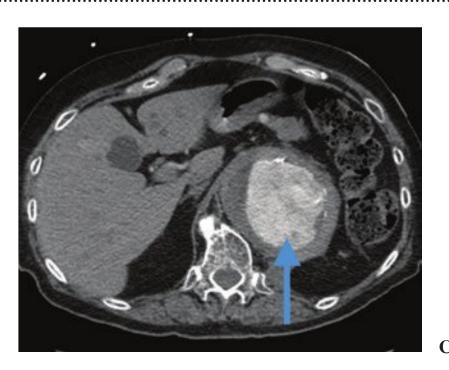


# Clinical Presentation

An 81-year-old woman with worsening atrial fibrillation and asymmetric blood pressures has a sudden onset of presyncope and shortness of breath (SOB) with severe ripping chest pain.







(A-C) Computed tomography (CT) shows mediastinal hematoma (thin arrows) with an aortic aneurysm (large arrow).

# ■ Dif erential Diagnosis

- Thoracic aortic aneurysm (TAA) rupture: When a transmural tear of the aorta occurs as a result of an expanding aneurysm. Chest radiograph findings of a TAA may include widening of the mediastinal silhouette, enlargement of the aortic knob, or displacement of the trachea from midline. A lateral view may demonstrate loss of the retrosternal air space. In addition, the aneurysms may also be completely obscured by the heart or too small to be seen on plain radiographs. TAA rupture findings on CT include mediastinal hematoma, stranding of the periaortic fat, and hemothorax; a high-attenuation "crescent" in the mural thrombus of a TAA may represent an acute contained or impending rupture.
- *Mediastinal hematoma*: It can occur from other causes including iatrogenic causes such as postsurgery and misplaced lines and can occur in trauma.

#### Essential Facts

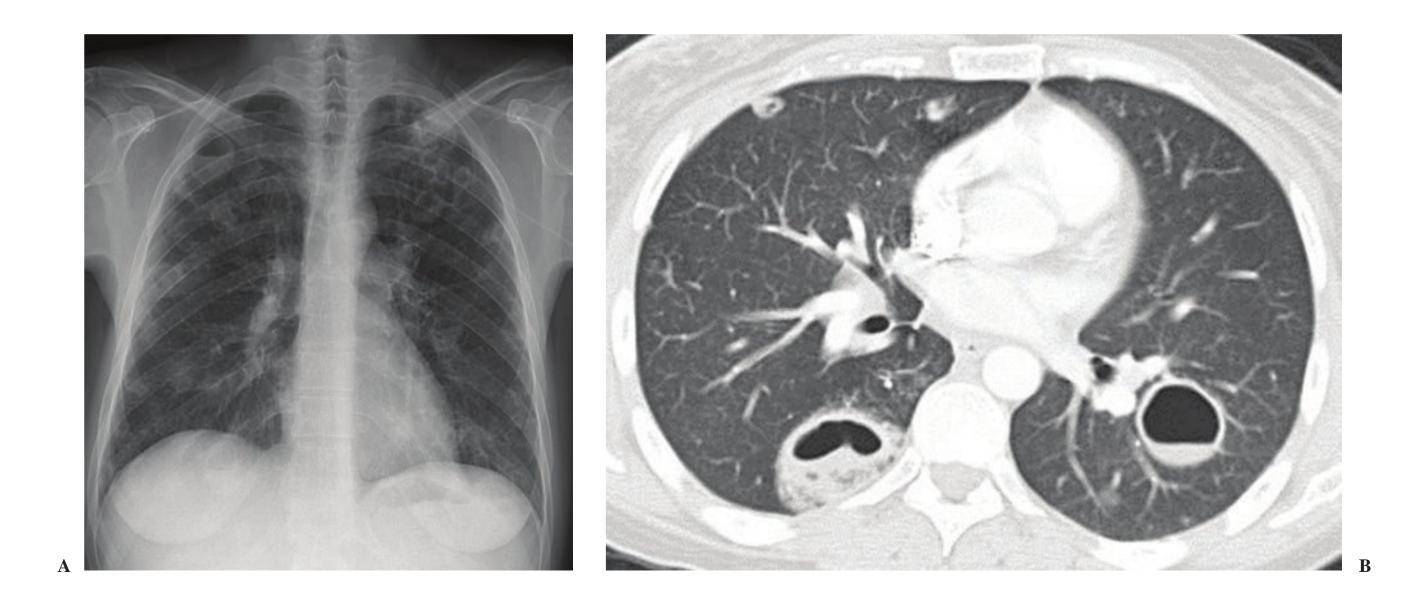
- The most common complications of thoracic aortic aneurysms are acute rupture or dissection.
- Aortic aneurysms are two to four times more common in men than in women, occurring in the sixth and seventh decades of life.
- The incidence of thoracic aortic rupture is 3.5 per 100,000 person-years.
- The most important determinant of rupture is the size, rate of expansion, and the location of the aortic aneurysm.
- Rupture of the ascending aorta may occur into the pericardium, resulting in acute tamponade.

- Rupture of the descending thoracic aorta may cause a left hemothorax.
- Patients with specific connective tissue diseases such as Marfan syndrome and Ehlers-Danlos are at increased risk for thoracic aortic aneurysms.
- Treatment involves emergent surgical repair in patients with acute rupture.
- Emergent surgical repair of a ruptured thoracic aortic aneurysm carries a 25 to 50% mortality as opposed to a 5 to 8% mortality with elective surgical repair.

# Other Imaging Findings

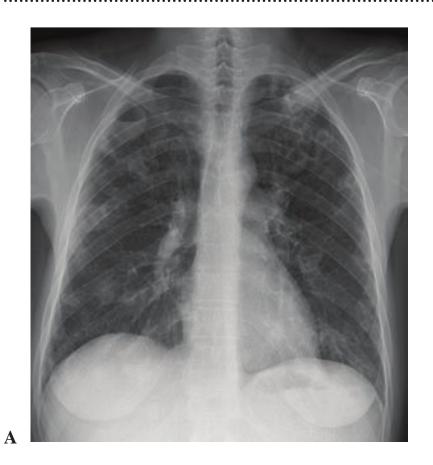
- Transesophageal echocardiography can help accurately differentiate aneurysm and dissection.
- Magnetic resonance imaging (MRI) and magnetic resonance angiography (MRA) can also help accurately demonstrate the location, extent, and size of the aneurysm and its relationship to branch vessels and surrounding organs.

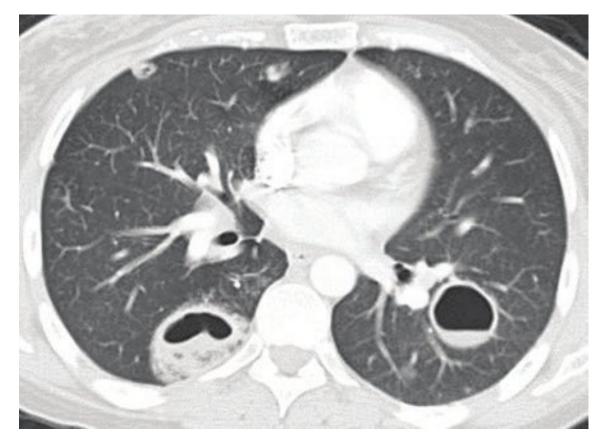
- ✓ CΓ is the imaging modality of choice for identifying aneurysm rupture.
- rysm rupture die before reaching the hospital and most patients die within 6 hours postrupture.
- ductus diverticulum in the isthmic portion of the aorta can be confused for a focal pseudoaneurysm.



# Clinical Presentation

A 42-year-old intravenous illicit drug user presents with an acute onset of dyspnea, hemoptysis, and fever.





(A) Posteroanterior (PA) radiograph demonstrates multiple cavities, some with air-fuid levels. (B) Computed tomography (CT) shows multiple cavities.

## **■** Dif erential Diagnosis

- Pulmonary septic emboli: They are generated from fragments of a thrombus that contain microorganisms, which can lead to focal abscesses in the lungs, commonly seen in the periphery of the lower lobes. Septic emboli may appear as multiple round nodules, which commonly cavitates producing thin-walled lesions. Wedge-shaped subpleural lesion with the apex of lesion directed toward pulmonary hilum may be evident. "Feeding vessel sign" may also be seen on CT scan.
- Squamous or transitional cell mets: Multiple pulmonary nodules or cavities. Metastases are generally discreet and do not coalesce, as may be seen with pulmonary septic emboli.
- Vasculitis such as Wegener granulomatosis: It can appear as multiple nodules and cavities. These lesions may be poorly or well demarcated and are frequently associated with areas of consolidation.

#### Essential Facts

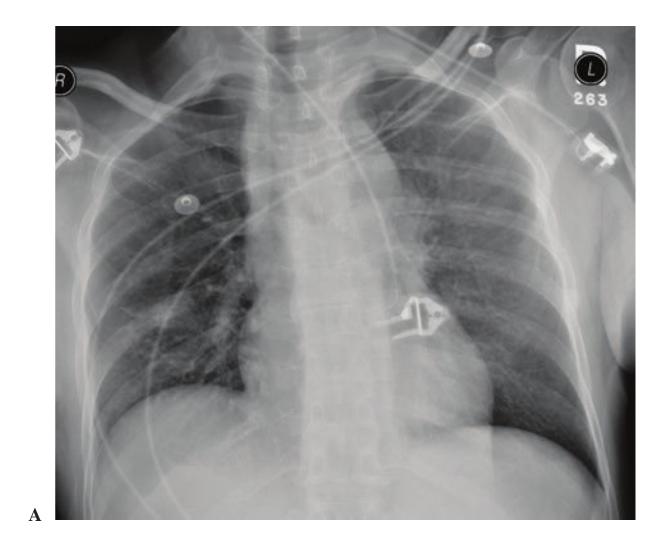
- Pulmonary septic emboli are an uncommon condition, often affecting individuals older than 40 years of age.
- Septic pulmonary emboli can travel to the lungs from several sources such as infected cardiac valves due to infective endocarditis with or without intravenous

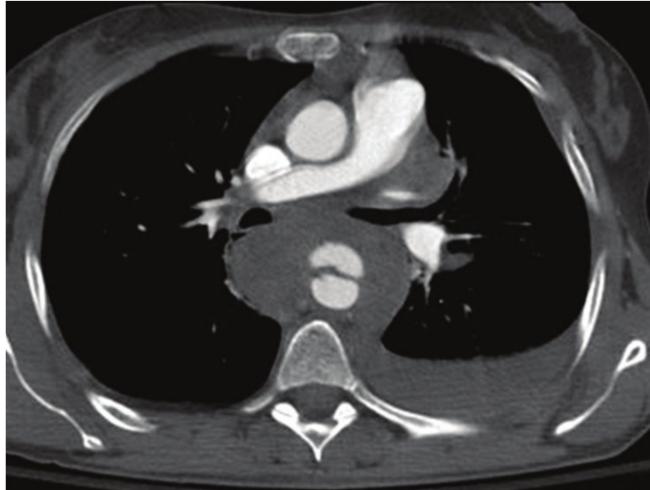
- (IV) drug use, pelvic or deep vein thrombophlebitis, infected venous catheters, peritonsillar abscesses, and osteomyelitis.
- It often involves bacterial organisms such as *Staphylococcus aureus* and *Streptococcus* and occasionally may involve fungi or parasites.
- In addition to the characteristic radiographic findings, the diagnosis of septic pulmonary emboli is made based on positive blood cultures.

#### Other Imaging Findings

- "Feeding vessel" sign consists of a pulmonary vessel connecting directly to a nodule or a mass. This sign has been considered highly suggestive of septic embolism.
- Echocardiogram: Septic pulmonary emboli are commonly due to infective endocarditis.

- ✓ The screening test of choice for septic pulmonary emboli is chest radiography; however, the extent of disease identified by CT is greater than that detected by radiography.
- inical and radiologic features at presentation are usually nonspecific, and the diagnosis of this disorder is frequently delayed.

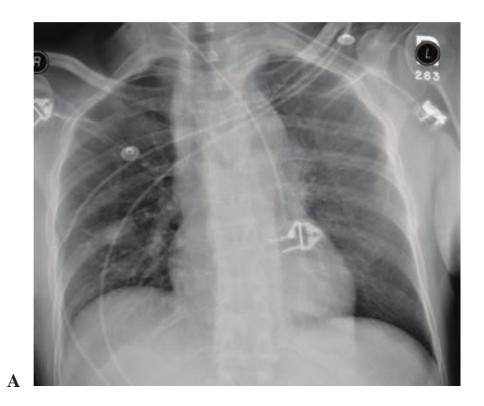


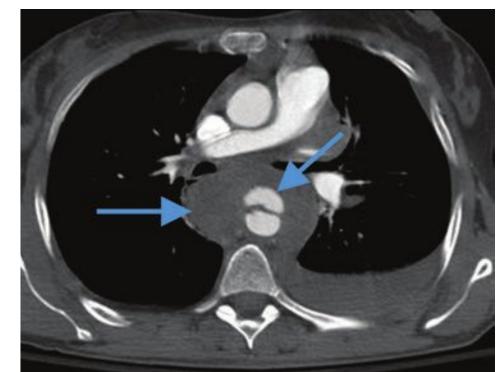


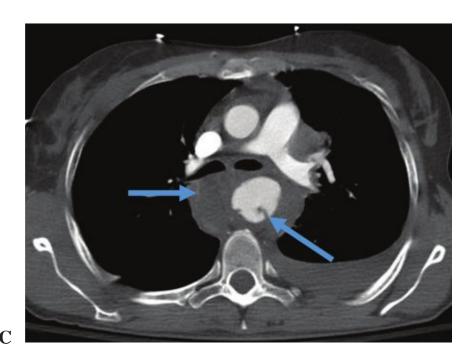


# Clinical Presentation

A 35-year-old man is brought by ambulance to the emergency department following a high speed motor vehicle accident.







(A) Chest X-ray (CXR) shows a wide mediastinum with indistinct aorta. (B, C) Computed tomography (CT) shows a pseudoaneurysm of the aorta (small arrows) with surrounding hematoma (large arrows).

# **■** Dif erential Diagnosis

- Traumatic aortic injury (TAI): This is a serious lifethreatening injury resulting from major blunt thoracic trauma. Widening of the superior mediastinum (subjective evaluation or . 8 cm at the aortic arch) and irregularity or obscuration of the aortic arch margin is frequently observed. Other signs, such as deviation of the trachea, depression of the left mainstem bronchus, and rightward displacement of a nasogastric tube can also be seen. On a CT scan, mediastinal hematoma, an indirect sign of aortic injury, appears as soft tissue attenuation material surrounding the mediastinal structures. However, direct signs such as irregularity of the aortic wall, presence of an aortic pseudoaneurysm, and abrupt caliber change of the aorta, are needed to conf rm this diagnosis.
- Mediastinal hematoma: Traumatic hematoma from venous bleeding can occur in trauma. A preserved fat plane between the hematoma and the aorta help distinguish this from aortic injury.

## Essential Facts

- Ninety percent of thoracic aortic injuries occur at the aortic isthmus, immediately distal to the left subclavian artery, and tears of the ascending aorta, the distal descending aorta, or abdominal aorta are much less common.
- Seventy percent of all thoracic aortic injuries are fatal at the scene of trauma.

- In, 60% of the cases, the adventitial layer is intact (partial or contained rupture).
- Traumatic aortic injury is treated urgently with surgery or endovascular repair.
- The rare patient who survives aortic injury without treatment may develop a chronic pseudoaneurysm.

## Other Imaging Findings

• Aortography: Findings diagnostic of aortic injury include an intimal tear, extravasation of contrast material, dissection with an intimal flap, pseudoaneurysm, and pseudocoarctation.

# ✓ Pearls & ➤ Pitfalls

- Mediastinal hematoma may result from causes other than aortic injury, such as fractures of the lower cervical or upper thoracic vertebrae or venous bleeding.
- ✓ In cases with equivocal f ndings and stable patient, cardiac gating of CT can be helpful.
- woutus diverticulum, a normal variant, can cause a smooth bulge in the proximal descending thoracic aorta and is a potential pitfall.

# Acknowledgements

Images courtesy of H. Shulman, Sunnybrook Hospital, University of Toronto.

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