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RADIOLOGY OF ACUTE ABDOMEN

MANUAL

for the students of the 3rd year of specialty "Medicine"

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The manual «Radiology of acute abdomen» was prepared to facilitate the preparation of practical classes in radiology for third-year students of speciality “Medicine”. The manual presents the urgent conditions of the abdomen (their classification, causes, stages, radiological signs and complications). This study guide is intended for students of medical HEI.

Навчальний посібник «Радіологія ургентних станів черевної порожнини» підготовлений з метою полегшити підготовку до практичних занять з радіології для англомовних студентів 3 курсу за спеціальністю «Медицина». У посібнику представлені ургентні стани черевної порожнини (їх класифікація, стадії, причини, радіологічні ознаки, ускладнення). Цей навчальний посібник призначений для студентів медичних ВНЗів.

CONTENTS

Introduction

Acute abdominal pain is a common presentation in the outpatient setting and can represent conditions ranging from benign to life-threatening. If the patient history, physical examination, and laboratory testing do not identify an underlying cause of pain and if serious pathology remains a clinical concern, diagnostic imaging is indicated.

Radiology (Medical Imaging) now plays a pivotal role in modern medical practice. Clinical decision making depends on timely and accurate interpretation of imaging studies particularly in acute situations. Its importance in daily clinical practice is reflected by the fact that almost no patient leaves the hospital without undergoing an imaging study.

Over the years, radiologists have established many signs that represent visual manifestations of myriad underlying pathophysiologic processes.

Many clinicians now need to interpret images themselves and the information provided is particularly useful for them.

The purpose of this guide is to review a number of radiological features associated with gastrointestinal tract pathologies and to teach students how to apply them to make a correct diagnosis.

All visual materials (roentgenograms, tomograms, sonograms) created by the authors of the manual, otherwise the source is indicated.

Historically the plain abdominal radiograph is mandatory in every patient presenting with an acute abdomen.

Plain abdomen film

Plain radiograph is the initial modality for investigating acute abdomen. Before the advent of CT, it was a primary means of investigating gastrointestinal pathology and often allowed indirect evaluation of other abdominal viscera.

Patient should be immobilized and exposure should be done in suspended respiration usually after full expiration

Indications

Although abdominal radiography has lower sensitivity and specificity than a CT of the abdomen, it still serves a role as an adjunct or optional test.

Current uses for abdominal radiography include:

- a preliminary evaluation of bowel gas in an emergent setting
- a negative study in a low pretest probability patient may obviate the need for a CT study and therefore lower radiation dose
- evaluation of radiopaque tubes and lines
- evaluation for radiopaque foreign bodies
- evaluation for postprocedural intraperitoneal/retroperitoneal free gas
- monitoring the amount of bowel gas in postoperative ileus
- monitoring the passage of contrast through the bowel
- colonic transit studies
- monitoring renal calculi

Contraindications

- pregnancy is a relative contraindication to the use of ionizing radiation
- non-ionizing studies (e.g. ultrasound or MRI) should be tried first

abdominal radiographs administer a much lower radiation dose than CT

Projections

Standard projections

- AP supine view
- PA erect view
- KUB view

Additional projections

- lateral decubitus view
- lateral view
- PA prone view
- dorsal decubitus view
- oblique views

AP supine view

AP supine view can be performed as a standalone projection or as part of an acute abdominal series. It demonstrates dilated bowel loops. Patient lies supine on the x-ray table. Patient is positioned such that symphysis pubis will be included in the film.

AP supine view

PA erect view

PA erect view abdomen ideal for the demonstration of air-fluid levels in suspected cases of intestinal obstruction and for demonstrating pneumoperitoneum. Patient is in erect posture. X-ray tube is positioned so that the central ray is horizontal and centering is done in the midline above highest point of iliac crest

PA erect view

KUB view

KUB view used to visualize calculi within the urinary system (kidneys, ureters, bladder).

Additional projections:

Generally, plain radiograph examination of the abdomen comprises an AP supine and PA erect view, supplemented by a number of additional views as clinically indicated.

- ***lateral decubitus view***

Lateral decubitus view performed as an alternative to the PA erect view to assess for free gas in the abdominal cavity.

- ***lateral view***

Lateral view often used as a problem solving view during the identification and localization of foreign bodies.

- ***PA prone view***

PA prone view performed if the patient is unable to lie supine.

- ***dorsal decubitus view***

Dorsal decubitus view used when it is unsafe to perform both a PA erect or a lateral decubitus view, this projection requires no patient movement.

- ***oblique views***

Oblique views used in barium studies and the location of foreign bodies and/or lines such as a Tenckhoff catheter.

When assessing an abdominal film, a study of three principal aspects will encompass the majority of abnormal findings:

- bowel gas pattern
- areas of calcification
- skeletal abnormalities

Bowel gas pattern

A marked variation exists in the amount of bowel gas in normal individuals, usually some gas being noted in the stomach, small and large bowel. Bowel gas pattern should be evaluated with particular reference to dilatation.

Generally, the small bowel lies in central position characterized by folds or valvulae conniventes forming complete bands across the bowel.

The large bowel, however, is situated peripherally, the haustral pattern forming incomplete transverse bands.

Small bowel dilatation is considered to be present if the width exceeds 3 cm.

Conditions that may be diagnosed by an alteration in the bowel gas pattern are:

- small bowel obstruction
- large bowel obstruction
- paralytic ileus
- cecal volvulus
- sigmoid volvulus
- toxic megacolon

Gas may be noted outside the bowel lumen in the:

- biliary system
- urinary tract
- abscess, colon wall or abdominal abscess
-

Calcification

Normal calcification

- costal cartilage
- mesenteric lymph nodes
- pelvic vein phleboliths

Abnormal calcification

Calcium indicates pathology in:

- pancreas
- renal parenchymal tissue
- blood vessels and vascular aneurysms
- gallbladder fibroids (leiomyoma)
- uterine fibroid

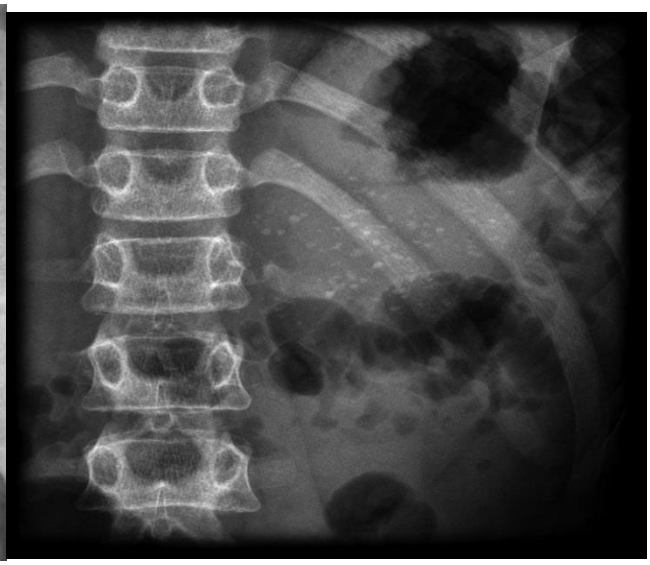
Calcium can make the following pathology visible:

- biliary calculi
- renal calculi
- prostate gland
- appendicolith
- bladder calculi
- teratoma

calcification of mesenteric lymph nodes

calcified uterine fibroid

calcification of pelvic vein phleboliths



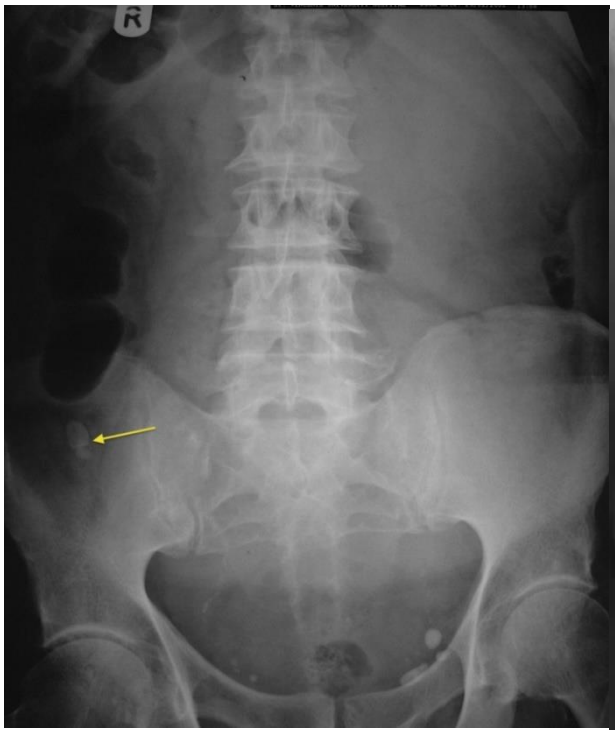
pancreatic calcifications

nephrocalcinosis: calcium salt deposits in the renal parenchyma

https://www.wikidoc.org/index.php Gallstone disease x ray

abdominal x-ray showing a calculus in the right kidney.

prostate gland calcifications



appendicolith

bladder calculi

Skeletal abnormalities

Skeletal abnormalities that may be shown on plain abdominal films are:

- degenerative changes in the spine or hips
- bony metastases
- Paget's disease
- vertebral body collapse

Fat Shadow

Fat density, which is between that of soft tissue and that of gas, outlines the contour of solid organs or muscles. In obese patients, fat may not be distinguishable from ascitic fluid on plain abdominal film. The flank stripe, also called the properitoneal fat stripe, is a line of fat next to the muscle of the lateral abdominal wall. The flank stripes are symmetrically concave or slightly convex in obese people and are located along the side of the abdominal wall. The normal properitoneal fat stripe is in close proximity to the gas pattern seen in the ascending or descending colon. Widening of the distance between the properitoneal fat stripe and the ascending or descending colon suggests fluid, such as abscess, ascitic fluid, or blood within the paracolic gutter.

Fat is present in the retroperitoneal space adjacent to the psoas muscle. The psoas muscle shadow may be absent unilaterally or bilaterally as a normal variant or as a result of inflammation, hemorrhage, or neoplasms of the retroperitoneum.

Unilateral convexity of the psoas muscle contour suggests an intramuscular mass or abscess. The quadratus lumborum muscles may be delineated by fat located lateral to the psoas shadow. In the pelvis, the fatty envelope of the obturator internus muscle is seen on the inner aspect of the pelvic inlet. The dome of the urinary bladder may be delineated by fat.

Other abnormalities

- hepatosplenomegaly
- mass lesions seen by distortion of the bowel gas pattern
- soft tissue masses arising from intra-abdominal and pelvic organs

Plain X-ray finding of hepatomegaly

Role of chest radiograph in acute abdomen

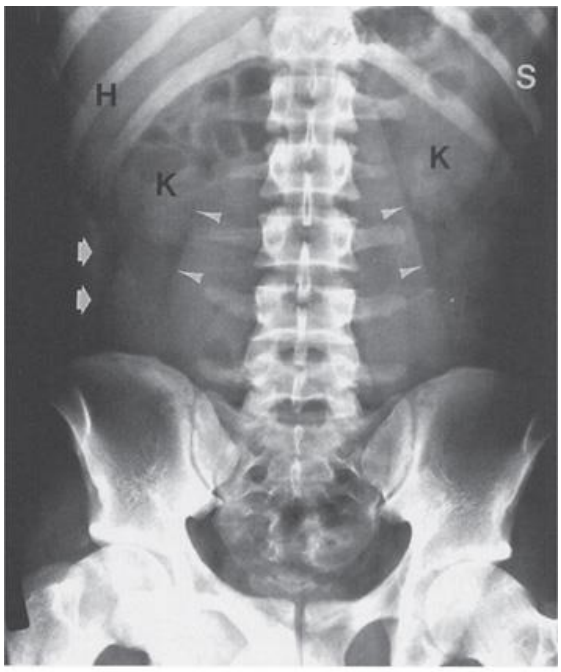
Erect chest radiograph is essential in cases of acute abdomen because it is best for: showing the presence of a small pneumoperitoneum as the gas is tangential to the x-ray beam.

A number of chest conditions may present as acute abdominal pain and mimic an acute abdomen, for e.g.: consolidation.

Acute abdominal conditions may be complicated by chest pathology like pleural effusion secondary to acute pancreatitis.

How to report a plain abdominal film?

- proportional fat planes should be commented
- look for the position of the gas bubble - comment should be made about the shape, position of the air bubble, distance of the air bubble from the diaphragm and displacement of the bubble
- look for normal gas pattern in small and large bowel
- look for normal and abnormal air fluid levels
- bilateral hemi-diaphragm should be assessed
- look for bilateral renal and psoas shadows
- comment should be made about the bony structures



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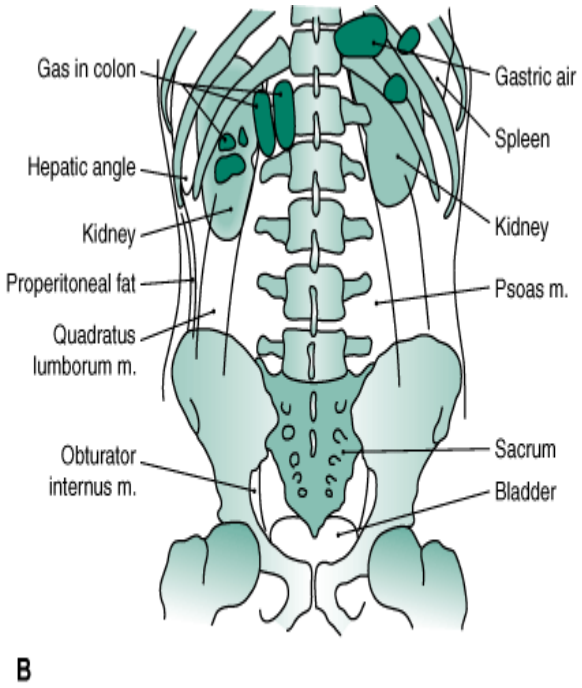


B

Ultrasound

Ultrasound is the major decision making modality in initial evaluation of a patient who presents with abdominal symptoms.

Ultrasound of the abdomen is the most utilised imaging modality for initial evaluation of abdomen as it is a fast, easily available, non-invasive, non-radiation technique that can demonstrate parenchymal organ as well as bowel pathologies and also look for abdominal fluid/collections. Transabdominal ultrasound is useful in patients with acute abdominal pain cases to look for appendicitis, cholecystitis, renal stones, ectopic pregnancy and intussusception.

Ultrasound can also be further tailored as trans-vaginal ultrasound can demonstrate female pelvic pathologies and scrotal ultrasound for testicular evaluation.

However, ultrasound is not useful in suspected peptic ulcer disease/gastritis and is low-yield in cases of non-specific abdominal pain and thus should not be indiscriminately ordered.

CT abdomen

While CT abdomen is useful for general evaluation of abdomen in cases of fever, sepsis, lymphoma and metastatic staging, various specific protocols have been devised to optimise diagnostic yield. Multi-phase protocols comprising of separate acquisitions in arterial, venous and delayed phases with one-time contrast administration is useful for characterization of hepatic and pancreatic masses. Similarly, renal masses and excretory system can be evaluated by multi-phase and CT urography protocols respectively/

Appropriate Ordering of Radiological Investigationsbowel disease can be evaluated with CT enterography/enteroclysis techniques where bowel lumen is distended with neutral contrast to optimise visualisation of mucosa as well as bowel wall. CT abdominal angiography is useful for evaluation of mesenteric ischaemia and gastrointestinal bleeds while CT portography can be specifically tailored for evaluation of splenoportal axis in cases of portal hypertension.

Non-contrast low dose CT remains the most sensitive technique for evaluation of ureteric stones. Thus the versatility of CT is extremely useful for evaluation of abdomen.

MRI of abdomen

MRI of abdomen is useful for evaluation of hepatobiliary system (MR cholangio-pancreaticography), excretory system (MR urography) and pancreas.

An advantage of MRI is the free of radiation and ability to get diagnostic information without the use of contrast by using various MR sequences. With its better tissue characterisation ability, contrast-enhanced multiphase MRI is used as a problem solving modality for hepatic masses.

MR enterography protocols have also been devised for long term follow-up in young patients with inflammatory bowel disease to minimise risks of radiation.

MRI is also superior to CT for evaluation of pelvic organs for urologic and gynecologic imaging.

Acute appendicitis

Acute appendicitis is the commonest acute surgical conditions. Appendicitis is inflammation of the appendix.

Symptoms commonly include

- right lower abdominal pain
- nausea
- vomiting
- decreased appetite

However, approximately 40% of people do not have these typical symptoms.

Complications of appendicitis include

- perforation
- widespread painful inflammation of the inner lining of the abdominal wall
- sepsis
- phlebitis with thrombosis of the portal vein
- liver abscess

Appendicitis is caused by a blockage of the hollow portion of the appendix. This is most commonly due to a calcified "stone" made of feces. Inflamed lymphoid tissue from a viral infection, parasites, gallstone, or tumors may also cause the blockage. This blockage leads to increased pressures in the appendix, decreased blood flow to the tissues of the appendix, and bacterial growth inside the appendix causing inflammation.

Discuss the utility of each imaging procedure

Role of CT:

CT scan is the most ideal imaging procedure for diagnosing appendicitis and its complications. Spiral CT is useful when you are not quite sure of the diagnosis from the history and physical exam and there may be cofounding variables such as old age and/or other morbidities.

CT showed the highest sensitivity and specificity among radiological options.

This not only allows the investigator to distinguish diffuse inflammation of appendix from an abscess, but also identifies many of the diseases involved in the differential diagnosis of acute appendicitis.

Role of ultrasound

Abdominopelvic ultrasound can be limited by gas in bowel.

Ultrasound is useful in pregnant woman with abdominal pain or young children where there is clinical doubt.

Ultrasound is reliable and sensitive for the detection of appendicoliths and the demonstration of an abnormally distended or thick-walled appendix.

Role of plain film

Sensitivity of plan film for diagnosis of appendicitis is low. Conventional abdominal radiography along with contrast-enema radiography no longer has a role.

Radiological signs are:

- sentinel loop: dilated atonic ileum containing a fluid level will be seen
- dilated caecum with widening of the properitoneal fat plane in right lower quadrant
- intestinal obstruction may be seen as several loops of small bowel matted together or stuck to the inflamed appendix
- appendicolith seen in 13% cases
- if abscess is formed indentation on the caecum on its medial border will noted with an air fluid level

Ultrasound features

- examination is done by Graded compression technique in the right iliac fossa
- blind ending tubular structure at the point of tenderness which is non compressible and measures >7 mm in diameter with no visible peristalsis suggests inflamed appendix

- peri-appendiceal collection is seen as hypoechoic collection in adjacent areas

CT features

- Ileus: dilated loops of bowel
- appendix > 7 mm in diameter
- an appendicolith
- failure of the appendix to fill with oral contrast medium
- enhancement of its wall with intravenous contrast medium
- peri-appendiceal inflammation/inflammatory infiltration of fat
- abscess
- inflammatory mass
- air pockets
- extraluminal gas from perforation
- pericecal lymphadenopathy
- cecal wall thickening

https://www.researchgate.net/
Acute appendicitis. Barium enema showing irregularity of appendicular wall and filling defect due to fecaliths.

https://radiologypics.com/2014/03/21/
Axial LAVA-Flex MRI demonstrates a dilated fluid filled appendix with abnormal thickening and enhancement of the wall of the appendix

Patient with Abdominal Pain

Abdominal pain				
Clinical history physical examination				
Specific findings			**Non-specific history Left upper quadrant pain ? Pancreatitis Elderly patient with sepsis/non-specific abdominal pain**	
History of surgery Constipation/obstipation Prior history of peptic ulcer disease Toxic patient	**RUQ Murphy`s positive colic**	**Flank pain Colic + Dysuria+**	**RLQ perilumbilical psoas/Rovsing/ obturator sign+**	**Younger female UPT=vaginal discharge**
Intestinal obstruction Perforation/pneumoperitoneum	**Cholecystitis**	**Renal ureteric stone**	**Appendicitis**	**Ectopic pregnancy/PID**
AXR standing/supine		**X-ray KUB**		
		Ultrasound		
		Complications+	**Transvaginal if VAS inconclusive**	
		CT abdomen		

Algorithm for the evaluation of Right Upper Quadrant Abdominal Pain

Patient history

<table>
<tr><td>Pulmonary symptoms</td><td colspan="2">Urinary symptoms</td><td>Colic</td></tr>
<tr><td>Consider pulmonary embolus or pneumonia</td><td colspan="2">Consider urinary tract infection or nephrolithiasis</td><td>Consider a hepatobiliary cause or nephrolithiasis</td></tr>
<tr><td colspan="4">Physical examination</td></tr>
<tr><td>Tachypnea, hypoxia or pulmonary findings</td><td colspan="2">Costovertebral or suprapubic tenderness</td><td>Perform ultrasonography pf abdomen; if non diagnostic, consider nephrolithiasis</td></tr>
<tr><td>Chest radiography; if non diagnostic, CT to evaluation pulmonary embolism</td><td colspan="2">Perform a urinalysis</td><td rowspan="4"></td></tr>
<tr><td rowspan="3"></td><td>pyuria</td><td>hematuria</td></tr>
<tr><td>Consider urinary tract infection or pyelonephritis</td><td>Consider nephrolithiasis</td></tr>
<tr><td></td><td>CT</td></tr>
</table>

Algorithm for the evaluation of Right Lower Quadrant Abdominal Pain

<table>
<tr><td colspan="3">Patient with a history of fever or pain that moves from the periumbilical area to the right lower quadrant of the abdomen</td></tr>
<tr><td>yes</td><td colspan="2">no</td></tr>
<tr><td rowspan="2">Consider peritonitis or appendicitis</td><td colspan="2">Assess for psoas sign, rigidity, rebound, guarding, or pain on the right side of the rectum</td></tr>
<tr><td>Positive findings</td><td>Negative findings</td></tr>
<tr><td colspan="2">Consider CT with intravenous contrast media</td><td>Perform urine, colon, or pelvic examination</td></tr>
</table>

Algorithm for the evaluation of the Left Lower Quadrant Abdominal Pain

<table>
<tr><td colspan="3">Patient with a history of fever or diverticular disease</td></tr>
<tr><td rowspan="2">yes</td><td colspan="2">no</td></tr>
<tr><td colspan="2">Assess for abdominal distention, tenderness, and rectal bleeding</td></tr>
<tr><td></td><td>Positive findings</td><td>Negative findings</td></tr>
<tr><td colspan="2">Consider CT with oral and intravenous contrast media</td><td>Urinary or gynecologic evaluation</td></tr>
</table>

Intestinal obstruction

- small bowel obstruction (SBO)
- large bowel obstruction (LBO)

Clinical presentation

The classic clinical features of bowel obstruction are:

- colicky abdominal pain
- vomiting
- abdominal distension
- absolute constipation
- unstable vital signs
- acidotic blood gas as seen in bowel ischemia

Etiology

Small bowel obstruction

Congenital causes

- jejunal atresia
- ileal atresia or stenosis
- enteric duplication
- midgut volvulus
- mesenteric cyst

- Meckel diverticulum

Extrinsic causes

- fibrous adhesions
- post-operative adhesions
- inflammation or bowel wall thickening at the transition point
- abdominal hernia

A rare cause of SBO

- masses
- extrinsic neoplasm
- intra-abdominal abscess
- aneurysm
- hematoma

Intrinsic bowel walls causes

- inflammation, e.g. Crohn, tuberculosis, eosinophilic gastroenteritis
- small bowel obstruction in Crohn disease may relate to:
- acute flare with luminal narrowing secondary to transmural inflammation
- tumor (rare) - primary small bowel neoplasms are rare (<2% all GI malignancy) and usually advanced at the time of SBO.
- small bowel involvement of metastatic disease is more common
- intestinal ischemia

Intraluminal causes

- swallowed, e.g. foreign body, bezoar
- gallstone ileus
- a rare complication of recurrent cholecystitis
- biliary-intestinal fistula with impaction of a gallstone in the small bowel
- meconium ileus (or meconium ileus equivalent, distal intestinal obstruction syndrome)
- migration of a gastric balloon

Large bowel obstruction

Common causes

- cancer
- volvulus
- diverticular disease

Uncommon causes

- intussusception
- hernia
- inflammatory bowel diseases
- extrinsic compression from abscess or other masses
- fecal impaction
- intraluminal foreign body

Small bowel obstruction

Small bowel obstruction (SBO) is a common clinical syndrome for which effective treatment depends on a rapid and accurate diagnosis.

Radiographic features

Imaging plays an important role in both diagnosing bowel obstruction as well as helping determine the choice and timing of appropriate management.

The main aims of imaging in cases of suspected bowel obstruction are:

- differentiate true mechanical obstruction from ileus or constipation
- localize the site of obstruction
- identify an underlying cause
- assess for complications (e.g. ischemia or perforation)
- assess the viability of bowel segments involved

Plain radiograph

Plain abdominal radiographs are used as a screening tool for bowel obstruction but do not exclude this if they are normal.

Gas and fluid accumulating proximal to the site of obstruction cause progressive dilatation of small bowel. Some features on plain abdominal films are:

- central distended loops of small bowel, often >3 cm in diameter
- transverse stripes of the valvulae conniventes generally extend across the whole of the small bowel
- in the large bowel, the haustrae do not cross the diameter of the colon
- absence of gas in the large bowel; if gas is still present, it indicates that obstruction is recent or that it is incomplete
- when obstruction is high, such as the duodenum or upper jejunum, the above sings may be absent with lack of small bowel distention or fluid levels
- the site of obstruction can be predicted: if only a few dilated loops are found, then the obstruction is likely to be upper jejunum, but a large number of distended loops, the more distal the site of obstruction

Oral contrast studies such as a small-bowel follow-through can offer additional information regarding the degree of obstruction.

Findings suggestive of obstruction include

- dilated loops of small bowel and a delayed transit time of barium through a transition point

Limitations of small-bowel follow-through include

- the length of time required to perform the study
- dilution of barium because of excess residual intraluminal fluid
- the inability of patients to drink the barium in an acute setting

Enteroclysis allows areas that are nondistensible or fixed to be more easily identified.

When plain abdominal films are equivocal, barium follow-through examination may identify the level of obstruction, the principal feature being a change in the caliber from the dilated segment to a collapsed distal small bowel.

A barium enema is always "safe' in any suspected obstruction.

Ultrasound

Sonography is not commonly used for the evaluation of SBO mainly because most of the time the bowel loops are filled with gas, producing non-diagnostic sonograms, and because adhesions, the most common cause of mechanical SBO, are not detected with this technique.

However, when the obstructed bowel segments are dilated and filled with fluid, not only can the level of obstruction be recognized but the cause of the obstruction can also be demonstrated by using the fluid-filled bowel as a sonic window.

Features on US may include:

- dilated small bowel loops greater than 2.5 cm in diameter is suggestive of small bowel obstruction
- ineffective peristalsis
- results in "to-and-fro" or "whirling" appearance of intra-luminal contents
- prominence of the valvulae conniventes present in dilated jejunal loops

Ultrasound has 90% sensitivity and 96% specificity in diagnosing small bowel obstruction.

CT

Plain radiographs are increasingly being replaced by CT to assess for bowel obstruction.

Features on CT may include:

- dilated small bowel loops >2.5 cm up from outer wall to outer wall normal caliber or collapsed loops distally
- small bowel feces sign
- Closed-loop obstructions are diagnosed when a bowel loop of variable length is occluded at two adjacent points along its course.
- U-shaped or C-shaped configuration beak sign at the site of fusiform tapering whirl sign reflecting rotation of bowel loops around a fixed point

Strangulation is defined as closed-loop obstruction associated with intestinal ischemia. Mainly seen when the diagnosis is delayed (up to 10% of small bowel obstructions) and associated with high mortality.

Features are non-specific and include:

- thickened and increased attenuation of the bowel wall
- halo or target sign
- pneumatosis intestinalis
- portal venous gas
- localized fluid or hemorrhage in the mesentery

MRI

MRI provides rapid, accurate identification of small-bowel obstruction and assists in the determination of cause without exposing the patient to radiation. MRI also utilizes intraluminal air as a natural contrast agent and is not limited by previous administration of barium. The diagnosis of small-bowel obstruction on MRI is similar to CT and involves identifying dilated loops of bowel proximal to the obstruction, a distinct transition point, and normal-caliber or collapsed bowel distally.

Multiplanar capabilities of MRI allow visualization of the cause of small-bowel obstruction.

https://radiopaedia.org/cases/small-bowel-obstruction-42?lang=us
Dilated small bowel loops with multiple air-fluid levels consistent with obstruction.

Large bowel obstruction

Large-bowel obstruction is an abdominal emergency with high morbidity and mortality rates if left untreated. Although abdominal radiography is usually the initial imaging study performed in patients suspected of having large-bowel obstruction, it may not be sufficient to distinguish obstruction from other causes of colonic dilatation. Computed tomography is the imaging method of choice as it can establish the diagnosis and cause of large-bowel obstruction. A contrast agent enema may be used to confirm or exclude large-bowel obstruction.

Radiographic features

Plain radiograph

Normal colonic caliber ranges from 3 to 8 cm, with the largest diameter in the cecum; the remainder of the colon is dilated when it is greater than 6 cm and the cecum is not larger than 9 cm in diameter.

- the colon is dilated proximal to the site of obstruction with a paucity or absence of gas distal to the obstruction
- air-fluid levels are often seen in the dilated colon on the upright or decubitus radiographs
- the presence of air-fluid levels suggest that the cause of obstruction is more acute since the colonic fluid has not been present long enough to be absorbed

CT

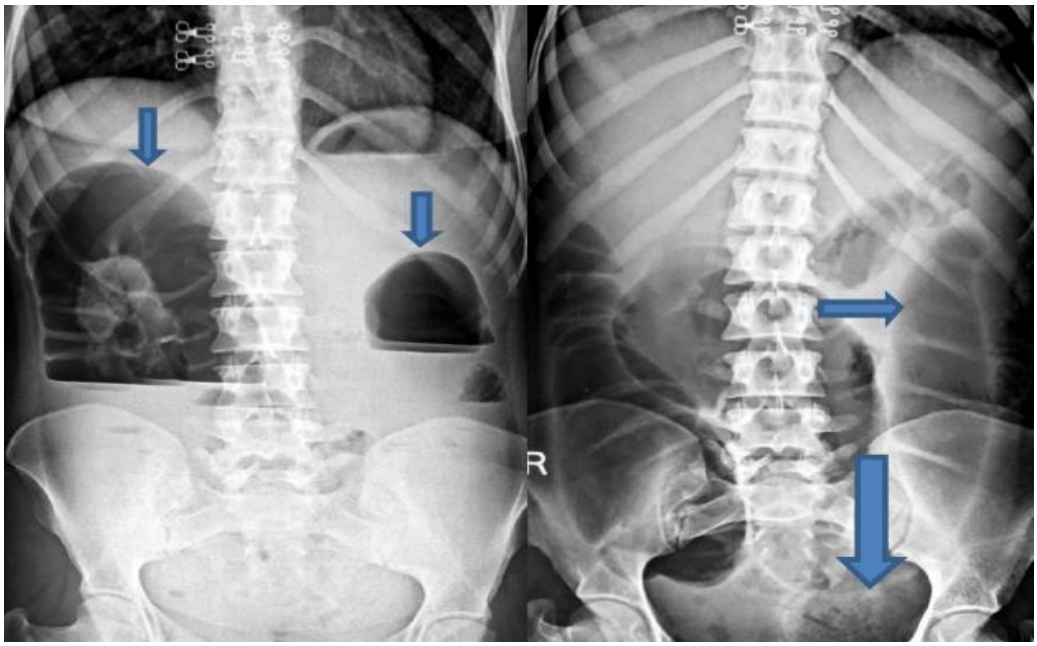
CT is the imaging modality of choice for the diagnosis of the cause of LBO. CT can be used to diagnose intraluminal, mural, and extramural causes of LBO. In patients with LBO secondary to malignancy, CT offers the additional benefit of detecting local and regional metastases.

- the diagnosis of LBO is based on dilated large bowel proximal to a transition point and decompressed bowel distal to the obstruction
- the presence of a transition point is considered a reliable finding for the diagnosis of LBO

The Contrast Enema

Although CT has become the preferred imaging study for evaluation of LBO, there are some indications for performing a contrast enema. The major advantage of the contrast enema is that it usually allows easy distinction between a LBO and colon pseudo-obstruction. It may also be used to confirm a colonic volvulus. The goal of the examination is to fill the colon adequately enough to detect the obstruction or demonstrate dilated colon without a transition point. Water-soluble iodinated contrast material should be used as it is easily absorbed in the peritoneum should there be a perforation. Additionally, if the enema is performed first, water-soluble contrast material does not cause an artifact on CT scans. The study should be performed under low pressure without inflation of the balloon.

To completely evaluate the colon, the patient must be able to rotate on the fluoroscopy table. This is particularly true for the sigmoid colon, which can be very redundant in the elderly patient.



https://appliedradiology.com/

Abdominal radiographs erect and supine reveal dilated large bowel loops (small arrows), and (B) lobulated mixed density lesion with internal mottled air foci at proximal sigmoid colon (large arrow).

Volvulus

Acute colonic volvulus accounts for approximately 10%–15% of LBO. Volvulus is defined as a twisting of the intestine upon itself that causes obstruction. If the twist is greater than 360°, the volvulus is unlikely to resolve without intervention.

Clinical symptoms of obstruction severe abdominal pain and distension, are due to the narrowing produced at the site of torsion. Vascular compromise at the site of volvulus leads to ischemia, necrosis, and perforation.

Sigmoid volvulus is three to four times more common than cecal volvulus (60%–75% vs 25%–33%, respectively), and volvulus of the transverse colon and splenic flexure is very rare (< 1%).

Causes are

- a mobile redundant colon on a mesentery and a fixed point about which the colon can twists
- sigmoid volvulus commonly occurs in the elderly, who have an elongated and chronically dilated sigmoid colon
- the more proximal colon volvuli occur due to a congenital defect in the cecum or transverse colon mesentery, which makes these segments of the colon more mobile and prone to twisting

Sigmoid volvulus

Sigmoid volvulus is the abnormal twisting of the sigmoid colon along the mesenteric axis, which leads to a closed-loop obstruction.

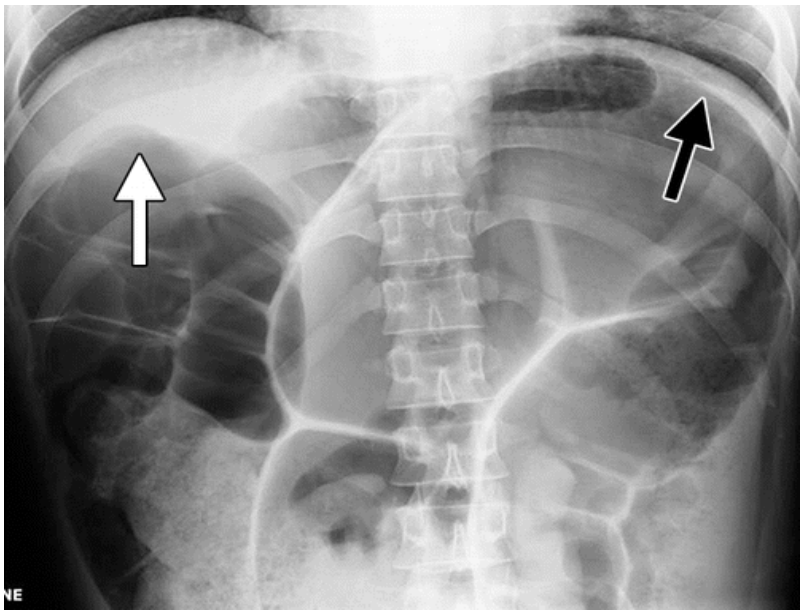
Radiological features

Plain radiograph

There are several classic signs describing the findings of colonic volvulus:

- ***The coffee bean sign*** describes the appearance of the volvulus, with apposition of the medial walls of the dilated loop of bowel forming the cleft of the bean and the lateral walls forming the outer walls of the bean; it can be seen in both sigmoid and cecal volvulus.

- ***The bird beak sign,*** seen in all colonic volvuli, describes the smooth, tapering transition point of the obstruction.
- ***The inverted U sign,*** an inverted ahaustral dilated sigmoid in the shape of an inverted "U" extending into the right upper quadrant, is specific to sigmoid volvulus.
- ***The northern exposure sign,*** also specific to sigmoid volvulus, describes the repositioning of the dilated sigmoid colon out of the pelvis to extend above the transverse colon. It is by far the most specific sign described related to sigmoid volvulus.
- Because sigmoid volvulus can be a closed-loop obstruction, there may be a substantial amount of gas in the more proximal colon and the small bowel.
- Absence of rectal gas is a common finding in sigmoid volvulus.



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Anteroposterior supine abdominal radiograph in a 58-year-old man with sigmoid volvulus and "northern exposure" sign shows markedly dilated sigmoid colon (black arrow) extending above the transverse colon (white arrow).

CT

CT is extremely helpful in the diagnosis of sigmoid volvulus.

the classic signs of sigmoid volvulus on CT scans

- absence of rectal gas
- U sign

- a single transition point in the sigmoid
- disproportionate enlargement of the sigmoid
- the coffee bean, kidney bean, and bent inner tube signs, all descriptors of the appearance of air-filled closed loop of colon, can all be seen in the setting of sigmoid volvulus
- a “beak” can be found at the point of twisting of the sigmoid colon and if necessary, may be confirmed with colonic contrast material
- the whirl signs, the appearance of spiraled loops of collapsed bowel with enhancing engorged vessels radiating from the twisted bowel, is often evident at the point of obstruction

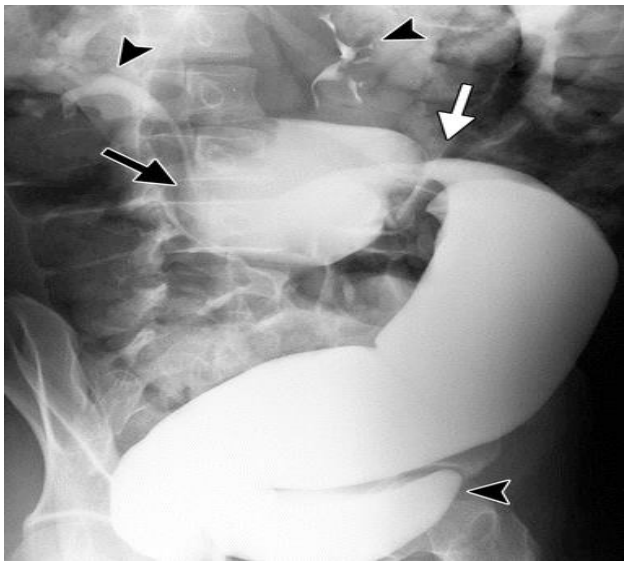
https://appliedradiology.com

Images in a 72-year-old woman with LBO caused by sigmoid volvulus. **(a)** CT scout image shows dilated, air-filled colon terminating in markedly dilated sigmoid colon folded upon itself with its apex (the “coffee bean sign”) in the midline upper abdomen (black arrow). The sigmoid also conforms to an “upside down U” configuration. There is no gas in the rectum (white arrow).

The water-soluble enema

The water-soluble enema is a helpful diagnostic tool in the confirmation of sigmoid volvulus.

- the classic beak sign is usually encountered at the site of torsion, and contrast material may not pass proximal to the transition point
- in some cases, however, the sigmoid volvulus does not produce a complete obstruction and contrast material may pass proximal to the beak, indicating a partial LBO; in these cases, the right colon and cecum are usually less dilated than the more distal colon.



https://appliedradiology.com
Anteroposterior supine abdominal radiograph after administration of water-soluble enema in a 64-year-old man with sigmoid volvulus shows a “beak” sign at the site of torsion (white arrow). Some contrast material is noted to pass above the level of obstruction (black arrow). Residual CT contrast material is seen in the renal collecting systems and bladder (arrowheads).

Cecal volvulus

Cecal volvulus is characterized by twisting of the cecum causing a proximal LBO. This phenomenon occurs when the right colon is not fused to the posterior abdominal wall. Pregnancy and recent colonoscopy, factors that result in dilatation of the right colon, predispose patients to cecal volvulus. In half of patients with cecal volvulus, the cecum twists in the axial plane, rotating along its long axis, appearing in the right lower quadrant. The other half of patients has a “loop” type of cecal volvulus, with the cecum twisting and inverting, resulting in the apex of the cecal twist in the left upper quadrant. The terminal ileum usually twists with the cecum. Identification of the displaced, gas-filled appendix confirms the diagnosis.

Radiological features

Plain radiograph

The diagnosis of cecal volvulus can be made in 75% of cases from the abdominal radiograph alone.

- the cecum rotates out of the right lower quadrant into the left upper quadrant and occasionally into the left lower abdomen or mid line
- here is often substantial cecal distension (> 9 cm), with little distal colonic gas
- an incompetent ileocecal valve causes dilatation of distal small bowel. The key to diagnosis with abdominal radiography is the recognition of displacement of the cecum out of the right lower quadrant
- if a contrast enema is performed, a classic beak sign will be demonstrated in the displaced ascending colon

It is important to recognize findings of ischemia in the cecum, which include pneumatosis in the cecal wall, pneumoperitoneum, and/or portal venous gas.

CT findings

- marked distension of the cecum in an abnormal location, usually in the mid or left upper abdomen
- the ileocecal valve is also displaced into the left upper quadrant. Coronal reformations confirm the abnormal location of the cecum
- the two limbs of the looped obstructed bowel taper and meet at the site of the twist, forming an appearance that resembles a bird’s beak
- the whirl sign can be found at the site of the twist
- the tightness of the twist is proportional to the degree of rotation
- given the proximal location of this LBO, small-bowel dilatation may also be an associated finding
- CT findings of ischemia associated with cecal volvulus include wall thickening, mural hypoenhancement, and pneumatosis

- mesenteric stranding and peritoneal fluid aid in the diagnosis of bowel wall ischemia

It is important to note that a distended cecum, 9 cm or greater, is at risk for perforation.

https://appliedradiology.com
Coronal reformatted CT images of the abdomen and pelvis in an 81-year-old woman with LBO caused by cecal volvulus. Image shows displaced cecum in the mid abdomen, with its apex located in the left upper quadrant (arrow). The ileocecal valve is displaced toward the left upper quadrant as well (arrowhead).

Transverse colon volvulus

The transverse colon volvulus is very uncommon, accounting for between 1%–4% of all colonic volvulus.

It occurs in patients with a redundant transverse colon on a long mesentery; failure of fixation of the mesentery may lead to mobility of the ascending colon and hepatic flexure, leaving these patients predisposed to transverse colon volvulus.

A contrast enema can confirm the diagnosis by demonstrating the classic beak at the point of obstruction in the transverse colon.

Findings at CT include LBO proximal to the twist in the mesentery. The right colon and cecum are midline or displaced to the left.

By far the least common site for reported colonic volvulus is the splenic flexure. Causes include postoperative adhesions, abnormal peritoneal attachments, and chronic constipation.

Adult Intussusception

Intussusception accounts for only a small number (< 1%–2%) of adult LBO cases.

The most common cause of a colocolonic intussusception is

- a primary colon carcinoma
- there are a number of benign lesions that can serve as lead points in colonic intussusception, the most common being adenomatous polyps and lipomas
- many other lesions have been reported to cause intussusception, including gastrointestinal stromal tumors, as well as a variety of appendiceal lesions, including the inverted appendiceal stump, endometriosis involving the appendix, and benign masses such as a mucocele
- other reported causes of LBO due to intussusception include eosinophilic colitis, pseudomembraneous colitis, and epiploic appendicitis

Abdominal radiographs may show only evidence of bowel obstruction, and if the lesion is in the right colon, the findings may mimic a SBO.

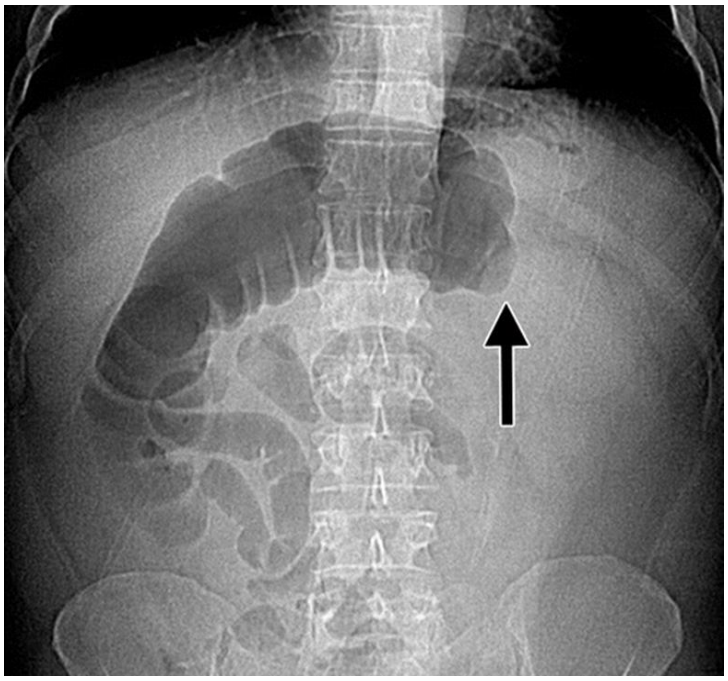
A contrast enema can identify the obstructing colonic mass and the classic "coil spring" appearance as the contrast material is trapped between the intussusceptum and intussuscipiens.

However, with signs and symptoms of a LBO, most patients will undergo an abdominal CT.

The CT findings of an ileocolic or colocolic intussusception include

- distended colon (the intussuscipiens) with a thickened wall an intraluminal intussusceptum telescoping within the intussuscipiens
- a curvilinear area of fat representing the invaginated mesenteric fat of the intussusceptum

- invaginated vessels may also be seen accompanying the intussusceptum
- the bowel has the appearance of a “target” in cross-section or sausage-shaped mass if in the longitudinal plane



https://appliedradiology.com
Plan abdominal film. Images in a 64-year-old man with LBO caused by a colocolonic intussusception.

ACPO or Ogilvie Syndrome

An Important Mimic of LBO.

ACPO (Ogilvie syndrome) was first described by Ogilvie in 1948 as a pseudo-obstruction secondary to interruption of sympathetic innervation of the colon. A number of etiologies have been implicated in causing colonic pseudo-obstruction. Although the exact pathophysiology is still unclear.

ACPO is most common in male patients over 60 years of age, and most are already hospitalized with a severe illness.

The symptoms of ACPO mimic those of LBO and include

- abdominal distension
- pain
- nausea
- vomiting

While they usually develop over 3 to 7 days, symptoms may occur more quickly. Abdominal tenderness, a common sign in the setting of LBO, is not a prominent feature of ACPO and its presence, especially in the presence of other signs of an acute abdomen, should prompt an immediate work-up to exclude perforation.

Abdominal radiographs

- demonstrate marked colonic distension predominantly involving the cecum, ascending colon, and transverse colon
- gas may also extend to the sigmoid colon and rectum

Because the cecum is routinely distended in ACPO, cecal ischemia and perforation are a major concern. Prolonged cecal dilatation beyond 2 to 3 days should prompt strong consideration for decompression with colonoscopy or surgery. The presence of pneumatosis in the cecum and/or ascending colon indicates ischemia of the bowel, and if not treated, the bowel will perforate. Free intraperitoneal air in ACPO suggests a colonic perforation and should prompt immediate surgery.

CT features

- colonic dilatation and with no obstructing lesion present.

https://radiopaedia.org/cases/8193/studies/9042?lang=us

Plan abdominal film. Colonic pseudo-obstruction (Ogilvie syndrome) is an acute colonic distention without an underlying mechanical obstruction.

Distinguishing between LBO and pseudo-obstruction is a major diagnostic challenge. In patients with diffuse colonic distention in the setting of ACPO, repositioning the patient after an initial supine radiograph of the abdomen and

obtaining additional images in a right lateral decubitus and/or prone position after a few minutes usually results in air filling the distal colon. This allows distinction between LBO and pseudo-obstruction. Furthermore, patients with a chronic colonic pseudo-obstruction can usually be established with prior abdominal radiographs and a history of chronically dilated large bowel.

Ultimately, if indistinguishable at abdominal radiography, the diagnosis may be made with a contrast enema. If the differentiation of LBO and ACPO remains problematic, CT may play a role in the diagnosis of ACPO. CT will allow characterization of the entire large bowel and help identify the presence or absence of a transition point.

Paralytic ileus

Functional ileus is one main category in which it is presumed that one or more loops of bowel lose their ability to propagate the peristaltic waves of the bowel, usually due to some local irritation or inflammation, and hence cause a functional type of "obstruction" proximal to the affected loop(s).

Clinical presentation

- paralytic ileus is marked by abdominal distension
- absent bowel sounds
- relatively little pain (as compared to mechanical obstruction)
- early paralytic ileus is marked by decreased or absent bowel sounds
- paralytic ileus may lead to complications causing jaundice
- electrolyte imbalance

There are two kinds of functional ileus.

- ***Localized ileus*** (also called sentinel loops) affects only one or two loops of (usually small) bowel.
- ***Generalized adynamic ileus*** affects all loops of large and small bowel and frequently the stomach.

Localized ileus

Pathophysiology

- Focal irritation of a loop or loops of bowel occurs most often from inflammation of an adjacent visceral organ, e.g., pancreatitis may affect bowel loops in the left upper quadrant, diverticulitis in the left lower quadrant.
- The loop(s) affected are almost always loops of small bowel and, because they herald the presence of underlying pathology, they are called sentinel loops.
- The irritation causes these loops to lose their normal function and become aperistaltic, which in turn leads to dilatation of these loops.
- Because a functional ileus does not produce the degree of obstruction that a mechanical obstruction does, some gas continues to pass through the defunctionalized bowel past the point of the localized ileus.
- Air usually reaches and is visible in the rectum or sigmoid.

Causes of a localized ileus

- cholecystitis
- pancreatitis
- appendicitis
- diverticulitis
- ulcer
- kidney/ureteral calculus

Radiological features

Plan abdominal film

- on conventional radiographs, there are one or two persistently dilated loops of small bowel
- persistently means that these same loops remain dilated on multiple views of the abdomen (supine, prone, upright abdomen) or on serial studies done over the course of time

- Dilated means the small bowel loops are persistently larger than 2.5 cm (small bowel loops involved in a functional ileus usually do not dilate as greatly as those which are mechanically obstructed).
- Infrequently, the sentinel loop may be large bowel, rather than small bowel. This can especially occur in the cecum, with diseases such as appendicitis.
- There are frequently air-fluid levels seen in sentinel loops.
- There is usually gas in the rectum or sigmoid in a localized ileus

Generalized adynamic ileus

Pathophysiology

- in a generalized adynamic ileus, the entire bowel is aperistaltic or hypoperistaltic. Swallowed air dilates and fluid fills all loops of both small and large bowels
- a generalized adynamic ileus is almost always the result of abdominal or pelvic surgery in which the bowel is manipulated during the surgery

Causes of a generalized adynamic ileus are

- postoperative (usually abdominal surgery)
- electrolyte imbalance

Radiological features

Plan abdominal film

- the entire bowel is usually air-containing and dilated, both large and small bowel; the stomach may be dilated as well
- the absence of peristalsis and the continued production of intestinal secretions usually produce many long air-fluid levels in the bowel
- since this is not a mechanical obstruction, there should be gas seen in the rectum or sigmoid
- bowel sounds are frequently absent or hypoactive

CT features

- multiple air-fluid levels throughout the abdomen
- elevated diaphragm

- dilatation of both large and small intestines
- no evidence of mechanical obstruction

Plan abdominal film. Marked distension of bowel loops with air-fluid levels. No evidence of mechanical obstruction.

Air under the diaphragm (perforation)

Gastrointestinal tract (GIT) perforation is a common medical emergency associated with considerable mortality, ranging from 30 to 50%.

Free abdominal air is also referred to as "pneumoperitoneum". It accumulates under one or both diaphragms when the patient is erect. Even small quantities can be detected on plain films

Causes:

- post laparotomy or laparoscopy is the commonest cause
- viscus perforation (peptic ulcer, colonic diverticulum

Clinical presentation varies:

- esophageal perforations can present with acute chest pain, odynophagia and vomiting
- gastroduodenal perforations with acute severe abdominal pain
- while colonic perforations tend to follow a slower progression course with secondary bacterial peritonitis or localized abscesses

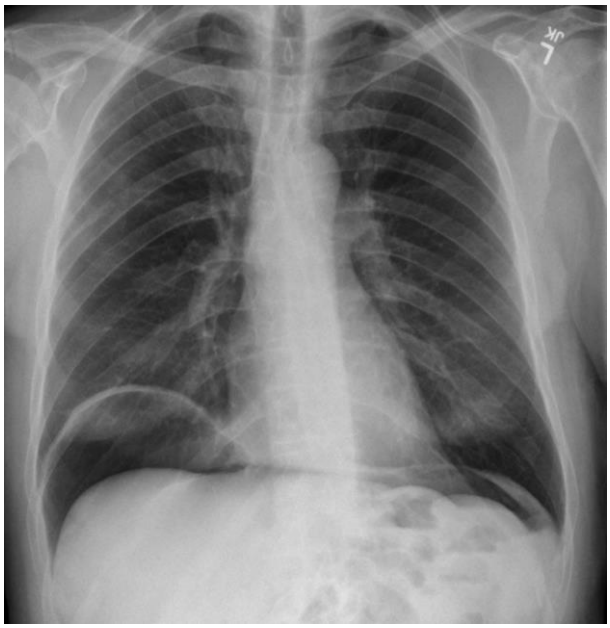
- a subset of patients may present with delayed symptoms, abscess mimicking an abdominal mass, or with sepsis

Radiological features

Chest x-ray film

- the erect position has to be maintained for a few minutes before air can be visualized as a crescentic area of lucency between the right diaphragm and liver or left diaphragm and spleen
- lateral decubitus abdominal films can be used for very ill patients; the best projection is the left lateral decubitus when free air will be seen between the right lateral margin of the liver and the peritoneal surface
- free air will not be seen in up to 20-30% of patients

Sometimes difficulty is encountered identifying the free air, either because of viscus distension or confusing gas shadows below the diaphragm. Large bowel interposition between the diaphragm and liver or spleen may simulate free air.

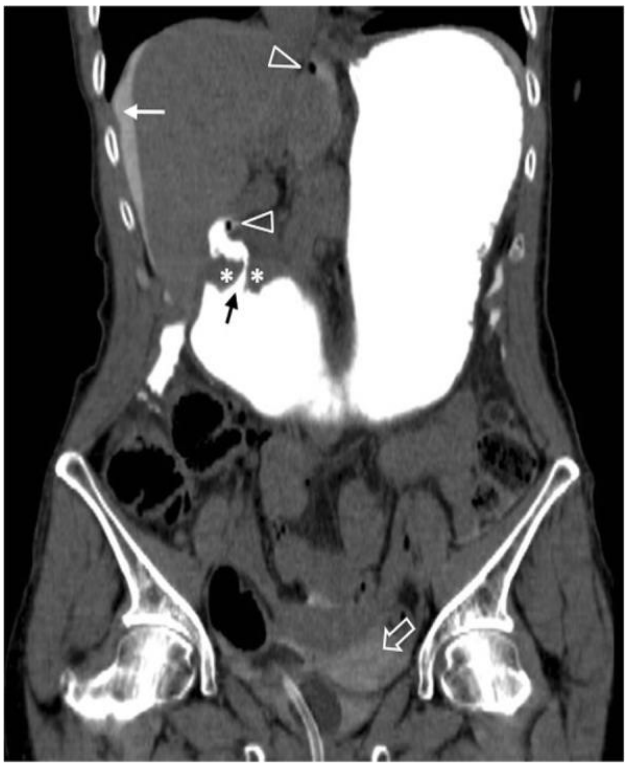


Chest x-ray film. Air under the diaphragm.

Direct multidetector computed tomography (MDCT) findings support the diagnosis and localize the perforation site while ancillary findings may suggest underlying conditions that need further investigation following primary repair of ruptured bowel.

MDCT findings include

- extraluminal gas
- visible bowel wall discontinuity
- extraluminal contrast
- bowel wall thickening
- abnormal mural enhancement
- localized fat stranding and/or free fluid
- localized phlegmon or abscess in contained perforation



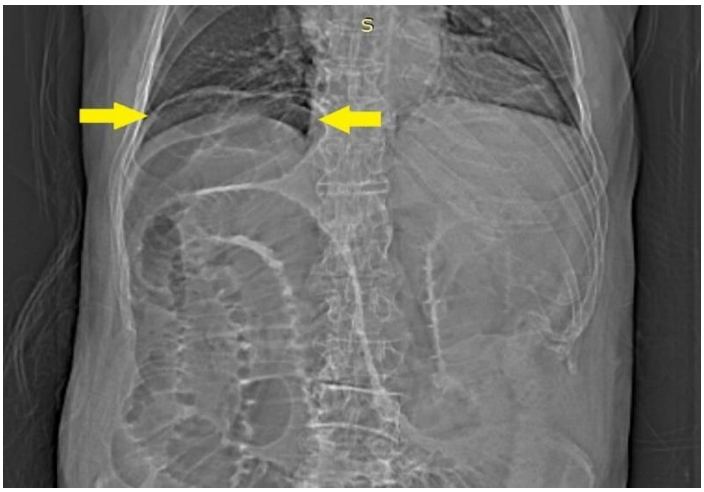
CT abdomen. 65-year-old patient with perforated duodenal ulcer. Coronal unenhanced image (modified soft tissue window) following oral contrast administration demonstrates a thickened duodenal wall (*), contrast leaking (black arrow) to the peritoneal spaces and free gas bubbles (arrowheads). Note hyperdensity of perihepatic free fluid (white arrow) compared with the diluted contrast in the rectouterine pouch (open arrow)

Pseudopneumoperitonium

Pseudopneumoperitonium describes any low attenuation within the abdominal cavity that masquerades as free intraperitoneal gas or pneumoperitoneum.

The following conditions simulate free air in the peritoneal cavity under of diaphragm:

- distended bowel
- sub-diaphragmatic fat
- curvilinear pulmonary collapse
- sub-phrenic abscess
- sub-pulmonic pneumothorax
- post hysterosalpingography
- pneumomediastinum (mimicking cupola sign)
- Chilaiditi sign - is a rare radiological sign that is described as the anterior interposition of the colon or the small intestine between the liver and the undersurface of the right diaphragm that may be mistaken as free intra-abdominal air
- pseudo-Rigler sign - may be seen when there is abundant omental or mesenteric fat outlining bowel loops or when the walls of two adjacent loops of gas-filled bowel are outlined by intraluminal gas
- diaphragmatic undulation
- gas within skin folds
- biliary, portal vein or bowel wall gas



https://radiopaedia.org/cases/166916/discussion?lang=us
Pseudopneumoperitonium

The anterior interposition of dilated small bowel loops between the liver and right hemidiaphragm (Chilaiditi sign) is a cause of pseudopneumoperitoneum on the scout view and abdominal radiograph.

Acute pancreatitis

Acute pancreatitis is a serious condition where the pancreas becomes inflamed over a short period of time.

Temporally, two phases of acute pancreatitis are identified in the Revised Atlanta Classification:

- ***Early*** - first week

Only clinical parameters are important for treatment planning and are determined by the systemic inflammatory response syndrome - SIRS, which can lead to organ failure.

- Late - after the first week

Morphologic criteria based on CT findings combined with clinical parameters determine the care of the patient.

The severity is classified into three categories based on clinical and morphologic findings:

- ***Mild*** - No organ failure and no local or systemic complications.

Moderate - Presence of transient organ failure less than 48h and/or presence of local complications.

- ***Severe*** - Persistent organ failure > 48 hour.

15-20% of cases.

Morphologically, there are two types of acute pancreatitis:

- Acute oedematous or interstitial pancreatitis.
- Acute necrotizing pancreatitis.
- Usually the necrosis involves both the pancreas and the peripancreatic tissues.
- Less commonly only the peripancreatic tissues.
- Rarely only the pancreatic parenchyma.

Symptoms of acute pancreatitis

- dull pain around the top of your stomach that develops suddenly
- this aching pain often gets steadily worse and can travel along your back or below your left shoulder blade
- eating or drinking may also make feel worse very quickly, especially fatty foods
- leaning forward or curling into a ball may help to relieve the pain, but lying flat on your back often increases the pain

Other symptoms

- nausea (feeling sick) or vomiting
- diarrhea
- indigestion
- a high temperature (fever)
- jaundice – yellowing of the skin and the whites of the eyes

CT is the imaging modality of choice for the diagnosis and staging of acute pancreatitis and its complications.

Ultrasound and ERCP with sphincterotomy and stone extraction play an important role in biliary pancreatitis.

The main role of ultrasound is:

- to identify gallstones as a possible cause
- diagnosis of vascular complications, e.g. thrombosis
- identify areas of necrosis that appear as hypoechoic regions
- assessment of clinically similar etiologies of an acute abdomen

Since the diagnosis of acute pancreatitis is usually made on clinical and laboratory findings, an early CT is only recommended when the diagnosis is uncertain, or in case of suspected early complications such as bowel perforation or ischemia.

Necrotizing Pancreatitis

Necrosis of pancreatic parenchyma or peripancreatic tissues occurs in 10-15 % of patients.

It is characterized by a protracted clinical course, a high incidence of local complications, and a high mortality rate.

There are 3 subtypes of necrotizing pancreatitis:

- Necrosis of both pancreatic parenchyma and peripancreatic tissues (most common).
- Necrosis of only extrapancreatic tissue without necrosis of pancreatic parenchyma (less common).
- Necrosis of pancreatic parenchyma without surrounding necrosis of peripancreatic tissue (very rare).
- Necrosis of the pancreatic parenchyma can be diagnosed on a contrast-enhanced CT $\geqslant$ 72 hours.

Necrosis of peripancreatic tissue can be very difficult to diagnose, but is suspected when the collection is inhomogeneous, i.e. various densities on CT.

MRI is superior to CT in differentiating between fluid and solid necrotic debris.

Radiological features

Plain abdominal film

- gas in the dilated duodenal loop optimally demonstrated in the left lateral decubitus position
- demonstration of the gas within the pancreas which appears as multiple small bubbles giving a mottled appearance
- «colon cut-off signs» due to spread of inflammation as no gas shadow is seen beyond the splenic flexure
- dilated small bowel loops
- loss of left psoas outline
- elevated left hemidiaphragm and left pleural effusion

Chest radiographs may demonstrate:

- pleural effusion, usually left-sided 25
- hemidiaphragm elevation
- basal atelectasis
- pulmonary edema suggestive of acute respiratory distress syndrome

Ultrasound features:

- diffuse enlargement of the pancreas with decreased echogenicity
- volume increase quantified as a pancreatic body exceeding 2.4 cm in diameter, with marked anterior bowing and surface irregularity
- decreased echogenicity secondary to fluid exudation, which may result in a marked heterogeneity of the parenchyma
- areas of necrosis are seen as hypoechoic areas within the gland
- pancreatic abscess is seen as circumscribed hypoechoic collection noted in the lesser sac and in the rest of the peritoneal spaces

CT features

typical findings

- focal or diffuse parenchymal enlargement
- changes in density because of edema
- indistinct pancreatic margins owing to inflammation
- surrounding retroperitoneal fat stranding

liquefactive necrosis of pancreatic parenchyma

- lack of parenchymal enhancement (should ideally be 1 week after symptom onset to differentiate from pancreatic hypoenhancement secondary only to edema)
- often multifocal
- infected necrosis
- difficult to distinguish from aseptic liquefactive necrosis
- the presence of gas is helpful (emphysematous pancreatitis)
- FNA helpful

abscess formation

- circumscribed fluid collection
- little or no necrotic tissues (thus distinguishing it from infected necrosis)
- hemorrhage
- high-attenuation fluid in the retroperitoneum or peripancreatic tissues
- calcification
- evidence of background chronic pancreatitis

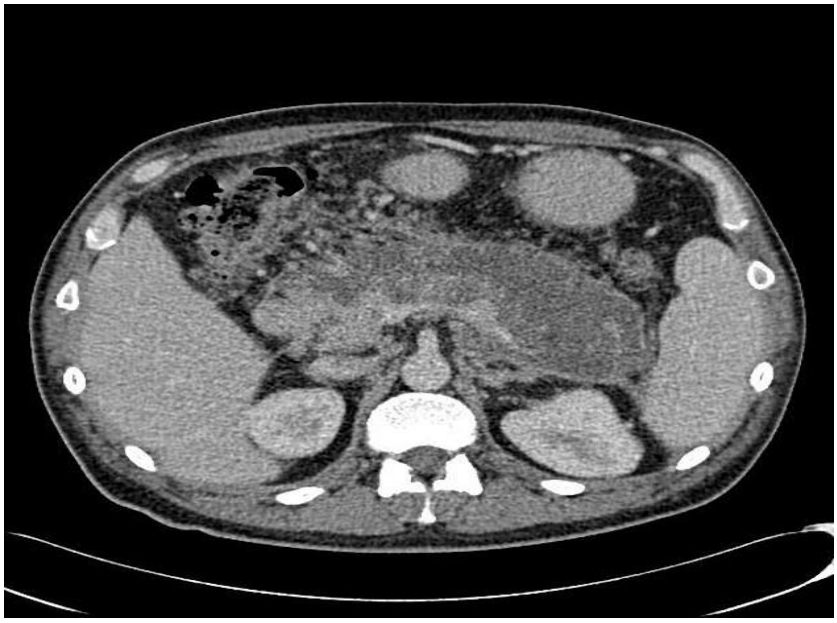
retroperitoneal fat necrosis

- low density collection showing minimal heterogeneity
- mimicking carcinomatosis

MRI

Contrast-enhanced MR is equivalent to CT in the assessment of acute pancreatitis.

Diffusion-weighted imaging shows hyperintense signal of the involved parenchyma with decreased ADC values



CT. Acute pancreatitis with associated walled-off pancreatic necrosis and peri-pancreatic edema

Acute cholecystitis

Acute cholecystitis is swelling (inflammation) of the gallbladder. Acute cholecystitis is the fourth most common cause of hospital admissions for patients presenting with an acute abdomen.

Symptoms of cholecystitis may include:

- severe pain in your upper right or center abdomen
- pain that spreads to your right shoulder or back
- tenderness over your abdomen when it's touched
- nausea
- vomiting
- fever

Cholecystitis symptoms often occur after a meal, particularly a large or fatty one.

Special forms of cholecystitis

Emphysematous cholecystitis

This special form of cholecystitis is usually –but not always- found in older diabetics and has characteristic US and CT feature. US shows air in the gallbladder fundus. CT confirms both intraluminal and intramural air.

Hemorrhagic cholecystitis

Hemorrhagic cholecystitis is rare and seen when gallbladder wall necrosis has led to intraluminal bleeding. It is more frequent in patients with anticoagulant therapy. US is usually aspecific but may show a large mass of sludge-like material and an irregular wall. CT shows hyperdense, non-attenuating masses within the gallbladder lumen

Xanthogranulomatous cholecystitis

This is a rare, but well recognized benign form of protracted cholecystitis.

It is possibly the result of multiple episodes of destructive inflammation due to the presence of stones.

It is important not to misdiagnose this entity as malignancy.

Cholecystitis mimicking malignancy

Acute cholecystitis sometimes is not recognized clinically, especially in the elderly, and may then be treated with antibiotics more than once.

This may cause mitigation and alteration of the normal inflammatory process leading to unusual US and CT findings.

In such cases not infrequently the diagnosis of gallbladder malignancy is suggested which may lead to ill-advised major surgery.

The gallbladder carcinoma is very rare, is usually inoperable at presentation and has a poor prognosis anyway.

The combination of clinical history, US and CT image, and the follow-up in time, can prevent unnecessary major surgery.

Acalculous cholecystitis

Acalculous cholecystitis is a confusing entity.

True acalculous, non-obstructive cholecystitis is extremely rare and is the result of primary ischemic necrosis of the gallbladder due to an episode of low-flow state, comparable with non-obstructive mesenteric ischemia (NOMI) leading to small bowel infarction.

It is often seen in older patients with other debilitating disease or after severe trauma.

The treatment is acute cholecystectomy.

Most patients diagnosed as “acalculous cholecystitis” are in fact patients with acute hydrops or cholecystitis in whom no stones can be found by US or CT, and also not at operation or in the pathological specimen.

However, when US unequivocally demonstrates hydrops in a patient, it is clear that there must be some sort of luminal obstruction, probably due to a very small stone or some sludge in combination with a narrow cystic duct.

Fistula formation

Acute cholecystitis can be complicated by perforation.

Most cases of perforated cholecystitis progress slowly and perforation is walled-off with local abscess formation.

Free perforation in acute cholecystitis is quite rare (as we discussed earlier).

Undiagnosed or untreated cholecystitis may also lead to fistula formation to the duodenum.

This is an uncommon complication, but when it occurs, most frequently there is passage of the stone to the small bowel, where it gets stuck and causes a gallstone ileus.

In rare cases of duodenal fistulisation, a large gallstone may get “stuck” at the fistula to the duodenum.

Due to secondary inflammatory and fibrous tissue, this may eventually lead to stenosis and obstruction.

This special situation is called “Bouveret syndrome” and its main clinical feature is gastric outlet obstruction.

Bouveret syndrome

In rare cases of duodenal fistulisation, a large gallstone may get “stuck” during a longstanding fistulisation process.

Due to secondary inflammatory and fibrous tissue, this may eventually lead to stenosis and obstruction of the duodenum.

This special situation is called “Bouveret syndrome” and its main clinical feature is gastric outlet obstruction.

Although rare, it is very important to make the correct diagnosis, because cholecystectomy is very dangerous and should be avoided.

Gallstone ileus

When untreated, acute cholecystitis may lead to new complications.

Purulent gallbladder contents including the gallstones may eventually evacuate to the duodenum or sometimes to the colon

This occurs usually in older patients, in whom cholecystitis often has remained undiagnosed and/or untreated.

It usually concerns a large stone, which classically gets stuck at the ileocecal valve, but in fact in most cases the stone obstructs the small bowel higher up in the ileum or even jejunum.

The diagnosis in most cases is much easier made using CT than US.

Fistula to the colon

This rare situation often develops subclinically and insidiously. In purulent cholecystitis the pus evacuates to the colon, however evacuation of the stones may take months or even years.

Patients eventually may develop chronic diarrhea due to bile irritation.

US signs are:

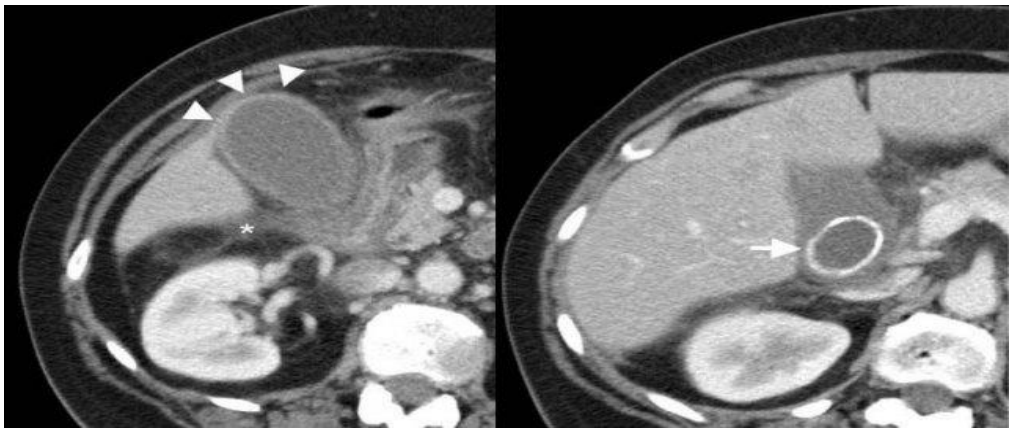
- a thick-walled gallbladder
- obstructing gallstone
- hydropical dilatation of the gallbladder
- occurrence of sludge as a sign of prolonged stasis
- hypervascularity of the gallbladder wall
- positive sonographic Murphy's sign (i.e., pain elicited by pressure over the sonographically located gallbladder)
- pericholecystic fat inflammation or fluid
- hyperemia of the gallbladder walls at power Doppler

CT in acute cholecystitis

CT can be very helpful in cases with a non-diagnostic US.

signs are:

- a thick-walled gallbladder
- obstructing gallstone
- a large gallbladder with only discrete pericholecystic changes
- a fuzzy corona around the gallbladder



https://radiologyassistant.nl/abdomen/biliary-system/gallbladder-wall-thickening
43-year-old woman with acute calculous cholecystitis. Contrast-enhanced CT shows a distended gallbladder (arrowheads) with a slightly thickened wall and subtle regional fat-stranding (asterisk). There is an impacted obstructing stone in the neck of the gallbladder (arrow).

Ruptured Aneurysm

Most abdominal aortic aneurysms rupture into the left retroperitoneum.

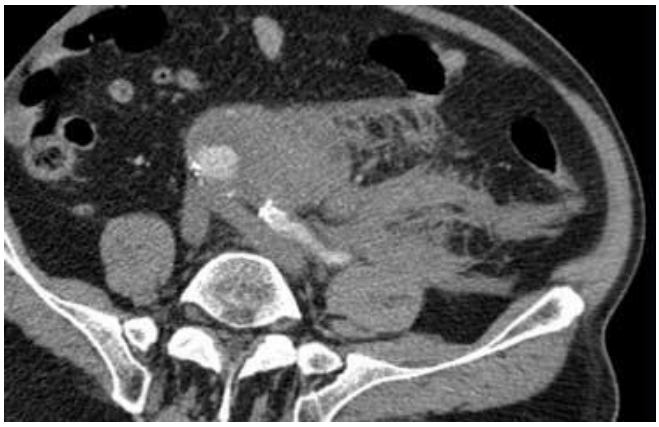
Clinically this may simulate sigmoid diverticulitis or renal colic due to impingement of the hematoma on adjacent structures.

However most patient will present with the classic triad of hypotension, a pulsating mass and back pain.

Continuous leakage will lead to rupture into the peritoneal cavity and eventually death.

Sonography is a quick and convenient modality, but it is much less sensitive and specific for the diagnosis of aneurysmal rupture than CT.

The absence of sonographic evidence of rupture does not rule out this entity if clinical suspicion is high.



https://radiologyassistant.nl/abdomen/acute-abdomen/practical-approach-to-acute-abdomen

Left retroperitoneal fluid collection due to ruptured aneurysm.

Abdominal Trauma

Trauma is the leading cause of death under the age of forty. Of all traumatic deaths, abdominal trauma is responsible for 10%.

Findings of abdominal trauma

- haemoperitoneum
- splenic trauma: most common
- hepatic trauma
- renal trauma
- pancreatic trauma
- gastrointestinal tract (bowel) trauma:
  - proximal jejunum is most commonly affected by blunt trauma, followed by the duodenum and ascending colon at the ileocecal valve region
  - descending colon is only rarely involved
- less common abdominal trauma injuries:
  - gallbladder
  - ureter
  - stomach
  - adrenal
- urinary bladder trauma
- vascular trauma: abdominal aortic injury and other major abdominal and pelvic vessel injuries (e.g. inferior vena cava, renal vessels, celiac axis, superior mesenteric vessels, lumbar vessels, and iliac vessels)
- abdominal wall trauma
- diaphragmatic rupture
- retroperitoneal hemorrhage
- hypoperfusion complex

Three imaging modalities (conventional radiography, ultrasonography, and CT) can be used to evaluate acute abdominal trauma. The appropriate selection of each

imaging modality is standardized by the Advanced Trauma Life Support (ATLS) protocol, which prioritizes the identification and management of potentially life-threatening injuries. The need for imaging must be weighed against the time required to perform it. When indicated, imaging is used during the primary survey (portable chest and pelvic radiography, FAST, or extended FAST [E-FAST]), secondary survey (CT, repeated FAST/E-FAST, or other conventional radiography), clinical observation, and admission.

Conventional Radiography

Conventional radiography has a very limited role in the evaluation of abdominal trauma owing to its poor sensitivity in identifying free fluid and organ injury.

However, a large amount of pneumoperitoneum may be detected on a portable supine trauma chest radiograph, which necessitates abdominal exploration in blunt mechanism and indicates peritoneal penetration in penetrating trauma. The main limitation is that the prevalence of such a finding is low, and pneumoperitoneum secondary to bowel injury, if present, is commonly observed in very small amounts, rendering it undetectable on radiography.

Conventional radiography remains helpful when free air or a foreign body is suspected (such as in gunshot or blast injuries), for the detection of apparent fractures, and as a follow-up in patients initially treated non-operatively

FAST

Ultrasonography plays an integral role in the initial evaluation of patients with abdominal trauma. The ATLS protocol recommends FAST or E-FAST as an adjunct to the primary survey with resuscitation. The aim of FAST, which has modest sensitivity, in this initial step is to detect free fluid, which can be blood or other traumatic fluids, including bowel contents. Pneumoperitoneum, bowel wall thickening, and mesenteric hematoma may be detected by ultrasonography, generally during either the secondary survey or admission.

CT

CT is the standard imaging modality for evaluating hemodynamically stable patients with blunt abdominal trauma, stab wounds to the flank and

thoracoabdomen, and gunshot wounds. For blunt bowel and mesenteric injuries, CT has high specificity but modest sensitivity for detecting lesions that require therapeutic laparotomy.

Optimal CT techniques are key to the accurate and reliable diagnosis of abdominal trauma. Although detailed techniques may vary from one center to another, at minimum, a trauma abdominopelvic CT should be performed with intravenous contrast administration in the arterial and portovenous phases to evaluate the mesenteric vasculature and delineation of the bowel walls. Unenhanced scanning may be useful for differentiating intrinsic hyperattenuating materials inside the bowel lumen, enteric contrast leakage, and AVCE.

Enteric (oral and/or rectal) contrast media are currently not recommended for the first CT in blunt abdominal trauma and are not routinely used in penetrating trauma.

Repeat CT

Repeat CT (with or without positive centric contrast) can be helpful in cases of persistent suspicion of significant bowel injury based on serial clinical examinations, inconclusive results of the initial CT, or in comatose polytrauma patients but there are no clinical signs warranting operative intervention. The scan should be performed at least 6 h after the initial CT to allow abnormalities to evolve and manifest. Some studies have suggested that the repeat scan be performed 24–48 h following trauma, although any decision should be weighed against the risks of delaying surgery to treat significant injuries. Concerning a suspected proximal bowel injury, such as in the duodenum, an immediate repeat CT with oral contrast can be helpful in differentiating full-thickness injury from partial-thickness injury when the initial CT is inconclusive and no clinical signs warrant immediate laparotomy

The findings to look for in abdominal trauma are the following:

- hemoperitoneum
- contrast blush consistent with active extravasation
- laceration: Linear shaped hypodense areas

- hematomas: oval or round shaped areas
- contusions: vague ill-defined hypodense areas that are less well perfused
- pneumoperitoneum
- devascularization of organs or parts of organs
- subcapsular hematomas

Hemoperitoneum

Hemoperitoneum (also haemoperitoneum, sometimes also hematoperitoneum) is the presence of blood in the peritoneal cavity. The blood accumulates in the space between the inner lining of the abdominal wall and the internal abdominal organs. Hemoperitoneum is generally classified as a surgical emergency; in most cases, urgent laparotomy is needed to identify and control the source of the bleeding. In selected cases, careful observation may be permissible. The abdominal cavity is highly distensible and may easily hold greater than five liters of blood, or more than the entire circulating blood volume for an average-sized individual. Therefore, large-scale or rapid blood loss into the abdomen will reliably induce hemorrhagic shock and, if untreated, may rapidly lead to death.

Causes of hemoperitoneum include:

- Penetrating trauma
- Blunt trauma, most commonly injuries to solid organs such as the liver and spleen.
- Vascular accidents, such as rupture of an abdominal aortic aneurysm, iliac aneurysm, or splenic aneurysm
- Bleeding due to a ruptured ectopic pregnancy or uterine rupture.
- Rupture of corpus luteum in some cases.
- Less commonly, bleeding due to a perforated gastric ulcer.
- Bleeding due to rupture of an intra-abdominal neoplasm, (e.g., Hepatoblastoma)
- Disseminated intravascular coagulation
- People on high dose of anticoagulants (blood thinners)

- Perforation of the colon

Radiological features

US

- Fluid is anechoic (black) on ultrasound.
- In the case of small amounts of hemoperitoneum, fluid may be visible only as an anechoic stripe separating the liver and the kidney on the right, or the spleen and the kidney on the left.
- Fluid may also accumulate between the spleen and diaphragm.
- Free fluid pooled in the pelvis is visible as anechoic collections lateral to the bladder on a transverse view.
- Free fluid may also be visible in the recto uterine recess (pouch of Douglas) in females using a sagittal view.
- In cases of gross hemoperitoneum, loops of bowel may be seen floating in blood.

CT

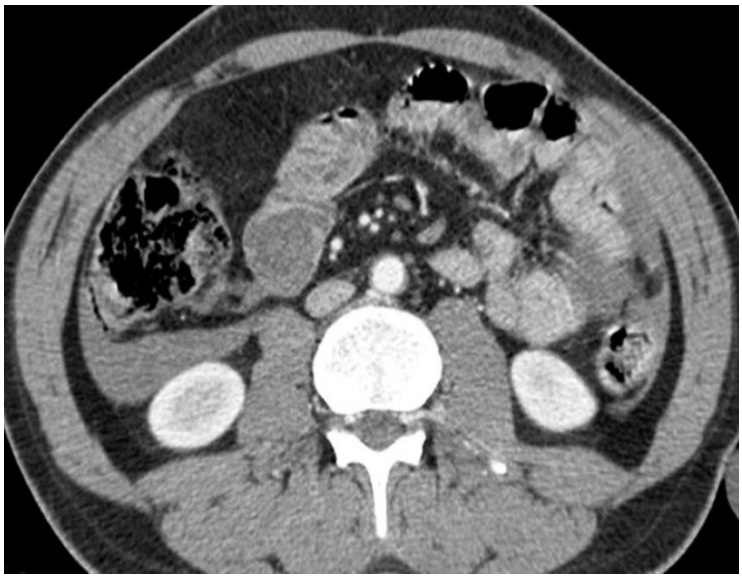
Traumatic hemoperitoneum may be detected at CT anywhere in the peritoneal cavity.

- The density of fluid in the abdomen suggests its composition (i.e. ascites/bowel contents/bile vs hemorrhage):
  - ***recent hemorrhage*** (acute bleed) measures 30-45 HU
  - ***clotted blood*** measures 45-70 HU
  - ***old blood*** products/seroma or blood in patients with anemia may measure <30 HU
- A collection of blood products can be homogeneous or heterogeneous (often low density with internal linear/nodular hyperdensities); fluid-fluid levels are often present.

MRI

- ***acute*** (<48 hours) hemoperitoneum has non-specific signal characteristics
- ***subacute*** (>3 weeks) may demonstrate concentric ring sign

- fluid-fluid levels (hematocrit effect) with high T1 / low T2 signal noted dependently



https://www.intechopen.com/chapters/38233
Axial contrast-enhanced CT images show hemoperitoneum: free fluid that has higher densities than gastric contents on CT soft-tissue windows. Intraperitoneal fluid is located in paracolic gutters and especially in perisplenic regions. Note that in the latter location hemoperitoneum have high density related to a splenic injury.

Pneumoperitoneum

Radiological features

CT

- Pneumoperitoneum is rare following blunt abdominal injury but can indicate bowel perforation. Soft-tissue windows are used at first, they can detect large amounts of Pneumoperitoneum who appear black.
- Smaller collections are attempted on lung windows, followed by bone windows.
- When detected on CT, it is not specific for bowel injury because air tracking from thoracic injuries can collect in the abdomen.
- Following penetrating abdominal injury, Pneumoperitoneum detected on CT is likely to indicate bowel perforation and prompts laparotomy in most cases.

US

Pneumoperitoneum is also sometimes visible on ultrasound.

- Air is hyperechoic and disrupts the ultrasound beam, preventing visualization of deeper structures.
- Because bowel gas is normally present in the anterior midline abdomen, free air should be sought overlying the liver, where air is not normally present.

Active bleeding

With the injection of contrast, active bleeding is visible as a bright white "blush" or amorphous collection on arterial phase imaging within a hypodense injured solid organ indicates active bleeding. This must be distinguished from normal enhancement of vessels within solid organs, such as portal and hepatic vessels within the liver. On delayed imaging the area of active extravasation remains high in attenuation and increases in size, a result of ongoing bleeding from the injured vessel after the initial phases of scanning.

Lacerations

Blunt or penetrating injuries may cut or rupture abdominal organs and/or blood vessels. Lacerations are a pattern of injury in which skin and underlying tissues are cut or torn.

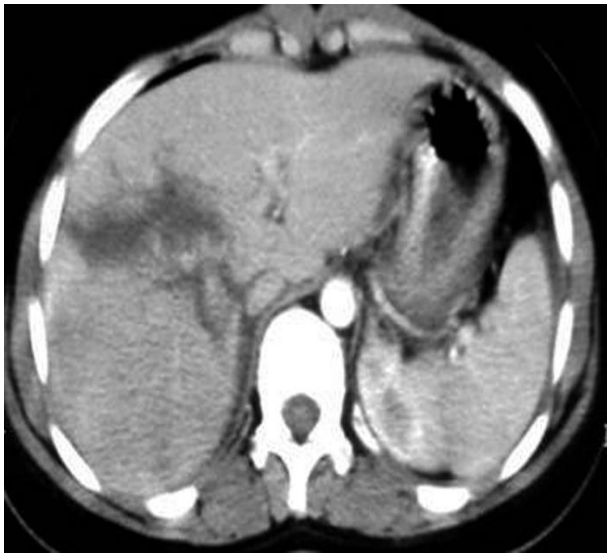
The laceration may initially be difficult to recognize in sonography or may appear slightly echogenic band. Acute splenic lacerations are seen on contrast-enhanced MDCT as linear or branching areas of low attenuation with well-defined margins. When lacerations extend through the organ capsule, hemoperitoneum results; if the capsule is intact, a subcapsular hematoma may be demonstrated. With time, the lacerations decrease in size and number. The margins become less well defined, and the area becomes isodense compared with normal splenic parenchyma. Although healing changes may be seen within 2 to 3 days, complete resolution may take weeks to months, depending on the size of the original injury. An increase in the number of lacerations on follow-up MDCT should alert the radiologist to the possibility of injury progression, and close clinical follow-up

with MDCT or angiography is advised. Splenic clefts may mimic lacerations on MDCT but typically have smooth or rounded margins. Fat may be periphery and become less visible, splenic clefts remain unchanged in appearance on delayed images.

https://www.intechopen.com/chapters/38233
Contrast enhanced CT scan: small splenic laceration that does not involve the hilum with free fluid surrounding the spleen

Fractures

When the bands of laceration cross the hypodense parenchyma, joining two opposite edges through the hilum, they are called fracture.



Contrast-enhanced CT scan showing a complex hepatic laceration: hepatic fracture

Contusions

They represent areas of injury. They appear on contrast-enhanced CT as parenchymal areas of low attenuation with irregular edges. Contusions are invariably a minor injury and gradually decrease in size as the injury heals.

https://www.intechopen.com/chapters/38233
Contrast-enhanced CT scan showing an hypodense area on the liver relevant to a hepatic contusion

Hematoma

Hematoma is generally defined as a collection of blood outside of blood vessels. Most commonly, hematomas are caused by an injury to the wall of a blood vessel, prompting blood to seep out of the blood vessel into the surrounding tissues. A hematoma can result from an injury to any type of blood vessel (artery, vein, or small capillary). A hematoma usually describes bleeding which has more or less clotted, whereas a hemorrhage signifies active, ongoing bleeding.

Radiological features

CT

Subcapsular hematomas:

- appear as crescentic regions of hyperdensity compared with adjacent normal parenchyma
- after contrast administration, subcapsular hematomas are seen as a low-attenuation collection between the splenic capsule and enhancing splenic

parenchyma that compress the underlying contrast-opacified organ parenchyma; this finding is useful in differentiating subcapsular hematomas from free intraperitoneal fluid or blood.

US

In sonography, it appears as a hyperechoic or hypoechoic rim or crescent

Intraparenchymatic hematomas

CT

- appear as a round hyperdensity compared with adjacent normal parenchyma
- after contrast administration, they appear as low-attenuation zones within the parenchyma; these may be homogeneous or inhomogeneous

US

On sonography, they are present as a localized area of increased echogenicity.

Contrast-enhanced CT scan: sub capsular splenic hematoma that involves more than 50% of surface area

Liver injury

The liver is frequently injured in blunt trauma. However, liver injuries can be detected in up to 25% of patients with blunt trauma if whole-body computed tomography (CT) is performed as the initial diagnostic procedure in severely injured patients admitted to the trauma center. Blunt liver trauma still carries a significant morbidity and mortality.

Detected lesions are the consequence of 3 different mechanisms: sudden deceleration such as in crash-car events, direct impact or penetrating wound. The more involved site is the right lobe, posterior–superior segments particularly, because it is the more voluminous portion of the liver; posterior superior hepatic segments are proximal to fixed anatomical structures such as ribs and spine, that may have an important role in producing the lesion. Coronal ligamentous insertion in this region increases the effect of the acceleration–deceleration mechanism. Associated lesions usually are homolateral costal fractures, lesions of the inferior right pulmonary lobe, haemothorax, pneumothorax, renal and/or adrenal lesions.

Traumatic lesions of the left hepatic lobe are rare and usually associated with direct impact of the superior abdomen. Associated lesions with left hepatic lobe injuries include sternal fractures, pancreatic, myocardial, duodenal and transverse colon lesions. Lesions of the caudate lobe are extremely rare, usually not isolated and are found with other significant lesions.

Generally, hemodynamically stable patients are submitted to sonographic examination for detection of fluid collections and, possibly, of parenchymal lesions. Sonographic findings of a traumatic lesion or of peritoneal fluid are an indication for CT examination. Patients in critical clinical condition go directly to CT examination of the abdomen and pelvis. CT with IV contrast is highly sensitive for liver injuries.

Radiological findings of traumatic lesion of the liver are:

- lacerations
- contusions
- subcapsular/central hematoma
- active hemorrhage
- periportal tracking
- juxtahepatic venous injuries
- avulsion of the hepatic pedicle.

Hepatic lacerations are the most common type of parenchymal liver.

Lacerations can be classified

- as superficial (<3 cm in depth)
- deep (>3 cm) [19]

The detection of active contrast material extravasation at CT is important because it indicates an ongoing, potentially life-threatening hemorrhage.

Liver injuries are graded in severity based on CT appearance using a six-point scale according to AAST scaling that guides nonoperative management. This scaling is regarding the lesion extension and bleeding.

The AAST (American Association for the Surgery of Trauma) liver injury scale, recently revised in 2018, is the most widely used liver injury grading system

Classification

grade I

- hematoma: subcapsular, <10% surface area
- laceration: capsular tear, <1 cm parenchymal depth

grade II

- hematoma: subcapsular, 10-50% surface area
- hematoma: intraparenchymal <10 cm diameter
- laceration: capsular tear 1-3 cm parenchymal depth, <10 cm length

grade III

- hematoma: subcapsular, >50% surface area; ruptured subcapsular or parenchymal hematoma
- hematoma: intraparenchymal >10 cm
- laceration: capsular tear >3 cm parenchymal depth
- vascular injury with active bleeding contained within liver parenchyma

grade IV

- laceration: parenchymal disruption involving 25-75% of a hepatic lobe or involves 1-3 Couinaud segments

- vascular injury with active bleeding breaching the liver parenchyma into the peritoneum

grade V

- laceration: parenchymal disruption involving >75% of hepatic lobe
- vascular: juxtahepatic venous injuries (retrohepatic vena cava / central major hepatic veins)

Additional points

- advance one grade for multiple injuries up to grade III
- for each grade, the worst feature is chosen, either hematoma or laceration (no need for both/all to coexist)
- "vascular injury" (i.e. pseudoaneurysm or AV fistula): appears as a focal collection of vascular contrast which decreases in attenuation on delayed images
- "active bleeding": focal or diffuse collection of vascular contrast which increases in size or attenuation on a delayed phase

Pancreatic injury

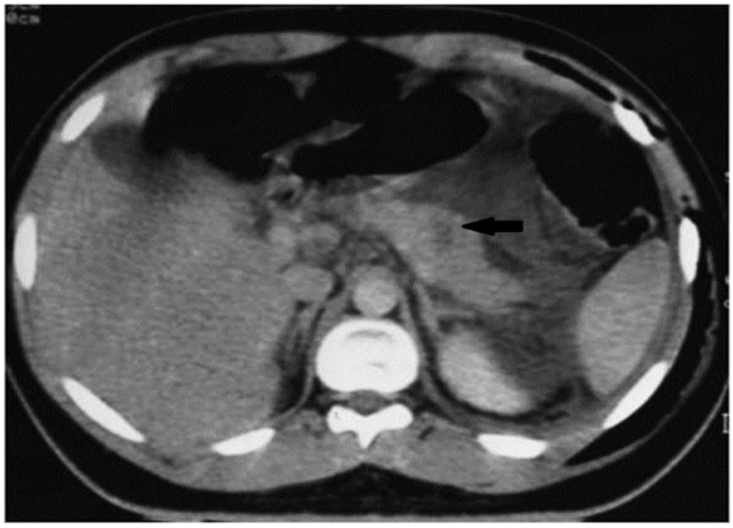
Pancreatic injuries are rare, occurring in around 2% of blunt trauma patients, but may be associated with high morbidity and mortality, particularly if diagnosis is delayed.

These injuries often occur during traffic accidents as a result of the direct impact on the upper abdomen of the steering wheel or the handlebars. localization pancreatic injuries are rarely isolated; Organ injuries most commonly associated are hepatic (46.8% of cases), gastric (42.3%), major vascular (41.3%), splenic (28.0%), renal (23.4%), and duodenal (19.3%).

Pancreatic injuries are often subtle and may be overlooked in patients with extensive multiorgan trauma. In 20%–40%, initial CT findings of patients with pancreatic injuries may be within normal limits in the first 12 hours after the injury. It is important to detect disruption of the pancreatic duct which is treated

surgically or by therapeutic endoscopy with stent placement, while injuries without duct involvement are usually treated nonsurgically.

Today, computed tomography (CT) provides the safest and most comprehensive means of diagnosis of pancreatic injury in hemodynamically stable patients.



Contrast enhanced axial CT in the portal-venous phase demonstrates an intraparenchymal pancreatic contusion (arrow).

Spleen injury

The radiologist has the essential task of providing an adequate diagnosis and classification of a splenic injury in order to refer the patient to a conservative treatment or to a surgical one.

The poly-injured patient's radiological study is different according to the dynamics of trauma and their clinical conditions upon arrival at the emergency room.

Poly-traumatized hemodynamically unstable patient: Basic diagnostic tests are performed (chest and pelvis X-Rays, US e-FAST) to find pneumothorax, hemothorax, and hemoperitoneum. If one of these three is diagnosed and the patient is still hemodynamically unstable, he is directed to the surgical room. In the emergency room, the doctors try to stabilize the patient (with plasma expanders, hemothorax and pneumothorax drainage, pelvis fracture stabilization) and, if they achieve a hemodynamic stability, the patient is subjected to a total-body contrast-enhanced MDCT scan (CE-MDCT).

Several types of splenic injury can occur:

- intraparenchymal and subcapsular hematoma

- contusion
- Laceration
- active extravasation
- contained vascular injury

Clotted blood has an attenuation of approximately 45–70 Hounsfield Units (HU); it is better seen in basal phase as a slightly hyperdense area, while unclothed blood has an attenuation of 30–45 HU.

CT features

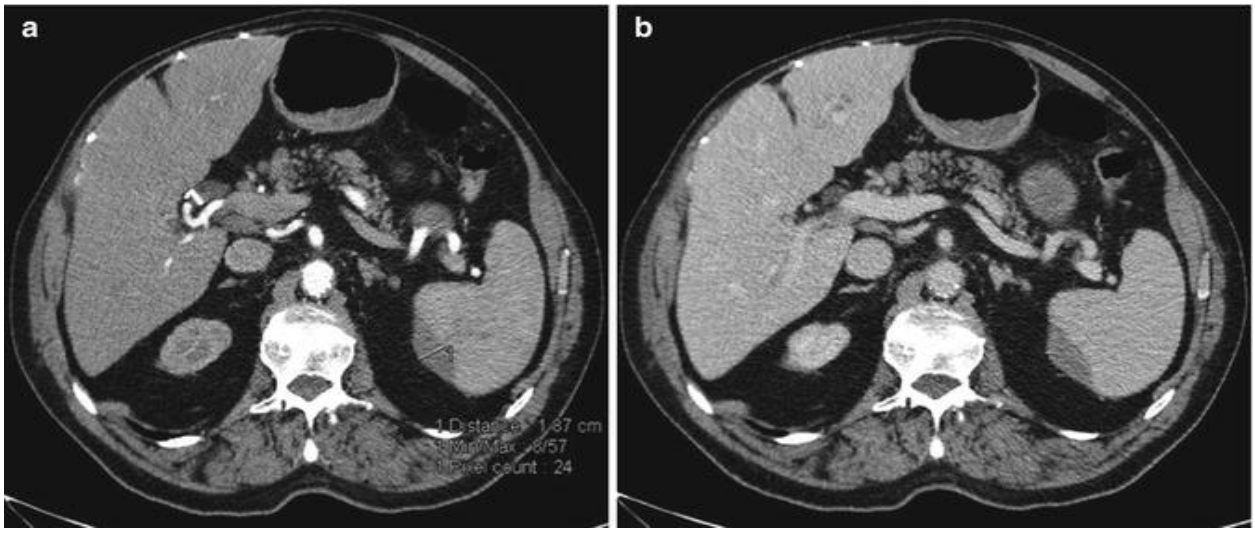
Parenchymal hematoma: At basal exam, a parenchymal hematoma may appear to be an area with defined margins, if it is made up of recent blood it is hyperdense but it can be iso-hypo-hyperdense compared to the surrounding parenchyma in relation to the time elapsed since the blood collected; during the dynamic phases, it is hypodense compared to the remaining parenchyma.

Subcapsular hematoma: Similarly, at basal exam, subcapsular hematoma has the same semeiotic of a parenchymal hematoma and appears like a peripheral crescent collection that displaces and marks the parenchyma the splenic parenchyma: it can even grow to considerable size, it is always hypodense during dynamic phases, and it can have a multi-stratified appearance due to repeated bleeding.

Splenic contusion: It is not well defined at baseline; instead at the contrast-enhanced exam, it appears as a small hypodense area with blurred margins caused by perilesional interstitial edema and local blood suffusion.

Laceration: It appears as a linear lack of parenchymal opacification with an irregular shape that may extend to the capsule. It is important to report the laceration site, which can be superficial, if it interests only the capsule, or deep, involving vascular structures of splenic hilum.

Severe disruption of splenic parenchyma can result in a “shattered” spleen. Vascular hilum injuries usually result in significant hemorrhage and cardiovascular instability.



https://radiologykey.com/splenic-injuries/

Grade 2: these CT axial pictures show a subcapsular hematoma, smaller than 3 cm, studied in both arterial (a) and venous phase, (b). The arterial phase is more sensitive for the evaluation of vascular injury including active bleeding and vascular lesions: in fact, it is a not replenished hematoma as we cannot see any sign of active bleeding

Summary

Acute abdomen is a common scenario encountered in the emergency radiology setting. There are many challenges associated with dealing with such patients, including optimizing the imaging technique as well as efficient and accurate image interpretation to allow timely management.

Modern diagnostic imaging offers wide range spectrum of modalities and techniques, which enables us to study the function and morphology of the human body in details that approaches science fiction.

The students should be aware of the spectrum of radiography, ultrasonography, CT and MRI findings associated with acute abdomen, including common misses and challenging presentations. Rapid assessment, diagnosis and treatment are essential as acute abdomen is an unstable condition.

The manual covers the examination techniques and interpretation of radiography, ultrasonography, CT and MRI images of acute abdomen. It is meant for 3-year student of speciality “Medicine”. The manual presents the urgent conditions of the abdomen (their classification, causes, stages, radiological signs and complications).

Recommended literature

Basic

1. Kravchuk S. Yu. Radiology: textbook for student and interns of medical institutions of higher education / S. Yu. Kravchuk. - Kyiv: AUS Medicine Publ, 2021. - 224 p.
2. Radiology and imaging of the gastrointestinal tract: manual / E.G. Nordio, N.V. Tumanskaya, S.A. Myagkov, D.V. Syvolap – Zaporizhzhia, ZSMU, 2022.- 86p.

Additional literature

1. Ultrasound diagnosis of pancreatic diseases: навч. посібник/ N.V. Tumanskaya, E.G. Nordio, T.M. Kichangina, D.V.Syvolap, S.A. Myagkov – Запоріжжя, ЗДМУ, 2020. - 71с.
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3. Kovalsky O. V. Radiology. Radiotherapy. Diagnostic imaging: textbook higher medical educational establishments of IV th accred. level / O. V. Kovalsky, D. S. Mechev, V. P. Danylevych. - 2nd ed. - Vinnytsya : Nova Knyha, 2017. - 504 p.