

# Blood in the Belly: CT Findings of Hemo- peritoneum<sup>1</sup>

## CME FEATURE

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## LEARNING OBJECTIVES FOR TEST 4

After reading this  
article and taking  
the test, the reader  
will be able to:

- Recognize the CT manifestations of hemoperitoneum.
- Describe the spectrum of disease associated with traumatic and nontraumatic hemoperitoneum.
- Identify key CT features that may help direct management.

## TEACHING POINTS

See last page

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Hemoperitoneum may occur in various emergent conditions. In the trauma setting, evidence of intraperitoneal blood depicted at computed tomography (CT) should lead the radiologist to conduct a careful search of images for the injured visceral organ (the liver or spleen). Specific CT signs, such as a sentinel clot or extravasation of intravascular contrast material, may indicate the source of bleeding and help direct management. In addition, the configuration of accumulated blood may help identify the injured organ; for example, triangular fluid collections are observed in the mesentery most often in the setting of bowel or mesenteric injury. Less commonly, hemoperitoneum may have a nontraumatic origin. Iatrogenic hemoperitoneum may occur as a complication of surgery or other interventional procedures in the abdominal cavity or as a result of anticoagulation therapy. Hemoperitoneum also may be seen in the setting of blood dyscrasias such as hemophilia and polycythemia vera. Tumor-associated hemorrhage, which most often occurs in hepatocellular carcinoma, hepatic adenoma, or vascular metastatic disease, also may produce hemoperitoneum. Other potential causes of nontraumatic hemoperitoneum are gynecologic conditions such as hemorrhage or rupture of an ovarian cyst and rupture of the gestational sac in ectopic pregnancy, and hepatic hematoma in syndromic hemolysis with elevated liver enzymes and low platelet count (HELLP syndrome). Vascular lesions (visceral artery aneurysms and pseudoaneurysms) that occur in systemic vascular diseases such as Ehlers-Danlos syndrome or in pancreatitis are another less common source of hemoperitoneum.

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**Abbreviation:** HELLP = hemolysis, elevated liver enzymes, and low platelet count

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**Causes and CT Findings of Hemoperitoneum**

Cause	Findings
<b>Traumatic</b>	
Solid organ injury	Sentinel clot sign with accumulations of high-attenuation fluid near or around the injured organ, in the paracolic gutters, and in the pelvis; serpiginous border of high-attenuation area suggestive of active extravasation of contrast material
Mesenteric or bowel injury	Triangular high-attenuation interloop mesenteric fluid collections; bowel wall thickening; high-attenuation free fluid indicative of active extravasation of intravenous contrast material from mesenteric tear or of oral contrast material from site of bowel injury
<b>Nontraumatic</b>	
Iatrogenic injury (complication of surgery, interventional procedure, or anticoagulation therapy)	High-attenuation fluid in surgical bed, at site of intervention, or around liver and spleen in patient undergoing anticoagulation therapy
Tumor-associated hemorrhage	Tumor site in liver, spleen, or peritoneum, with surrounding high-attenuation fluid; sentinel clot sign
Gynecologic condition (ruptured ovarian cyst, ectopic pregnancy, HELLP syndrome)	Fluid with internal echogenicity or high attenuation around the uterus and adnexa; associated mixed-attenuation adnexal mass with a high-attenuation component or fluid-fluid level
Vascular lesion (aneurysm or pseudoaneurysm of visceral artery)	Accumulation of contrast material within an apparent aneurysmal sac surrounded by high-attenuation free fluid; clinical history of systemic vascular disease (eg, Ehlers-Danlos syndrome) or pancreatitis

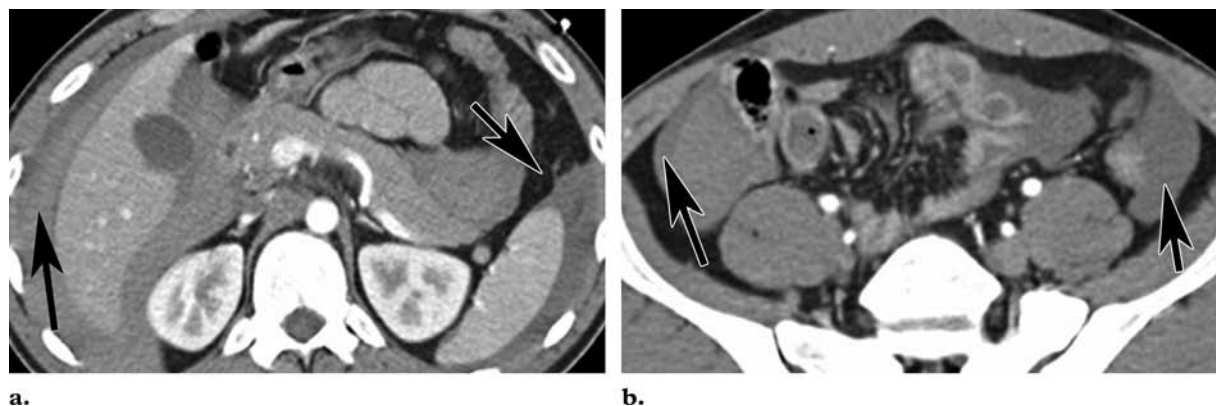
**Introduction**

Although ultrasonography (US) may be used for the evaluation of hemoperitoneum in the trauma patient, computed tomography (CT), because of its speed and proximity to the trauma bay, is used increasingly for such evaluations. CT has high sensitivity for the detection of even small effusions of blood in the peritoneal cavity (1). Numerous CT signs and findings of hemoperitoneum, including a sentinel clot, active arterial extravasation, and mesenteric fluid, may enable the radiologist to locate sources of intraperitoneal hemorrhage and help direct management. Trauma-related injury to a solid organ, particularly to the liver or spleen, is by far the most common cause of hemoperitoneum. However, the radiologist must be aware of the myriad of other possible causes of hemoperitoneum that are unrelated to trauma, especially hemorrhage from a tumor, rupture of an ovarian cyst or of the affected anatomy in an ectopic pregnancy, and iatrogenic bleeding as a result of surgery or other therapy. This article provides an overview of the key CT findings seen in patients with traumatic and nontraumatic hemoperitoneum (Table).

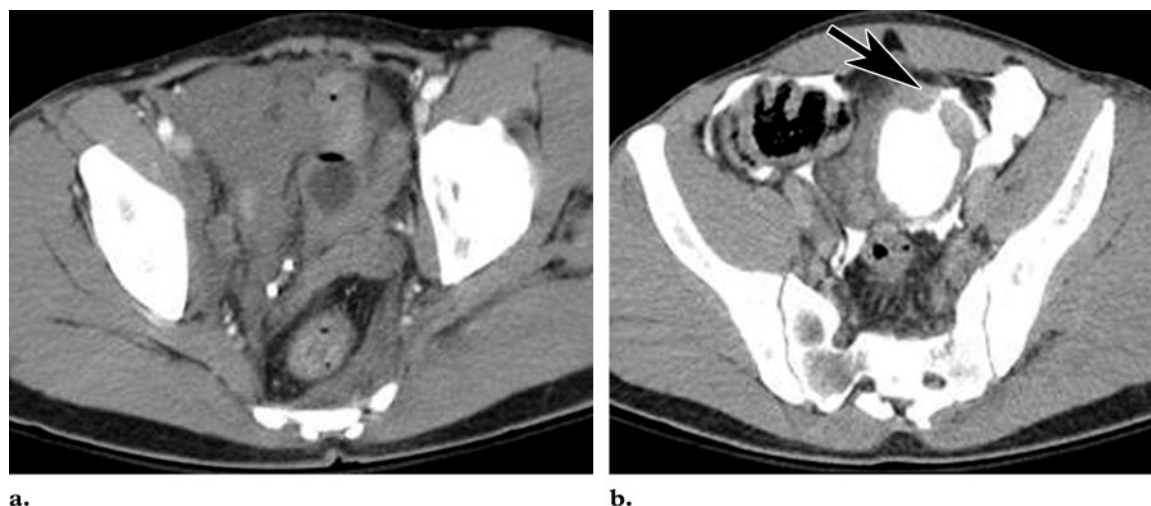
**CT Signs of Hemoperitoneum****Peritoneal Spaces**

The peritoneal cavity contains the liver, spleen, bowel, stomach, and mesentery. In the supine position, the most dependent portion of the abdomen is the hepatorenal fossa (Morison pouch), and the most dependent portion of the pelvis is the pelvic cul-de-sac (pouch of Douglas). Hemoperitoneum starts near the site of injury and flows along expected anatomic pathways. Hemorrhage from the liver typically flows in a caudal direction from the perihepatic spaces and hepatorenal fossa, along the right paracolic gutter, and into the cul-de-sac, which is the rectouterine space in women and rectovesical space in men (Fig 1). Similarly, hemorrhage from the spleen typically flows in a caudal direction from the perisplenic spaces, along the left paracolic gutter, and into the pelvis (2). A large volume of blood may collect in the pelvis without an obvious hematoma surrounding the source organ. Thus, the appearance of the cul-de-sac is crucial to the diagnosis of hemoperitoneum. Small amounts of fluid or blood in this region may be the only sign of an intraperitoneal injury and should prompt a careful inspection of images of the viscera (3–6).

It is important to bear in mind that, in trauma cases, significant abdominal injuries may be



**Figure 1.** Typical flow pattern of hemorrhage from a liver laceration. **(a)** Contrast material-enhanced CT image shows high-attenuation fluid (arrows) in perihepatic and perisplenic regions, the hepatorenal fossa, and the lesser sac. **(b)** Contrast-enhanced CT image at a lower level than **a** shows blood tracking laterally along the paracolic gutters (arrows).



**Figure 2.** Free intraperitoneal fluid after trauma. **(a)** Contrast-enhanced CT image shows a large volume of high-attenuation free intraperitoneal fluid. A subsequent CT cystogram revealed that most of the fluid was urine leaking from an injured bladder. **(b)** Contrast-enhanced CT image shows leakage of urine from a bladder rupture at the 1-o'clock position (arrow).

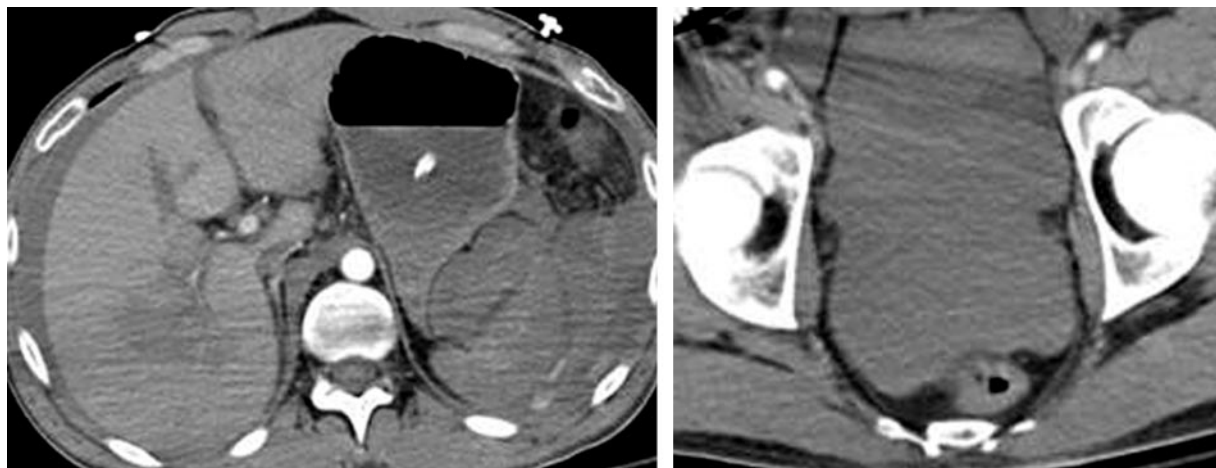
present without apparent hemoperitoneum. For example, intraparenchymal lacerations or contusions may be present without penetration of the organ capsule. Knowledge of the relationship of abdominal organs to the surrounding peritoneal spaces is crucial. For example, because the bare area of the liver is contiguous with the retroperitoneum, retroperitoneal fluid rarely may be the only sign of hepatic injury, although intraperitoneal fluid is more commonly seen in cases of solid organ injury. In a patient with abdominal trauma, a CT finding of free intraperitoneal fluid without solid organ injury should arouse suspicion about the possible presence of a bowel laceration or perforation (7,8).

### High Attenuation of Blood

The utility of CT for the detection of hemoperitoneum lies in its ability to depict the difference between low-attenuation fluid and blood, which has a higher attenuation. Attenuation measurements at CT can help differentiate among simple as-

cites, unclotted blood from recent bleeding, hematoma, bile, urine, chyle, and active bleeding (9). The attenuation values of fluids that have approximately the same density as water (eg, bile, urine, and the intestinal contents) range from 0 to 15 HU. The recognition of such fluids on CT images can be aided by visual comparison with adjacent fluid-filled structures such as the urinary bladder and gallbladder. Attenuation should be directly measured in cases in which the differences are subtle, because the appearance may be misleading. The administration of both intravenous and water-soluble oral contrast material may be helpful; the presence of free fluid from a bowel perforation can be confirmed by showing free intraperitoneal water-soluble oral contrast material, and urinary ascites can be distinguished from hemoperitoneum with delayed phase (urographic phase) CT or CT cystography (Fig 2).

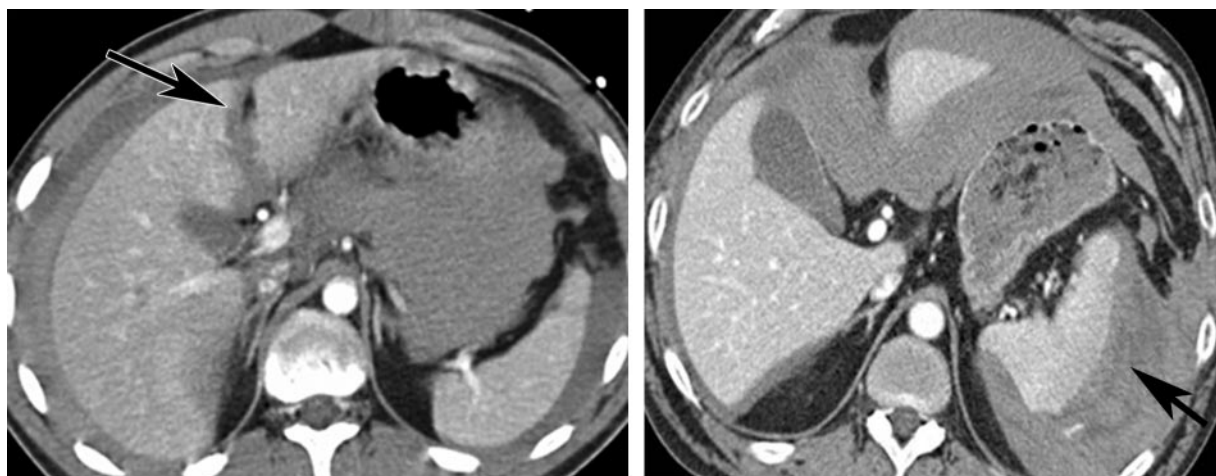




a.

b.

**Figure 3.** Low-attenuation hemoperitoneum in a hemophiliac patient with a splenic rupture. (a, b) Contrast-enhanced CT images (b at a lower level than a) show much lower attenuation in the intraperitoneal hemorrhage than in the adjacent muscle. The patient's hematocrit level was 0.24 at the time of CT.



a.

b.

**Figure 4.** Sentinel clot sign. (a) Contrast-enhanced CT image shows a sentinel clot secondary to laceration along the fissure for the ligamentum teres (arrow), in the perihepatic space and lesser sac. (b) Contrast-enhanced CT image obtained in a patient who was undergoing anticoagulation therapy for a protein C deficiency shows a sentinel clot (arrow) surrounding the spleen.

#### Teaching Point

Blood usually has higher measured attenuation than other body fluids; however, its attenuation may vary, and its CT appearance often depends on the age, extent, and location of the hemorrhage. Because of its high protein content, unclot-

ted extravascular blood usually has a measured attenuation of 30–45 HU; however, its attenuation must be assessed on the basis of the individual patient. For example, hemoperitoneum may have a measured attenuation of less than 30 HU in a patient with a decreased serum hematocrit level (2) (Fig 3) or in a patient with a hemorrhage that is more than 48 hours old (10).



a.



b.

**Figure 5.** Bleeding hepatoma. (a) Unenhanced CT image shows perihepatic and perisplenic fluid, with an area of slightly higher attenuation (arrow) indicative of a clot along the left hepatic lobe. (b) Contrast-enhanced CT image shows the origin of the clot, a ruptured mass (arrow) that subsequently was proved to be a hepatocellular carcinoma, as well as active extravasation (arrowhead).



**Figure 6.** Hematocrit effect. Contrast-enhanced CT image shows an obvious layer of high attenuation produced by sedimented blood cells (arrow) in a pelvic hemoperitoneum.

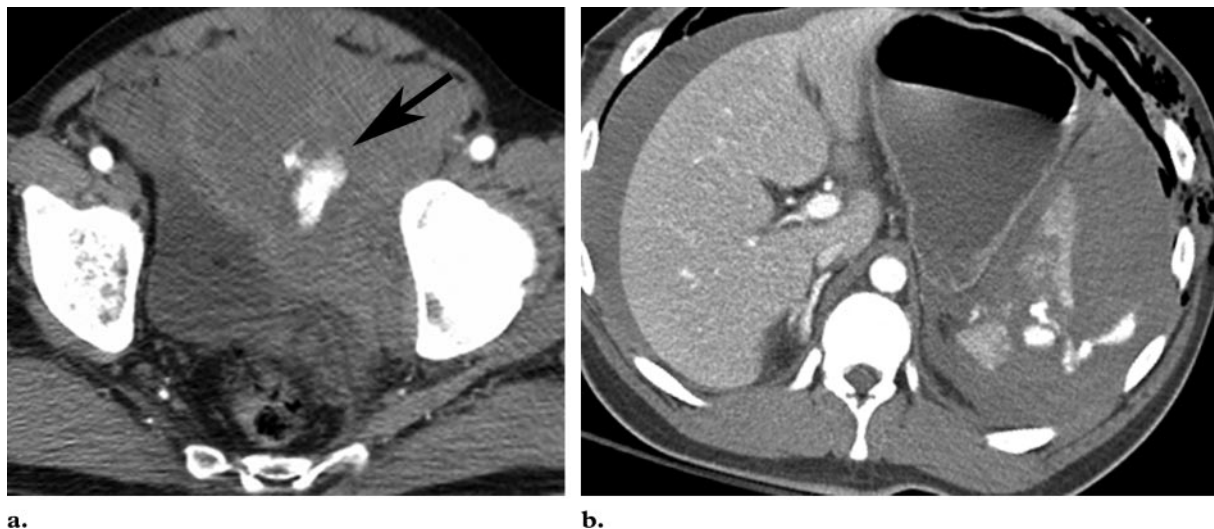
The measured attenuation of clotted blood is 45–70 HU. The body attempts hemostasis by forming a blood clot at the site of injury. Thus, on CT images, the highest-attenuation hematoma, or sentinel clot, is that closest to the site of bleeding, whereas lower-attenuation unclotted blood is located farther from the source (11). The sentinel clot sign is useful for identifying the dominant

source of hemoperitoneum in patients with multiple injuries from trauma (Fig 4). The detection of a high-attenuation clot may be facilitated by using narrow window settings. The sentinel clot sign also may be valuable in cases of nontraumatic hemoperitoneum (Fig 5). Occasionally, the CT appearance of fresh blood in the peritoneal cavity is altered by the hematocrit effect, in which sedimented red blood cells produce a dependent layer of high attenuation within the hemoperitoneum (Fig 6).

Active arterial extravasation of contrast material is depicted at CT with a measured attenuation value higher than that of free or clotted blood, a feature indicative of the presence of intravenous contrast material in the blood. In a series of trauma patients, Shanmuganathan et al found attenuation values of extravasated contrast material that ranged from 85 to 370 HU, with a mean of 132 HU (12). Although in many cases hemoperitoneum can be managed nonsurgically with excellent results (13–15), a CT finding of active bleeding is indicative of a need for emergent embolization or surgical treatment (12,16,17). The visually apparent attenuation in an area of active bleeding resembles that in the aorta or

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**Figure 7.** Active arterial extravasation. Note the sentinel clot sign produced by serpiginous areas of high attenuation surrounded by lower-attenuation areas of hematoma. **(a)** Contrast-enhanced CT image shows active bleeding from a branch of the internal iliac artery (arrow) in a patient with pelvic fractures. **(b)** Contrast-enhanced CT image shows active bleeding from a splenic rupture due to blunt trauma.

adjacent arteries. A focus of active bleeding may appear as a serpiginous or amorphous high-attenuation area intermixed with or surrounded by a large hematoma (Fig 7). On images obtained with soft-tissue window settings, active extravasation may have attenuation that allows it to be mistaken for adjacent bone or a bone fracture. The use of bone window settings in the evaluation of images of the region should prevent such confusion. Free oral contrast material from a perforated bowel also may appear as a focal area of high attenuation, but there is no surrounding hematoma like that seen in arterial extravasation.

### Mesenteric Fluid

Hemorrhage from the bowel or mesentery typically flows into areas between bowel loops, termed interloop spaces. Mesenteric fluid has a characteristic triangular shape due to the mesenteric leaves that surround the bowel and entrap fluid (Fig 8). Liver or splenic hemorrhage more typically descends peripherally along the paracolic gutters into the pelvis and is not entrapped in interloop spaces. Thus, centrally located, triangular areas of high-attenuation abdominal fluid should prompt a search for intraperitoneal bowel or mesenteric injury (7,8).



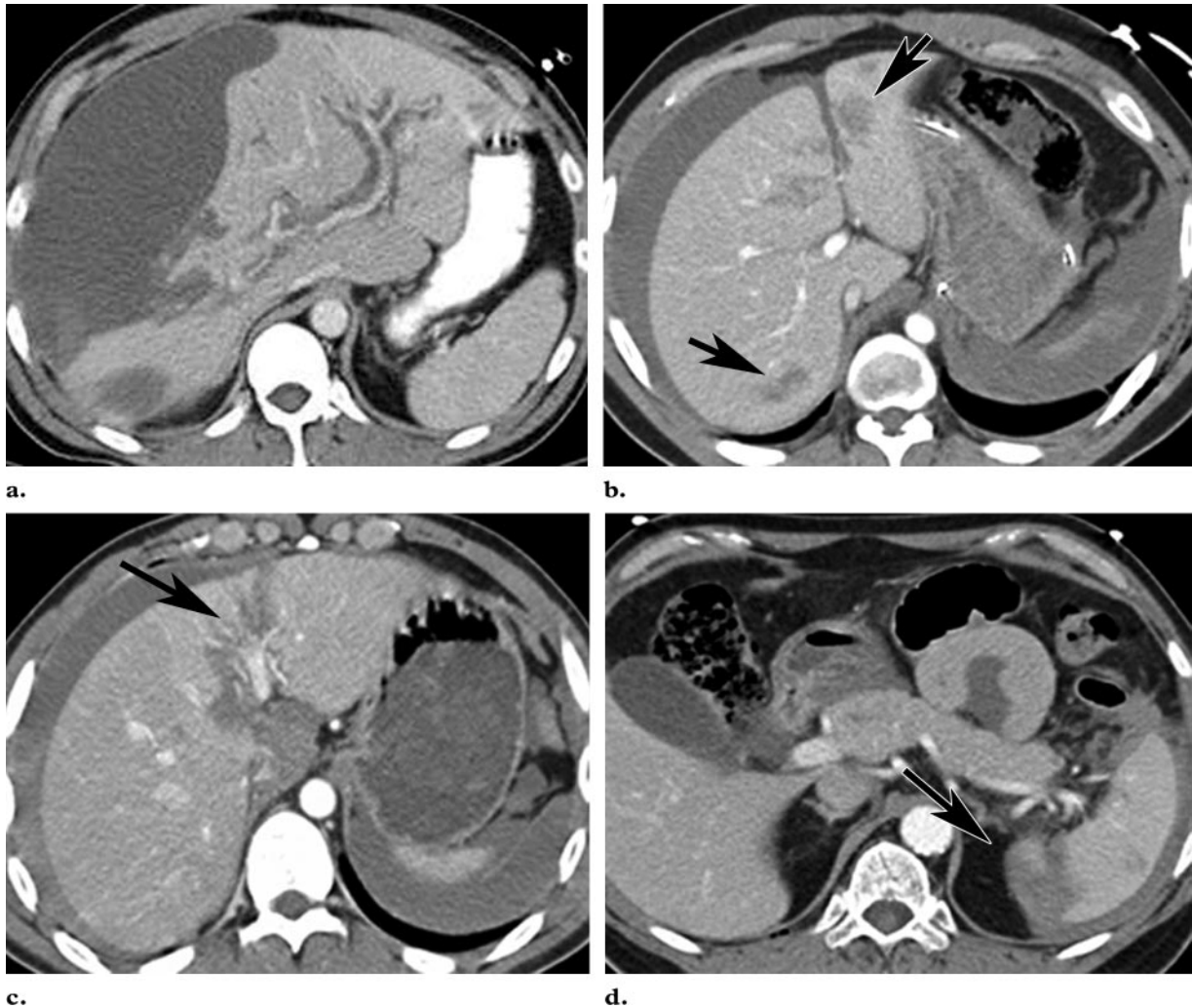
**Figure 8.** Mesenteric tear. Contrast-enhanced CT image depicts high-attenuation triangular fluid collections (arrows) within the mesentery of the distal small bowel in a patient with a surgically proved ileal mesenteric tear.

## Traumatic Hemoperitoneum

### Solid Organ Injury

The spleen is the most frequently injured organ in blunt abdominal trauma; splenic injuries account for 40% of abdominal organ injuries (18). Injuries





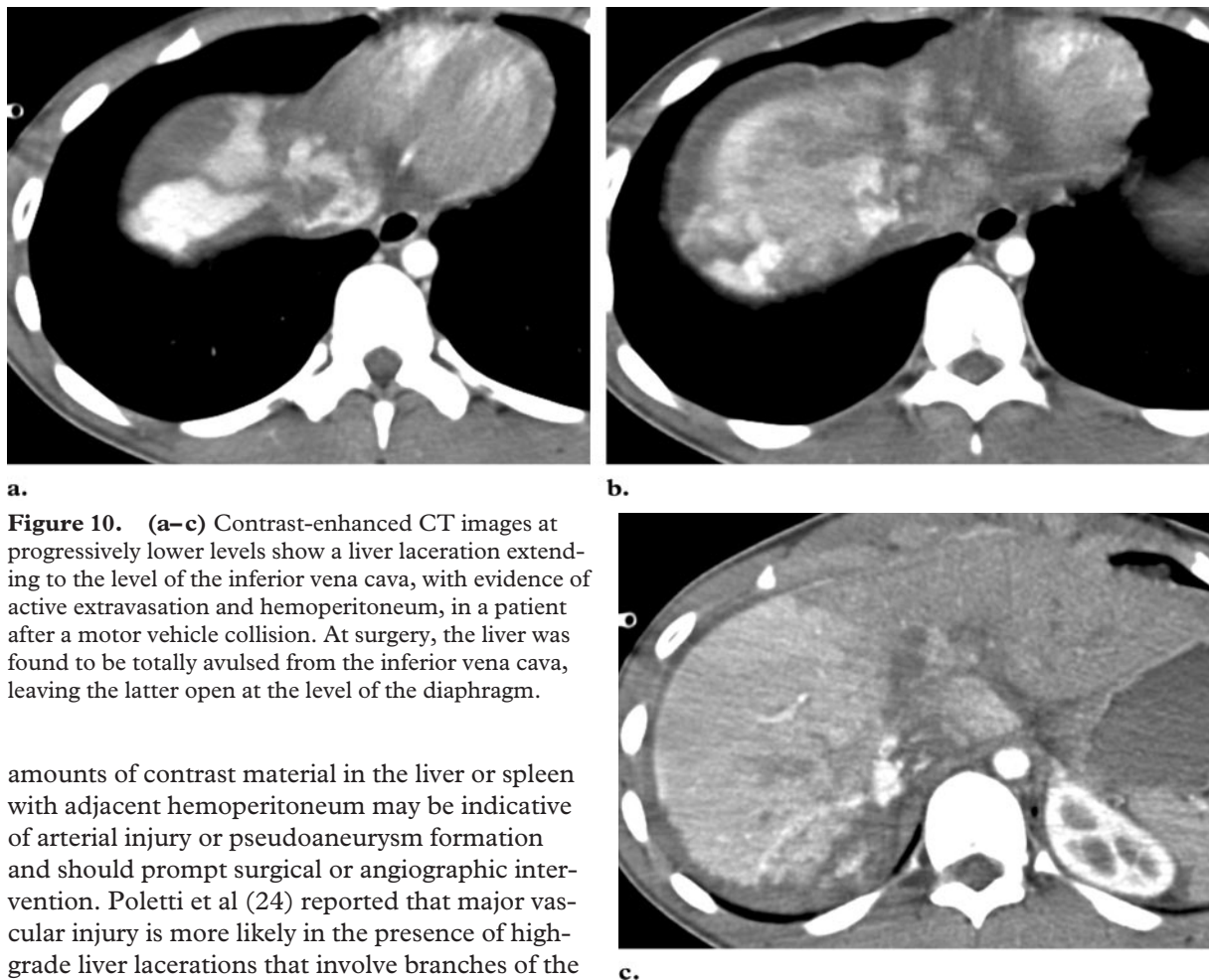
**Figure 9.** Spectrum of hepatic and splenic injuries due to trauma. **(a)** Contrast-enhanced CT image shows a large subcapsular hepatic hematoma with laceration and periportal edema and with a typical indentation in the fibrous capsule of the liver. **(b)** Contrast-enhanced CT image shows multiple irregular low-attenuation contusions in both hepatic lobes (arrows). **(c)** Contrast-enhanced CT image depicts a single hepatic laceration that extends alongside the fissure of the ligamentum teres (arrow). Lacerations commonly occur along the natural planes of hepatic vessels and fissures. **(d)** Contrast-enhanced CT image shows a single jagged laceration in the posterior tip of the spleen (arrow).

to the liver account for 20% of solid organ injuries related to blunt abdominal trauma (19). However, the liver is the single most commonly injured organ when blunt and penetrating trauma are combined. There are numerous systems for classifying visceral injuries, all of which include the following categories, in some form: intraparenchymal contusion or hematoma, subcapsular hematoma, laceration, fracture, and vascular pedicle injury (Fig 9) (20–22).

In the trauma setting, CT can help accurately diagnose the type and extent of the primary injury, determine the presence and amount of hemoperitoneum, and detect associated injuries (19,23).

Traumatic injury to the right hepatic lobe, especially the posterior segment, is much more common than is left lobe trauma, whereas injury to the caudate lobe is rare. The presence of small

**Teaching Point**



**Figure 10.** (a–c) Contrast-enhanced CT images at progressively lower levels show a liver laceration extending to the level of the inferior vena cava, with evidence of active extravasation and hemoperitoneum, in a patient after a motor vehicle collision. At surgery, the liver was found to be totally avulsed from the inferior vena cava, leaving the latter open at the level of the diaphragm.

amounts of contrast material in the liver or spleen with adjacent hemoperitoneum may be indicative of arterial injury or pseudoaneurysm formation and should prompt surgical or angiographic intervention. Poletti et al (24) reported that major vascular injury is more likely in the presence of high-grade liver lacerations that involve branches of the hepatic or portal veins or from which there is active bleeding, and these findings should prompt angiography. There is also a high likelihood of venous disruption and biliary injury in the presence of lacerations that extend into the region of the inferior vena cava or the major hepatic veins (25) (Fig 10). Fang et al (16,17) showed a significant correlation between the need for surgical intervention and the presence of hepatic and intraperitoneal bleeding or parenchymal contrast material extravasation in association with hemoperitoneum (Fig 11).

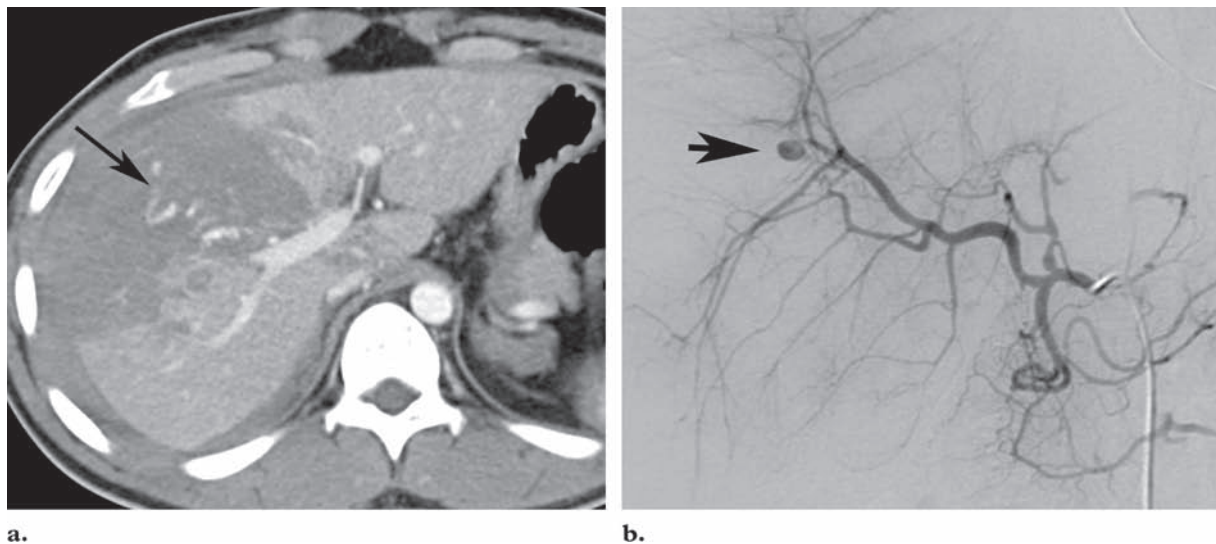
### Bowel and Mesenteric Injuries

Bowel and mesenteric injuries are found in approximately 5% of patients who undergo surgery for blunt abdominal trauma (26). Bowel and mesenteric injuries usually occur together but also

may occur separately, with purely mesenteric avulsions sometimes seen in the setting of seat-belt-related injuries. Bowel injuries can be difficult to detect clinically; abdominal rigidity, pain, and decreased bowel sounds are found during the physical examination of only one-third of patients at initial presentation (27). Undiagnosed bowel injuries are associated with significant morbidity and mortality from peritonitis, sepsis, and hemorrhage (6).

CT has high accuracy for the detection of bowel and mesenteric injuries (28). Various investigators in previous studies reported sensitivity of 84%–94% and accuracy of 84%–99% for the diagnosis of bowel injury at CT (29,30). The presence of free air is a less common sign of bowel perforation than is the presence of free fluid, especially in cases of small-bowel injury; the intraluminal contents of the small bowel consist mostly





**Figure 11.** Liver laceration with pseudoaneurysm formation. **(a)** Contrast-enhanced CT image shows a large liver laceration with internal pooling of high-attenuation material (arrow), a finding suggestive of an aneurysm or pseudoaneurysm. **(b)** Angiogram shows a pseudoaneurysm (arrow).



**Figure 12.** Mesenteric tear. Contrast-enhanced CT image shows active extravasation from jejunal mesenteric vessels with associated jejunal injury and mesenteric hemorrhage indicated by a triangular region of hemoperitoneum (arrow).

of fluid rather than gas. More reliable signs of bowel or mesenteric injury are interloop fluid, mesenteric hematoma or infiltration, wall thickening with associated enhancement, and bowel wall discontinuity (31,32). Oral contrast material extravasation, though rare, is the most specific sign of bowel rupture. Active extravasation of intravenous contrast material can be seen in the setting of mesenteric vessel injury (Fig 12).

The intraperitoneal bowel segments that are most commonly affected by trauma are the portion of the jejunum near the ligament of Treitz and the portion of the ileum near the ileocecal valve, presumably because these segments are more fixed than the rest of the small bowel. Injury occurs more commonly on the antimesenteric side than on the mesenteric side.

### Nontraumatic Hemoperitoneum

Nontraumatic hemoperitoneum may occur spontaneously or may be iatrogenic. Spontaneous hemoperitoneum is an uncommon and often unsuspected condition that may be catastrophic if it is not promptly diagnosed and treated. It may be associated with severe abdominal pain and distention, a decreased hematocrit level, or, more rarely, hypovolemic shock (33). However, these signs may not be present or may be equivocal, and the hematocrit level in a serum sample obtained at initial presentation may not reflect the extent of a hemorrhage (34). In such cases, the diagnosis frequently is made on the basis of radiologic findings (35,36). Nontraumatic hemoperitoneum has various possible causes, including hemorrhage from a highly vascular neoplasm (tumor-associated hemorrhage), hemorrhage or rupture of an ovarian cyst, rupture of the gestational sac or

other affected anatomic part in an ectopic pregnancy, and bleeding from a vascular lesion such as an arterial aneurysm. Nontraumatic hemoperitoneum also may result from anticoagulation therapy, surgery, or an invasive procedure.

In nontraumatic hemoperitoneum, as in traumatic hemoperitoneum, it is critical to identify any active bleeding. A finding of active bleeding should lead to the abandonment of a conservative management strategy in favor of surgical or endovascular intervention. After active bleeding has been excluded, a careful search should be undertaken for the source of hemoperitoneum (35).

### Iatrogenic Causes

Any surgical procedure performed within the peritoneal cavity may be complicated by hemoperitoneum (Fig 13). Even minimally invasive percutaneous or endovascular procedures occasionally lead to intraperitoneal hemorrhage (Figs 14, 15).

Bleeding diatheses are common in patients who are undergoing anticoagulation therapy with heparin or coumadin. In most cases, the risk of bleeding is directly related to the intensity of the anticoagulant effect (37). Anticoagulation therapy most commonly causes hemorrhage into the psoas or rectus muscles, but it also occasionally results in hemoperitoneum. Hemoperitoneum due to rupture of the gallbladder or spleen has been reported in patients undergoing anticoagulation therapy (38,39). The use of CT to evaluate such patients for abdominal hemorrhage had a direct effect on clinical management for about one-half of the patients in one study, and positive and negative findings at CT were equally likely to affect management (40).

Like anticoagulation therapy, blood dyscrasias may alter coagulation status and lead to hemoperitoneum (Fig 16).

### Tumor-associated Hemorrhage

Spontaneous hemoperitoneum rarely occurs in the absence of trauma, a surgical or interventional procedure, or anticoagulation therapy (41). In such cases, the possibility of the rupture of an unidentified neoplasm must be excluded. Although the occurrence is uncommon, any primary or



**Figure 13.** Hematoma after a pancreatoduodenectomy (Whipple operation). Contrast-enhanced CT image shows a large abdominal hematoma that involves the left perihepatic and perisplenic space, with evidence of active extravasation (arrow).

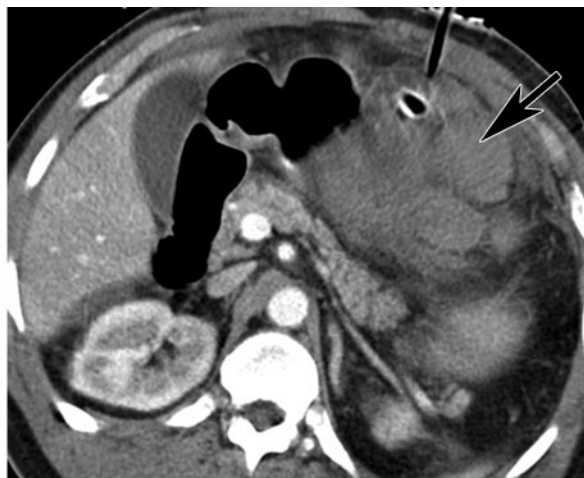
metastatic tumor can rupture and bleed into the peritoneal cavity.

The most common cause of nontraumatic hepatic hemorrhage is a hypervascular neoplasm such as hepatocellular carcinoma or hepatocellular adenoma (36). Hepatocellular carcinoma is commonly seen in the setting of cirrhosis or chronic hepatic inflammation and is the most common primary malignancy of a solid organ in the global population (42). Rupture has been reported to occur in 6.9%–14% of cases of hepatocellular carcinoma in Asia and Africa, where the prevalence of this type of cancer is high, and it is the most common cause of nontraumatic hemoperitoneum in male patients of all ages; however, ruptured hepatocellular carcinoma is less common in Europe and the United States (43,44). Patients with large or peripherally located tumors devoid of normal overlying tissue are at a higher risk for rupture (45). There also seems to be a higher likelihood of rupture in patients with both cirrhosis and hepatocellular carcinoma (36,46). In these cases, a wide spectrum of imaging findings can be seen, ranging from minor intrahepatic bleeding to subcapsular hemorrhage and rupture through the hepatic capsule into the peritoneum. Blood-tinged ascites is present in almost all cases (47). Necrosis and hemorrhage also may occur in less common hypervascular hepatic tumors, such

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14.

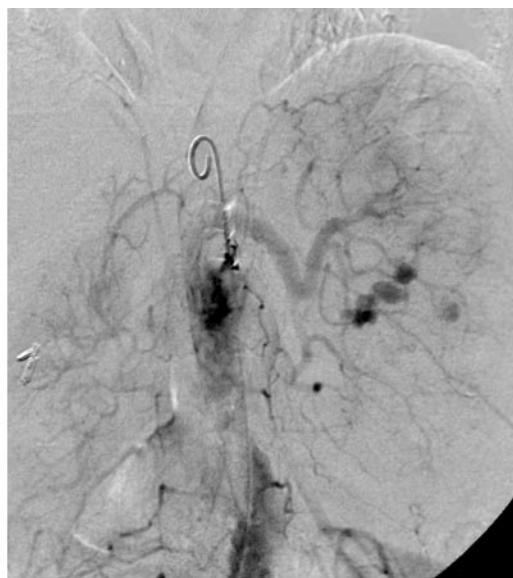


15.

**Figures 14, 15.** Hematoma after interventional procedures. (14) Contrast-enhanced CT image shows a hematoma within the lesser sac after a laparoscopic Nissen fundoplication. (15) Contrast-enhanced CT image in another patient depicts a large perigastric hematoma (arrow) after a percutaneous gastrostomy tube placement.



a.



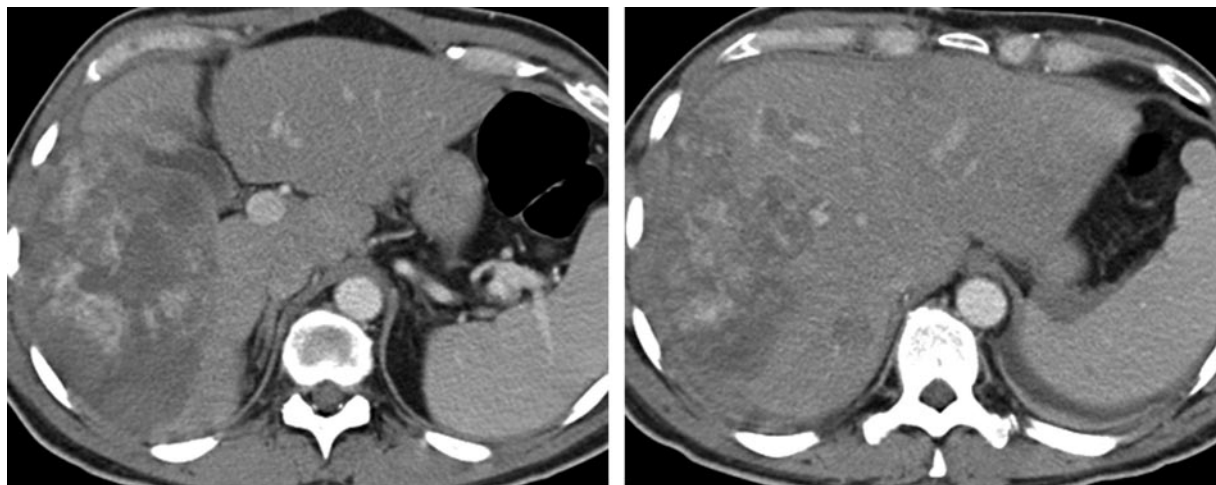
b.

**Figure 16.** Splenic rupture. (a) Contrast-enhanced CT image shows a splenic rupture and pooling of contrast material in a patient with splenomegaly due to polycythemia vera. (b) Angiogram reveals multiple splenic pseudoaneurysms that were subsequently treated with embolization.

as hepatic angiosarcoma (Fig 17) (48). Hemangiomas, though common, are not associated with nontraumatic hemoperitoneum. A lesion that resembles a hemangioma on CT images obtained in

a patient with nontraumatic hemoperitoneum may actually be an atypical angiomatous hepatic lesion such as an angiosarcoma.





a.

b.

**Figure 17.** Ruptured hepatic angiosarcoma. (a, b) Contrast-enhanced CT images (a at a higher level than b) show a heterogeneous low-attenuation lesion in the left hepatic lobe, with evidence of increased vascularity, active extravasation, and hemoperitoneum. At pathologic analysis, the lesion was found to be a hepatic angiosarcoma. The high-attenuation material adjacent to the lesion represents perihepatic blood secondary to a capsular rupture.



18.

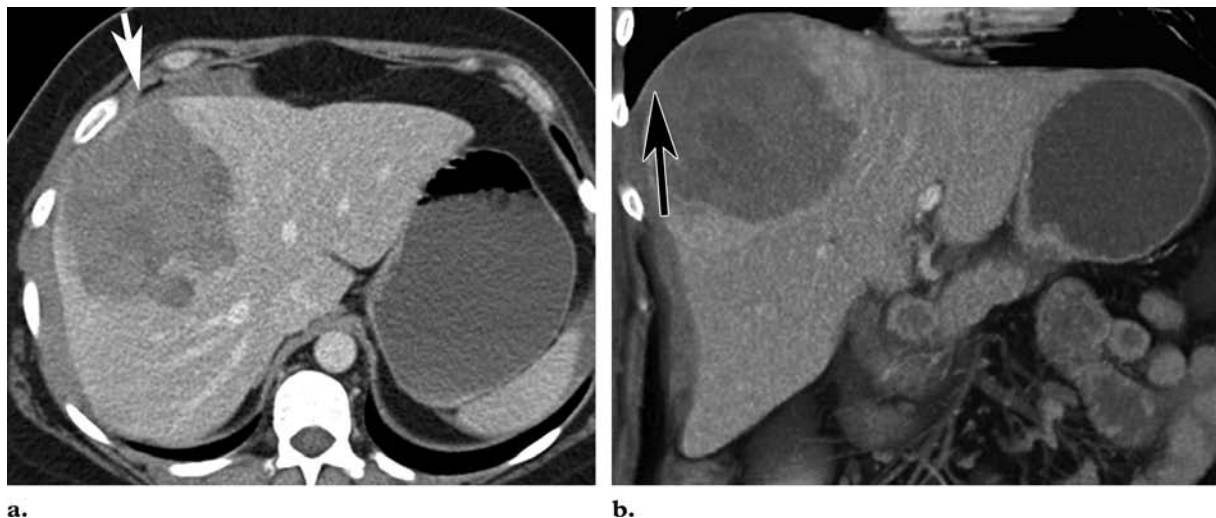


19.

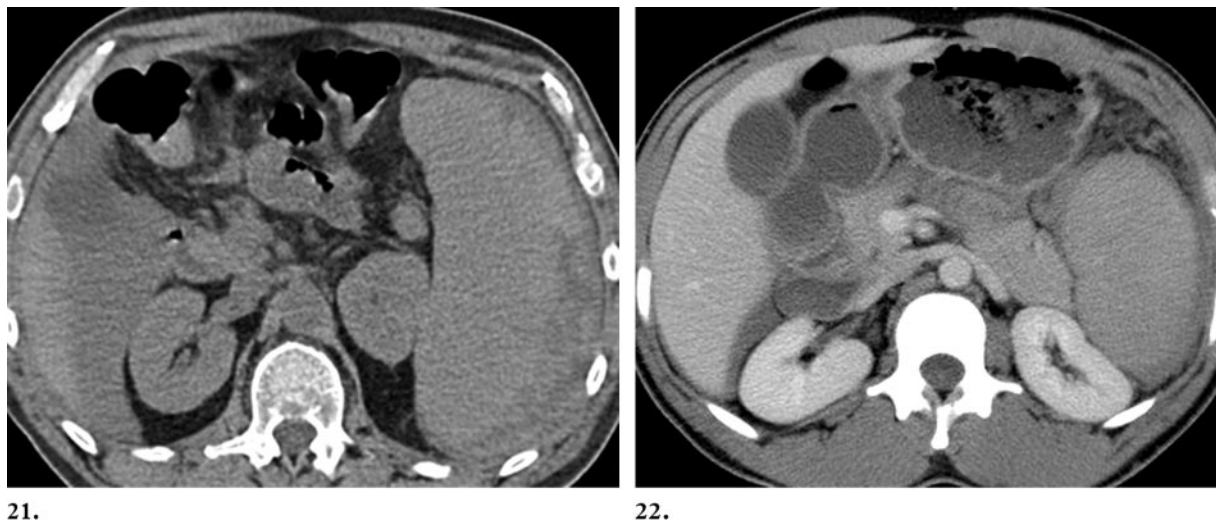
**Figures 18, 19.** Hemorrhagic metastases. (18) Contrast-enhanced CT image shows marked hemoperitoneum with active extravasation in a patient with metastatic peritoneal melanoma. Note the sentinel clot that surrounds the tumor implant, and the subcutaneous melanotic nodule (arrowhead) in the left posterior region. (19) Contrast-enhanced CT image depicts multiple hemorrhagic hepatic lesions with central high attenuation in a patient with known metastatic testicular choriocarcinoma. Hemoperitoneum (arrow) is seen adjacent to the largest lesion.

The spontaneous rupture of a metastatic lesion in a solid organ is rare but usually results in massive hemoperitoneum (47). Lung carcinoma, renal cell carcinoma, and melanoma are the metastatic lesions that most often cause hemoperitoneum (Figs 18, 19) (41).

Hemoperitoneum associated with a benign neoplasm most often occurs with hepatic adenoma. These tumors are strongly associated with oral contraceptive use and estrogen steroid therapy; they most often are found in women of childbearing age who have a history of prolonged oral contraceptive use (49). The identification of a hepatic adenoma is essential, given the associated risk of life-threatening hemorrhage (50). Focal nodular



**Figure 20.** Ruptured hepatocellular adenoma. **(a)** Contrast-enhanced CT image shows a large heterogeneous low-attenuation mass (arrow) in the right hepatic lobe, and a loss of liver capsule integrity anterolaterally. **(b)** Coronal volume-rendered CT image shows the peripherally enhancing mass, ruptured liver capsule, and perihepatic hemorrhage (arrow).



**Figures 21, 22.** Splenic rupture. **(21)** Unenhanced CT image shows an enlarged spleen with a perisplenic sentinel clot in a patient with lymphoma and thrombocytopenia who was evaluated for flank pain. **(22)** Contrast-enhanced CT image shows a hemoperitoneum that surrounds an enlarged ruptured spleen in a patient with malaria. (Fig 22 courtesy of Howard J. Harvin, MD, Scottsdale, Ariz.)

hyperplasia, in contrast, is not usually accompanied by spontaneous hemorrhage. Large adenomas are prone to bleed (51), and because the tumor capsule is incomplete, a hemorrhage may spread into the liver or the abdominal cavity (Fig 20) (52). For these reasons, although a very low rate of malignant degeneration has been reported, hepatic adenomas are surgically resected (53).

Pathologic splenic rupture may occur as a complication of a viral infection, including infec-

tion by cytomegalovirus, malaria, or Epstein-Barr virus (54); a congenital disease; a metabolic abnormality such as Gaucher disease or amyloidosis (55); and, rarely, a neoplastic process such as hemangiomatosis, angiosarcoma, leukemia, or lymphoma (Figs 21, 22) (56). The prevalence of bleeding has been correlated directly with



**Figure 23.** Ruptured hemorrhagic ovarian cyst. **(a)** Contrast-enhanced CT image shows an adnexal cyst with an internal hematocrit level (arrow), surrounded by a pelvic hemorrhage. A curvilinear focus of extravasation (arrowhead) visible posterior to the cyst was found at surgery to represent active bleeding from an internal iliac artery branch. **(b)** Contrast-enhanced CT image from a different patient shows an ovarian cyst (arrow) and surrounding hemorrhage with a hematocrit effect.

increased splenic weight (56). At times, even seemingly minor trauma, such as that caused by lying prone, can induce hemorrhage in patients with splenomegaly.

### Bleeding Due to Gynecologic Conditions

The primary imaging modality used for the assessment of gynecologic conditions is US. However, CT is often requested if the clinical findings are nonspecific. The reproductive tract is the most common source of spontaneous hemoperitoneum in women of childbearing age. The most common gynecologic sources of bleeding are ectopic pregnancy and ruptured ovarian cyst (57, 58). Hemoperitoneum also has been seen in the setting of endometriosis and uterine rupture, but such occurrences are uncommon (36,59).

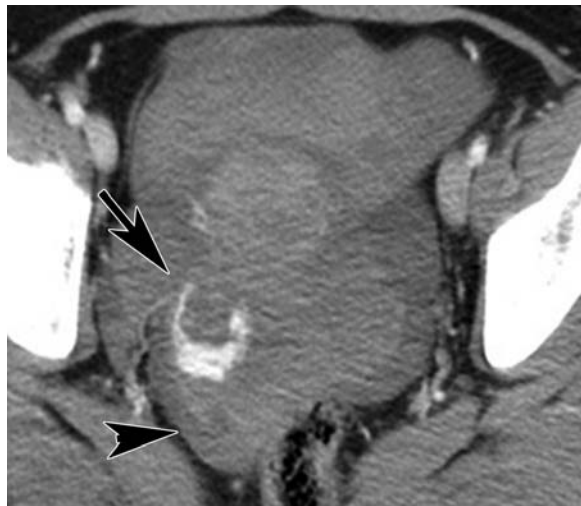
A hemorrhagic ovarian cyst (usually, a corpus luteal or follicular cyst) is a frequent cause of acute pelvic pain in women of childbearing age (57). Accurate diagnosis of a hemorrhagic ovarian cyst is important because, although it rarely causes a clinically significant blood loss, the clinical manifestations may be confused with those of conditions that require immediate surgery, such as appendicitis (60,61). Hemorrhage into an ovarian cyst is a relatively common occurrence, but few hemorrhagic ovarian cysts rupture and cause hemoperitoneum (61). Fluid with internal echogenicity or high attenuation can be seen surrounding the uterus and adnexa in the presence of recent bleeding, and an associated mixed-attenu-

ation adnexal mass with a high-attenuation component and at times a fluid-fluid level may be present (Fig 23) (57).

Ectopic pregnancy can cause life-threatening bleeding and therefore must be considered in every woman of childbearing age who presents with abdominal or pelvic pain. Ectopic pregnancy accounts for up to 1% of pregnancies, with 97% of occurrences located in either the ampullary (most common) or the isthmic portion of the fallopian tube (62). Risk factors include previous ectopic pregnancy, pelvic inflammatory disease, in vitro fertilization, use of an intrauterine device, and tubal surgery (63,64). In the context of a positive human chorionic gonadotropin level of more than 2000 IU/L and no intrauterine pregnancy, the finding of an extraovarian mass is highly suggestive of an ectopic pregnancy (Fig 24) (58). Hemoperitoneum in a patient with an ectopic pregnancy is not necessarily indicative of tubal rupture; however, the larger the amount of fluid, the higher the likelihood of tubal rupture (36).

HELLP syndrome is a peripartum condition that comprises the clinical triad of hemolysis, elevated liver enzymes, and low platelet count (65,66). Disseminated intravascular coagulation occurs in 20%–40% of patients with HELLP syndrome, and other complications, including hepatic infarction, hematoma, hepatic rupture, and placental abruption, may occur (67). CT may be the modality of choice for the demonstration of subcapsular hematoma, hepatic rupture, and hemoperitoneum (Fig 25) (36,68). Hepatic infarction appears on CT images as a wedge-shaped peripheral area with low attenuation and without a mass effect (68).





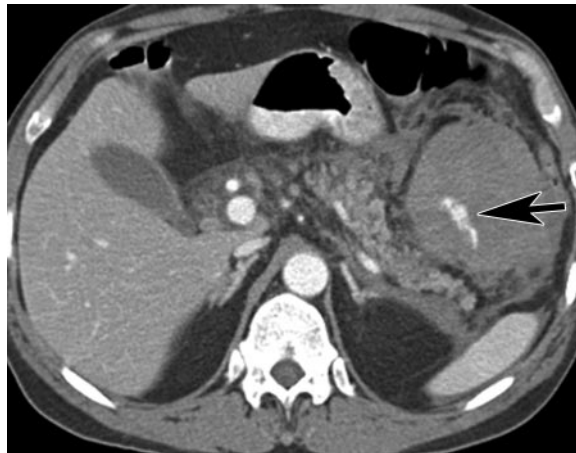
**Figure 24.** Adnexal rupture due to an ectopic pregnancy. CT image shows a hemorrhagic right adnexal mass that corresponds to an ectopic gestational sac with associated active extravasation (arrow) and blood in the cul-de-sac (arrowhead). Ectopic pregnancy and rupture were proved at surgery. (Courtesy of Alvaro Huete, MD, Santiago, Chile.)



**Figure 25.** HELLP syndrome. Coronal CT image demonstrates a subcapsular hematoma (arrow) in a recent postpartum patient with a history of HELLP syndrome. Note the hypervascularity of the postpartum uterus.

### Vascular Sources

Intraperitoneal bleeding from vascular lesions (eg, ruptured abdominal aortic aneurysms) is less common than retroperitoneal hemorrhage from such lesions. However, abdominal aortic aneurysms



**Figure 26.** Hemorrhagic pancreatitis. Contrast-enhanced CT image shows a hematoma in the gastrocolic ligament, with a focus of active extravasation (arrow). At angiography, the bleeding vessel was found to be a pancreatic branch of the splenic artery. Subsequent embolization was successful.

with very large leaks occasionally result in bleeding that extends into the peritoneal cavity (69).

Splenic artery aneurysms account for 60% of visceral artery aneurysms (70). Splenic artery aneurysms are four times as common in women as they are in men, and the rate of rupture is particularly increased during pregnancy (71). Spontaneous rupture occurs in 3%–10% of splenic artery aneurysms and produces a high mortality rate, estimated to be approximately 36% (72). Hepatic artery aneurysms are the second most common type (20%) of visceral artery aneurysms (73). In young patients, splanchnic artery aneurysms should precipitate a thorough search for systemic vascular disease, most notably type IV Ehlers-Danlos syndrome. These patients may present with a spontaneous aneurysm rupture, and angiography may be contraindicated because of the risk of aneurysm formation at the site of puncture. Pseudoaneurysms of the hepatic, splenic, and gastroduodenal arteries are complications that must be excluded during an imaging evaluation for pancreatitis (Fig 26) (74).

### Summary

There are numerous causes of hemoperitoneum in both traumatic and nontraumatic settings. CT is the imaging modality of choice because of its ability to help distinguish blood from other fluids. The crucial initial steps for the radiologist are to use the various CT signs to detect the presence of intraperitoneal blood, locate the source of hemorrhage, and determine whether emergent intervention is indicated. After these steps are completed, a differential diagnosis may be generated on the basis of the clinical history and radiologic findings.

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## Blood in the Belly: CT Findings of Hemoperitoneum

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### Page 112

Blood usually has higher measured attenuation than other body fluids; however, its attenuation may vary, and its CT appearance often depends on the age, extent, and location of the hemorrhage.

### Page 113

On CT images, the highest-attenuation hematoma, or sentinel clot, is that closest to the site of bleeding, whereas lower-attenuation unclotted blood is located farther from the source.

### Page 113

Although in many cases hemoperitoneum can be managed nonsurgically with excellent results, a CT finding of active bleeding is indicative of a need for emergent embolization or surgical treatment.

### Page 115

In the trauma setting, CT can help accurately diagnose the type and extent of the primary injury, determine the presence and amount of hemoperitoneum, and detect associated injuries.

### Page 118

The most common cause of nontraumatic hepatic hemorrhage is a hypervascular neoplasm such as hepatocellular carcinoma or hepatocellular adenoma.