Intra- and Retroperitoneal Hemorrhages

Philippe Otal, Julien Auriol, Marie-Charlotte Delchier, Marie-Agnès Marachet, and Hervé Rousseau

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Abstract

Spontaneous intraperitoneal or retroperitoneal hemorrhage can result from a vast variety of causes. When exception is made for hemoperitoneum caused by gynecological conditions, best explored by transvaginal ultrasonography, computed tomography (CT) is, in most cases, the best imaging modality, allowing not only the localization of the bleeding, but also the analysis of the underlying cause. Despite the high diagnostic performance of magnetic resonance imaging in most of the diseases described in this chapter, CT offers many advantages, such as its high availability in an emergency and a much shorter scan time.

1 Introduction

Spontaneous intraperitoneal or retroperitoneal hemorrhage can result from a vast variety of causes. When exception is made for hemoperitoneum caused by gynecological conditions, best explored by transvaginal ultrasonography (US), computed tomography (CT) is, in most cases, the best imaging modality, allowing not only the localization of the bleeding, but also the analysis of the underlying cause. Despite the high diagnostic performance of magnetic resonance imaging (MRI) in most of the diseases described in this chapter, CT offers many advantages, such as its high availability in an emergency and a much shorter scan time.

P. Otal (✉) · J. Auriol · M.-C. Delchier · M.-A. Marachet · H. Rousseau
Service de radiologie, Hôpital Rangueil,
1, Avenue Jean-Poulhès, TSA 50032,
31059 Toulouse Cedex 9, France
e-mail: otal.p@chu-toulouse.fr

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2 Intraperitoneal Bleeding

Hemoperitoneum is a common finding in abdominal traumatism. Nontraumatic hemoperitoneum is a less frequent situation, requiring prompt diagnosis and treatment. Hemoperitoneum induced by a hepatic, splenic, or peritoneal tumor or gynecological disorders (such as ectopic pregnancy or ruptured ovarian cyst) is more common than intraperitoneal bleeding associated with syndromic hemolysis, elevated levels of liver enzymes, and low platelet counts (HELLP syndrome), blood dyscrasia, or anticoagulation therapy. An unsuspected diagnosis is often made because the clinical symptoms are not specific, consisting of abdominal pain and hypovolemic shock. Thus, imaging plays a determinant role in the management of such situations. Although US is an efficient technique in the diagnosis of hemoperitoneum, its performance is limited in the workup of the cause. CT is able to detect a small amount of intraperitoneal blood and allows the diagnosis of most nontraumatic causes. US remains the modality of choice for the diagnosis of hemorrhage arising from the pelvis, particularly ectopic pregnancy.

2.1 Common CT Features of Intraperitoneal Bleeding

Intraperitoneal effusion of blood from the site of bleeding depends both on gravity and on anatomy. The most dependent compartments of the peritoneal cavity are the hepatorenal fossa (Morison pouch) and the pelvic cul-de-sac (pouch of Douglas). Although blood effusion originating from the liver usually reaches the pelvis along the right paracolic gutter, the communication between the perisplenic space and the left paracolic gutter is limited by the left phrenicocolic ligament.

The CT density of intraperitoneal blood depends on several factors. First, when a clot forms, hemoglobin concentrates and densities increase up to 90 HU (New and Aronow 1976). Nevertheless, intraperitoneal blood appears with low attenuation in the case of low hematocrit (Levine et al. 1996). The hematocrit effect designates the dependent sedimentation of red blood cells. The CT appearance of intraperitoneal blood also depends on its age. Clot lysis starts within several days and results in density attenuation reduction toward that of water. When clot resorption is inhomogeneous or in the case of intermittent rebleeding, the CT appearance becomes more heterogeneous (Wolverson et al. 1983).

When the diagnosis of intraperitoneal bleeding is made, localization of its source is a challenging issue for CT because an emergent radiological or surgical hemostasis may be obtained. The sentinel clot sign describes the relatively higher attenuating hematoma that tends to form near the bleeding site (Fig. 1). Visualization of the images with a narrow window width is helpful in the case of a low-attenuation gradient between the hematoma and the surrounding structures. Localization of the bleeding source is sometimes indicated by an active arterial extravasation of the intravenous contrast material. A delayed acquisition sometimes reveals a low-grade extravasation or allows a better understanding of the distribution of the extravasated contrast material. Even when no extravasation is depicted, contrast material injection is essential in the diagnosis of the bleeding source because it may reveal solid abdominal organ abnormalities.

2.2 Intraperitoneal Bleeding of Hepatic Origin

Hepatic conditions resulting in spontaneous intraperitoneal bleeding are dominated by hypervascular neoplasm.

2.2.1 Hepatocellular Carcinoma

Spontaneous rupture of hepatocellular carcinoma (HCC) is less frequent in Europe and America than in Asia and Africa, where it occurs in up to 14% of cases, probably owing to the size of the tumor at diagnosis. Several theories have been advanced to explain spontaneous rupture of HCC (Mortele et al. 2003): (1) rupture of a parasitic artery or vein (e.g., inferior phrenic vessel), (2) laceration of superficial HCC, occurring spontaneously or as a consequence of a minor trauma, and (3) complete hepatic vein occlusion by vascular invasion. Large peripheral HCC, with no overlying parenchyma, is more prone to bleed (Kanematsu et al. 1992). The manifestation of HCC bleeding ranges from intratumoral minor bleeding to intraperitoneal tumoral rupture through

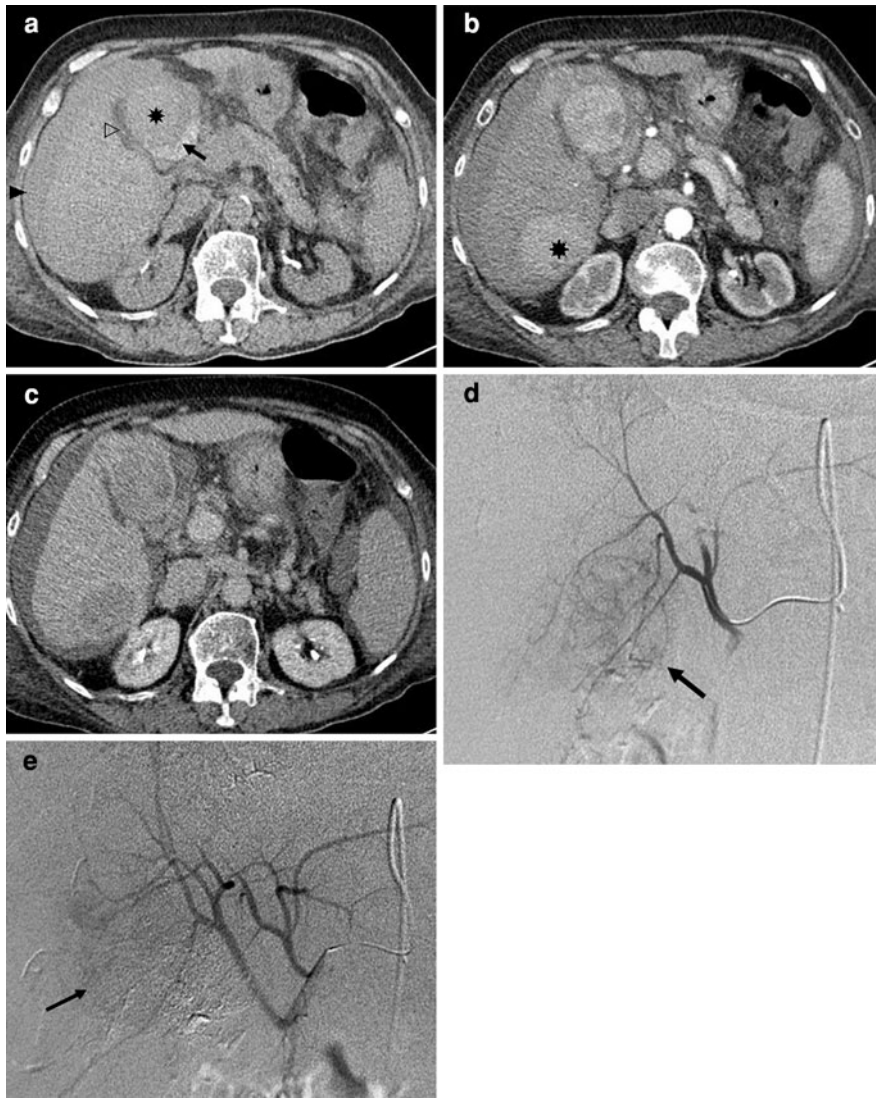

Fig. 1 Intraperitoneal bleeding caused by a ruptured hepatocellular carcinoma (HCC). **a** On unenhanced computed tomography (CT) with appropriate windowing, a subcapsular sentinel clot (*arrow*) is present around a hepatic mass (*star*) in the caudate lobe. Fluid in the peritoneal space (*closed triangle*) is hyperdense compared with bile in the gallbladder (*open triangle*). **b** On enhanced CT, the hepatic mass shows the usual enhancement of HCC in the arterial phase. A second lesion is present in the posterior aspect of the right lobe (*star*). Fibrotic changes of liver manifest themselves as capsular irregularity. **c** In the portal phase, both hepatic lesions show typical washout. **d** The arterial feeding of the hepatic mass is confirmed by selective angiography performed before chemoembolization. **e** Devascularization of the HCC after injection of an emulsion of doxorubicin and lipiodol followed by Gelfoam particles. The second lesion appears on this nonselective angiogram (*arrow*)

subcapsular hematoma. Right hypochondrial pain and shock dominate the symptoms. Diagnosis relies more on CT than on depiction of blood-stained ascites. A subcapsular sentinel clot is often present (Fig. 1). Even when contrast material injection does not reveal the specific enhancement pattern of HCC (early enhancement and washout), diagnosis can be advanced when a subcapsular mass is visible in a cirrhotic liver. When vital prognosis is not threatened, MRI can be considered as a very reliable diagnostic tool for both HCC and hemorrhagic complications. Angiography has no role to play in the diagnosis of ruptured HCC, but transarterial catheter embolization is often the best therapeutic option in patients with very high risk of postoperative morbidity and mortality (Kim et al. 2006).

Hemoperitoneum can be encountered in a cirrhotic patient without HCC, usually attributed to the rupture of intraperitoneal varices from portal hypertension. Nevertheless, no specific cause is found in one third of patients (DeSitter and Rector 1984).

2.2.2 Benign Hepatocellular Tumor

Although intraperitoneal bleeding from a hepatic origin suggests the diagnosis of HCC when the liver is cirrhotic, adenoma is the more frequent cause of

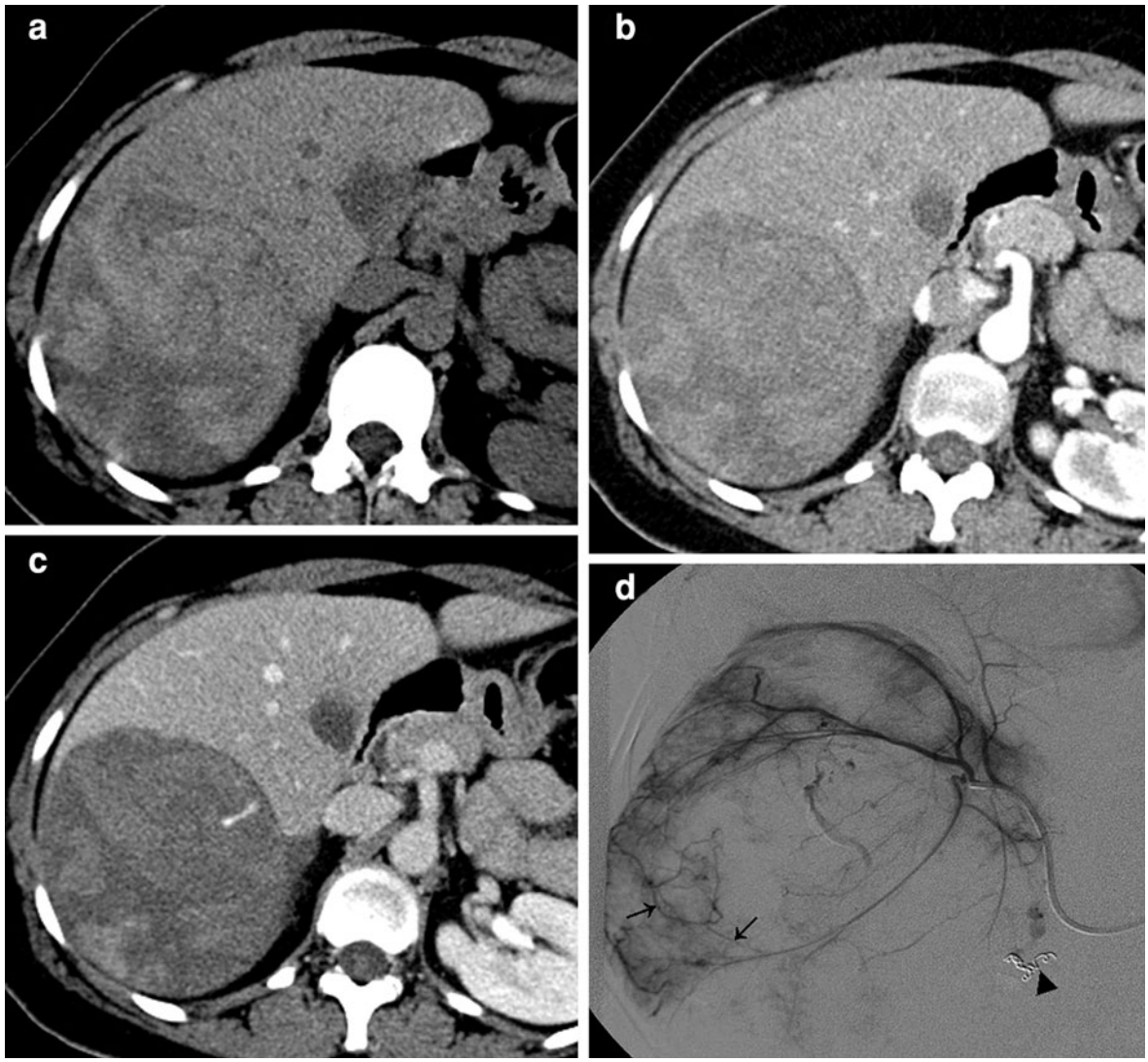

Fig. 2 Patient with spontaneous intraperitoneal bleeding caused by hepatocellular adenoma in a 22-year-old woman. **a** Precontrast CT shows a focal intrahepatic bleeding. **b** In the arterial phase of contrast enhancement, no change is visible in the hematoma. **c** In the portal phase, an extravasation appears inside the lesion. Otherwise, no tumor staining is depicted. **d** An angiogram is obtained during the embolization procedure. Coils (*closed triangle*) are seen in the feeding vessels of the inferior aspect of the tumor. Selective opacification of another arterial branch feeding the mass shows peripheral centripetal vessel (*arrows*) characteristics of adenoma

hepatic tumor bleeding in women of childbearing age with a prolonged use of oral contraceptives (Meissner 1998). Metabolic disorders such as type 1 glycogen storage disease or Gaucher disease are far less common. Although adenoma is solitary in most cases, it is not uncommonly associated with focal nodular hyperplasia. The status of adenomatosis is a rare condition, defined by the presence of at least ten lesions. The risk of spontaneous bleeding of hepatic adenoma is high enough, besides the potential transformation in HCC, to indicate a preventive treatment, either surgery or embolization. Recent advances in pathology have allowed the individualization of subgroups of hepatic adenomas more prone to spontaneous bleeding (Bioulac-Sage et al. 2007). Imaging suggests the diagnosis when intrahepatic, subcapsular, or intraperitoneal hemorrhage is related to a hypervascular tumor and when the liver does not show

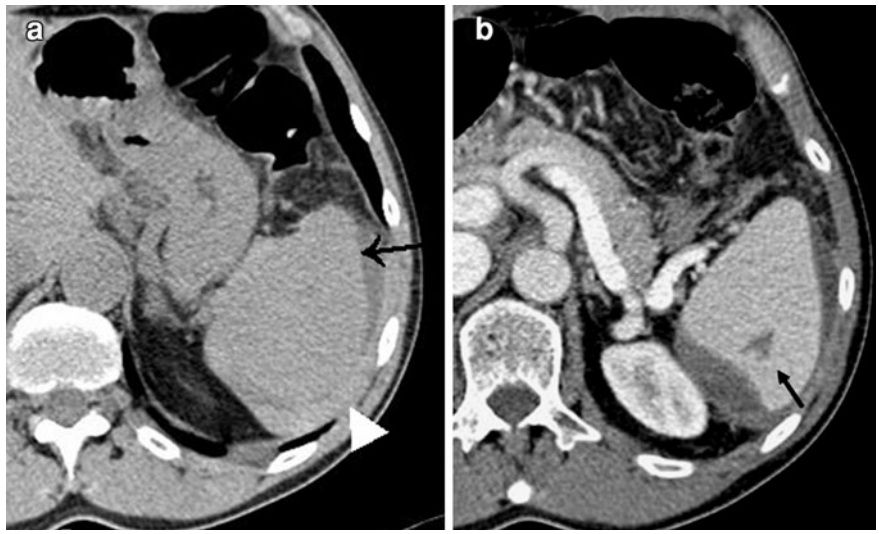

Fig. 3 Spontaneous splenic rupture in a young patient with mononucleosis infection. **a** Precontrast CT shows a perisplenic peritoneal effusion with a sentinel clot (*arrow*). **b** Splenic fracture appears after intravenous contrast material injection (*arrow*)

fibrotic changes (Fig. 2). Selective embolization of the hepatic artery can be proposed as the first approach in the management of patients with hemorrhaging hepatocellular adenomas (Stoot et al. 2007). Follow-up of small (less than 5 cm) steatotic adenomas in female patients is recommended by some teams because the risk of complication is low in that particular group (Dokmak et al. 2009).

Unlike adenoma, focal nodular hyperplasia is usually discovered incidentally, and spontaneous rupture has rarely been reported (Becker et al. 1995).

2.2.3 Hemangioma

Hemangioma is the most common benign hepatic tumor. It rarely becomes symptomatic. Local compression signs (pain, vomiting) are more frequent than spontaneous hemorrhage (Casillas et al. 2000). Pregnancy is an established condition of higher risk of rupture, in association or not in association with consumptive coagulopathy, HELLP syndrome, or cocaine abuse.

2.2.4 Metastasis

Spontaneous rupture of liver metastases is rare (Casillas et al. 2000). In most of the reported cases, primary cancer originates from lung, kidney, and melanoma. Colon, pancreas, gallbladder, testicular cancers, and choriocarcinoma also produce hepatic metastases prone to spontaneous bleeding. Bleeding is favored by different factors, such as necrosis (spontaneous or chemotherapy-induced), increased abdominal pressure (caused by straining, coughing), subcapsular location, and local venous congestion resulting from tumor obstruction. In this situation of palliative care, angiographic embolization is a valuable tool.

2.2.5 HELLP Syndrome

This syndrome was first described by Weinstein (1982). It is a serious obstetric condition, in preeclamptic or eclamptic women, associated with hemolysis, elevated levels of liver enzymes, and low platelet count, and is able to evolve quickly toward hepatic necrosis or infarction, and disseminated intravascular coagulopathy. US is often the first imaging modality used to rule out gallbladder disease in a patient presenting with right upper quadrant pain. Even if subcapsular and intrahepatic hematoma can be diagnosed by US, contrast-enhanced CT is the best modality to depict not only the hemorrhagic complications (hematoma, liver rupture, hemoperitoneum) but also the ischemic ones, with hepatic infarction and their characteristic peripheral wedge-shaped areas (Nunes et al. 2005).

2.3 Intraperitoneal Bleeding of Splenic Origin

Spontaneous splenic rupture is known to occur in pathological conditions such as infection (mononucleosis, malaria) and metabolic disorders (amyloidosis, Gaucher disease) (Fig. 3). Uncommonly, the

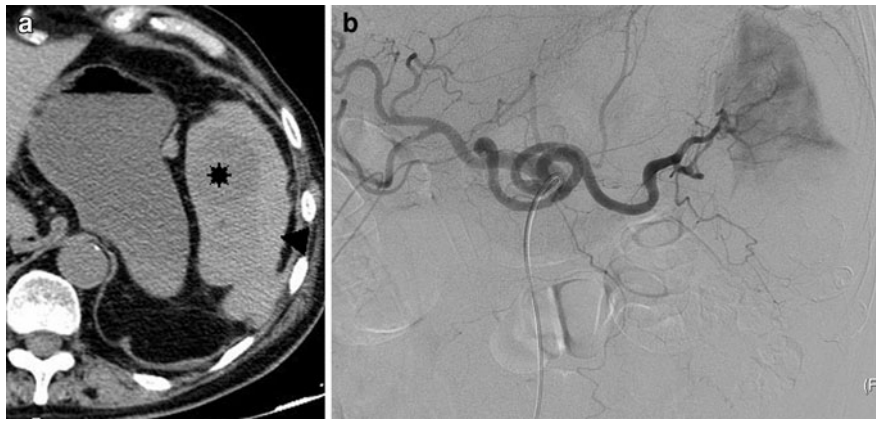

Fig. 4 Spontaneous splenic rupture in a patient with melanoma and splenic metastases. **a** Precontrast CT shows hemoperitoneum (*closed triangle*) around the spleen. A spontaneously hypointense splenic mass is visible (*star*). **b** Celiac artery opacification demonstrates a poorly enhanced lesion of the inferior lesion of the spleen, responsible for splenic rupture

underlying pathological process is a tumor, either a congenital cyst or neoplasm (hemangiomatosis, angiosarcoma, leukemia, lymphoma, metastasis) (Fig. 4). CT is obviously the modality of choice for the diagnosis of splenic rupture and the depiction of an underlying mass. Rupture of an accessory spleen has rarely been reported and is also best depicted by CT.

In the differential diagnosis of bleeding splenic tumor, particularly hemangioma, the possibility of peliosis must be kept in mind: this rare condition of unknown cause results in the development of blood-filled cavities in the spleen and, more rarely, the liver, lymph nodes, and bone marrow. These masslike lesions demonstrate contrast pooling and may also rupture into the peritoneal cavity.

Spontaneous rupture of splenic artery aneurysm yields a high rate of mortality, estimated to be approximately 36% (Shanley et al. 1996). Splenic artery aneurysms are much more frequent in women, and the risk of rupture is particularly increased during pregnancy. Even if plain film may reveal the classic "signet ring" in the left upper quadrant, CT angiography is the best diagnostic modality prior to percutaneous embolization.

2.4 Intraperitoneal Bleeding of Miscellaneous Gastrointestinal Origin

Peptic ulcer is very uncommonly responsible for intraperitoneal hemorrhage. CT is able to describe the gastric origin of the bleeding unless radiopaque oral contrast material has been given.

Intraperitoneal hemorrhage may be the manifestation of vascular complication of pancreatitis when a pseudoaneurysm ruptures in the peritoneal cavity. Because retroperitoneal complications are more frequent, this condition is detailed in Sect. 3.4.

2.5 Intraperitoneal Bleeding of Gynecological Origin

Ectopic pregnancy or ruptured ovarian cyst is the most common cause of intraperitoneal hemorrhage from gynecological origin. If a diagnosis is made on the basis of clinical and biological features, transvaginal US is the best modality to depict both the hemoperitoneum and its underlying cause. If the clinical findings are nonspecific, CT is often the first imaging modality applied, but the depiction of a hemoperitoneum associated with adnexal abnormalities, cystic or not, should result in the realization of transvaginal US, which allows a better characterization of the lesions, unless the hemodynamic status of the patient requires an emergent laparoscopy.

3 Retroperitoneal Bleeding

Retroperitoneal hemorrhage is a rare clinical situation, originating in most cases from a ruptured abdominal aortic aneurysm (AAA). Rupture of an aortic branch and spontaneous hemorrhage of a retroperitoneal organ are less common. The urological causes are dominated by renal neoplasms. Clinical diagnosis is difficult for many reasons. No specific

clinical sign exists because lumbar pain is the dominating symptom. Even in the case of ruptured AAA, the classic triad associated with sudden abdominal or flank pain, shock, and pulsatile abdominal mass is encountered in a minority of cases. Furthermore, bleeding may be insidious and progressive, over days, making diagnosis more difficult. Similarly, biological tests lack specificity, consisting in deglobulinization signs.

Thus, diagnosis always relies on imaging evaluation. Despite its availability, US plays a minor role. Acoustic windows to the retroperitoneum may be limited by overlying bowel gas, and a small amount of retroperitoneal hematoma is easily missed. Even when the retroperitoneal hematoma is demonstrated, its origin remains difficult to identify, an AAA or large enough renal masses excepted. In contrast, CT has several advantages: it is readily available, fast to perform, both sensitive and specific in the diagnosis of retroperitoneal blood effusion, and very effective in the evaluation of most of the local causes of spontaneous bleeding. As a consequence, the role of MRI is of limited value, but its high resolution is useful in rare cases where CT lacks contrast for depicting a neoplasm within the blood suffusion. Another option in this situation is to perform serial CT to detect a causative lesion. Angiography is of limited value from a diagnostic point of view, except in rare cases where small vessels, beyond the domain of CT angiography, are to be depicted, such as in cases of panarteritis nodosa or arteriovenous malformations. Inversely, angiography plays an important therapeutic role, through embolization and stent-graft placement.

3.1 Ruptured AAA

AAA is frequent, encountered in 2–4% of the population older than 50 years (Bengtsson et al. 1992). Most AAAs are true aneurysms and involve the aortic segment below the renal arteries. Conventionally, diagnosis relies on an abdominal aorta diameter of 3 cm or more. When the rupture involves the anterior aortic wall, death by intraperitoneal hemorrhage is sudden. Patients who reach the emergency department present in most cases with rupture of the posterolateral wall, resulting in a retroperitoneal hemorrhage. The clinical triad is associated with sudden abdominal or flank pain, shock, and pulsatile abdominal mass. Rupture into the inferior vena cava is much less common, resulting in an aortocaval fistula. Rupture into the duodenum is very rare in the case of native AAA and involves almost exclusively patients with a history of aortic bypass.

US is of limited value in the diagnosis of ruptured AAA: even a large amount of retroperitoneal hematoma can be missed. Furthermore, in the absence of retroperitoneal hematoma, US is unable to detect signs of impendent rupture. Despite its high diagnostic performance in this field, MRI has no role to play in an emergency because of its limited availability and its long acquisition time. Furthermore, even in the case of contraindication to the injection of iodinated contrast material, unenhanced CT allows accurate diagnosis of ruptured AAA. Owing to its widespread availability in the emergency department and its high speed of realization, CT is the imaging modality of choice for the diagnosis not only of AAA but also of acute aortic syndrome. CT also has high diagnostic performance in other emergent situations with clinical symptoms that are sometimes confused with those of abdominal disorders such as pancreatitis, appendicitis, and bowel obstruction.

Diagnosis of rupture is evident when a retroperitoneal hematoma is seen near an AAA (Rakita et al. 2007). Retroperitoneal hematoma appears as a hyperattenuating collection involving one or more retroperitoneal compartments, with a predilection for perirenal and pararenal spaces and psoas muscle (Fig. 5). Intraperitoneal effusion is usually delayed.

A direct sign of ruptured AAA, consisting in the extravasation of intravenous contrast material into the retroperitoneal space, is uncommon but not mandatory to establish the diagnosis. Otherwise, contrast material injection is useful for locating the digestive and renal branches of the aorta and defining their relationships with the aneurysmal neck (Fig. 5). This information, of limited value for the vascular surgeon, becomes of crucial importance for the interventional radiologist when an endoluminal stent-graft placement is planned. The endovascular repair of ruptured AAA plays an increasing role in patients at high risk of surgery as long as they remain relatively stable.

The draped aorta sign is encountered in cases of contained ruptures of AAA and refers to the presence of thrombus of the aneurysmal sac leaking toward the adjacent vertebral bodies (Halliday and al-Kutoubi 1996).

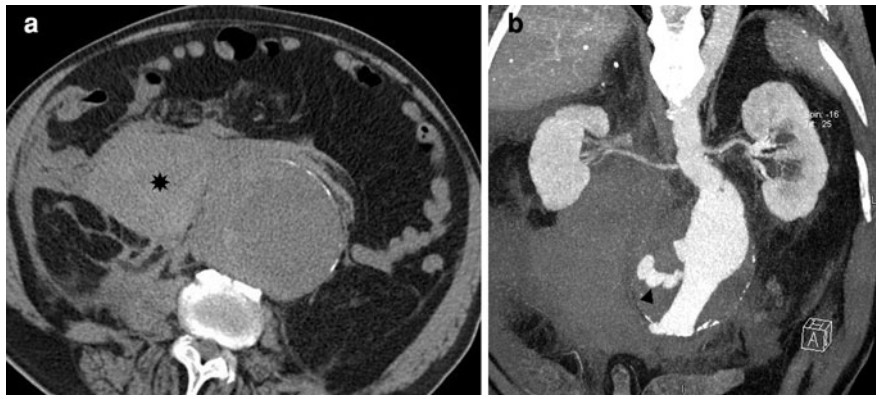

Fig. 5 Ruptured abdominal aortic aneurysm (AAA). **a** Axial unenhanced CT shows a heterogeneous hyperattenuating collection (*star*) in the right retroperitoneal space. **b** Frontal reformation of contrast-enhanced CT allows evaluation of the length of the aneurysmal proximal neck. Active extravasation is seen inside the aneurysmal thrombus (*closed triangle*)

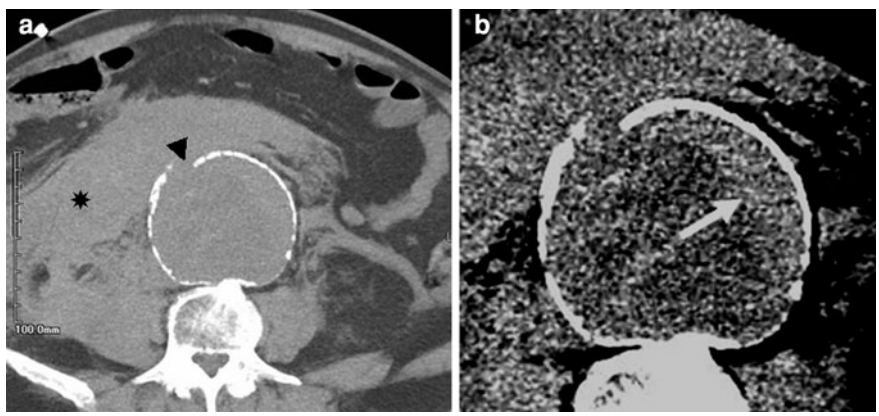

Fig. 6 Ruptured AAA. **a** Hemoretroperitoneum is visible around an AAA presenting a focal interruption (*closed triangle*) of otherwise circumferential wall calcifications. **b** A different windowing of the same slice depicts the hyperattenuating crescent sign (*arrow*)

This sign is present when the posterior wall of the aorta closely follows the contour of an adjacent vertebral body.

When the diagnosis of ruptured AAA is made clinically and retroperitoneal hemorrhage is absent, attention must be paid to radiological findings predictive of impending rupture. The value of the depiction of a focal interruption of otherwise circumferential wall calcifications is enhanced when a previous CT scan demonstrating a continuous calcification wall is available (Siegel and Cohan 1994) (Fig. 6).

The hyperattenuating crescent sign, even if not specific, is an early sign of impending or acute rupture, best depicted on unenhanced CT. It reveals the recent hemorrhage within either the peripheral wall or the aneurysm wall, appearing as a hyperdense cleft (Fig. 6). The sensitivity and specificity of the crescent sign for the diagnosis of complicated AAA are 77 and 93%, respectively (Mehard et al. 1994).

Spontaneous rupture of an iliac aneurysm is less frequent than AAA rupture, and can be clinically misleading. Diagnosis relies on CT angiography, with imaging features similar to those of AAA rupture (Fig. 7).

3.2 Perirenal Bleeding

Spontaneous perirenal hemorrhage is, according to an old literature review, related to a renal mass in almost 90% of cases (McDougal et al. 1975). In that review, 57.7% of perirenal hematomas arose from a renal tumor, 33.4% of them were malignant [most of them were renal cell carcinoma (RCC)], and 24.3% were benign [dominated by angiomyolipoma (AML)]. Vascular disease (17.9% of cases) included periarteritis nodosa, ruptured renal artery aneurysm, renal vein thrombosis, arteriovenous malformation, and renal infarction. The remaining causes were infection

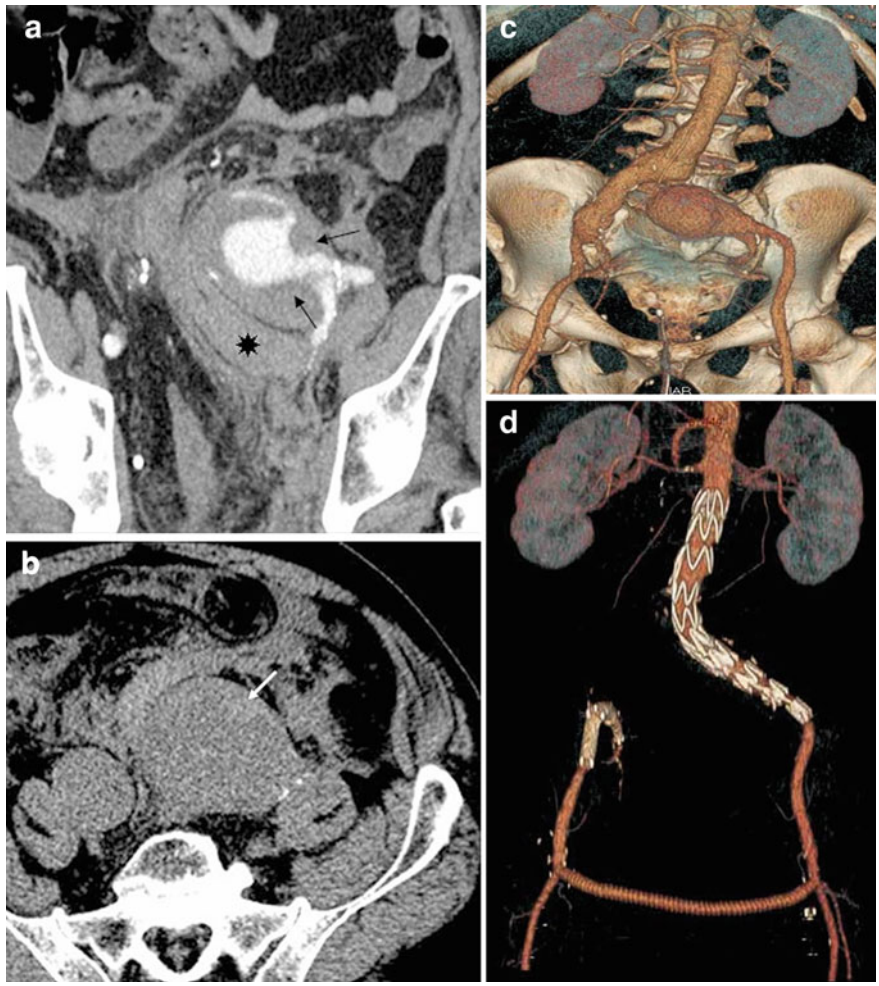

Fig. 7 Spontaneous rupture of an iliac artery aneurysm. **a** The left common iliac artery aneurysm is partially thrombosed (*arrows*) and surrounded by retroperitoneal blood effusion (*star*). **b** The precontrast slice reveals a hyperattenuating crescent sign (arrow). Volume rendering image of the aorta and iliac arteries before (**c**) and after (**d**) endovascular repair (aorto-uni-iliac stent graft, occlusion of the right external and internal iliac arteries) completed by a femorofemoral bypass

(10.3%), nephritis, blood dyscrasias, lithiasis, and hydronephrosis.

A higher incidence (30%) of AML was noted in a more recent series (Sebastia et al. 1997). Retroperitoneal bleeding is the first manifestation of approximately 15% of AMLs (Mouded et al. 1978; Pode and Caine 1992), particularly those of 4 cm or more, which are prone to bleed once in 50% of cases (Oesterling et al. 1986). The differing degree of vascularity of these masses, composed of fat, smooth muscle, and vessels, explains partly the differing risk of spontaneous bleeding. Pregnancy is a recognized facilitating factor of bleeding. CT provides an almost specific diagnosis when depicting fat within the lesion (Fig. 8).

Among malignant neoplasms, RCC yields most of the spontaneous renal bleeding. Despite its low incidence of spontaneous bleeding, RCC is in some series the most common renal neoplasm associated with spontaneous perirenal bleeding, owing to its high prevalence. Renal metastases prone to bleed arise from choriocarcinoma, melanoma, and lung carcinoma.

Hemorrhages from vascular origin are rare, dominated by the rupture of a renal artery aneurysm. Renal parenchyma infection (pyelonephritis, abscess, tuberculosis), renal cystic diseases, hydronephrosis, and lithiasis are more rarely involved in retroperitoneal hemorrhage. Infectious renal processes such as cortical abscesses may induce spontaneous perirenal hemorrhage by arterial erosion (Murray et al. 1979).

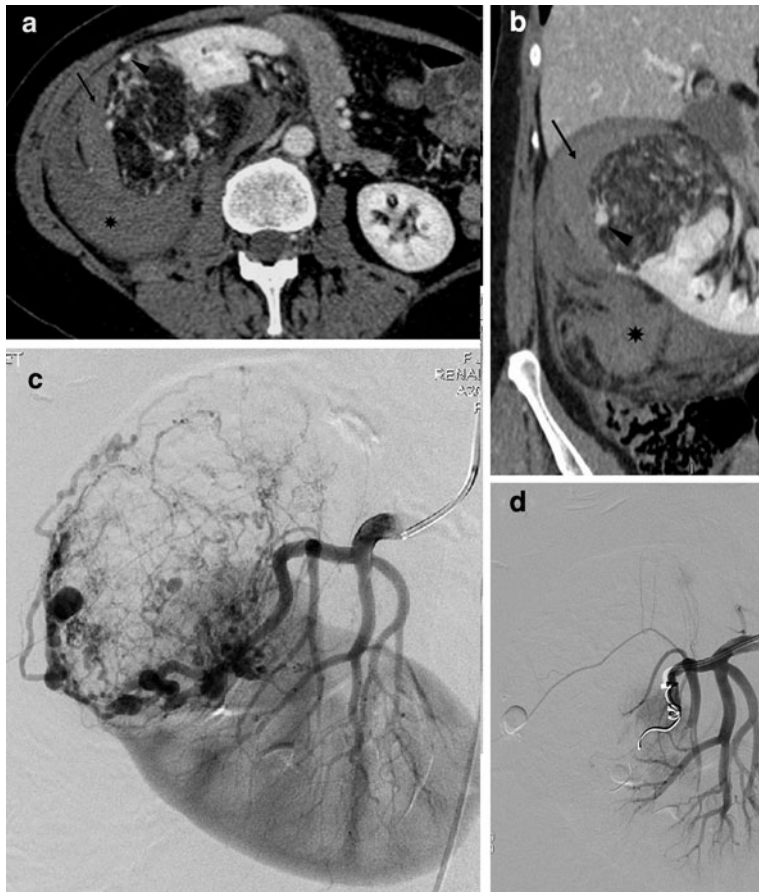

Fig. 8 Spontaneous bleeding of an angiomyolipoma of the right kidney. **a** A large fatty mass of the right kidney is surrounded by a subcapsular hematoma (*arrow*) and a hemoretroperitoneum (*star*). **b** The relationships between the subcapsular hematoma (*arrow*) and the retroperitoneal bleeding (*star*) are well depicted on the coronal reformation. Large pseudoaneurysms (*closed triangle*) are present within the renal mass. **c** Selective renal angiography confirms the presence, at the upper pole of the kidney, of radiolucent mass containing several peripheral pseudoaneurysms. **d** The result of selective coil embolization

Table 1 Causes of spontaneous adrenal hemorrhage (Kawashima et al. 1999)

Stress[a]: surgery, sepsis, burns, hypotension, pregnancy, exogenous adrenocorticotropic hormone, exogenous steroids
Neonatal stress[a]: difficult labor or delivery, asphyxia, hypoxia, septicemia, hemorrhagic disorders, extracorporeal membrane oxygenation, associated renal vein thrombosis
Hemorrhagic diathesis or coagulopathy[a]: anticoagulants, antiphospholipid syndrome, systemic lupus erythematosus, disseminated intravascular coagulopathy
Underlying adrenal tumors[a]: pseudocyst, myelolipoma, hemangioma, pheochromocytoma, adrenocortical adenoma, adrenocortical carcinoma, metastases (bronchogenic carcinoma, angiosarcoma, melanoma)
Idiopathic disease

[a] Causes of bilateral adrenal hemorrhage

Rupture of a renal cyst as a local cause of perirenal hemorrhage is very rare because a renal cyst usually ruptures into the pyelocaliceal system. It has been demonstrated that end-stage kidney disease favors perirenal hemorrhage by cumulating factors such as platelet function alteration and heparinization for hemodialysis.

3.3 Periadrenal Bleeding

Conditions facilitating spontaneous adrenal bleeding are rare and are summarized in Table 1. From a clinical point of view, the risk of adrenal insufficiency, even if rare, must be kept in mind because associated with bilateral massive adrenal hemorrhage,

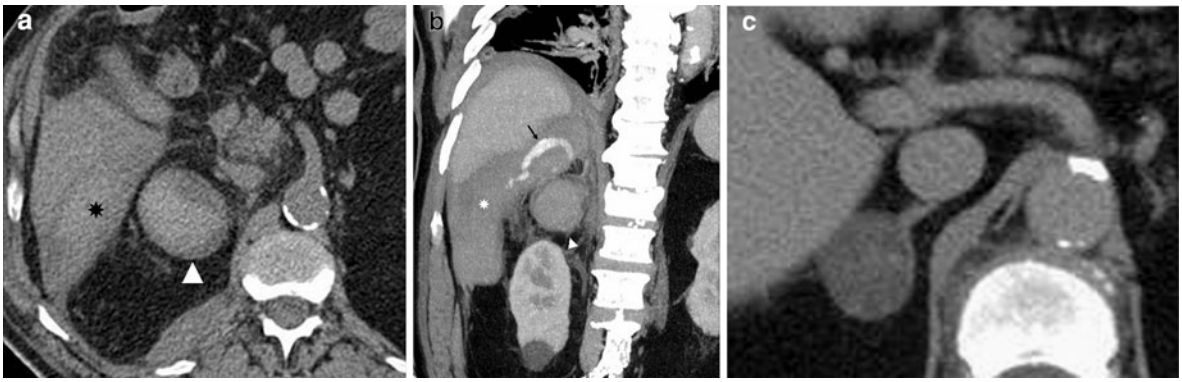

Fig. 9 Spontaneous bleeding of an adrenal adenoma as a complication of anti-vitamin K treatment. **a** On precontrast CT, the right adrenal gland appears enlarged and hyperdense (*open triangle*). A hematoma (*star*) is present at the posterior face of the liver, extending from the retroperitoneal space through the area nuda hepatis. **b** After intravenous contrast material injection, active bleeding is visible in the perihepatic hematoma (*arrow*). **c** A CT scan performed 6 months earlier confirms the typical hypodense pattern of an adrenal adenoma

adrenal insufficiency destroys more than 90% of each gland.

Stress-induced adrenal hemorrhage is seen in surgery, sepsis, burns, fulminant meningococcemia (Waterhouse–Friderichsen syndrome), pregnancy, and with administration of adrenocorticotropic hormone or steroids. Adrenal hemorrhage results in the combination of hypervascularity (induced by an increase in local secretion of adrenocorticotropic hormone) and elevated adrenal venous pressure (secondary to venoconstriction). General processes such as disseminated intravascular coagulopathy may also participate in adrenal hemorrhage. In antiphospholipid syndrome, the *primum movens* for adrenal hemorrhage is adrenal vein thrombosis.

Adrenal hemorrhage in neonates may result from hypoxia, septicemia, coagulopathy, or a difficult delivery, particularly if the mother is diabetic. The association of adrenal hemorrhage with renal vein thrombosis in neonates must also be remembered.

Adrenal hematoma is round or oval, usually associated with a periadrenal fat stranding, which may also involve the perirenal space. The possible extension of spontaneous perirenal or perihepatic hematoma to the periadrenal fat makes it sometimes difficult to determine from which organ the hemorrhage arises.

One imaging challenge concerns patients without a general risk factor for spontaneous adrenal bleeding, raising the question of a possible underlying cystic or solid mass. Comparison of unenhanced and enhanced CT scans is essential. MRI may play a role in difficult cases. Otherwise, serial CT may reveal the underlying mass, whereas the clot resolves (Kawashima et al. 1999).

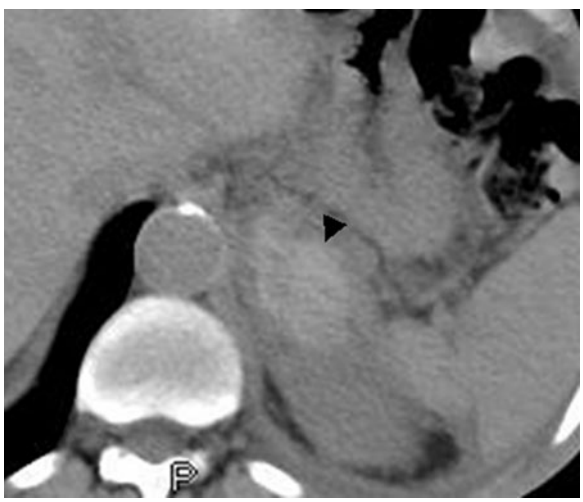

Fig. 10 Spontaneous hemorrhage of an adrenal metastasis from lung cancer: enlarged spontaneously hyperdense left-sided adrenal mass (*closed triangle*)

Nevertheless, some cases remain unsolved. For example, it is almost impossible to distinguish a hemorrhagic cyst from a hemorrhagic neoplasm in the case of a cystic lesion with an irregular thick wall. Similarly, the characteristic fatty component of a myelolipoma may be obscured by the superimposed hematoma.

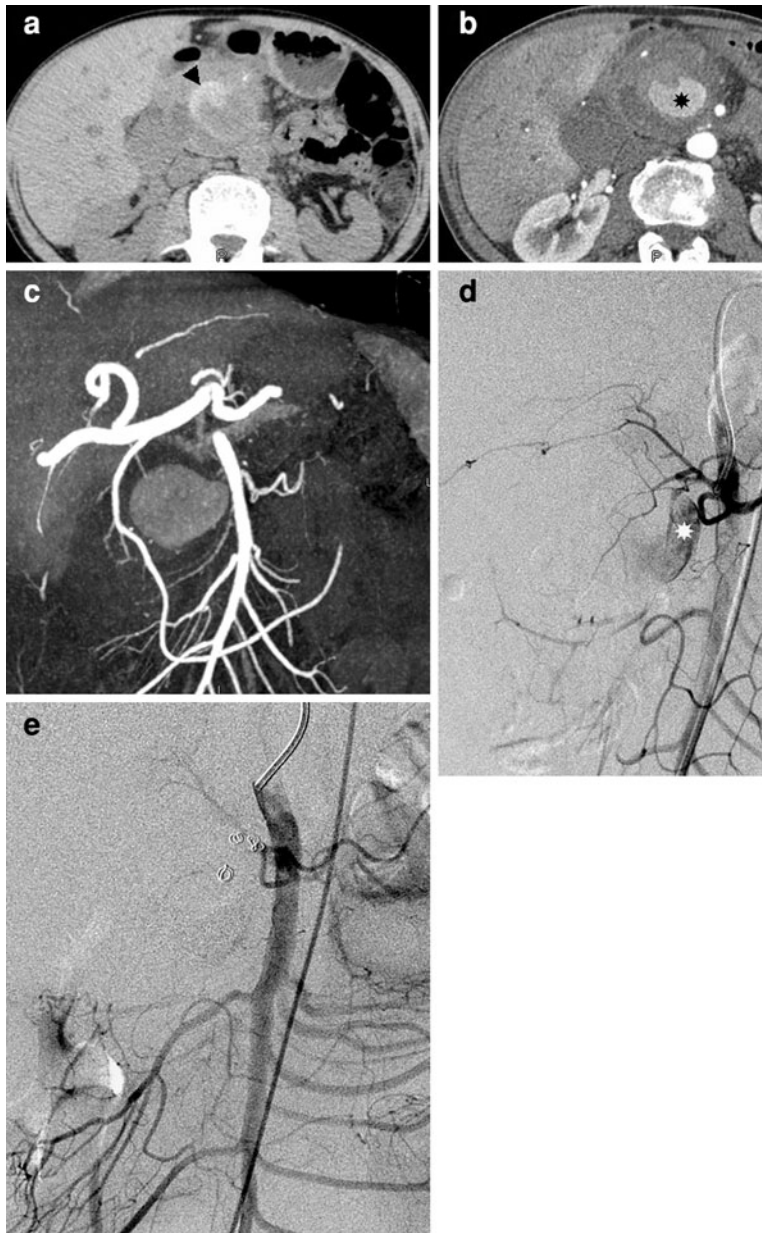

Fig. 11 Spontaneous retroperitoneal bleeding of a peripancreatic pseudoaneurysm in a patient with acute pancreatitis. **a** On precontrast CT, a hyperdense crescent sign (*closed triangle*) is depicted. **b** After intravenous contrast material injection, the pseudoaneurysm (*star*) is enhanced between the superior mesenteric artery and the gastroduodenal artery. The pseudoaneurysm is best depicted on the coronal maximum intensity (MIP) projection (**c**). **d** Selective angiography of the superior mesenteric artery confirms the presence of the pseudoaneurysm, which appears excluded after coil embolization (**e**)

Despite its high prevalence, adrenal adenoma is exceptionally complicated by a hemorrhage (Fig. 9). Pheochromocytoma is the commonest adrenal neoplasm revealed or complicated by spontaneous bleeding. Liquefaction of former intraglandular hematoma is thought to explain the classic, although uncommon, presentation of a pheochromocytoma as a cystic mass. Intratumoral hemorrhage is a common feature of adrenocortical carcinoma. Among secondary adrenal neoplasms, metastases from lung and melanoma origin are the most prone to bleed and hemorrhage can be the initial manifestation of the metastasis (Fig. 10).

3.4 Peripancreatic Bleeding

Owing to their mainly retroperitoneal location, pathological processes affecting the pancreas, particularly acute or chronic pancreatitis, may induce a

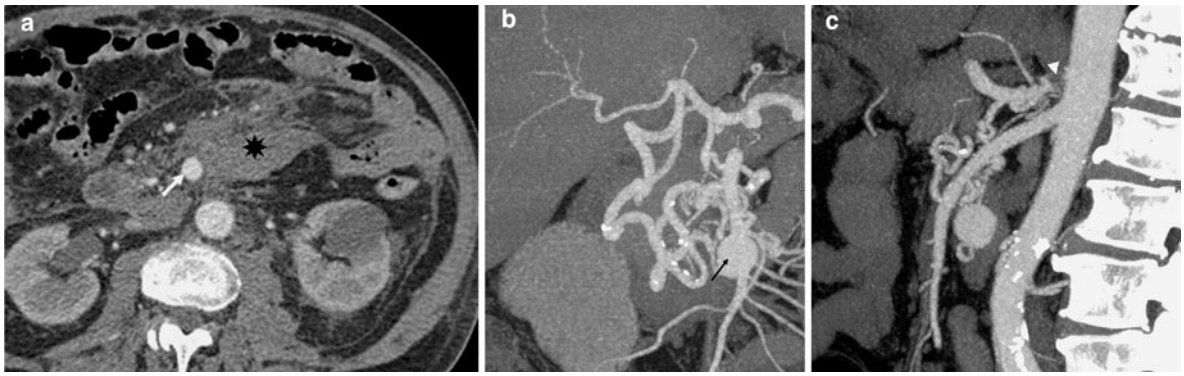

Fig. 12 Ruptured aneurysm of a pancreaticoduodenal artery in a patient with occlusion of the celiac trunk. **a** The pseudoaneurysm (*arrow*) is complicated by a blood effusion within the root of the mesentery (*star*). Its relationships with the pancreaticoduodenal arcades are best demonstrated on the coronal MIP projection (**b**). **c** Sagittal MIP projection confirms the occlusion of the celiac trunk (*open triangle*)

retroperitoneal bleeding. Pseudoaneurysm is observed as a complication of acute or chronic pancreatitis. The erosion of the artery may be biological (resulting from the autodigestion of the pancreatic or peripancreatic artery by elastase and trypsin) or mechanical (by erosion of a pancreatic pseudocyst into a neighboring visceral artery, converting a pseudocyst into a pseudoaneurysm) or both. Rupture of the pseudoaneurysm may involve the pancreatic ducts (resulting in wirsungorrhagia), the bile ducts (resulting in hemobilia), the gastrointestinal tract, the retroperitoneal spaces, or the peritoneal cavity. Splenic, pancreaticoduodenal, and gastroduodenal arteries are the most frequently involved vessels. CT is the best imaging tool, able to depict the pseudoaneurysms associated with features of chronic or acute pancreatitis (Fig. 11). Information obtained from CT simplifies the approach to the targeted vessel during subsequent angiographic embolization. CT may also reveal other causes of hemorrhage such as rupture of gastric varices in the case of segmental portal hypertension or splenic rupture.

Another condition favoring a retroperitoneal bleeding is the rupture of a pancreaticoduodenal artery developing as the complication of a celiac trunk or superior mesenteric artery stenosis (Fig. 12). As opposed to the false aneurysms, developing as a consequence of a local injury, such as pancreatitis, the lesion in that particular case is a true aneurysm. This is a much more uncommon situation, described for the first time by Sutton and Lawton (1973). A literature review in 1999, gathering 52 cases, found a prevalence of celiac trunk lesion of 63% (De Perrot et al. 1999). The theory originally proposed by Sutton and Lawton, based on the increased blood flow in the collateral network developing at the expense of the pancreaticoduodenal arcades, is supported by the description of cases where the treatment of the celiac trunk stenosis (direct revascularization or arcuate ligament section) allowed complete aneurysm regression. The same hypothesis is supported by another series that demonstrated 80% of peripancreatic artery dilatation in the group with celiac trunk stenosis and none in the control group (Patten et al. 1991). In a more recent review of 36 cases of aneurysm of the pancreaticoduodenal arteries associated with a celiac trunk stenosis, the size of the aneurysm did not appear as a factor for rupture because most ruptured aneurysms measured less than 10 mm, whereas all nonruptured aneurysms measured 10 mm or more (Ducasse et al. 2004). When ruptured, the pancreaticoduodenal artery aneurysm requires an emergent radiological arterial embolization. Later, to prevent recurrence, a surgical resection of the arcuate ligament and treatment of the celiac artery stenosis are recommended by several authors.

3.5 Systemic Causes of Spontaneous Retroperitoneal Bleeding

Systemic causes of retroperitoneal bleeding are dominated by polyarteritis nodosa. In this systemic vasculitis, fragility of the media of small and medium-sized

arteries results from the deposition of immune complexes in the arterial wall and leads to microaneurysms and hemorrhage. Multiorgan involvement is common. Kidney is involved in approximately 80% of cases, with a risk of perirenal hemorrhage (Maes et al. 2000). Abdominal complications may also occur because the mesenteric arteries are involved in 60% of cases (Adajar et al. 2006).

4 Conclusion

Spontaneous intraperitoneal and retroperitoneal hemorrhages can result from a vast variety of causes. CT plays an essential role in the positive and etiological diagnoses of most of the situations. It also affords important data for the interventional radiologist when hemostatic embolization or stent-graft placement is planned. MRI is of very limited value in this clinical situation, whereas US remains an essential tool in the evaluation of gynecological disorders.

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