Biliary Emergencies

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Abstract

Computed tomography (CT) is an important tool in the workup of patients with biliary emergencies. Optimal settings are mandatory to take full advantage of multidetector CT and to obtain the best multiplanar images with the lowest achievable radiation dose. CT is also part of an imaging strategy together with ultrasonography and magnetic resonance imaging. CT is a problem solver in the case of cholecystitis, most often complementary to ultrasonography, especially in the case of complications such as abscesses. CT is also an important tool to assess unusual diseases such as Mirizzi syndrome and ischemic cholangitis. Because CT is a tool that is available 24/7, the radiologist should be familiarize himself or herself with appropriate protocols and with interpretation of common and/or severe diseases, because most of clinical situations will require urgent medical decisions, mainly based on imaging.

1 Introduction

Although computed tomography (CT) is the workhorse of imaging in the case of abdominal emergencies, examination of the biliary tract is one field where ultrasonography (US) and magnetic resonance imaging (MRI) challenge CT. US has been the initial procedure for years and is still recommended when acute cholecystitis is suspected or when bile duct dilatation is anticipated in a patient with a potential obstructive jaundice. It has also been proposed as an adjunct to the clinical examination. This bedside US

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would help in the triage of patients (Endo 2010). Although the role of MRI in emergency patients has been very low until now, some authors are now exploring the capability of MRI in these conditions. MRI has some advantages, such as high tissue contrast, sensitivity to fluid and inflammation, allowing cholangiopancreatography, and improved spatial resolution and examination duration (Tkacz et al. 2009). Conversely, with CT it might be difficult to identify bile duct stones when they are poorly mineralized, and the radiation dose is a drawback (Brenner 2010). Also, although US and MRI have native 3D capabilities, CT was primarily a 2D method. The third dimension really appeared as a competitive adjunct with the development of multidetector CT (MDCT), especially with machines that include at least 16 detector rows, opening the possibility of nearly isotropic imaging (Choi et al. 2007). For bile ducts, volumetric examination through multiplanar navigation is clearly a necessity (Choi et al. 2007).

The availability of CT machines is also an important feature in emergency conditions. CT has definitely taken a leading role in the management of abdominal emergencies at large, and is now widely available 24/7 in most institutions that are in a position to take care of these patients (Mills et al. 2010). Therefore, availability is less a problem for CT than for other modalities such as MRI. For some institutions that do not host a specialized radiologist, sending images through a teleradiology system for remote reporting is also a possibility.

Because patients with acute abdomen should be examined with short notice, there are three competing major modalities, and the radiologist who is in charge of these patients should know how to manage all three modalities and make the best use of each as far as necessary, dealing with complementarities and substitution. Therefore, the clinician will appreciate this integrated management of imaging modalities.

Finally, in some situations, interventional radiology can be helpful, because it can solve the problem itself, become a temporary substitute for surgery in fragile patients, or even be a complement to surgery. Therefore, every radiologist should know the potential role of interventional radiology in these conditions, and appreciate the anatomical possibilities, as well as the optimal method for guidance, which is very commonly either CT or a combination of US and fluoroscopy.

In this chapter, the role of CT will be stressed, but in every situation the reader will be reminded of the role of US and MRI and the possibility of interventional radiology to help the radiologist become a complete global imaging expert.

2 CT Technique

2.1 How Many Rows?

Although CT examination of the bile ducts can be performed with virtually all CT machines, MDCT is a clear advance owing to the possibility to perform isotropic or nearly isotropic imaging. Given the complex anatomic orientation of the bile ducts and gallbladder, appreciation of all structures requires at least axial, coronal, and sagittal views with a similar spatial resolution (Choi et al. 2007).

It is also obvious that examination should never be focussed on the usual area of the bile ducts, for several reasons. First, although there are many anatomical variants, a distended gallbladder may be found as low as the right iliac fossa. Second, the bile ducts accompany the liver when it is displaced or enlarged. Again, finding the gallbladder in the right iliac fossa is possible in the case of liver enlargement. Third, some diseases of the bile ducts may lead to bile leakage, and therefore may be associated with peritoneal or even sometimes retroperitoneal fluid, which could be found down in the pelvis. Finally, the examination is usually motivated by symptoms that may correspond to disease of bile ducts as well as to many other emergency conditions. Therefore, the minimum examination should include the abdomen and the pelvis. Relying on clinical background, and also age characteristics, one should discuss if the inclusion of chest CT during the same examination is desirable or not. In a patient with severe infection, examination of the chest is recommended. Conversely, if the symptoms are clearly located to the bile ducts and if the patient is young, one can question if the additional radiation dose given for additional chest CT acquisition is justified or not. However, in this case, US would have been a better option from the beginning.

To compromise between the acquisition volume, duration of apnea, and the necessity to provide isotropic images, MDCT machines with 16 rows and above are most appropriate. If machines with fewer than 16 rows are used, the compromise would probably be to increase the pitch and decrease the volume to maintain spatial resolution. Obviously, 64-row machines are best adapted to the examination of the bile ducts, given the necessity to examine the whole abdomen, as well as the chest in many cases.

2.2 Plain Images

Another question is the necessity to perform plain imaging and/or postcontrast imaging. The main advantage of plain images is that they allow the detection of calcifications. This might be critical because, unlike urinary stones, the vast majority of biliary stones, at least those found in the common bile duct, are only faintly calcified or not calcified at all. Therefore, postcontrast images carry the risk of overlooking common bile duct stones (Neitlich et al. 1997). Conversely, adding another acquisition will increase the overall radiation dose (Brenner 2010).

Therefore, there is no unique answer to this question. The decision to perform plain imaging should be taken by the radiologist, in the context of clinical symptoms and previous US examination. Schematically, if there is suspicion of a common bile duct stone, if US findings are inconclusive, and if MRI is unavailable, CT should probably be performed using both plain and enhanced imaging.

In rare cases, iodine cannot be injected into the patient, owing to the presence of a contraindication. Although the amount of information will be much less, plain CT might, however, provide some useful information, such as the presence of calcifications, blood, or gas or the identification of a large tissue mass.

2.3 Contrast Enhancement

In most cases, intravenous contrast medium injection is mandatory, in order to better delineate normal tissue, tumor, and inflammation.

There are no specific requirements for contrast medium injection related to bile duct examination, and the injection rate and the iodine concentration are similar to those in most routine abdominal protocols. A total dose of 2 ml/kg and an injection rate of 1–2 ml/s are common and suitable settings.

The best single acquisition is performed in the portal phase, starting 70–90 s after injection has started. These slices are optimal to evaluate normal and abnormal bile duct wall and surrounding tissues and vessels.

In very rare instances, additional acquisition could be useful. In the case of bleeding of unknown origin, or suspicion of ischemic disease of the bile ducts, it might be useful to include an acquisition in the arterial phase as well. These situations are uncommon.

Delayed images are usually unnecessary.

2.4 Acquisition Parameters

Slice thickness is a confusing issue with MDCT. Slice collimation, primary reconstruction, and secondary reconstruction are usually completely different. Slice collimation is dependent on the detector characteristics. Most modern devices can acquire images with a collimation of approximately 0.6–1 mm. However, these slices are raw data and are seldom reconstructed as images, because the signal-to-noise ratio is not optimal, at least for an acceptable radiation dose (Gallix et al. 2006).

Most commonly, thicker slices are reconstructed. There are several options depending on the machine and the workstation. Because the biliary tree is a somewhat complex anatomic structure, multiplanar reconstructions are very useful, and sometimes not just in the common three planes (axial, coronal, sagittal). Oblique reconstructions are interesting, and specific planes should be adapted to the patient's specific anatomy, and to the findings for a disease.

Therefore, it is desirable to reconstruct a set of thin slices (approximately 1–1.25 mm) with an overlapping reconstruction to improve the quality of images reconstructed in alternative planes. Some workstations provide on-the-fly fast reconstruction in all directions, using the set of thin slices, and making easier the navigation in the volume. However, there are drawbacks: the signal-to-noise ratio is still not optimal and the number of slices is very high, which is a problem for storage and image transmission.

As a compromise, most centers now produce systematic and automatic reconstruction of 2–3-mm-thick slices in axial, coronal, and sagittal planes. Thinner slices are available on workstations in order to perform additional postprocessing, but may or may not be recorded on storage systems (picture archiving and communication system) and are usually not recorded on mobile media such as a CD-ROM.

The voltage is a very important issue for the optimization of the radiation dose to which the patient is exposed. Except in severely overweight patients, the voltage should not be set over 120 kV. In very thin patients, it is sufficient to use 100 kV. Most machines come with different software aiming to decrease an unnecessarily high radiation dose. A radiation dose report is provided for each examination. It is the radiologist's responsibility to check that the CT dose index and LDP are within acceptable limits.

2.5 Main Protocols

As a summary, there are four different protocols for CT of the bile ducts:

1. The most common protocol consists in a single acquisition, in the portal phase (70–90 s) after injection of iodine.
2. If there is suspicion of a common bile duct stone, a noncontrast acquisition should be added.
3. If the patient's general condition is poor, for instance, with intense fever, and if the symptoms are unclear, it is wise to include a chest CT acquisition as well.
4. In the case of bleeding, an arterial phase acquisition is mandatory.

However, these are general orientations and the radiologist should fine-tune the protocol according to the clinical questions. He or she should keep in mind that the expected quality of the examination and the radiation dose should be appropriately adapted to the patient's characteristics and symptoms.

Because CT is only one tool among others for these patients, the radiologist should be familiar with the indications, possibilities, and limits of alternative methods such as US and MRI. Ideally, the radiologist could be able to decide which examination is best suited to the patient or which sequence of examinations is appropriate. In that case, it is likely that US will be the first examination performed in the vast majority of cases.

3 Gallbladder Disease

3.1 Acute Cholecystitis

Acute cholecystitis is a very common disease. It accounts for 3–10% of all patients with abdominal pain (Brewer et al. 1976). Most of the patients are over 50 years old. In 90–95% of patients, it is attributable to gallbladder stones. It is likely that the stones in the gallbladder are deleterious for several reasons. First, there could be a direct mechanical inflammation related to contact of the stone with the mucosa. Second, this inflammation may cause a small hemorrhage that might increase inflammation again and favor infection. However, the third process might be the most important one. The stone may block the outflow, increasing the pressure within the gallbladder and favoring the development of infection. The degree of obstruction and its duration are important factors. If the obstruction is incomplete and short, the patient has biliary colic. If the obstruction is total and durable, acute cholecystitis can develop (Kimura et al. 2007).

In less than 10% of cases, cholecystitis may develop in a gallbladder with no preexisting stones. This "acalculous" cholecystitis is mainly observed in patients with a severe general condition, such as in patients in an intensive care unit for any reason, in the postoperative period in patients who have undergone heavy surgery, and more commonly in patients with a recent polytrauma or blunt trauma of the abdomen. For this reason, it should be remembered that the absence of a gallbladder stone does not preclude the possibility of a cholecystitis. The pathogenesis is somewhat similar to that of calculous cholecystitis. Even if there is no stone, stasis and functional obstruction of the bile outflow is probably the main reason for infection and inflammation. There is a lack of stimulation for gallbladder emptying, which is also enhanced by medications such as opioid analgesics. Gallbladder ischemia and the presence of mediators of inflammation due to the associated disease are also cofactors.

A specific situation is the patient with recent chemoembolization, who is exposed to ischemic cholecystitis (Wagnetz et al. 2010). In this case, the diagnosis is easy, given the clinical background. Cholecystitis related to radioembolization is a similar issue (Atassi et al. 2008).

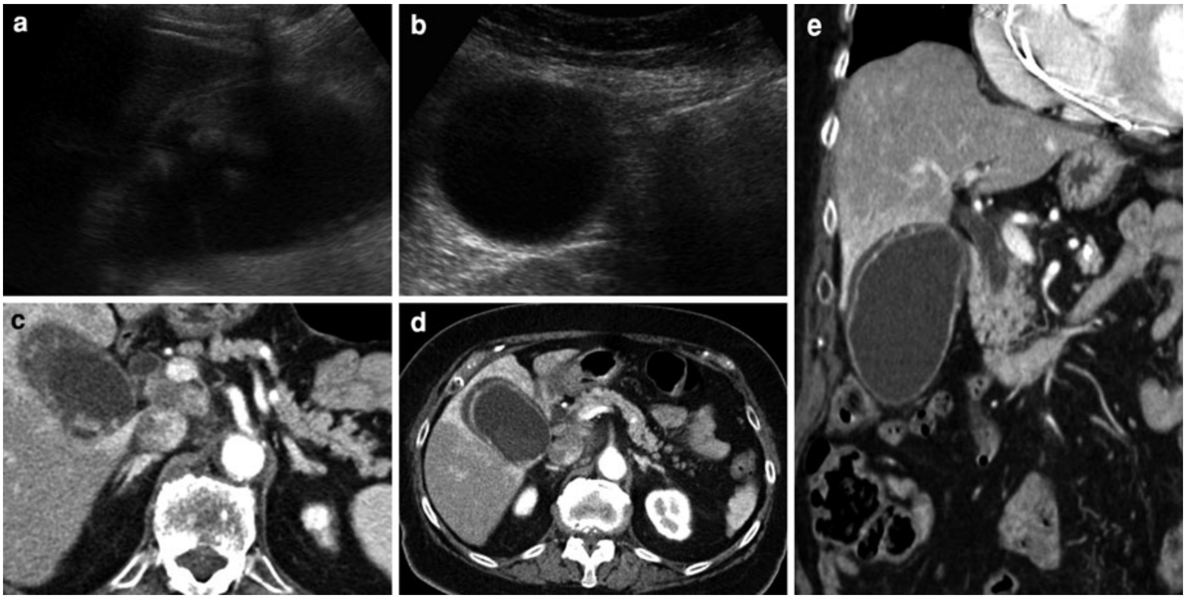

Fig. 1 A 88-year-old woman with abdominal pain and a Murphy sign on clinical examination. **a** Ultraonography (US) findings were misleading because there was some material within the gallbladder but it was "floating". Shadowing was mild. **b** No definite wall thickening in the gallbladder fundus. Although the diagnosis of acute cholecystitis was likely, computed tomography (CT) was performed because of some ambiguous features. **c–e** Postcontrast CT in the axial (**c**, **d**) and in the coronal (**e**) planes. Obvious thickening of the gallbladder wall was seen. On the upper slice (**c**), the gallbladder wall seemed highly inflammatory, with some mucosal disruption. On the lower slice (**d**) the wall appeared as homogeneously thickened. On the coronal image (**e**), the difference between the obviously thickened wall in the upper part of the gallbladder contrasts with the rather normal appearance of the fundus, as noticed on US. See also in **c** slightly hyperdense material appearing within the gallbladder as well as hyperemia of the surrounding liver, related to gallbladder inflammation

There are several stages of acute cholecystitis (Kimura et al. 2007). Initially, the cholecystitis is only edematous. There is no damage to the gallbladder wall except reversible edema. Necrotizing cholecystitis is the second stage. There is damage to the mucosa, but lesions are not transmural. Suppurative cholecystitis is the third stage. Active necrosis is present and there is a risk of perforation and pericholecystic abscesses. Finally, chronic cholecystitis is the result of repeated occurrences of attenuated episodes. Mucosal atrophy is observed as well as fibrosis.

Acute cholecystitis presents as a progressively increasing pain of the right upper quadrant or of the epigastric area. Pain may be continuous or acuminated. One major characteristic is that the palpation of the gallbladder area reinforces the pain, which should be same as the spontaneous pain, and should prevent the patient from breathing in deeply. If the palpation is done in the same condition, but in a slightly different area, the same characteristics do not appear. This is known as the Murphy sign. Hyperthermia is present, but moderate. In the case of very severe hyperthermia, one should suspect a complication such as perforation.

In most circumstances, US should be the first examination performed for the detection of cholecystitis, at least if it is clinically suspected. US has the potential to identify the gallbladder stone, thickening of the gallbladder wall, and hypervascularization of the inflamed wall, as depicted with color Doppler US (Ralls et al. 1985, Jeffrey et al. 1995). Also, US has the potential to reproduce the clinical Murphy maneuver, and to check that the target area for palpation is really related to the gallbladder (Ralls et al. 1982).

There have not been so many studies comparing the results of US and CT for the detection of acute cholecystitis. Only Mirvis et al. (1986) found that the final results were very similar, and their study was limited to a very short series of 15 cases, in which sensitivity and specificity were both 100%. Because technology has improved so much, MDCT should

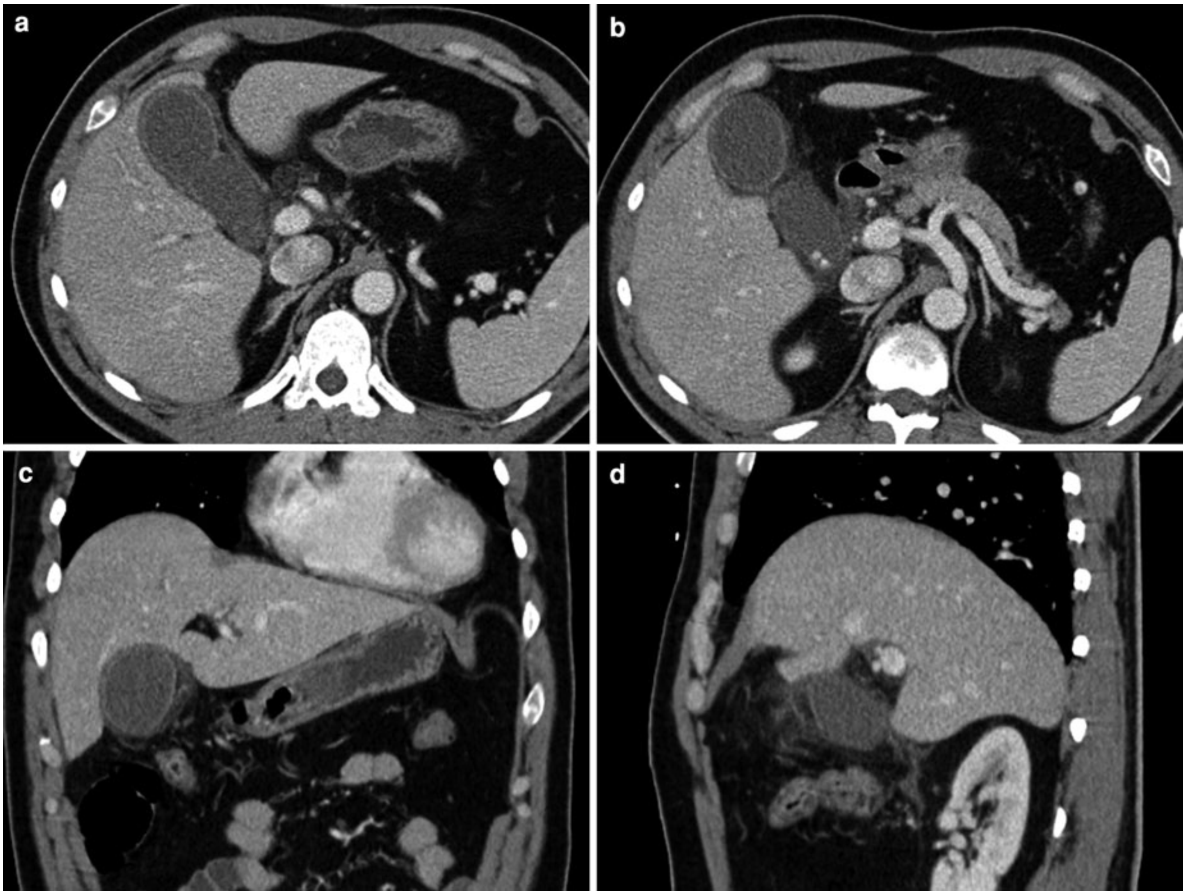

Fig. 2 Typical cholecystitis associated with gallstones. A 44-year-old man with right upper quadrant pain, fever, and a Murphy sign. CT in the axial (**a**, **b**) coronal (**c**), and sagittal (**d**) planes confirms gallbladder wall thickening, hyperattenuation of the perivesicular fat, and stranding, associated with calcified gallstones in the neck of the gallbladder

also be an excellent tool for this purpose. Compared with US, the only drawback of CT was that gallstones were not always identified. However, this did not prevent the correct diagnosis being made using the other signs for inflammation.

When US findings are positive and typical, there is no need for additional CT. However, US has limitations. Access to the gallbladder area may be difficult owing to gas interposition and a small stone in the gallbladder neck might be challenging to identify. Finally, in not all cases of cholecystitis is there a thickened wall and even wall thickening can be heterogeneous (Fig. 1). Gangrenous cholecystitis may have with a very thin wall, and carry a high risk of perforation.

Because CT is typically performed in challenging cases, and because the identification of a stone in the gallbladder neck might be difficult, it is advisable to start the examination with plain images acquired through the upper abdomen only. Arterial phase images are not mandatory. Portal phase images are the best adapted sequence. Thin slices are desirable because the anatomy of the gallbladder is rather complex. In addition to conventional axial, coronal, and sagittal planes, oblique reconstructions through the long axis and the short axis of the gallbladder allow optimal analysis of the gallbladder wall. This is critical because one of the goals of CT examination is to detect fistulization through the gallbladder wall, mainly to the liver parenchyma.

The most common feature of cholecystitis is thickening of the gallbladder wall (Figs. 1, 2, 3, 4). Usually the threshold is 3 mm. Measurement of the gallbladder wall is not so easy because there are several layers, with enhanced mucosa, and edematous submucosa (Fig. 3) One should measure the whole gallbladder wall, and not only the enhanced layer, which is often limited to the mucosa. After contrast medium injection, there is a marked enhancement of the gallbladder wall, either homogeneous or layered owing to preferential enhancement of the mucosa (Fig. 2). Edema of the periphery of the gallbladder wall may be seen as a hypodense ring, which is often interpreted as a perivesicular localized peritoneal fluid collection (Fig. 3). Actually, this cannot be the case because there is no peritoneal recess between the superior part of the fundus and the liver. Fluid can be present as well. A very small quantity is only the result of local inflammation and is not necessarily pejorative.

Gallbladder wall thickening is not specific to cholecystitis, as it can be found in other circumstances, such as portal hypertension, adenomyomatosis, and acute hepatitis. Portal hypertension is not a problem because there are no clinical symptoms for a cholecystitis. Adenomyomatosis can be associated with colic pain, in the case of a commonly associated gallbladder stone. However, there is no fever or inflammation of the gallbladder wall, and the appearance of very small cystic lesions within the wall is rather characteristic. Conversely, acute hepatitis can occur with a very similar pain. Evaluation of liver test results is useful because cholecystitis is rarely associated with a very high level of transaminases, whereas hepatitis is usually associated with marked cytolysis.

Mucosal sloughing is another sign for cholecystitis (Fig. 5). However, it is difficult to identify owing to mild changes of attenuation between the mucosa and the bile, which can be hyperattenuating itself.

Hyperemia of the surrounding liver is often associated with cholecystitis and can be a helpful ancillary sign. Of course, it is likely that localized liver hyperemia is related to inflammation of the gallbladder wall, and this may help one differentiate inflammation from other causes of wall thickening (Fig. 1).

Stranding and hyperattenuation of the perivesicular fat is a second sign frequently observed. Although this appearance is consistent with regional inflammation, its specificity is rather low.

Difficulty to see gallstones on CT sometimes makes it difficult to differentiate between calculous

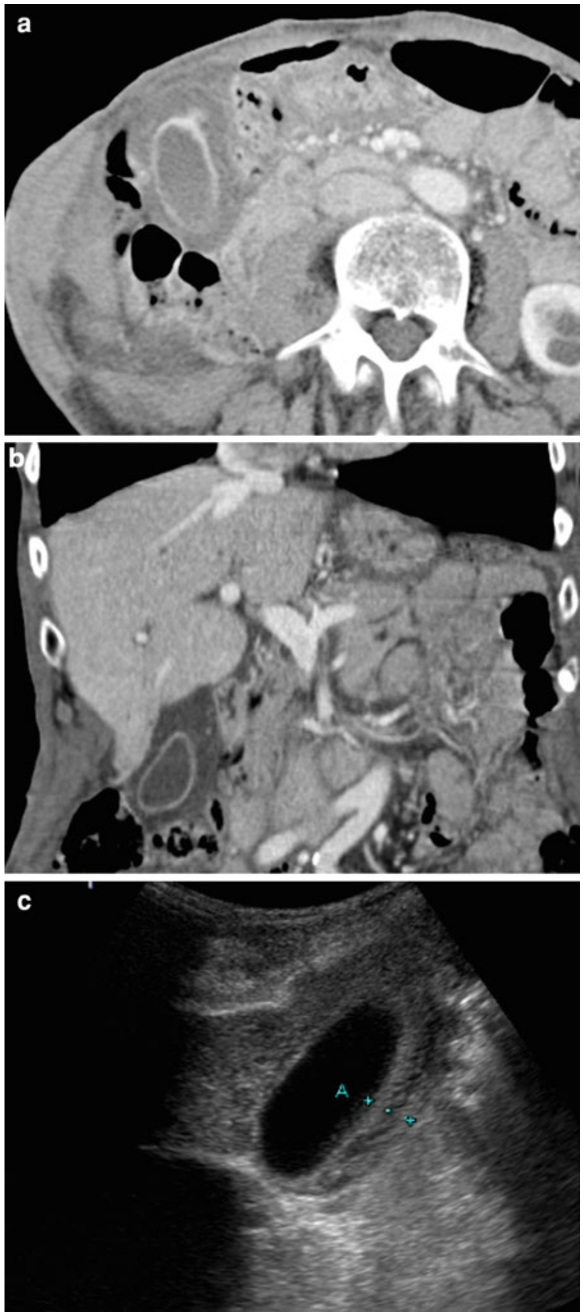

Fig. 3 Edematous thickening of the gallbladder wall in a patient with acute cholecystitis. A 91-year-old man without any medical record with abdominal pain and fever. Because the clinical features were unclear, CT was performed initially. Postcontrast CT in the axial (**a**) and coronal (**b**) planes shows a hypoattenuating rim surrounding the gallbladder. The initial report concluded there was peritoneal perivesicular accumulation of fluid. US performed immediately thereafter (**c**) showed that this was part of a markedly enlarged gallbladder wall

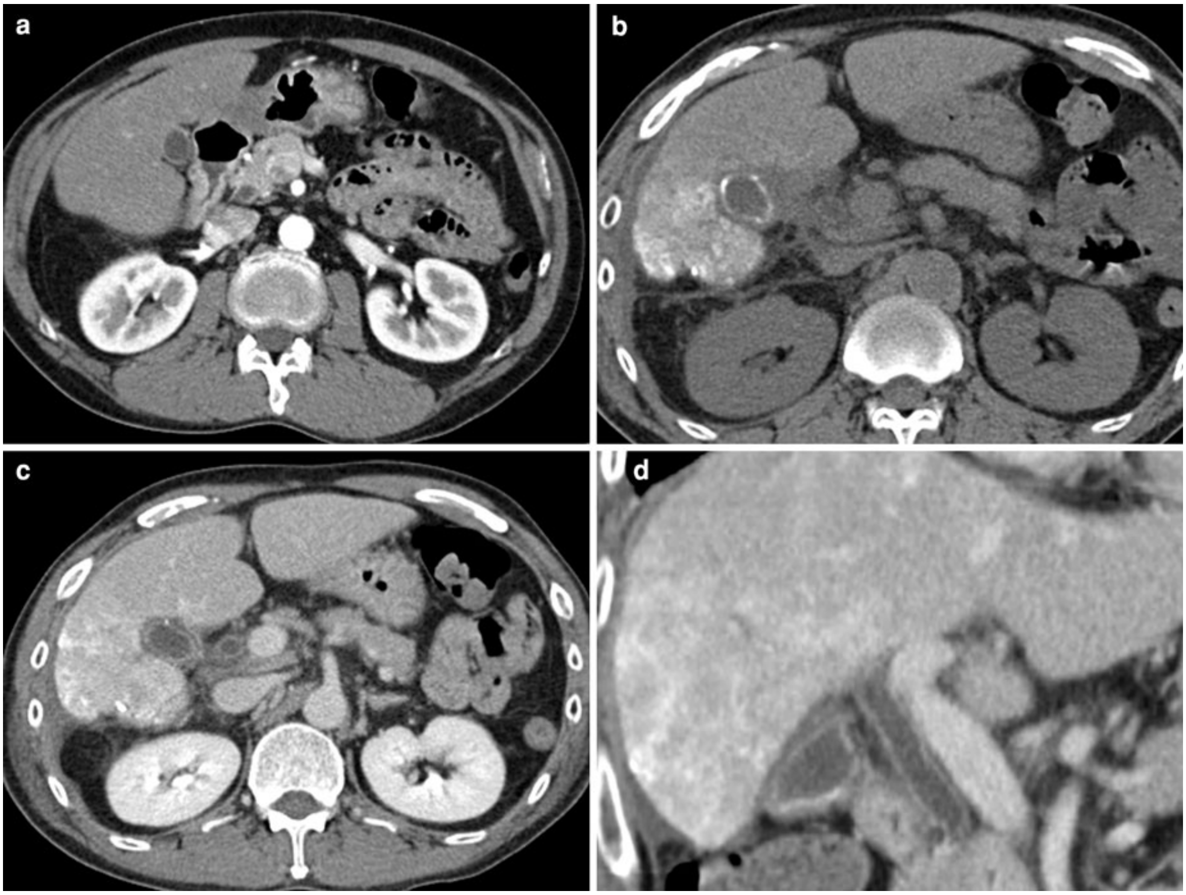

Fig. 4 Ischemic cholecystitis after chemoembolization. A 55-year-old man underwent chemoembolization for palliative treatment of hepatocellular carcinoma. Three days after chemoembolization, the patient complained of severe pain in the right upper quadrant. **a** On CT performed 1 month before, the gallbladder was unremarkable. **b** CT on the third day after chemoembolization. Plain image showing the presence of Lipiodol within the gallbladder wall. **c–d** After injection, the gallbladder wall is thickened and appears layered on the axial (**c**), and coronal (**d**) images

and acalculous cholecystitis. Stones can be completely overlooked because their attenuation can be similar to that of bile. In some cases, narrowing the window allows visualization of slightly hyperattenuating stones within the gallbladder (Fig. 1). Finally, the clinical background helps in differentiating calculous and acalculous cholecystitis when the context is, for instance, that of an ischemic cholecystitis related to chemoembolization (Fig. 4), severe associated disease or trauma, or the complication of bile duct stenting.

Some CT criteria have been gathered to facilitate the diagnosis and are reported in Table 1.

Complications of cholecystitis are as follows:

- Emphysematous cholecystitis is an exceptional occurrence characterized by the presence of gas within the gallbladder wall or even within the cavity (Wu et al. 2010b). The presence of air is related to necrosis and/or development of anaerobic bacteria. Obviously, if the air is within the lumen, it should not be confused with a common aerobilia, following surgery, endoscopic sphincterotomy, or sometimes spontaneous fistulization within the bowel. The presence of some air within the gallbladder wall is one of the signs for acute cholecystitis, although it is rarely encountered.
- Perforation of the gallbladder within the peritoneum is a rare but life-threatening event. A very small amount of peritoneal fluid is usually associated with inflammation and is not pejorative. If the quantity of fluid increases, and moreover if the clinical presentation is more a peritonitis than a

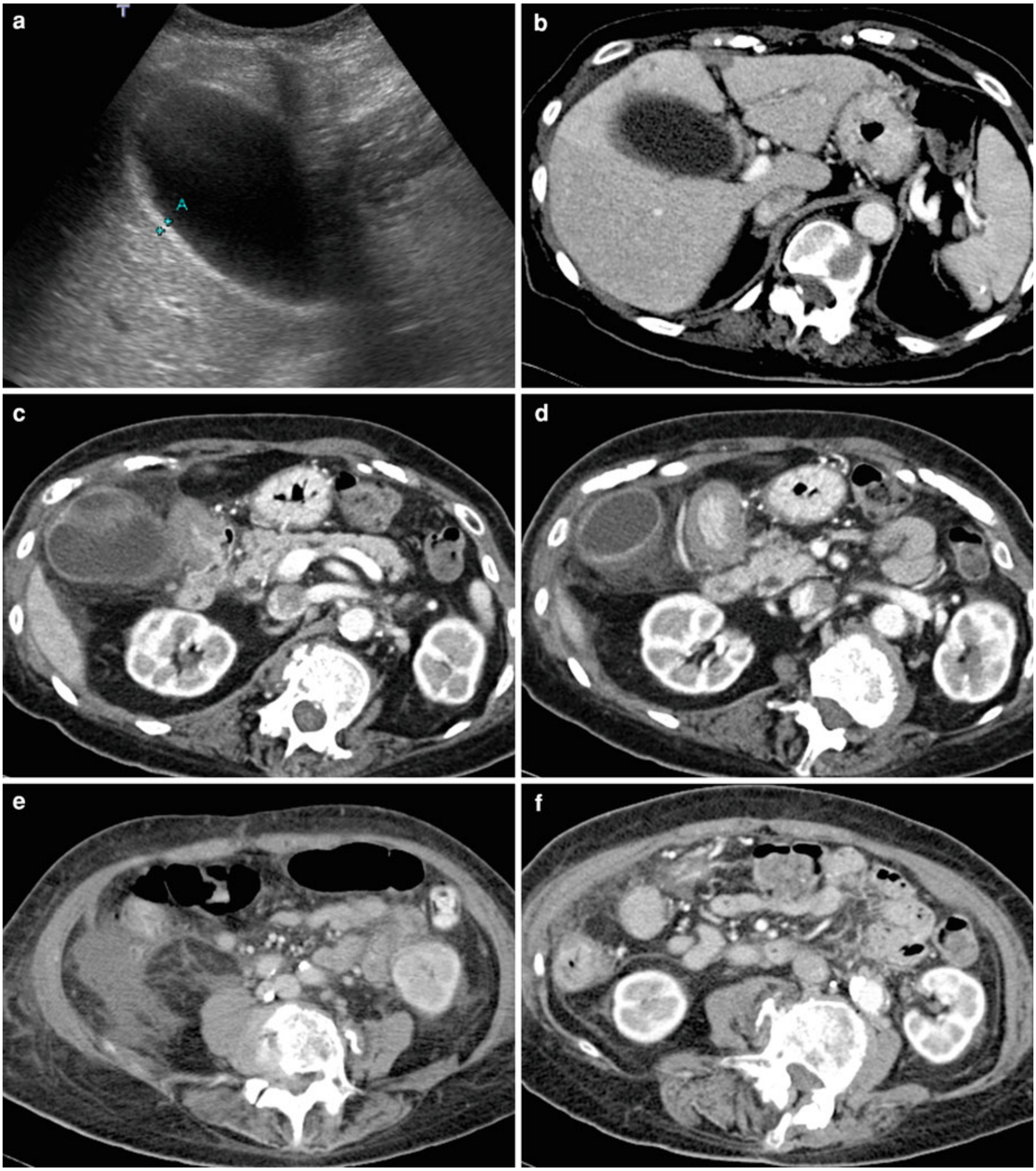

Fig. 5 Acalculous acute cholecystitis. An 82-year-old man with pulmonary embolism in an intensive care unit. On the basis of abdominal pain and an elevated white cell blood count, acalculous cholecystitis was suspected. The diagnosis was made by CT after inconclusive US findings. Antibiotics were given, but there was deterioration on the second day. CT showed increased peritoneal effusion, and the patient was successfully treated with percutaneous cholecystostomy **a** US findings were inconclusive, showing a moderate thickening of the wall as well as gallbladder distension. It was unclear if there was a Murphy sign. **b–d** CT performed the same day shows perfusion abnormalities in the liver next to the gallbladder bed (**b**), thickened gallbladder wall as well as sloughing (**c**), and hyperattenuation of the surrounding fat. **e** CT on the second day shows peritoneal effusion. **f** A percutaneous cholecystostomy was performed under bedside US guidance. The recovery was uneventful

Table 1 Criteria for the diagnosis of acute cholecystitis on computed tomography. Either two major criteria or one major criterion and two minor criteria satisfy the CT diagnosis of acute cholecystitis. (Adapted from Barie and Eachempati 2010)

Major criteria	Minor criteria
Gallbladder wall thickening more than 3 mm	Gallbladder distention (more than 5 cm in transverse diameter)
Subserosal halo sign (intramural lucency caused by edema)	High-attenuation bile (sludge)
Pericholecystic infiltration of fat	
Pericholecystic fluid (without either ascites or hypoalbuminemia)	
Mucosal sloughing	
Intramural gas	

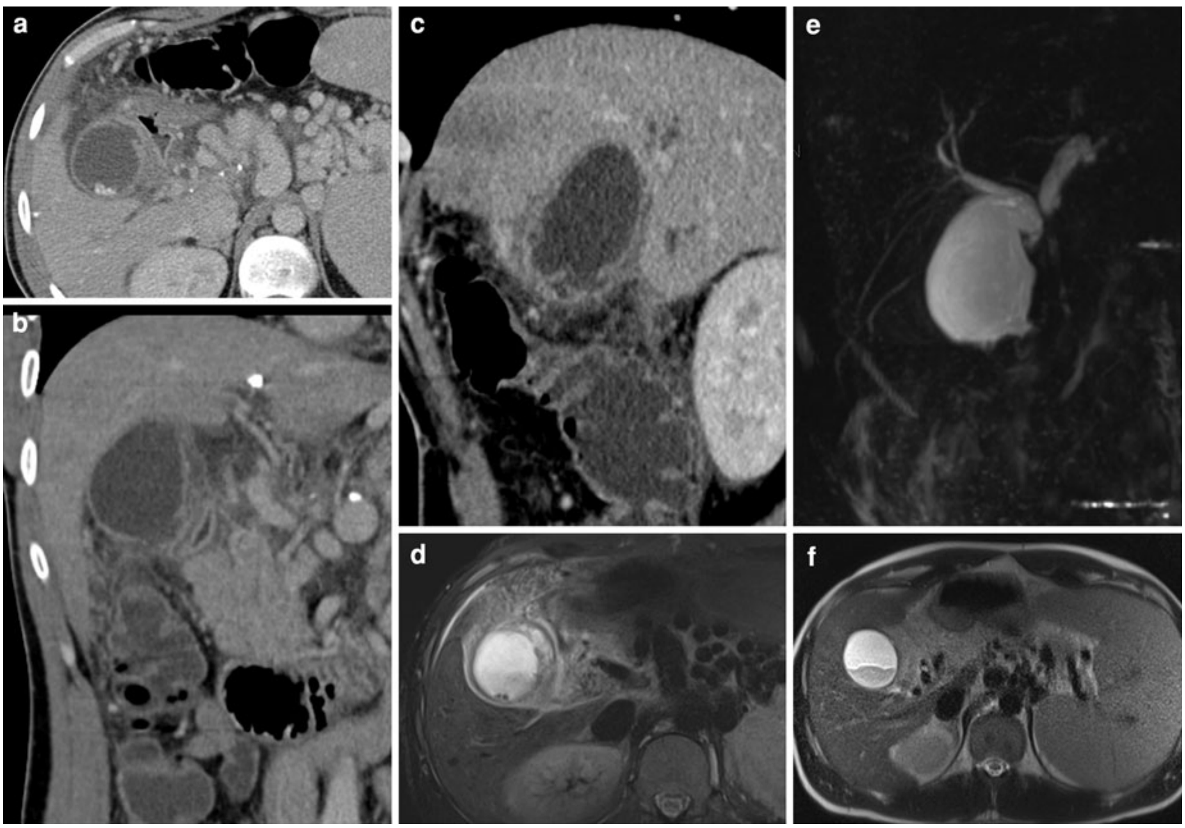

Fig. 6 Perforated cholecystitis in a patient with portal cavernoma. A 30-year-old patient with a history of portal cavernoma. US findings were inconclusive owing to the presence of portal collaterals. Postcontrast CT in the axial (**a**), coronal (**b**), and sagittal (**c**) planes shows abnormalities of the gallbladder wall, and a localized defect in the gallbladder wall. Magnetic resonance imaging (MRI) confirms the irregularities of the gallbladder wall in the fundus on T2-weighted axial images (**d**) and on magnetic resonance cholangiopancreatography (**e**) and fluid–fluid level on a T2-weighted half-Fourier acquisition single shot turbo spin echo sequence (**f**)

localized pain, perforation of the gallbladder and peritoneal bile leakage should be suspected. Subtle perforation of the gallbladder wall can sometimes be suspected before leakage (Fig. 6).

- Gangrenous cholecystitis is related to necrosis of the wall. Consequently, the gallbladder wall thickening might be absent, and, by virtue of necrosis, there is no enhancement after injection of contrast medium

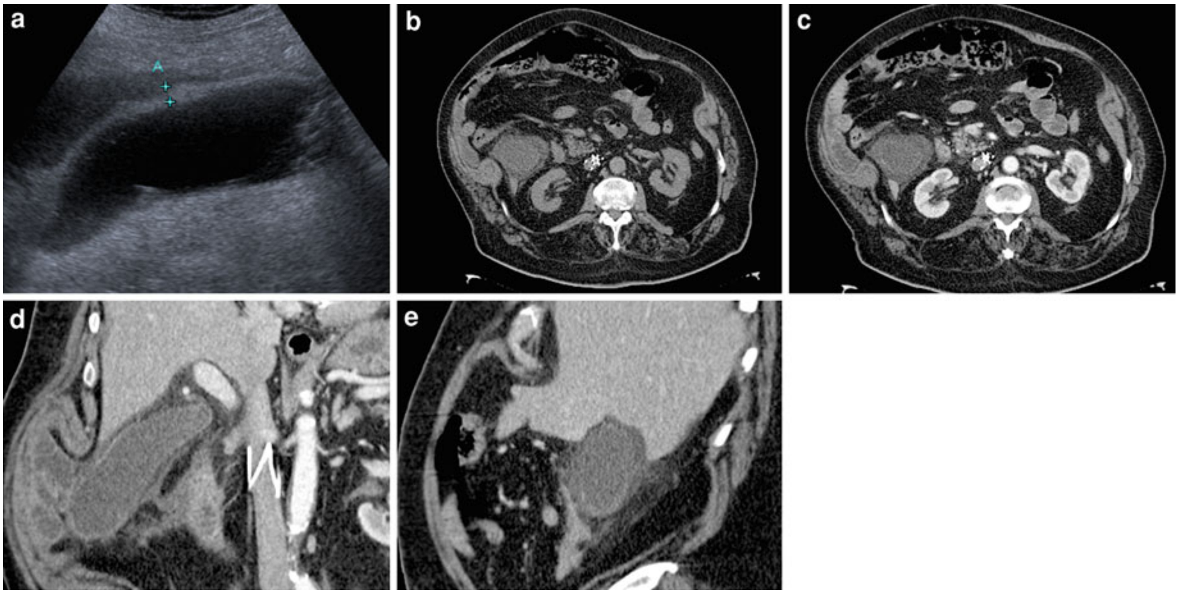

Fig. 7 Acute gangrenous cholecystitis. Am 85-year-old patient with fever and pain in the right flank. On surgery, gangrenous cholecystitis with minimal localized perforations was seen. **a** US shows a distended gallbladder with stones and thickening of the gallbladder wall. Gallstones are not identified, **b** Plain CT shows the gallbladder with hyperattenuation surrounding fat. **c–e** Post contrast CT in the axial (**c**), coronal (**d**), and sagittal (**e**) planes show that there is virtually no enhancement of the gallbladder wall

(Fig. 7). However, the wall is usually irregular, some places showing thickening and enhancements, others being thin and without enhancement. Gangrenous cholecystitis is usually associated with severe clinical symptoms, prompting rapid surgery. It occurs in up to 7.1% of cases of cholecystitis (Tokunaga et al. 1997). There are some discriminating CT signs for gangrenous cholecystitis. One is the presence of perfusion defects in the gallbladder wall, either localized or generalized. The appearance could be that of a poorly enhanced gallbladder wall (Wu et al. 2010a). In a series of 25 patients, the presence of a perfusion defect was 100% predictive of gangrenous cholecystitis, whereas conversely, 30% of gangrenous cholecystitis did not come with such defects.

- The most common complication of cholecystitis is liver abscess formation (Fig. 8). Abscesses usually develop in segments IV or V of the liver and are related to direct fistulization through a perforation of the superior aspects of the gallbladder wall. The role of CT in the depiction of liver abscesses is extremely important because US may fail to detect these complications, at least when they are small. However, this is a critical issue for treatment planning. It precludes the possibility for simple laparoscopic surgery and alternatively may require initial percutaneous drainage or even open surgery. The detection of liver abscesses requires careful multiplanar examination. The abscess is best depicted on portal phase imaging. Enhanced wall of the abscess is very common. It is sometimes associated with nonspecific regional liver enhancement; however, this hyperemia can be seen even in the absence of any liver abscess (Fig. 1). Conversely, gallbladder cancer can mimic cholecystitis with liver abscess (Fig. 9). The appearance can be extremely confusing because a gallbladder stone can be associated and there could be hypervascularization of the adjacent liver parenchyma as well (Fig. 10).
- Generally speaking, CT is slightly superior to US for the exact depiction of the disease, not only the presence or absence of abscesses, and also to appreciate the amount of inflammation. As some of these patients are fragile because of age or comorbidities, there are alternatives to classic surgery, such as percutaneous drainage of the gallbladder, which can often facilitate delayed surgery,

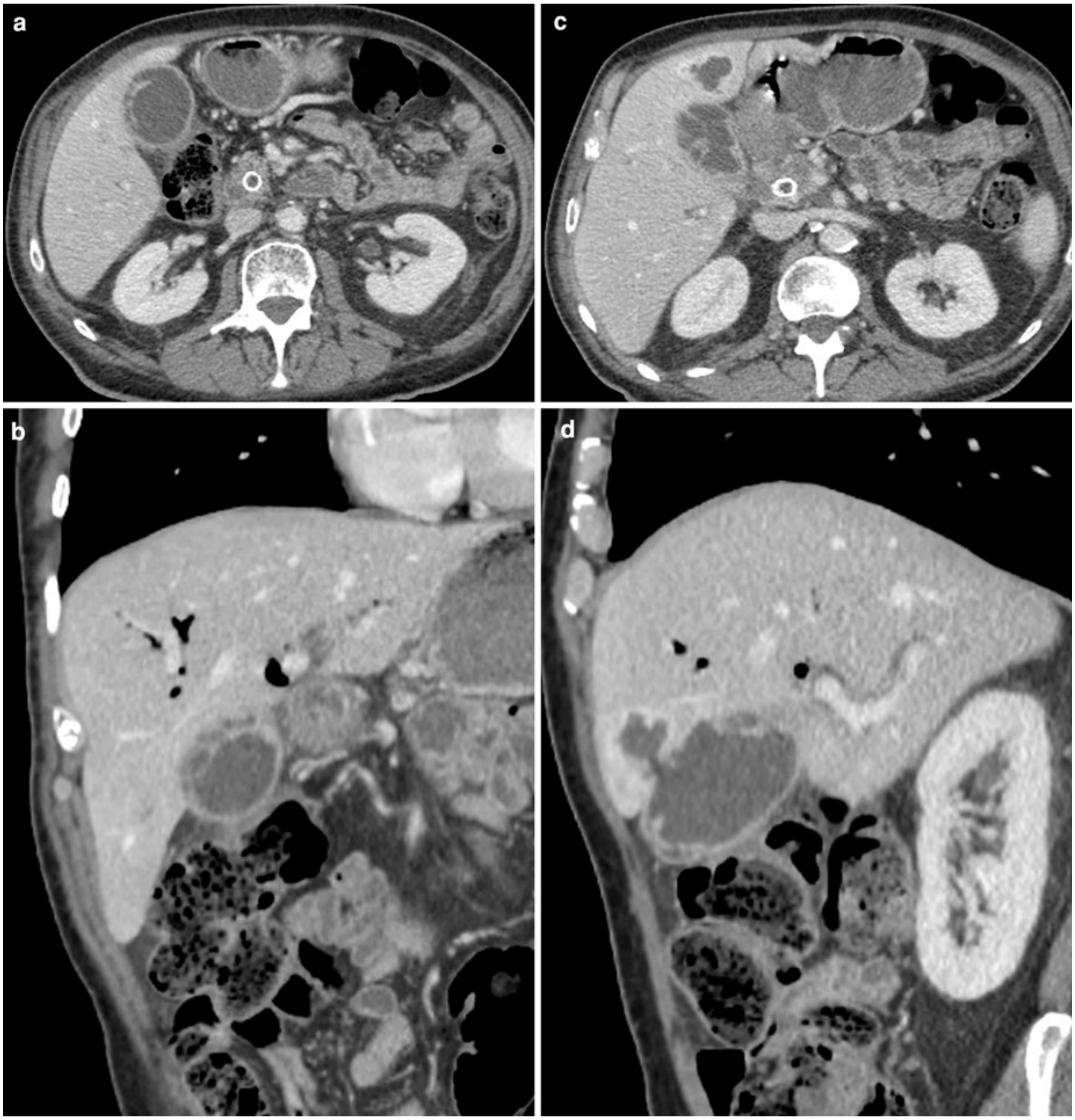

Fig. 8 A 72-year-old man with cancer of the pancreas treated with chemotherapy and metallic stenting of the common bile duct, experiencing fever and tenderness of the right upper quadrant. Postcontrast CT shows the pancreatic tumor and the stent, and a gallbladder with thickened wall and mucosal sloughing in the axial (**a**) and coronal (**b**) planes. In the adjacent liver, there is a hypoattenuating mass with enhanced contours (**c**). Communication between this liver abscess and the inflamed gallbladder is better visualized in the sagittal plane (**d**)

or even partial resection of the gallbladder, trying to avoid difficult dissections near the cystic duct and the common bile duct, in order to avoid severe complications such as intraoperative injury of the common bile duct or of the right hepatic duct. Even if US findings are positive, in these fragile patients it might be wise to perform CT to provide a more precise topographical evaluation of the disease. CT

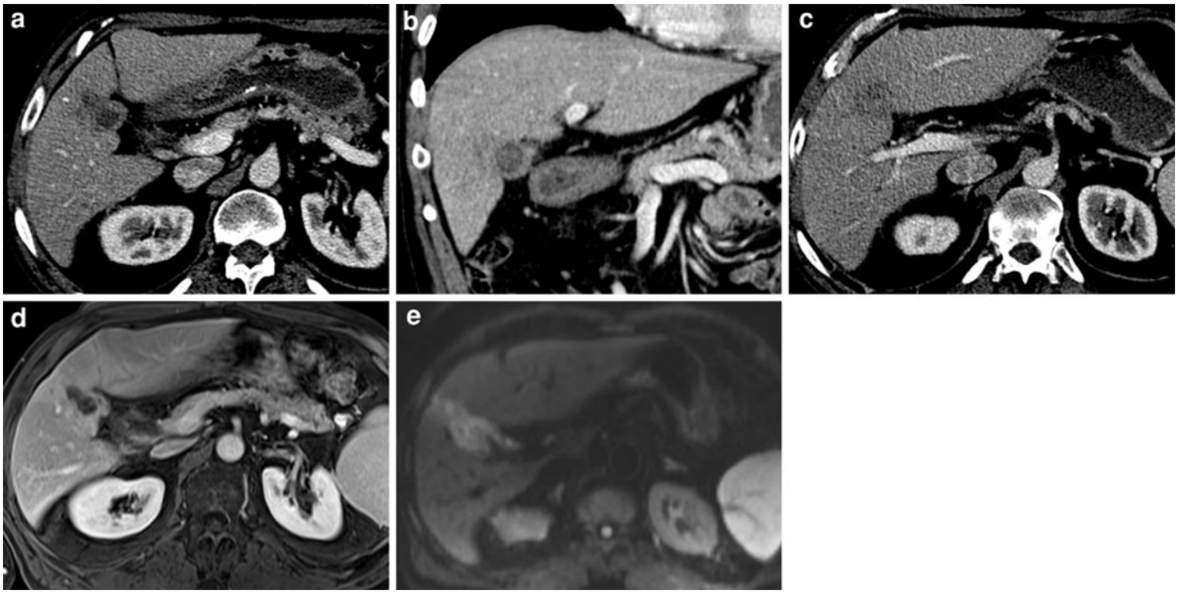

Fig. 9 Gallbladder cancer mimicking cholecystitis. A 64-year-old patient is treated for lymphoma of the neck. He presented with mild fever and increasing pain of the right upper quadrant. US shows enlargement of the gallbladder wall without the Murphy sign. CT and MRI could not differentiate between chronic cholecystitis and cancer. Fine-needle aspiration was performed and confirmed malignancy. The tumor was surgically removed. CT shows enlargement of the gallbladder wall on axial (**a**) and coronal (**b**) planes. **c** In the segments IV and V of the liver, there is a hypoattenuating area. MRI was performed. Gd-enhanced T1-weighted images in the portal phase (**d**) confirmed gallbladder wall thickening and a hypointense area in adjacent liver, whereas the diffusion-weighted image (**e**) showed diffuse restriction of the area

can also be a useful tool for close follow-up of fragile patients when the risk of surgery seems high and there is discussion whether an interventional or a surgical is best (Fig. 7).

3.2 Mirizzi Syndrome

Mirizzi syndrome is a rare and challenging situation. A stone is impacted in the cystic duct. This stone mechanically erodes the duct wall, and produces an inflammatory mass. Because the cystic duct is in very close relationship with the hepatic duct, this mass at least compresses the common bile duct, at the level of the hepatic duct, or even creates a complex fistula. Depending on the severity, Mirizzi syndrome can be classified as stage I if there is only a compression of the common bile duct and stages II–V according to the presence of fistulas of the common bile duct and the duodenum, with or without stone ileus (Solis-Caxaj 2009). This classification may not be universally accepted, but it translates the fact that surgical procedures can widely differ from one stage to another. The role of imaging is to delineate the existence or at least the risk of fistulas.

Usually, the main clinical finding is jaundice, owing to the obstruction of the hepatic duct. Surgery can be very difficult because there is at least inflammation of the hepatic duct, if not fistulas and some destruction of the common bile duct wall. Resection of the stone and the gallbladder is not easy.

Mirizzi syndrome should be suspected when a patient presents with bile duct dilatation at the level of the common hepatic duct and above, with a stone located in the area of the obstruction (Fig. 11). Because the stone is surrounded by inflammation, the appearance might be challenging. Sometimes irregular enhancement is seen, mimicking a tumor. The gallbladder stone is sometimes only faintly calcified, only at the periphery, and the calcified ring might be incomplete. For this reason, Mirizzi syndrome is frequently overlooked as a tumor, unless the specific location is identified, leading to consideration of this possibility.

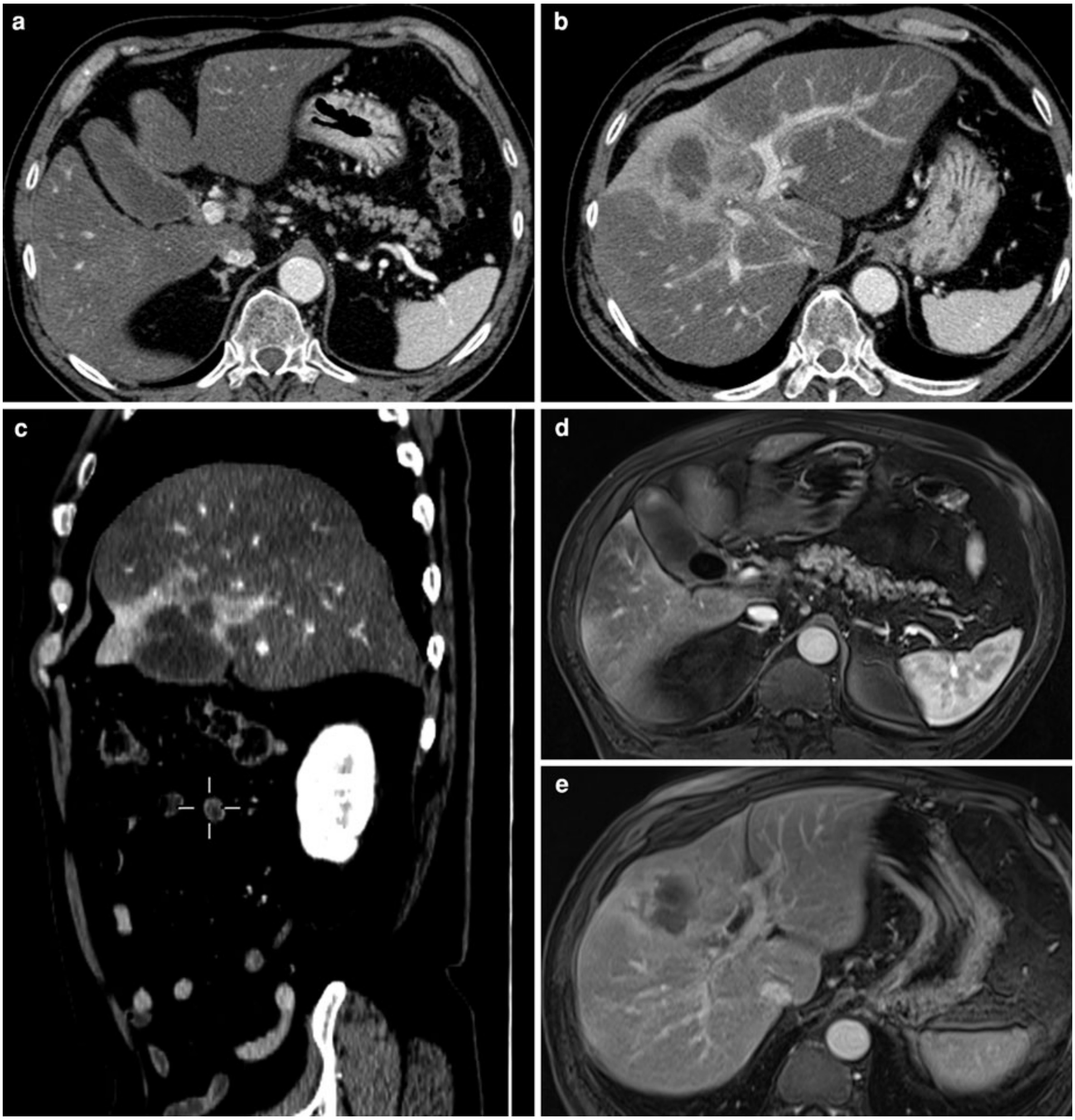

Fig. 10 Gallbladder cancer mimicking perforated cholecystitis. A 66-year-old patient with abdominal pain and fever. CT and MRI favor the hypothesis of a calculous cholecystitis with intrahepatic abscess formation related to gallbladder wall perforation. Surgery demonstrated that it was in fact a large bulky gallbladder carcinoma, associated with inflammatory changes. Contrast-enhanced CT shows a gallbladder with an irregular wall (**a**) and a hypoattenuating mass within segments IV and V of the liver (**b**) associated with liver perfusion changes of inflammatory type. There is an obvious communication with the gallbladder on the sagittal plane (**c**) MRI (T1-weighted Gd-enhanced) confirms the presence of a large gallstone, not apparent on CT (**d**), and the adjacent mass within the liver (**e**)

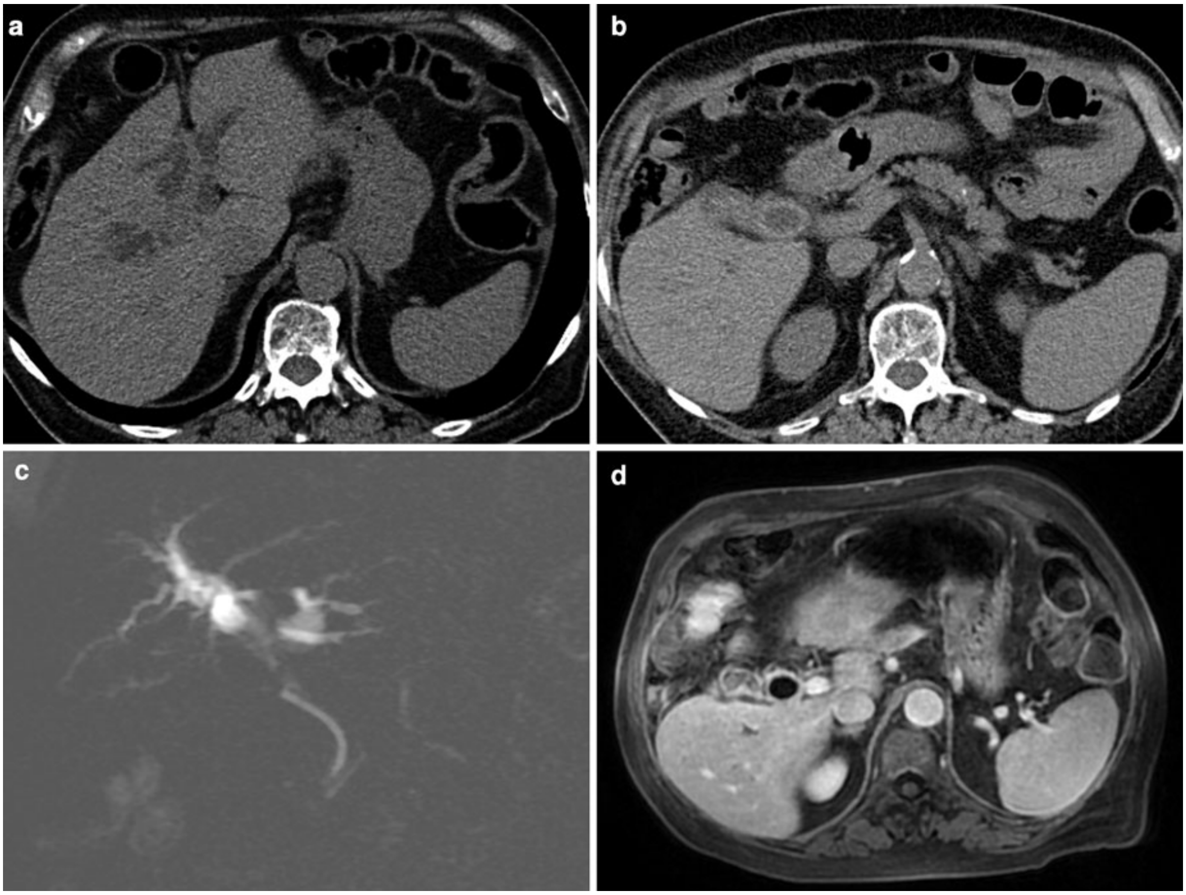

Fig. 11 Mirizzi syndrome. A 72-year-old man with progressive jaundice. US shows dilatation of intrahepatic bile ducts, but not of the lower common bile duct. The gallbladder area is difficult to analyze. Plain CT (**a**, **b**) and MRI (**c**, **d**) were performed. On plain CT, intrahepatic dilation of the bile duct is seen (**a**). On a lower slice (**b**), a stone is detected, appearing as hypoattenuating in the center and slightly hyerattenuating at the periphery. In the gallbladder fossa, the stone is seen in the gallbladder neck area, and the gallbladder seems to be collapsed. On the magnetic resonance cholangiogram (**c**), intrahepatic dilatation is confirmed and the lower common bile duct is normal. On contrast-enhanced images in the axial plane (**d**), the stone is clearly visible and the gallbladder seems atrophic. On surgery, Mirizzi syndrome was confirmed. The hepatic duct was inflammatory and there were two small fistulas between the cystic duct and the hepatic duct. Cholecystectomy and drainage of the common bile duct were performed and the postoperative period was uneventful

The diagnosis benefits greatly from the complementary of CT and magnetic resonance cholangiopancreatography (MRCP). In a study of 52 patients, the overall sensitivity, specificity, positive predictive value, negative predictive value, and accuracy of the combination of MRCP and CT were 96.0, 93.5, 83.5, 98.5, and 94.0%, respectively. Corresponding values for CT were 42.0, 98.5, 93.0, 83.5, and 85.0%, respectively (Yun et al. 2009).

From a treatment point of view, surgery is mandatory. The stone and the gallbladder should be removed, but the inflammatory mass is usually not resected. Cautious intubation of the hepatic duct and postoperative drainage, sometimes prolonged, allows progressive healing and hopefully a satisfactory recovery of the bile duct continuity (Hubert et al. 2010).

3.3 Phlegmonous Cholecystitis

“Phlegmonous cholecystitis” means that inflammatory processes related to acute cholecystitis resolve in part,

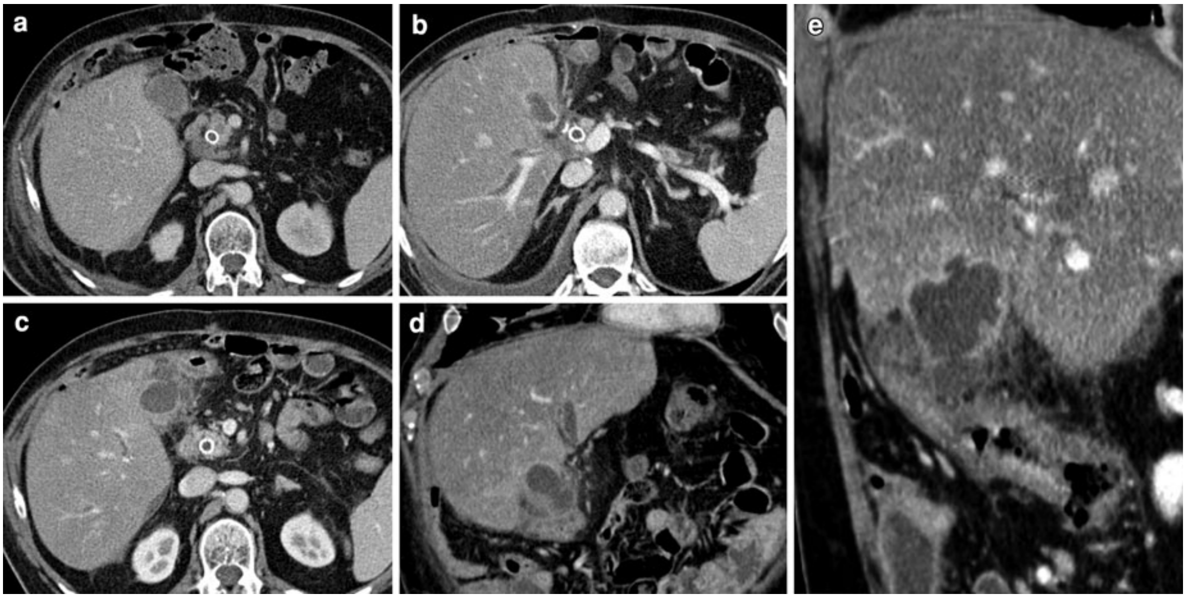

Fig. 12 Phlegmonous cholecystitis in a patient with a bilairy stent. A 58-year-old patient had biliary stenting as a palliative treatment of unresectable pancreatic adenocarcinoma. He presented with mild fever, and permanent pain of the right upper quadrant. **a** CT 2 months before showed no abnormalities of the gallbladder. **b** CT upon admission showed enhanced wall of the gallbladder after contrast medium injection. **c** On a lower level, CT shows a heterogeneous mass surrounding the gallbladder and extending to the transverse colon. There is a discontinuity of the gallbladder wall. **d** The coronal plane image shows that the perforation of the gallbladder extends toward the transverse colon, which is included within the inflammatory mass. **e** The sagittal plane image confirms the extension of this mass and shows also small perforation of the upper aspect of the gallbladder

most commonly because cholecystitis has initially been overlooked, and because a treatment had been administered, including antibiotics. From an acute disease, it evolves into a subacute disease. The inflammatory process tends to self-limit, and produces an inflammatory mass near the gallbladder fossa. This mass is a combination of the inflammatory gallbladder itself, inflamed perivesicular fat, and also adhesion of small bowel caused by regional inflammation (Fig. 12).

From a clinical point of view, the patient has subacute pain, fatigue, tenderness of the right upper quadrant without a Murphy sign. The patient may have moderate hyperthermia. Weight loss can be observed. Biologically, inflammation is constant, but the white cell counts are not always increased. From this clinical and biological description, one can imagine that a gallbladder tumor is suspected as the first hypothesis.

On US, it is a challenging situation because the palpated mass is poorly limited and the gallbladder may not be recognizable. CT has a clear advantage in this case, but one might nevertheless hesitate in deciding between the two hypotheses of subacute inflammation and gallbladder cancer.

There are several features that help one differentiate the two diseases. In the case of cancer, the gallbladder wall thickening is usually irregular and poorly limited. In subacute cholecystitis, enhanced images commonly show a layered pattern of the gallbladder wall, mainly due to the presence of perivesicular fat which is inflamed, but remains nevertheless hypodense and may in that case produce a halo. This halo is clearly absent in the case of a tumor.

In the case of subacute cholecystitis, it is exceptional to observe discrete collected abscesses. In that case, seeing round hypoattenuating lesions within segments IV or V of the liver would clearly be more indicative of a tumor. Finally, gallbladder tumors have a tendency to invade the infundibulum and the common bile duct, whereas subacute cholecystitis does not produce common bile duct obstruction, with the exception of Mirizzi syndrome, which is a clinically different situation.

However, none of these features are absolutely specific. There are some difficult cases in which a percutaneous biopsy might be recommended.

Although the positive findings are helpful in most cases, there are still situations in which it is appropriate to combine the advantages and complementarities of US and CT. However, one last advantage of CT is its very high specificity. If the CT findings are normal, the hypothesis of a cholecystitis might reasonably not be considered.

3.4 Gallbladder Haemorrhage

This is a very exceptional situation. Haemorrhage in the gallbladder is a rare cause of abdominal pain encountered in the setting of trauma, malignancy, and bleeding diathesis, such as renal failure, cirrhosis, and anticoagulation (Parekh and Corvera 2010). It happens also when chronic or acute lesions of the gallbladder erode a branch of the cystic artery. In most cases, the hemorrhage is only seen as melena. Only when it is extremely abundant does it develop into hematemesis. However, the hemorrhage does not always communicate with the gallbladder lumen. In this case, the consequence is either a hemoperitoneum or a localized hematoma. When such a complication is suspected, it is better to plan an acquisition in the arterial phase; however, this situation is extremely rare and not necessarily suspected clinically if there is no exteriorized digestive bleeding. Nevertheless, in most cases, extravasation of contrast medium is still visible in the portal phase and even sometimes more clearly. Identification of the bleeding is important because it can be life-threatening, and might be treated with transarterial embolization rather than surgery, which is difficult in such a situation.

4 Intrahepatic and Extrahepatic Bile Duct Diseases

Emergencies related to intrahepatic and extrahepatic bile duct lesions are mainly related to cholangitis and its consequences. This is a life-threatening condition, because infection in the bile ducts may lead to liver abscesses and moreover septicemia.

4.1 Cholangitis

Cholangitis is a condition with acute inflammation and infection in the bile duct. Acute obstructive cholangitis is defined by the association of lethargy, mental confusion and shock, fever jaundice, and abdominal pain (Reynolds and Dargan 1959). This so-called Reynolds pentad is indicative of a very severe condition requiring emergency biliary decompression, which is the only way to treat the disease. The prognosis is rather poor because the mortality ranges from 10 to 30% (Kimura et al. 2007). There are no direct signs of cholangitis on imaging. Cholangitis is a clinical diagnosis and imaging helps to define the cause of the biliary disease and to evaluate the consequences. Cholangitis is potentially a life-threatening condition and is a true emergency (Lee 2009). The two commonest causes are obstructive and iatrogenic.

Obstruction of the bile duct induces stasis and favors the development of infection. However, this very seldom happens in the case of progressive obstruction, mainly represented by tumors, whether biliary or pancreatic. Usually, cholangitis is associated with bile duct stones. The reason is not completely clear. However, one can imagine that stones are foreign bodies that produce inflammation of the mucosa and that this may favor the development of infection. Another possibility is that common bile duct stones are commonly multiple. Some small stones are able to go through the papilla and are eliminated. However, during this process, the papilla might experience a transient dysfunction, allowing retrograde communication of duodenal lumen and bile ducts, and consequently bacterial contamination of the bile. Iatrogeny is probably the commonest cause of cholangitis. Previous biliary surgery such as choledocoduodenal or hepaticojejunal anastomosis, endoscopic sphincterotomy, and percutaneous or endoscopic biliary stenting and drainage are the commonest situations. Rarely, contamination is related to direct cholangiography, especially after endoscopic retrograde

Fig. 13 Choledocolithiasis. A 66-year-old man with Reynolds pentad. US was initially performed and detected mild bile duct dilatation but the lower part of the common bile duct could not be examined. CT was performed and identified a common bile duct stone. As this stone is rather large and calcified, it is seen on plain images, in the axial (**a**) and sagittal (**b**) planes. The coronal image (**c**) is from the image set acquired after injection of contrast medium. In this case, because of stone characteristics, injection did not impair stone visualization

cholangiopancreatography (ERCP). However, this method is likely to induce cholangitis only if there is an associated biliary disease such as tumor obstruction or sclerosing cholangitis. For this reason, and because of the development of noninvasive imaging with CT and moreover MRCP, ERCP is only seldom performed for diagnostic purposes. There are exceptional circumstances of cholangitis not related to stones or to previous intervention. Single cases of direct perforation by a duodenal ulcer have been reported.

4.2 Significance of Pneumobilia

CT is able to identify the signs of previous surgery, either because of the findings related to the presence of an anastomotic jejunal loop or because of aerobilia. However, the presence of air in the bile ducts greatly differs according to the type of previous surgery and between individuals. The presence of air is not a complete guarantee that the anastomosis is patent, and absence of air in the bile ducts does not mean that the anastomosis is abnormal. Air is only an ancillary sign drawing the attention to potential previous intervention on the bile ducts.

4.3 Common Bile Duct Stones

Detection of common bile duct stones is a common problem with imaging. US is widely used for detection. However, the reported sensitivity is disappointing because of technical difficulties to access the lower bile duct area in some patients, and also related to the small size of the stone, which might be undetectable. Although the sensitivity has been improved recently, with a highest reported score of 86% (Ripolles et al. 2009), it should be kept in mind that the stone is easier to identify by US if the bile

◄ **Fig. 14** Small stone of the common bile duct. An 82-year-old man with recent episodes of right upper quadrant pain and mild fever. US shows a gallstone but no sign of cholecystitis. The common bile duct was not dilated. Plain CT shows a small stone in the lower common bile duct, seen because of its mild hyperattenuation on the axial plane image (**a**). Coronal multiplanar reconstruction shows the stone and the common bile duct, which is not enlarged (**b**). CT shows a gallbladder stone as well (**c**)

ducts are dilated and if the stone is larger than 4 mm. Conversely, MRCP and endoscopic US (EUS) have the highest scores for sensitivity and specificity. Consequently, US can be an easy initial examination because it is best suited to detect bile duct dilatation and to localize the level of obstruction. EUS has a sensitivity of nearly 100%, but conversely a specificity of 95%, owing to some ambiguous findings that may be confused with very small stones (Lee et al. 2010). In the study of Lee et al. (2010), comparing US, CT, and EUS, the sensitivity of US and CT was only 26%, whereas the specificity was 93% and the negative predictive value was 70%. CT sensitivity has been reported at very different levels. Since the initial enthusiasm (Neitlich et al. 1997) and a score as high as 88%, based on the identification, on plain CT, of hyperdense stone, other reports have shown that the sensitivity is likely to be much lower, especially when comparing CT and MRCP (Soto et al. 2000). Soto et al. (2000) reported a sensitivity was 65% for unenhanced helical CT and 96% for magnetic resonance cholangiography. The specificity was 84% for unenhanced helical CT and 100% for magnetic resonance cholangiography. Differences in sensitivity were significant, but they were not significant for specificity.

In summary, it appears that CT might clearly overlook common bile duct stones, especially when contrast-enhanced studies are performed only, because the hyperattenuation is lacking or is minimal (Figs. 12, 13, 14). Therefore, it is highly recommended to perform plain imaging when one of the goals of the examination is to detect potential common bile duct stones. If stone detection is the only question for the examination, it is advisable to propose a substitution by MRI if this is available because of its much higher sensitivity.

Recently, the performance of CT for the identification of biliary stones as the cause of acute pancreatitis

Fig. 15 A 43-years-old woman who underwent laparoscopic cholecystectomy. A few weeks later, she presented with mild jaundice, complicated with fever and right upper quadrant pain. The patient had a surgical injury of the common bile duct during cholecystectomy. CT with minimum-intensity projection reconstruction in the coronal plane (**a**) showed dilatation of intrahepatic ducts and the hepatic duct, whereas the lower common bile duct was normal. Axial enhanced CT (**b**) shows a heterogeneous mass in the posterior sector of the right lobe of the liver, consistent with abscess formation. After antibiotic therapy, the patient had surgery for biliary-enteric anastomosis

was reported and the role of CT was enhanced, but rather as a provider of several signs, including pericholecystic increased attenuation of the liver parenchyma, gallbladder wall enhancement and thickening, pericholecystic fat stranding, and stones in the gallbladder and common bile duct (Yie et al. 2010). In this series, the stone in the common bile duct was identified in 50% of cases.

4.4 Liver Biliary Abscesses

Biliary infection is one of the major causes of liver abscesses. Identification of abscesses is usually easy, as they are usually multiple and associated with an obvious biliary disease (Cerwenka 2010) such as surgical injuries related to cholecystectomy (Fig. 15). However, there might be some difficulties in the identification of the abscesses.

- In the case of small abscesses, it might be difficult to differentiate peripheral dilated bile ducts and small abscesses. Usually, this is solved using multiplanar reconstruction, showing that the abscesses are not tubular in shape in any direction.
- When a malignant tumor is the cause of bile duct obstruction and infection, it is very challenging, though extremely important, to differentiate abscesses and metastases. CT is usually limited for this purpose as it displays only a focal hypoattenuating image with some peripheral vascularization, which is in accordance with either possibility. Moreover, central necrosis of a metastatic tumor and liquefaction of the abscess are exactly the same. In this case, MRI might be very helpful given the clinical importance of such a diagnosis. Nevertheless it should be kept in mind that patients with malignant obstruction of the bile duct seldom have cholangitis, unless previous direct access to the bile ducts has been performed.

CT in an easy tool for guidance when drainage is planned. However, the initial step is usually to treat the biliary obstruction, because resolution of bile outflow interruption might be sufficient to improve the situation, in combination with antibiotics. Drainage of biliary abscesses is necessary only when they are large or when they persist after correct biliary drainage.

4.5 Ischemic Cholangitis

Ischemic-type biliary lesions are of increasing importance. Virtually all cases are related to previous intervention. This disease accounts for a major part of patients' morbidity and mortality after orthotopic liver transplantation. The exact origin of this type of biliary complication remains unknown (Heidenhain et al. 2010). These lesions can also be secondary to pancreatic surgery when there is an impairment of the liver arteries. Ischemic cholangitis can also be secondary to endoscopic retrograde maneuvers, to chemoembolization, or to arterial infusion chemotherapy (Shrikhande et al. 2002).

In some cases, ischemia is localized and its consequence is the development of a bile duct stenosis. In other cases, ischemia is dramatic and a diffuse destruction of the bile ducts is observed. There is no specific direct sign for ischemic cholangitis. However, the diagnosis is rather clear given the clinical background. In severe cases, extensive destruction of the bile ducts is observed, with the formation of intrahepatic irregular bile lakes. These bilomas are commonly contaminated and this may lead to dramatic infections and risk of liver failure, septicemia, and death.

5 Conclusion

Biliary emergencies are common, mainly represented by cholecystitis and cholangitis. CT is one of the available tools. However, in many cases, US should be performed first. CT has the advantages, in clinically equivocal cases, of being able to perform a more exhaustive survey of potential diseases in several areas. The technique should be appropriate, with the permanent necessity to an produce examination with the quality adapted to the clinical questions and with a radiation dose which is as low as possible. The role of MRI is also increasing. The radiologist should therefore be regarded as the person who will decide which is the best examination or the most logical combination in order to achieve emergency diagnosis and optimal preparation and staging for the treatment.

References

Atassi B, Bangash AK, Lewandowski RJ et al (2008) Biliary sequelae following radioembolization with yttrium-90 microspheres. J Vasc Interv Radiol 19:691–697

Barie PS, Eachempati SR (2010) Acute acalculous cholecystitis. Gastroenterol Clin North Am 39:343–357

Brenner DJ (2010) Should we be concerned about the rapid increase in CT usage? Rev Environ Health 25:63–68

Brewer BJ, Golden GT, Hitch DC, Rudolf LE, Wangensteen SL (1976) Abdominal pain. An analysis of 1,000 consecutive cases in a university hospital emergency room. Am J Surg 131:219–223

Cerwenka H (2010) Pyogenic liver abscess: differences in etiology and treatment in Southeast Asia and Central Europe. World J Gastroenterol 16:2458–2462

Choi JY, Lee JM, Lee JY et al (2007) Assessment of hilar and extrahepatic bile duct cancer using multidetector CT: value of adding multiplanar reformations to standard axial images. Eur Radiol 17:3130–3138

Endo Y (2010) A prospective evaluation of emergency department bedside ultrasonography for the detection of acute cholecystitis. Ultrasound Q 26:228

Gallix BP, Aufort S, Pierredon MA, Garibaldi F, Bruel JM (2006) Une angiocholite: comment la reconnaître? Quelles conduites à tenir? J Radiol 87:430–440

Heidenhain C, Pratschke J, Puhl G et al (2010) Incidence of and risk factors for ischemic-type biliary lesions following orthotopic liver transplantation. Transpl Int 23:14–22

Hubert C, Annet L, van Beers BE, Gigot JF (2010) The "inside approach of the gallbladder" is an alternative to the classic Calot's triangle dissection for a safe operation in severe cholecystitis. Surg Endosc 24:2626–2632

Jeffrey RB Jr, Nino-Murcia M, Ralls PW, Jain KA, Davidson HC (1995) Color Doppler sonography of the cystic artery: comparison of normal controls and patients with acute cholecystitis. J Ultrasound Med 14:33–36

Kimura Y, Takada T, Kawarada Y et al (2007) Definitions, pathophysiology, and epidemiology of acute cholangitis and cholecystitis: Tokyo guidelines. J Hepatobiliary Pancreat Surg 14:15–26

Lee JG (2009) Diagnosis and management of acute cholangitis. Nat Rev Gastroenterol Hepatol 6:533–541

Lee JH, Lee SR, Lee SY et al (2010) The usefulness of endoscopic ultrasonography in the diagnosis of choledocholithiasis without common bile duct dilatation. Korean J Gastroenterol 56:97–102

Mills AM, Baumann BM, Chen EH et al (2010) The impact of crowding on time until abdominal CT interpretation in emergency department patients with acute abdominal pain. Postgrad Med 122:75–81

Mirvis SE, Vainright JR, Nelson AW et al (1986) The diagnosis of acute acalculous cholecystitis: a comparison of sonography, scintigraphy, and CT. AJR Am J Roentgenol 147:1171–1175

Neitlich JD, Topazian M, Smith RC, Gupta A, Burrell MI, Rosenfield AT (1997) Detection of choledocholithiasis: comparison of unenhanced helical CT and endoscopic retrograde cholangiopancreatography. Radiology 203:753–757

Parekh J, Corvera CU (2010) Hemorrhagic cholecystitis. Arch Surg 145:202–204

Ralls PW, Halls J, Lapin SA, Quinn MF, Morris UL, Boswell W (1982) Prospective evaluation of the sonographic Murphy sign in suspected acute cholecystitis. J Clin Ultrasound 10:113–115

Ralls PW, Colletti PM, Lapin SA et al (1985) Real-time sonography in suspected acute cholecystitis. Prospective evaluation of primary and secondary signs. Radiology 155:767–771

Reynolds BM, Dargan EL (1959) Acute obstructive cholangitis; a distinct clinical syndrome. Ann Surg 150:299–303

Ripolles T, Ramirez-Fuentes C, Martinez-Perez MJ, Delgado F, Blanc E, Lopez A (2009) Tissue harmonic sonography in the diagnosis of common bile duct stones: a comparison with endoscopic retrograde cholangiography. J Clin Ultrasound 37:501–506

Shrikhande S, Friess H, Kleeff J et al (2002) Bile duct infarction following intraarterial hepatic chemotherapy mimicking multiple liver metastasis: report of a case and review of the literature. Dig Dis Sci 47:338–344

Solis-Caxaj CA (2009) Mirizzi syndrome: diagnosis, treatment and a plea for a simplified classification. World J Surg 33:1783–1784 (author reply 1786–1787)

Soto JA, Alvarez O, Munera F, Velez SM, Valencia J, Ramirez N (2000) Diagnosing bile duct stones: comparison of unenhanced helical CT, oral contrast-enhanced CT cholangiography, and MR cholangiography. AJR Am J Roentgenol 175:1127–1134

Tkacz JN, Anderson SA, Soto J (2009) MR imaging in gastrointestinal emergencies. Radiographics 29:1767–1780

Tokunaga Y, Nakayama N, Ishikawa Y et al (1997) Surgical risks of acute cholecystitis in elderly. Hepatogastroenterology 44:671–676

Wagnetz U, Jaskolka J, Yang P, Jhaveri KS (2010) Acute ischemic cholecystitis after transarterial chemoembolization of hepatocellular carcinoma: incidence and clinical outcome. J Comput Assist Tomogr 34:348–353

Wu CH, Chen CC, Wang CJ, Wong YC, Wang LJ, Huang CC, Lo WC, Chen HW et al (2010a) Discrimination of gangrenous from uncomplicated acute cholecystitis: accuracy of CT findings. Abdom Imaging. doi:10.1007/s00261-010-9612-x

Wu JM, Lee CY, Wu YM (2010b) Emphysematous cholecystitis. Am J Surg 200:e53–e54

Yie M et al (2010) Diagnostic value of CT features of the gallbladder in the prediction of gallstone pancreatitis. Eur J Radiol. doi:10.1016/j.ejrad.2010.05.022

Yun EJ, Choi CS, Yoon DY et al (2009) Combination of magnetic resonance cholangiopancreatography and computed tomography for preoperative diagnosis of the Mirizzi syndrome. J Comput Assist Tomogr 33:636–640