Gallbladder Stones and Common Bile Duct Stones

4

Michael R. Cox

4.1 Introduction

Gallstone disease and complications from gallstones are a common clinical problem throughout the world. The clinical presentation ranges between asymptomatic gallstones and patients with recurrent attacks of biliary pain requiring elective laparoscopic cholecystectomy (LC) through to patients with severe illness such as cholangitis or severe acute biliary pancreatitis.

Most cases of symptomatic or complicated gallbladder disease can be managed with LC. Common bile duct (CBD) stones associated with gallbladder stones may be managed either at the time of LC with other laparoscopic techniques or with post-operative endoscopic retrograde cholangio-pancreatography (ERCP). The one exception is patients with severe cholangitis where urgent ERCP is the initial treatment to obtain source control of the sepsis. CBD stones after cholecystectomy are usually managed with ERCP.

This chapter shall discuss the epidemiology, natural history, pathological processes, clinical presentations, management and complications of treatments. Most of the illustrations are factitious case scenarios describing relevant facets to provide clinical explanations and augment the main manuscript.

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4.2 Epidemiology

Gallstones are common, with a prevalence of 10–15% in adult Caucasian populations [1, 2]. In certain ethnic groups, particularly American Indians in both North and South America, the prevalence of gallstones is up to 70% [3, 4]. Asian populations including China, Japan and the Indian subcontinent have a lower prevalence of between 2 and 6% [4, 5]. The prevalence in sub-Saharan Africa is even lower, between 1 and 2%, and even lower than that in Masai and Bantu tribes [6].

Although, the annual incidence of patients who develop gallstone-related symptoms and complications requiring surgical intervention is only 1–2%, the high prevalence results in a high disease burden. Emergency presentations with acute complications of gallstone disease are the second most frequent reason for acute gastrointestinal admissions [7]. The annual number of laparoscopic cholecystectomies performed in the USA and UK exceeds 700,000 and 57,000, respectively [2, 8].

The majority (greater than 80%) of gallstones are cholesterol stones; the remainder are pigment stones or mixed stones. Cholesterol stones arise from the combination of supersaturation of cholesterol, biliary stasis, accelerated nucleation of cholesterol crystals and mucus hypersecretion of the gallbladder [9]. The supersaturation of cholesterol is due to the imbalance of the three components of bile: cholesterol, lecithin and bile salts. This results in the production of cholesterol microcrystals. The accelerated nucleation of these crystals with subsequent aggregation leads to the formation of gallstones. The risk factors for cholesterol stones can be grouped as non-modifiable and modifiable (see Table 4.1).

Table 4.1 Risk factors for the development of cholesterol gallstones

Non-modifiable factors	*Mode of action of non-modifiable factors*
Family history	Genetic and environment (diet)
Female gender	Increased oestrogen with modification of hepatic lipoprotein receptors and promotion of cholesterol production
Pregnancy	Increased oestrogen with modification of hepatic lipoprotein receptors and promotion of cholesterol production in addition to stasis secondary to the effect of progesterone
Increasing age	Increased cholesterol supersaturation due to a reduction in bile salt synthesis
Modifiable factors	*Mode of action of modifiable factors*
Gastric surgery or vagotomy	Biliary (gallbladder and CBD) stasis
Obesity	Increased biliary cholesterol
Rapid weight loss	Increased supersaturation of bile and biliary stasis
Prolonged fasting	Gallbladder stasis
Spinal cord injury	Biliary stasis
Crohn's disease or ileocolic resection	Reduced bile salt reabsorption with subsequent reduction in bile salt concentration in the biliary tree
Genetics	Lith genes

Pigment stones fall into two categories: black and brown. Black pigment stones arise from either an increased level of conjugated bilirubin due to chronic or recurrent haemolysis (e.g. sickle cell disease and autoimmune haemolysis) or increased levels of unconjugated bilirubin associated with hepatic cirrhosis or alcohol abuse. Brown stones or mixed stones (calcium bilirubinate) occur secondary to bacterial (less commonly parasitic) degradation of bile and are usually associated with biliary stasis. This process can occur within the gallbladder, the common bile duct (CBD) or the intrahepatic ducts. When this process occurs in the CBD, these are considered primary CBD stones and usually associated with a dilated bile duct, a duodenal diverticulum and/or ampullary stenosis. Patients with previous endoscopic biliary interventions for benign or malignant disease are also prone to the development of these primary bile duct (brown pigment) stones due to poor drainage related to either sphincterotomy stenosis or a chronically dilated CBD.

4.3 Natural History of Gallstones

Of patients with gallstones, over 80% remain asymptomatic and never suffer from complications of the gallstones [1, 9]. The risk of developing symptoms or complications ranges between 1 and 2.3% per annum [10–15]. The majority of asymptomatic gallstones do not require surgery until symptoms or complications develop [16, 17] or in the presence of coexisting pathologies such as porcelain gallbladder, associated polyps or recurrent salmonella infection. Symptoms are usually due to obstruction of the gallbladder outlet (with gallstone impacted in Hartmann's pouch, neck or cystic duct), the CBD or the ampulla of Vater.

4.4 Gallstone Symptoms

The dominant symptom of gallstone disease is biliary colic or more correctly biliary pain as the pain of the gallbladder is not cramping but constant. Biliary pain occurs when the outlet of the gallbladder (Hartmann's pouch, neck or cystic duct) is obstructed with a stone. The pain is usually of rapid but not sudden onset. It is often the most severe pain ever experienced by the patient. It most often arises in the right upper quadrant but can occur in the epigastrium, the retrosternal area or even the left upper quadrant. Biliary pain typically radiates to the right scapular area. Radiation to the right shoulder occurs in association with significant gallbladder inflammation, as with acute cholecystitis. The patient with biliary pain is restless and often feels nauseated. Vomiting may be associated with severe pain. The pain may occur at any time of the day but typically occurs either 15–30 min after a meal (due to cholecystokinin-induced gallbladder contraction) or during the night. The relatively constant pain rises to a peak for over 30–60 min and typically lasts for several hours before remitting. Biliary pain will usually resolve completely, although some patients will report a low-grade pain for a longer period after the

resolution of severe pain. Some patients also have minor episodes of discomfort, typically after a fatty meal, and this is better termed fatty food intolerance. Biliary pain is common and is often associated with other symptoms including flatulence, dyspepsia and abdominal bloating. Having said that, the *sine qua non* is biliary pain and it is the frequency and severity of that which determines whether a cholecystectomy is required.

When biliary pain persists for 12 h or more, acute cholecystitis is likely to supervene. In this setting the symptoms include a fever and patients may have a tachycardia, as part of the systemic inflammatory response.

Symptoms associated with common bile duct (CBD) stones include biliary pain, which usually cannot be distinguished from pain associated with gallbladder stones. These patients may also have evidence of cholestasis with jaundice, dark urine and pale stools or may only have evidence of cholestasis on liver function tests (LFT). The diagnosis of acute cholangitis is a clinical one, and it is essential to determine whether the biliary pain is associated with jaundice and fever with rigours (Charcot's triad). Common bile duct stones can also cause acute biliary pancreatitis, and the pain associated with this can usually be distinguished from pain due to bile duct stones. In this setting there is a constant epigastric pain that radiates directly through to the back, in the mid-thoracic area.

4.5 Pathological Complications of Gallstones

The complications of gallstones are related to the persistent obstruction of the biliary tree with either acute or chronic inflammation (Table 4.2). Of note, most patients with symptomatic gallstones present with biliary colic as described above. This is an episode of pain where the pain resolves completely.

Table 4.2 Complications of gallstones

Acute cholecystitis • Mucocoele • Empyema • Gangrenous cholecystitis • Emphysematous cholecystitis
Chronic cholecystitis
Obstructive jaundice
Cholangitis
Biliary pancreatitis
Mirizzi syndrome
Cholecysto-duodenal fistula • Gallstone ileus
Cholecysto-choledochal fistula • Gastric outlet obstruction
Cholecysto-colonic fistula

Table 4.3 Sequelae of acute cholecystitis

Resolution
Mucocoele
Empyema
Gangrenous cholecystitis
Perforation
Emphysematous cholecystitis
Chronic cholecystitis

4.5.1 Gallbladder Stones

4.5.1.1 Acute Cholecystitis

Acute cholecystitis occurs when the obstruction of the gallbladder outlet by the stone persists beyond 12 h. This results in acute inflammation due to the increase in intraluminal pressure caused by a combination of outlet obstruction and an influx of fluid into the gallbladder lumen. Secondary bacterial infection in the static bile may occur; however, the majority of cases of acute cholecystitis do not develop secondary infection. The pathological sequelae of acute cholecystitis are (Table 4.3):

- *Resolution*
  When managed nonoperatively, an episode of acute cholecystitis shall resolve in all but 10–20% of cases [18–22]. Although there may be clinical resolution, the acutely inflamed gallbladder does not return to its normal state. There may be ongoing inflammation resulting in the development of a thick walled and indurated gallbladder leading to chronic inflammation and fibrosis. This progression of inflammation despite the lack of symptoms is relevant to the management of patients presenting with acute cholecystitis.
- *Mucocoele*
  Persistent obstruction of the gallbladder outlet without secondary infection may result in a mucocoele. The gallbladder mucosa reabsorbs the bile and excretes mucin into the gallbladder lumen causing distension of the gallbladder. An ultrasound some weeks after an episode of prolonged pain will demonstrate a stone impacted in the neck of the gallbladder with a large distended gallbladder (Fig. 4.1).
- *Empyema*
  Secondary infection of the obstructed gallbladder results in the development of an empyema. This may be associated with a clinical presentation of acute cholecystitis 3–4 days into the acute episode. However, an empyema may also be detected at delayed surgery in the case of a failed trial of conservative treatment after the initial episode of acute cholecystitis (Fig. 4.2). At the delayed operation, the gallbladder is chronically inflamed with pus in the lumen. These patients may not have had any evidence of sepsis.

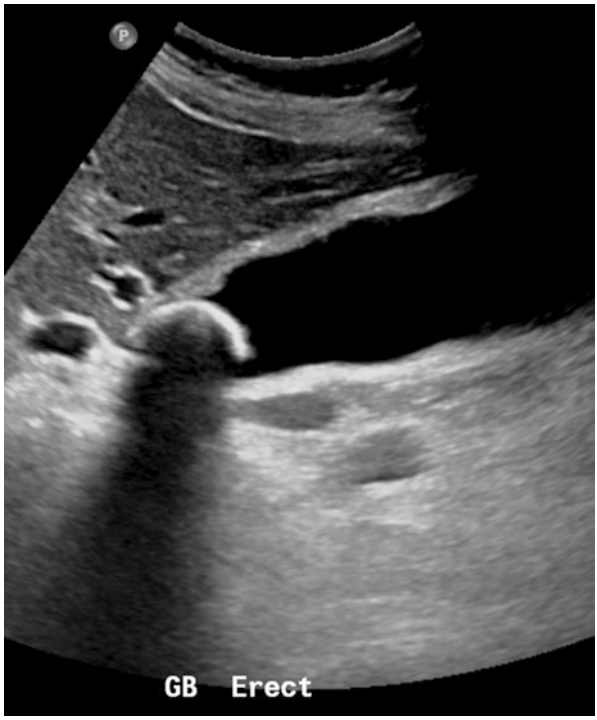

Fig. 4.1 An ultrasound in a 32-year-old woman who presented with an episode of biliary colic lasting >36 h, 6 weeks earlier. She did not seek medical assistance at that time. She presented at the time of the ultrasound with an easily palpable mass in right upper quadrant. The ultrasound confirmed a stone impacted in the neck with a grossly distended gallbladder with a thickened wall. At surgery, the gallbladder was drained and contained mucin

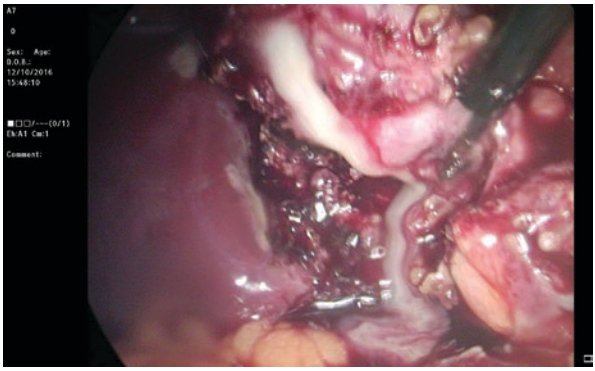

Fig. 4.2 A 42-year-old man that presented with a prolonged episode of pain for 2–3 days to his General Practitioner (GP) 8 weeks prior to the surgery. The GP managed this with oral analgesia and oral antibiotics. He was then assessed surgically and a LC organised. At LC he had a severely chronic inflamed gallbladder with a stone impacted in the Hartmann's pouch. The illustration was taken mid-way through the dissection, note the pus flowing down from the hole higher in the gallbladder. The culture from the pus was negative

- *Gangrenous cholecystitis*
  Gangrenous cholecystitis or gallbladder necrosis (Fig. 4.3) is thought to be due to the reduced blood flow and reduced perfusion of the gallbladder wall due to the increased intramural pressure and the release of various vasoactive peptides associated with the gallbladder sepsis resulting in end arterial thrombosis and ischaemia.
- *Perforation*
  Gangrenous cholecystitis may be complicated by a perforation of the gallbladder wall. In most cases the perforation is walled off and may appear as a pericholecystic abscess on an ultrasound or CT scan (Fig. 4.4). At other times it will be found at cholecystectomy when dissecting the omental adhesions off the inflamed gallbladder will reveal a sealed-off perforation. Occasionally (less than 10%) the perforations are not contained (Fig. 4.5). The patient will present with a sudden onset of severe generalised pain after a period of prolonged biliary pain. These patients will have signs of peritonitis and a differential diagnosis will often include a perforated peptic ulcer. The clue to the diagnosis being gallbladder perforation is the preceding history of prolonged biliary-type pain prior to the sudden onset of generalised pain.
- *Emphysematous cholecystitis*
  Emphysematous cholecystitis is a variation of gangrenous cholecystitis associated with gas either in the gallbladder wall or in the gallbladder lumen (Fig. 4.6). The intraluminal gas needs to be differentiated from gas due to either a previous ERCP and sphincterotomy or the presence of a cholecysto-enteric fistula. The gas is due to secondary infection by gas-forming organisms within the lumen or the gangrenous wall of the gallbladder. Similar to gangrenous cholecystitis, this may be associated with gallbladder perforation (Fig. 4.7).

4.5.1.2 Chronic Cholecystitis

This usually occurs with multiple recurrent episodes of biliary pain associated with some degree of acute inflammation that resolves leading to fibrosis. Chronic cholecystitis is suspected when the ultrasound shows a thick walled, often contracted gallbladder containing stones and little or no fluid (Fig. 4.8). Rarely, chronic inflammation is associated with fistulae formation: cholecysto-choledochal (Mirizzi types II, III and IV), cholecysto-duodenal or cholecysto-colonic fistulae. There is some evidence that chronic inflammation may be associated with the development of gallbladder carcinoma [23].

4.5.1.3 Mirizzi Syndrome

Pablo Mirizzi, an Argentinian surgeon, described this syndrome as obstructive jaundice due to an extrinsic compression of the common hepatic duct (with or without a fistulous communication between the gallbladder and the common hepatic duct) from stones impacted in the cystic duct, gallbladder neck or Hartmann's pouch. Since his initial description, there have been a number of modifications. The most

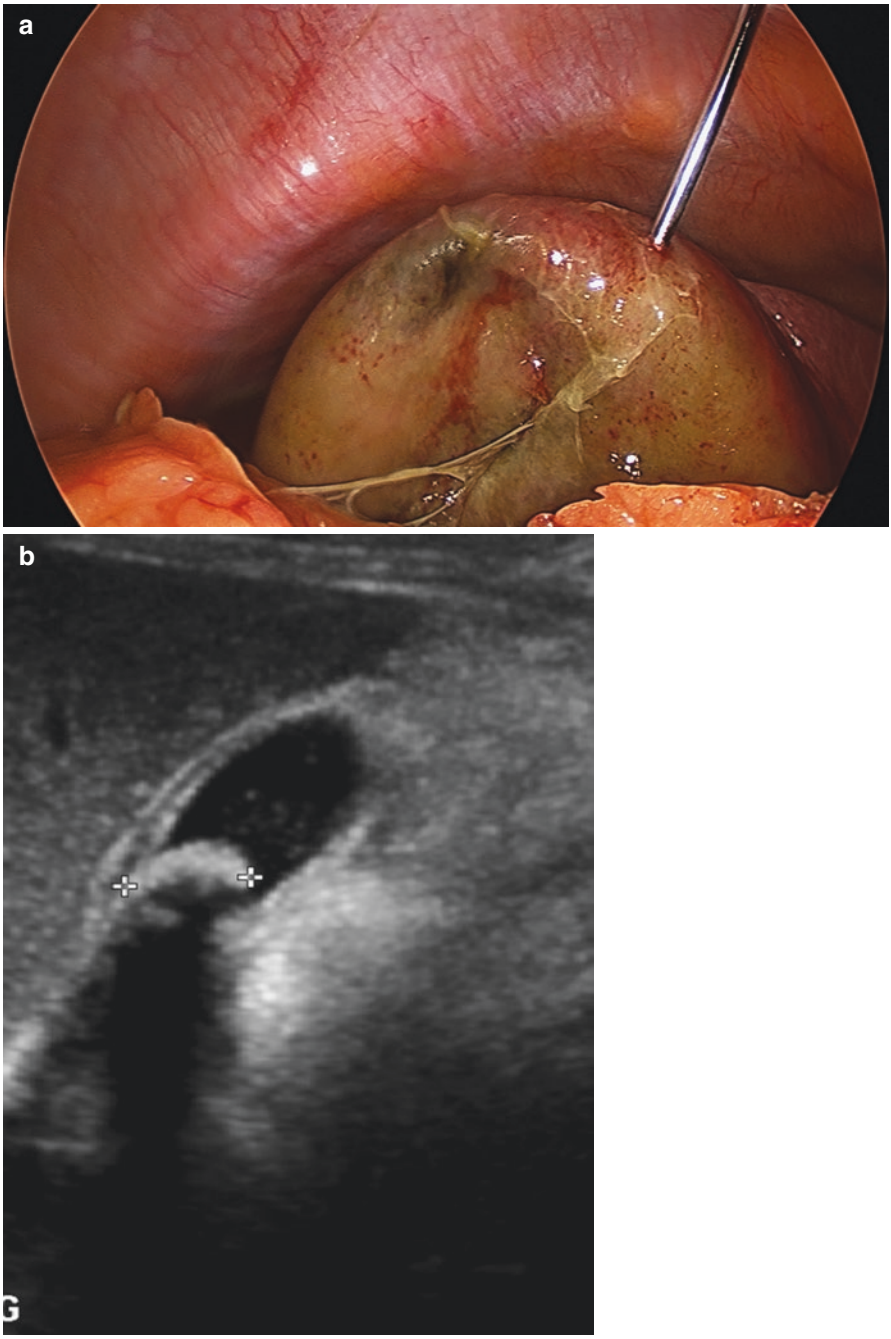

Fig. 4.3 A 52-year-old man who presented with 48 h of prolonged biliary pain with right upper quadrant tenderness and evidence of sepsis with fever, tachycardia and elevated white cell count (22,000). An urgent LC was performed. (**a**) The gallbladder was clearly gangrenous and was very distended and tense, so it was drained with a Concord needle. (**b**) The ultrasound on this confirmed a stone impacted in the neck of the gallbladder with a thickened gallbladder wall associated with pericystic fluid. However, there are no ultrasound features that predicted the gangrenous cholecystitis

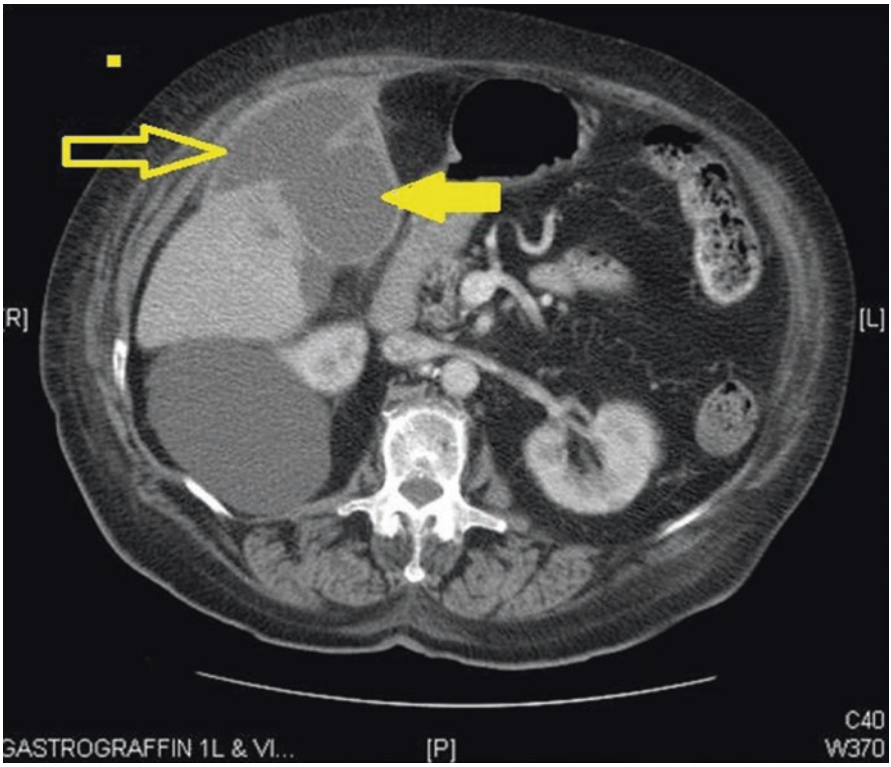

Fig. 4.4 CT scan in a 72-year-old woman who presented with 6 days of upper abdominal pain, fevers and night sweats. The CT revealed an inflamed gallbladder (solid arrow) with an obvious defect in the fundus and a large contained collection (outlined arrow). At operation this was a walled-off perforation. It had been walled off predominantly between the omentum, abdominal wall and liver

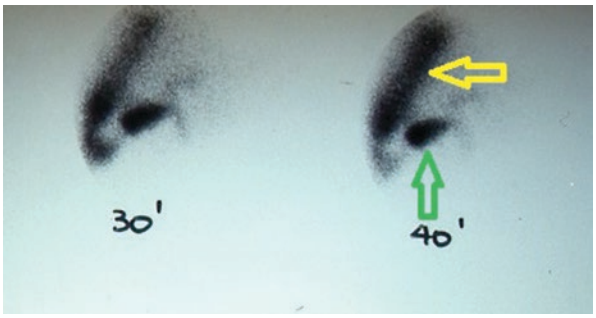

Fig. 4.5 DIDA scan at 30 and 40 min in a patient that presented with a sudden onset of generalised abdominal pain after a 3-day history of prolonged typical biliary pain. An ultrasound confirmed acute cholecystitis with a large amount of free intra-abdominal fluid. The DIDA scan demonstrated the gallbladder (green arrow) with leakage of a large amount of bile into the peritoneal cavity (yellow arrow). Emergency LC revealed a free perforation of a gangrenous gallbladder

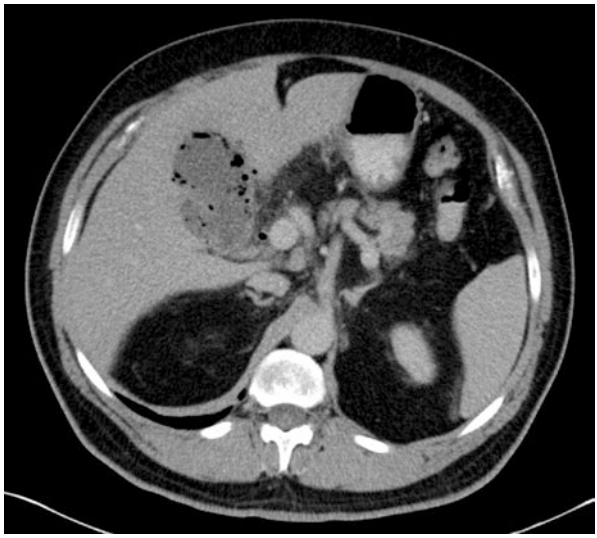

Fig. 4.6 A CT scan demonstrating emphysematous cholecystitis in a 52-year-old man who presented with a 10-day history of biliary pain, fevers and night sweats

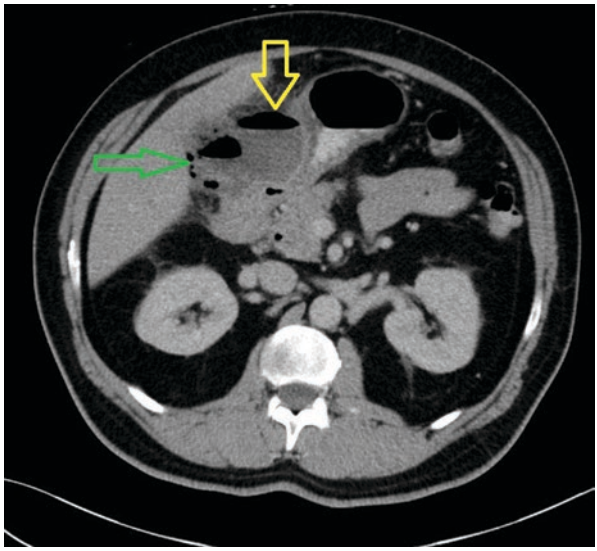

Fig. 4.7 A 56-year-old lady presented with a 2 weeks history of right upper quadrant pain, anorexia, weight loss and night sweats. A provisional clinical diagnosis was made of a hepatic abscess. The CT demonstrated acute emphysematous cholecystitis (green arrow) associated with an abscess (yellow arrow) adjacent to the gallbladder due to a contained perforation

frequently used and pathologically relevant is that by Csendes [24] which considers the presence and extent of any cholecysto-choledochal fistula that is relevant to subsequent management (Fig. 4.9). The development of the cholecysto-choledochal fistula (Fig. 4.10) is related to the severe chronic inflammation produced in the gallbladder and subsequent erosion of a large stone into the common hepatic duct. In types III and IV, this is associated with partial or complete destruction of the mucosa and smooth muscle wall of the common hepatic duct.

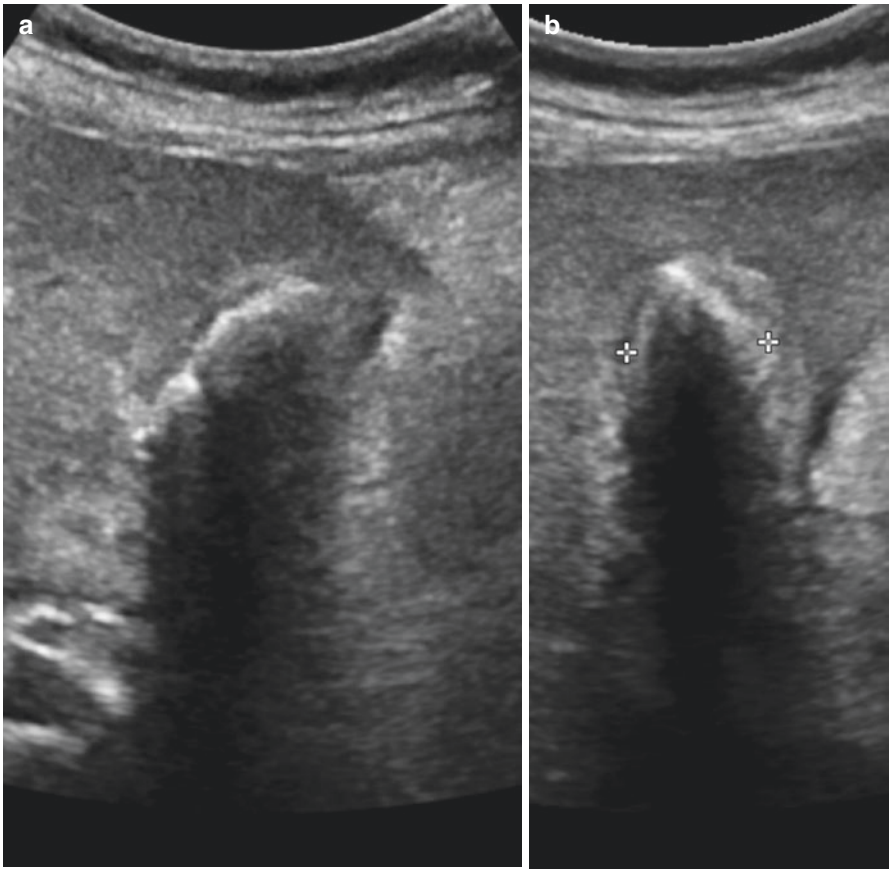

Fig. 4.8 An ultrasound in a 62-year-old lady that had multiple previous episodes of biliary pain, some taking 2–3 days to resolve. The gallbladder is thick walled, contracted, full of stones with virtually no bile in the lumen on both sagittal (**a**) and coronal (**b**) views

4.5.1.4 Cholecysto-enteric Fistula

Chronic inflammation of the gallbladder can cause an adherence and potential erosion into other adjacent organs. The two organs that are most often affected are the first part of the duodenum and the hepatic flexure of the right colon.

Cholecysto-duodenal Fistula

There are several clinical presentations of this problem, and they depend on the size of the gallstones that may migrate through the fistula and the subsequent patency of the fistula.

Gallstone ileus is a well-recognised but rare complication of gallstone disease that is the most common problem associated with a cholecysto-choledochal fistula. It is due to the passage of a large stone through the fistula into

Type	Figure	Description
I		External compression of the common hepatic duct due to a stone impacted at the neck of the gallbladder or at the cystic duct.
II		The fistula involved less than one-third of the circumference of the common bile duct.
III		Involvement of between one-third and two-thirds of the circumference of the common bile duct.
IV		Destruction of the entire wall of the common bile duct.
V		Cholecystoenteric fistula together with any other type of MS.

Fig. 4.9 Csendes classification of Mirizzi syndrome noting the extent of the erosion by the stone through the common hepatic duct [24]

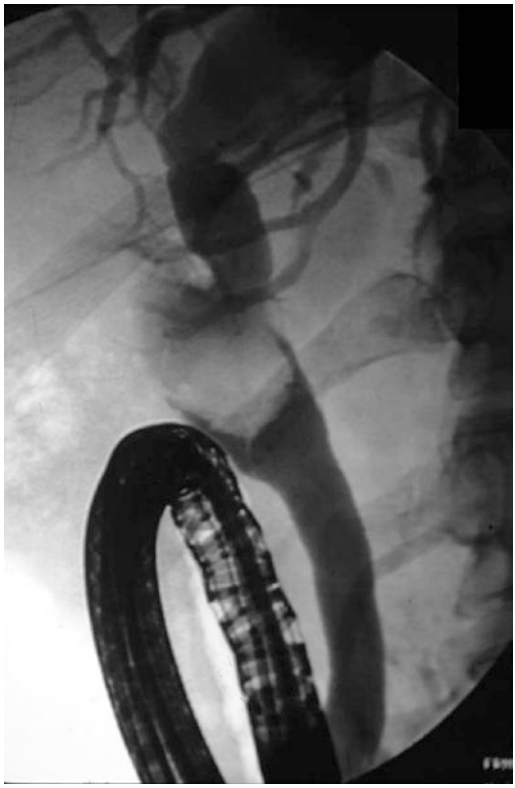

Fig. 4.10 An ERCP of an 82-year-old man that presented with intermittent painless jaundice and low-grade fevers. The large stone lies across the cholecysto-choledochal fistula extending into the common hepatic duct (type II Mirizzi)

the proximal duodenum and subsequent migration of that stone through the small bowel until it causes an obstruction at the midpoint of the small bowel or at the terminal ileum (Fig. 4.11). The clinical presentation is that of a small bowel obstruction. Usually plain abdominal radiography will reveal pneumobilia, with the biliary tree outlined with gas, implicating a patent fistula and cystic duct.

Rarely, the stone passing through the cholecysto-duodenal fistula is so large that it does not migrate through the small bowel but causes gastric outlet obstruction. This is either at the level of the first part of the duodenum or more commonly it moves retrograde into the stomach and obstructs the pylorus.

Occasionally a cholecysto-duodenal fistula would be noted in a patient presenting with cholangitis (Fig. 4.12). Presumably in this instance some of the stones in the gallbladder may have passed through the fistula without causing any intestinal obstruction. Primary or secondary common bile duct stones then causes biliary obstruction. As the biliary tree is already contaminated due to the fistula with the duodenum, sepsis invariably results.

Cholecysto-colonic Fistula

This is a very rare complication of gallbladder stone disease. It may present with episodes of cholangitis and biliary sepsis due to debris within the common bile duct producing a cholangitis-type picture. This will usually require surgical intervention,

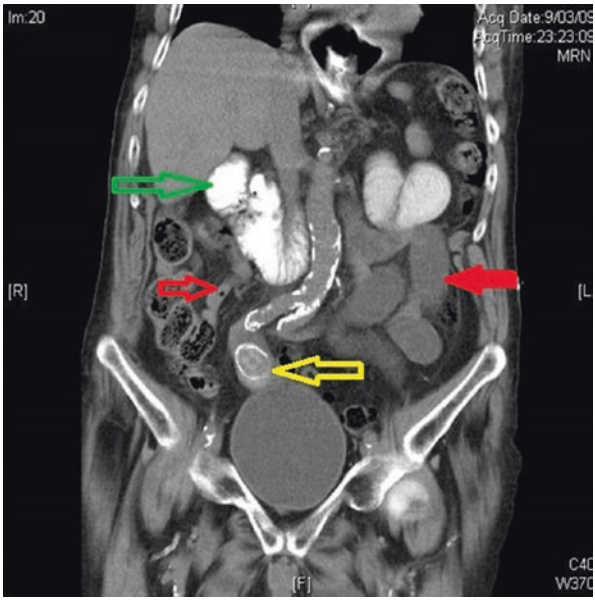

Fig. 4.11 An elderly lady presented with a small bowel obstruction but no prior abdominal surgery. Sagittal views of a CT scan confirmed a distal small bowel obstruction with dilated loops in the left abdomen (solid red arrow) and collapsed loops of small bowel (outlined red arrow) in the right abdomen with a large calcified gallstone in the terminal ileum (yellow arrow). There is contrast in the duodenum flowing back into the contracted gallbladder (green arrow) through the cholecysto-duodenal fistula, but there was no gas seen in the biliary tree

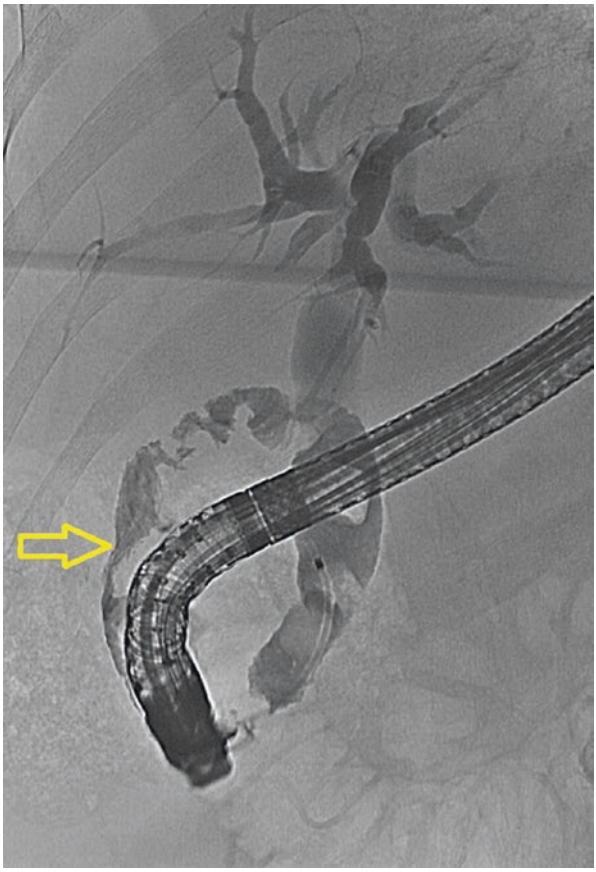

Fig. 4.12 An ERCP in an elderly man who presented with severe cholangitis. There was no prior history of biliary symptoms. The CBD contained three secondary CBD stones. The cholecysto-duodenal fistula is clearly identified (yellow arrow)

by en bloc cholecystectomy with limited colectomy. Like cholecysto-duodenal fistula, a cholecysto-colonic fistula may only become apparent at operation for severe chronic cholecystitis without any other symptoms.

4.5.1.5 Gallbladder Carcinoma in Association with Chronic Cholecystitis

There is some evidence that long-standing chronic inflammation (including the presence of a porcelain gallbladder) may be a factor in the development of gallbladder carcinoma [23]. However, gallstones are unlikely to be the sole factor as gallstones have a very high prevalence (10–15%) in Western societies [1, 2], yet gallbladder carcinoma is relatively rare with an incidence of 1 in 300,000 in the USA [25]. Although the risk of gallbladder carcinoma is 2.3–21 times greater in the presence of gallstones, both share similar risk factors including age, ethnicity (in particular certain South American Indian populations) and female gender [26, 27].

Therefore, at best, gallstones associated with marked chronic inflammation may be a factor in the development of gallbladder carcinoma. (*Gallbladder Cancer will be dealt with in detail in Chapter 15.*)

4.5.2 Common Bile Duct (CBD) Stones

Stones in the CBD may occur due to the migration of stones from the gallbladder into the cystic duct. These are termed secondary CBD stones. Primary CBD stones (brown pigment/mixed stones) arise due to chronic stasis in the CBD (see above). Primary and secondary CBD stones can usually be distinguished by their cause, contents and appearance (Table 4.4). Regardless of whether the stones are primary or secondary, the presentation and complications arising from CBD stones are the same.

- Biliary pain
  At the time of presentation of gallbladder stones with biliary pain, 10–18% of patients will have associated CBD stones, with the vast majority of these being secondary CBD stones [28]. The stones in the CBD may occlude the distal CBD and cause recurrent episodes of biliary pain identical to the pain produced by obstruction of the gallbladder outlet (see above). If the obstruction of the CBD is transient and resolves, the pain resolves with no associated features such as jaundice or sepsis. When the gallbladder is still present, the biliary pain may be due either to obstruction of the gallbladder outlet or the common bile duct stones.
- Obstructive jaundice
  Obstructive jaundice occurs when the obstruction of the common bile duct persists beyond 12–18 h. Unlike malignant causes for obstructive jaundice, the jaundice due to biliary obstruction by a stone will fluctuate over a period of days and may resolve. Obstructive jaundice due to stones is often associated with biliary pain but not invariably so, whereas obstruction due to a malignancy (pancreatic cancer, biliary cancer or external compression by malignant nodes) is usually painless. The other distinguishing feature between obstructive jaundice due to

Table 4.4 Differentiation between primary and secondary CBD stones

Characteristics	Primary CBD stones	Secondary CBD stones
Site of origin	Common bile duct	Gallbladder stones that have migrated into the common bile duct
Composition	Calcium bilirubinate Calcium palmitate Cholesterol	Cholesterol or calcium bilirubinate (pigment stone)
Appearance	Dark yellow to brown	Yellow (cholesterol) and black (pigment)
Shape	Often conforms to the lumen of the common bile duct	Round, mulberry-like or faceted (cholesterol stones), spiculated (pigment stones)

gallstones is that the level of obstruction fluctuates and is usually mild with bilirubin levels rarely over 150 umol/L.

- Cholangitis
  CBD obstruction may be associated with secondary bacterial infection and result in cholangitis leading to septicaemia. The result of an ascending infection of the obstructive biliary tree is due to bacteria, under pressure, entering the systemic circulation via peribiliary lymphatics and/or hepatic veins.
- Acute biliary pancreatitis
  (See chapter on Acute Pancreatitis.)

4.5.3 Gallbladder Polyps

The majority (95%) of gallbladder polyps diagnosed on ultrasound are non-neoplastic, which may be defined as cholesterol polyps (60%), adenomyomatosis (25%) or inflammatory polyps related to cholesterolosis (10%) [29]. The majority of gallbladder polyps are asymptomatic, although cholesterol polyps may occlude the gallbladder outlet causing biliary pain. Some may even pass into the CBD and obstruct the ampulla of Vater causing biliary pain, jaundice or acute biliary pancreatitis. Neoplastic polyps account for less than 5% of gallbladder polyps [29].

4.5.4 Recurrent Pyogenic Cholangitis

Recurrent pyogenic cholangitis (RPC) is characterised by brown pigment stone formation in the intrahepatic bile ducts with associated biliary strictures of the intrahepatic biliary tree. It was originally described by Digby from Hong Kong in 1930 [30] and occurs almost exclusively in people that have lived in Southeast Asian countries [31, 32]. It usually presents in the fourth or fifth decade of life with an equal incidence in males and females [33, 34]. The precise pathogenesis of RPC is not known.

4.6 Clinical Presentation and Investigation

The distinction between different gallstone-related pathologies is achieved by a combination of clinical, laboratory and imaging studies. Although there is a spectrum of pathologies and an overlap between clinical presentations, a series of discrete clinical presentations will be discussed.

4.6.1 Asymptomatic Gallstones

Incidental gallstones usually present when an ultrasound or CT scan has been performed for another reason. The additional assessment required is a careful clinical history to ensure that these are truly asymptomatic and the patient has not had any episodes of biliary pain or fatty food intolerance (see above). A patient with apparent asymptomatic gallstones may initially deny any of these symptoms, but when a

Table 4.5 Symptoms that may be attributed to gallstone disease but are not due to gallstone disease

Fatty food intolerance
Nausea (not associated with episodes of pain)
Episodic vomiting (not associated with episodes of pain)
Abdominal bloating
Dyspepsia
Heartburn/belching
Altered bowel habits/diarrhoea
Flatus
Non-specific food intolerance

detailed clinical description of typical biliary pain is given, they will then remember and state this has occurred in the past. Almost invariably an alternative diagnosis has been made, such as gastritis, peptic ulcer disease, gastro-oesophageal reflux disease and ischaemic heart disease. The gallstones are then considered symptomatic and managed accordingly. If there are no episodes of biliary pain, there may be other gastrointestinal symptoms, as detailed in Table 4.5. In the absence of any episodes of biliary pain, the gallstones should be considered asymptomatic and surgery is not indicated.

The possibility of CBD stones should always be considered when there is a diagnosis of gallbladder stones, even if asymptomatic. CBD stones can remain asymptomatic for many years. This is supported by the data that shows that the median time following LC to the presentation of symptomatic retained common bile duct stones is 4 years [35]. When CBD stones become symptomatic, almost half of the patients develop a significant problem with cholangitis or acute pancreatitis [35]. The assessment for the presence of CBD relates to identifying elements of Charcot's triad (see above). Liver function tests are examined for evidence of cholestasis. An ultrasound is reviewed to determine if the bile duct is dilated (greater than 6 mm) and if stones are seen in the CBD. This is not an ideal method of diagnosing CBD stones, because of the presence of duodenal gas. If the patient has risk factors for CBD stones (e.g. cholestasis and/or dilated CBD), the bile duct should be imaged by MR or CT cholangiography.

4.6.2 Biliary Pain

Biliary pain is the dominant symptom upon which decisions based around the management of gallstones are made. Many call it biliary colic, but this is a misnomer as the pain is constant and not crampy in nature. Biliary pain occurs when a gallstone obstructs the outlet of the gallbladder (Hartmann's pouch, neck or cystic duct) or obstructs the CBD (usually at the ampulla). The pain is sudden in onset, constant and usually severe that arises in the lower chest, epigastric or right upper quadrant of the abdomen. It may then become more widespread and may radiate to the back in the mid-thoracic or right subscapular area or radiate to the right shoulder. The duration is longer than 15 min and may last up to 8 h, after which it usually resolves completely, although some patients report a period of discomfort after the severe pain resolves. During the pain the patient will describe being restless and unable to get comfortable. Between episodes of pain their patient is well and pain free.

In association with biliary pain, the patient may complain of nausea and occasionally vomiting. Others may complain of sweating and an uneasy feeling. The pain may occur after a meal which may be fatty, although this is often not consistent. Patients with recurrent episodes often report that some of the episodes will wake them from sleep in the middle of the night. Other symptoms that patients and non-surgical clinicians may attribute to the gallstones are summarised in Table 4.5. Note that these occur independent of the episodes of pain. As a general rule these symptoms which can be defined as functional gut symptoms are not caused by the gallstones. In a large population-based study, 88% of the patients presenting for LC for pain had these functional gut symptoms. While the biliary pain resolved in over 90% of patients, the functional gut symptoms were unchanged in over two-thirds of the patients following their cholecystectomy [36].

4.6.3 Recurrent Biliary Pain

Recurrent biliary pain is where there are repeated episodes of biliary pain that resolve completely and often last for less than 8 h. The clinical examination may reveal a palpable gallbladder mass that would suggest a mucocoele (Fig. 4.1). Although unlikely in recurrent biliary pain, evidence of jaundice needs to be looked for.

Investigations are used to confirm the diagnosis of gallstones and determining whether there is any complication or specific pathology associated with the gallstones.

Liver Function Tests (LFT) These are used to assess the possibility of CBD stones or some degree of biliary obstruction such as Mirizzi syndrome. Normal LFT have a reasonable negative predictive value with only 3% of patients coming to cholecystectomy with normal LFT having CBD stones identified on routine operative cholangiography (OC) [37]. Elevated LFT may indicate a CBD stone, but it has been known for a long time that the sensitivity, specificity and positive predictive values of these tests are low [38, 39]. Nonetheless, it is important to assess and to discuss the possibility of CBD stones and how this would be managed when discussing LC with a patient with recurrent biliary colic.

Ultrasound Ultrasound is the best initial imaging for the investigation of gallstone disease. Most patients presenting with recurrent biliary colic due to gallstones will have either a single or multiple stones that are mobile in the gallbladder with no associated gallbladder wall thickening, pericystic fluid or duct dilatation (Fig. 4.13). The ultrasound may reveal a stone that is impacted in the gallbladder neck with or without associated sludge but with no evidence of inflammation (thickened wall, pericystic fluid or local tenderness) (Fig. 4.14). These patients with this ultrasound finding are more likely to have frequent episodes of biliary pain or developed acute cholecystitis. Alternatively, the ultrasound may reveal a mucocoele (Fig. 4.1). Other

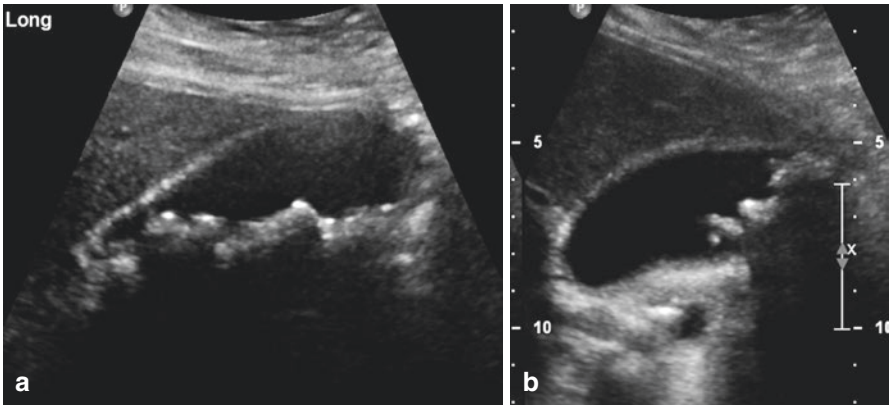

Fig. 4.13 An ultrasound in a 62-year-old woman presenting with recurrent biliary colic with five episodes in the last month. (**a**) Supine study shows multiple stones in the gallbladder. The gallbladder wall is not thickened or contracted. (**b**) Erect study reveals all the stones are mobile with no stones in the region of the gallbladder neck

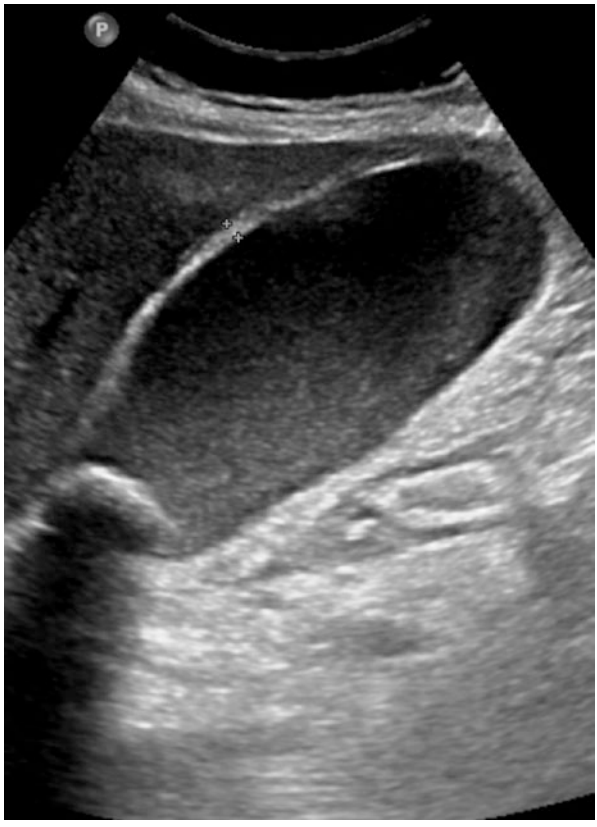

Fig. 4.14 A 28-year-old male presented with one episode of biliary colic that resolved. An ultrasound performed 10 days later revealed a stone impacted in the neck of the gallbladder, a moderate amount of sludge but a normal gallbladder wall and no focal tenderness. A similar ultrasound finding may be seen in a patient presenting with clinical acute cholecystitis

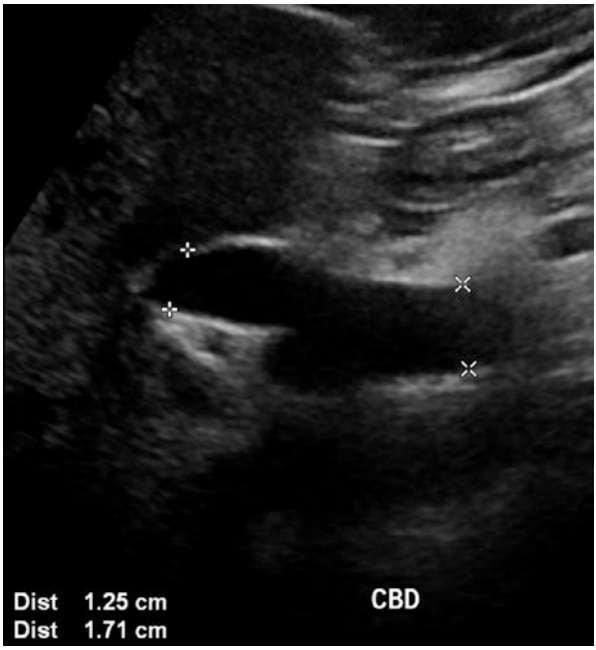

Fig. 4.15 An ultrasound in a 68-year-old woman that presented with recurrent biliary colic. Her LFT were elevated and the ultrasound revealed a dilated common bile duct of 12.5 mm. At laparoscopic cholecystectomy, the cholangiogram revealed a single 8 mm CBD stone

patients with recurrent biliary colic may have a gallbladder with a thickened wall which is contracted around the stone(s) indicating marked chronic inflammation (Fig. 4.8).

The diameter of the CBD is also relevant. A patient with a duct diameter of less than 6 mm with normal LFT is unlikely to have CBD stones. A dilated CBD (Fig. 4.15) may be associated with CBD stones. As with LFT, dilation of the CBD has a low sensitivity and specificity but is certainly associated with a higher incidence of CBD stones. Like elevated LFT, this information is used to discuss with the patient (and family) the possibility of CBD stones at LC and their management. The demonstration of a stone within the CBD on ultrasound is highly predictive of CBD stones at surgery (Fig. 4.16).

Further biliary imaging with CT cholangiography, magnetic resonance cholangio-pancreatography (MRCP) or endoscopic ultrasound are seldom required in patients presenting with recurrent biliary colic unless there is suspicion of another associated pathology (e.g. malignancy).

4.6.4 Acute Cholecystitis

Acute cholecystitis is defined as a patient presenting with typical biliary pain that persists beyond 24 h. If there is secondary bacterial infection, there may be symptoms such as fever or night sweats. Rigours would be an uncommon occurrence in acute cholecystitis and is a clinical indication that the cause of the sepsis is more likely to be cholangitis, rather than acute cholecystitis. When the pain has been

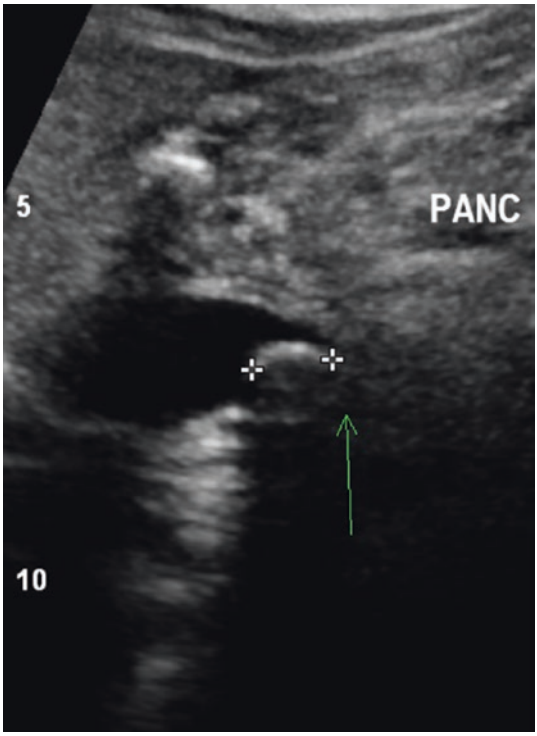

Fig. 4.16 An 88-year-old lady who presented with recurrent biliary pain and intermittent episodes of obstructive jaundice. An ultrasound revealed a stone in the distal common bile duct adjacent to the pancreas in a dilated common bile duct. The cholangiogram at LC revealed multiple CBD stones

present for over 36 h, fevers and night sweats may indicate the development of either acute gangrenous cholecystitis (Fig. 4.3a), an empyema of the gallbladder (Fig. 4.2), emphysematous cholecystitis (Fig. 4.6) or a walled-off perforation (Fig. 4.7).

Clinical examination may reveal the presence of a fever and tachycardia in the patient with associated sepsis. However, many patients with acute cholecystitis do not have secondary bacterial infection and shall be afebrile and usually not have a tachycardia.

Abdominal examination almost always reveals upper abdominal tenderness which is either localised to the right upper quadrant or more generalised. The tenderness is usually made worse with deep inspiration, when it is often incorrectly called Murphy's sign. The clinical examination may detect right upper quadrant tenderness or a positive Murphy's sign. Murphy's sign is where there is initially no pain on palpation of the right upper quadrant and then with deep inspiration the patient complains of localised pain. This is due to the inflamed gallbladder which is initially not palpable moving down with deep inspiration and coming against the palpating fingers. This would indicate an ongoing transmural inflammation and that there may be some degree of acute cholecystitis which may be either ongoing or resolving. Like recurrent biliary colic, the investigations focus on establishing the diagnosis of gallstones and the assessment of the severity of the disease.

Liver Function Tests LFT are done to assess the likelihood of CBD stones as previously discussed. A derangement of LFT may occasionally be present in patients

Fig. 4.17 The operative cholangiogram of a 42-year-old male presenting with acute cholecystitis with pain of 3-day duration. His LFT were raised with a bilirubin of 29. The ultrasound revealed multiple stones in a thick-walled gallbladder with pericholecystic fluid. There was no duct dilation. The operative cholangiogram revealed a type I Mirizzi syndrome with the stone impacted in the cystic duct compressing the common hepatic duct, and a non-dilated CBD

with severe acute cholecystitis, with severe gallbladder inflammation involving the adjacent liver. In patients with acute cholecystitis, clinically elevated liver function tests may also be associated with type I (Fig. 4.17) or type II Mirizzi syndrome.

Inflammatory Markers The main inflammatory marker used clinically in acute cholecystitis is the white cell count. Leucocytosis (greater than 15,000) indicates the likelihood of secondary bacterial infection, which despite being commonly used is seldom referred to in studies on acute cholecystitis [20, 21]. Similarly, C-reative protien (CRP) may be used but this is not a common clinical practice as it does not impact on the management of the patient.

Ultrasound This will detect the presence of gallbladder stones, and in acute cholecystitis, it will usually demonstrate a stone impacted in the neck of the gallbladder (Fig. 4.3b). Other features include thickening of the gallbladder wall, pericystic fluid (Fig. 4.18) and localised tenderness solicited by pressing the ultrasound probe over the gallbladder (‘ultrasonographic Murphy’s sign’). The presence of sludge (Fig. 4.19) may also occur in patients with acute cholecystitis but is not diagnostic of acute cholecystitis. Some patients may not have demonstrable stones but have a thickened gallbladder wall, pericystic fluid and sludge (Fig. 4.19). These patients usually have small stones obstructing the cystic duct which escape detection by ultrasound even while there are other features of acute cholecystitis.

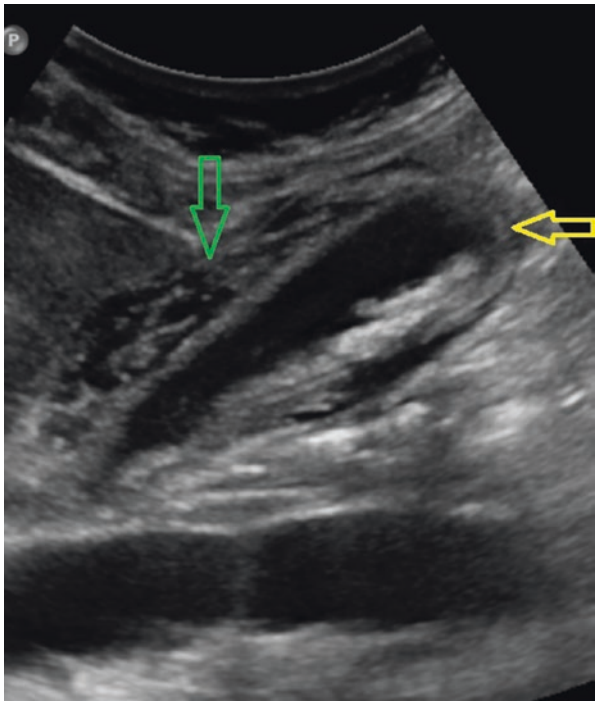

Fig. 4.18 A 22-year-old woman who was 3 months post-partum presented with 24 h of biliary pain. The ultrasound revealed multiple gallstones, marked pericystic oedema (green arrow) and a thickened fundal area (yellow arrow)

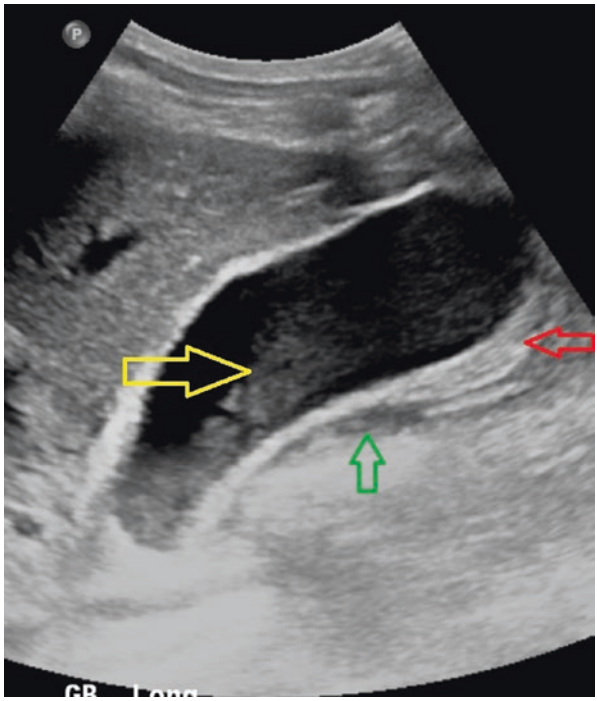

Fig. 4.19 A 50-year-old lady presenting with 4-day history of constant biliary pain. An ultrasound demonstrated a thickened oedematous gallbladder wall (red arrow) with pericystic fluid (green arrow) and a large amount of sludge (yellow arrow) within the gallbladder lumen. No stones could be demonstrated in the gallbladder. At urgent LC she had gangrenous cholecystitis with a 4 mm stone impacted in the cystic duct

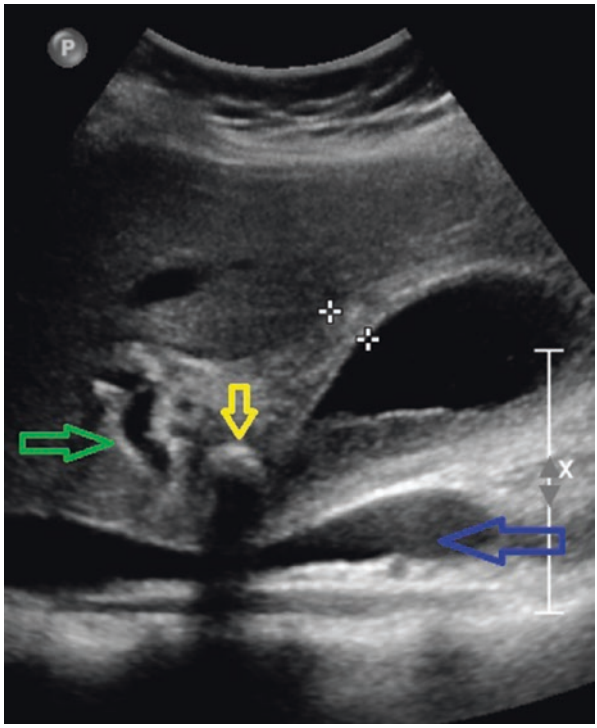

Fig. 4.20 A 28-year-old woman was 6 weeks post-partum with acute cholecystitis clinically and a mild elevation of LFT. The ultrasound demonstrated a stone impacted in the gallbladder neck/cystic duct (yellow arrow) with associated gallbladder wall oedema and sludge. The stone is close to the common hepatic duct with mild dilation (green arrow). The posterior structure (blue arrow) is the portal vein. At LC a type I Mirizzi syndrome was confirmed

In patients presenting with acute cholecystitis, the ultrasound may indicate the possibility of Mirizzi syndrome. This would be a stone impacted in the neck of the gallbladder in close proximity to the common hepatic duct with or without dilatation of the common hepatic duct and intrahepatic ducts (Fig. 4.20). While the stone may be large, this is not always the case. Such patients with this finding will invariably have elevated LFT.

4.6.5 Obstructive Jaundice

Obstructive jaundice is most often due to a stone within the CBD. The various types of Mirizzi syndrome (Fig. 4.9) may also present with obstructive jaundice. Presentation with obstructive jaundice may have an episode of prolonged pain where the pain settles but the jaundice persists for a period of time. Alternatively, obstructive jaundice may be associated with persistent pain. It is important that patients that present with pain and obstructive jaundice but do not have sepsis be considered differently from patients with cholangitis.

The clinical assessment is the same as that for biliary colic and acute cholecystitis. As gallstones and cancer can coexist, it is important to consider a malignant cause in patients presenting with obstructive jaundice. Therefore, clinical features suggestive of a malignant cause need to be considered (Table 4.6).

Table 4.6 Clinical features that may indicate a malignant cause for obstructive jaundice rather than CBD stones

Absence of biliary pain
Previous malignancy (gastrointestinal, breast, melanoma or lymphoma)
Loss of weight
Anorexia
Persistent worsening jaundice (greater than 5 days)
Recent onset diabetes
Steatorrhoea
Pruritus
Palpable gallbladder
Ascites
Sister Mary Joseph's nodule
Cervical lymphadenopathy

Laboratory Investigations LFT are key to the assessment of a patient with jaundice. An elevated alkaline phosphatase (ALP) or gamm-glutamyl transpeptidase (GGT) may indicate a more chronic obstruction. However, when the biliary obstruction is acute, the aspartate aminotransferase (AST) and alanine transaminase (ALT) may be markedly elevated (above 500) with a normal or mildly elevated ALP. This is not due to a hepatic insult, but due to the sudden acute biliary obstruction with a stone. A bilirubin over 200 ug/L is unusual in obstructive jaundice due to CBD stones and should arouse suspicion at the possibility of a malignant obstruction. Tumour markers such as Ca19-9, CEA and LDH may be assessed when considering a malignant cause. Note, however, that Ca19-9 is usually elevated in obstructive jaundice for benign causes as well as malignant causes and should be considered unreliable for the prediction of a malignant cause.

Imaging Ultrasound should confirm a diagnosis of gallstones and may also demonstrate a dilated CBD (Fig. 4.15) or stones in the CBD (Fig. 4.16). An ultrasound may also indicate the possibility of Mirizzi syndrome (Fig. 4.20). There are a series of features on ultrasound that may raise concern that the cause of the obstructive jaundice may not be a CBD stone but may be a malignancy (Table 4.7). In these circumstances the imaging with CT scan, MRCP or endoscopic ultrasound should be performed. Similarly, where there are clinical indicators (Table 4.6) that there could be a risk of malignancy, further imaging is required.

4.6.6 Cholangitis

Cholangitis is suspected clinically by the presence of either Charcot's tirad (pain, fever and jaundice) or Reynolds' pentad [40] (pain, fever, jaundice, confusion and hypotension). The clinical assessment is for acute cholecystitis and obstructive jaundice. The additional features are the evidence of sepsis and presence of systemic inflammatory response syndrome as seen in patients with acute cholecystitis.

Table 4.7 Ultrasound findings suggesting a cause other than common bile duct stones for obstructive jaundice

No stones in the gallbladder
Dilated intrahepatic ducts but no stone impacted in the neck of the gallbladder or in close proximity to the common bile duct
Mass in the gallbladder wall
Mass in the porta hepatis
Hypoechoic liver lesions
Mass in the head of the pancreas
Dilated pancreatic duct
Ascites

Laboratory investigation These include LFT as well as white blood cell count. A mandatory laboratory investigation when cholangitis is considered are blood cultures to confirm bacteraemia and aid selection of subsequent antibiotics.

Imaging Similar to acute cholecystitis or obstructive jaundice, imaging is initially with an ultrasound; although in a septic patient, CT scan may be useful to exclude other causes such as an hepatic abscess or an infected collection elsewhere in the abdominal cavity. Patients that live in or have immigrated from Southeast Asian countries presenting with cholangitis need to have the possibility of RPC considered and an MRCP [41, 42] performed in addition to an ultrasound.

The key feature in the assessment of cholangitis is to accurately diagnose and then assess the severity of the cholangitis. The Tokyo guidelines for the management of acute cholangitis and cholecystitis were first published in 2007 [43] and reviewed and updated in 2013 [44]. The diagnosis is based on the assessment of three criteria: systemic inflammation, cholestasis and imaging (Table 4.8). This allows the diagnosis to be categorised as either suspected or definite (Table 4.8). The severity of cholangitis is classified as grade I (mild), grade II (moderate) or grade III (severe) (Table 4.9). The diagnosis and severity are then used to determine the treatment which will be discussed later in this chapter.

4.6.7 Acute Biliary Pancreatitis

Acute biliary pancreatitis is discussed in detail in the chapter on acute pancreatitis. Briefly the clinical diagnosis is established by the presence of two or three criteria [45]:

1. Typical clinical picture with severe abdominal pain
2. Elevated serum lipase and/or amylase
3. Imaging (ultrasound, CT or MRI) confirming the presence of acute pancreatitis

Further assessment and investigation aim to confirm the diagnosis of biliary cause and assess the severity of pancreatitis.

Table 4.8 Criteria for the diagnosis of cholangitis [44]

A	*Systemic inflammation*
A-1	Fever and/or rigours
A-2	Laboratory data; evidence of inflammatory response (leucocytosis, elevated CRP)
B	*Cholestasis*
B-1	Clinical obstructive jaundice
B-2	Laboratory data; abnormal LFT
C	*Imaging*
C-1	CBD dilatation
C-2	Evidence of the aetiology on imaging (stricture, stone, stent, etc.)

Suspected diagnosis	One item in A + one item in either B or C
Definite diagnosis	One item in A, one item in B and one item in C

Table 4.9 Grading of severity of cholangitis [44]

Grade I (mild) acute cholangitis	
Grade I acute cholangitis does not meet the criteria of either grade II or grade III cholangitis at initial diagnosis	
Grade II (moderate) acute cholangitis	
Grade II acute cholangitis is associated with any two of the following conditions:	
• Abnormal white cell count (greater than 12,000/mm^3, less than 4000/mm^3)	
• High fever (greater than 39 °C)	
• Age (greater than 75 years)	
• Hyperbilirubinaemia (bilirubin greater than 100)	
• Hypoalbuminaemia (less than 30)	
Grade III (severe) acute cholangitis	
Grade III acute cholangitis is defined as acute cholangitis that is associated with the onset of dysfunction in at least one of any of the following organs/systems:	
• Cardiovascular dysfunction	Hypotension requiring dopamine greater than 5 ug/kg/min or any dose of noradrenaline
• Neurological dysfunction	Disturbance of consciousness/reduced consciousness
• Respiratory dysfunction	Pa02/Fi02 ratio greater than 300
• Renal dysfunction	Oliguria, serum creatinine greater than 200
• Hepatic dysfunction	INR greater than 1.5
• Haematological dysfunction	Platelet count less than 100,000/mm^3

4.7 Treatment

The current mainstream treatment for symptomatic gallbladder stones is laparoscopic cholecystectomy (LC). Detailed technical aspects of the operation have been described in the literature [46–48]. The avoidance of bile leak and CBD injury are essential, and the key points for the operation address the following:

1. Division of the peritoneum over the gallbladder infundibulum on both the right and left sides of the gallbladder (Fig. 4.21a,b) [46, 48].
2. Dissection of the gallbladder off the cystic plate of the liver and dissecting the superior portion of Calot's triangle prior to any attempt to dissect out the inferior portion of Calot's triangle (Fig. 4.21c,d) [46, 48].
3. Careful dissection of the fibro-fatty tissue in Calot's triangle to identify the cystic duct and cystic artery (Fig. 4.21e). If in doubt, the junction between the cystic duct and common duct should be displayed [47, 48].
4. Demonstration of the 'critical view of safety' as defined by Strasberg [47] (Fig. 4.21f).

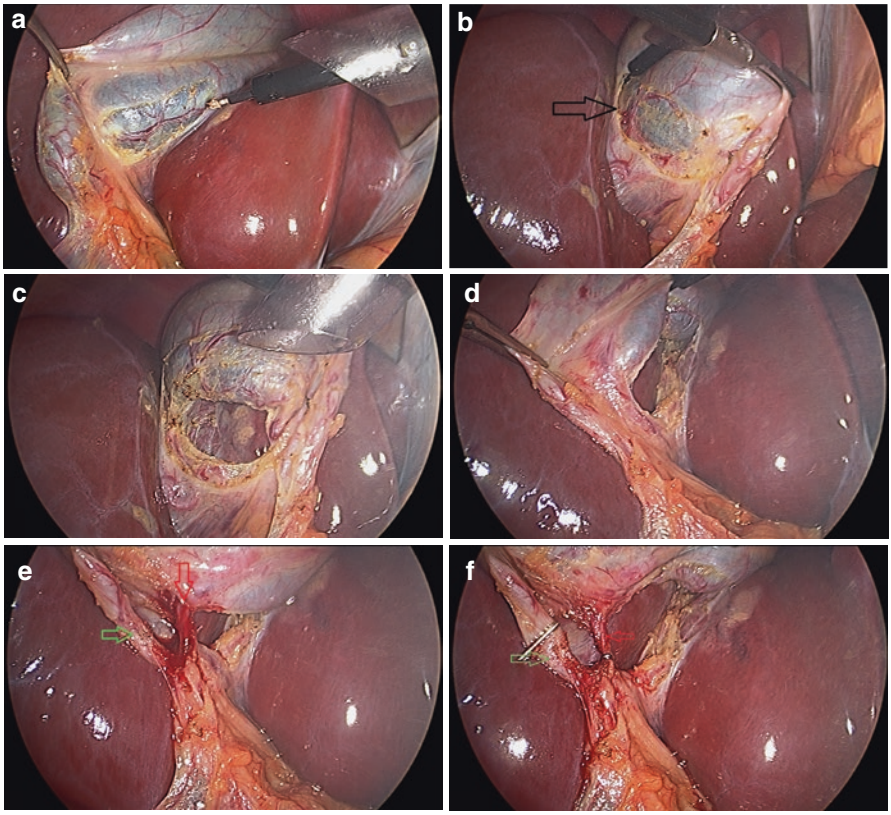

Fig. 4.21 (**a**) Dissection of the peritoneum on the left and (**b**) subsequently on the right side of the gallbladder. This exposes the lower aspect of the cystic plate (arrow). (**c**) Dissection of the gallbladder off the lower portion of the cystic plate from the lateral side of the gallbladder opening the superior part of the Calot's triangle. (**d**) Medial side of the gallbladder demonstrating the dissection of the gallbladder off the cystic plate and dissection of the superior part of Calot's triangle. Note that the cystic duct and cystic artery have not yet been dissected. (**e**) After the dissection of the fatty tissue away from the distal gallbladder, the cystic duct (green arrow) and artery (red arrow) are clearly demonstrated. (**f**) The critical view [47] is achieved with the gallbladder off the cystic plate, and the only two structures going to the gallbladder are the cystic artery (red arrow) and cystic duct (green arrow)

Where the inflammation is severe and prevents the safe dissection of the lower portion of the Calot's triangle, the distal gallbladder that has been mobilised off the lower portion of the cystic plate of the liver can be safely transected (Fig. 4.28a), the stones removed and, if the dissection cannot be continued, the distal stump of the gallbladder be left in situ [49–51]. Any subsequent bile leak can be managed expectantly [50] (Sect. 4.8.2 Bile Leak).

Early in the laparoscopic era, some surgeons were advocating a fundus-down approach as a safe dissection technique for the difficult inflamed gallbladder based on the open surgery fundus-down technique [52]. However, the laparoscopic 'fundus-down' technique is dangerous with a strong association of extreme vasculobiliary injuries reported by Strasberg and Gouma [53]. This occurs due to the lack of retraction of the fundus over the liver that significantly changes the orientation of the tissues compared to that normally obtained. Further to this, the associated inflammation and poor orientation obscure the distal edge of the cystic plate as the dissection descends on the gallbladder and results in the dissection continuing along the liver down to the right portal structures, rather than staying on the gallbladder wall at the commencement of Calot's triangle [53].

The role for routine intraoperative cholangiography (OC) is debated. Good dissection technique and accurate recognition of key structures is most important in avoiding CBD injury [47, 48]. The literature is not particularly helpful in determining the value of OC in reducing the risk of CBD injury because the studies are of poor quality. However, there is good evidence to suggest that the performance and correct interpretation of routine OC may result in early detection of the CBD injury, reducing the extent of the injury and preventing resection of the duct complex. Studies using large databases have demonstrated that the performance of OC is associated with a significant reduction in the incidence and severity of CBD injury [54–58]. Another advantage of routine OC is that it will detect 3% of CBD stones that are unsuspected at the time of LC. Clearly, OC will also detect stones that are anticipated or suspected on the basis of preoperative assessments. Having detected these stones, the OC will then allow for specific treatment and removal of these stones (see later). Finally, the routine use of OC to assess the biliary tree is useful when managing post-operative complications such as bile leaks or jaundice and in patients who present sometime later with recurrent symptoms.

The correct interpretation of the OC is important. All intrahepatic ducts should be displayed, the relationship of the cystic duct to the common hepatic duct identified, CBD diameter measured, a normal tapering of the distal CBD with the absence of any filling defects with free flow of contrast into the duodenum (Fig. 4.22).

4.7.1 Asymptomatic Gallstones

The incidence with patients presenting with asymptomatic gallstones seems to be increasing with increased used of various forms of cross-sectional imaging to assess various abdominal symptoms. Therefore, patients presenting with asymptomatic gallstones is a distinct clinical entity. The natural history of truly asymptomatic

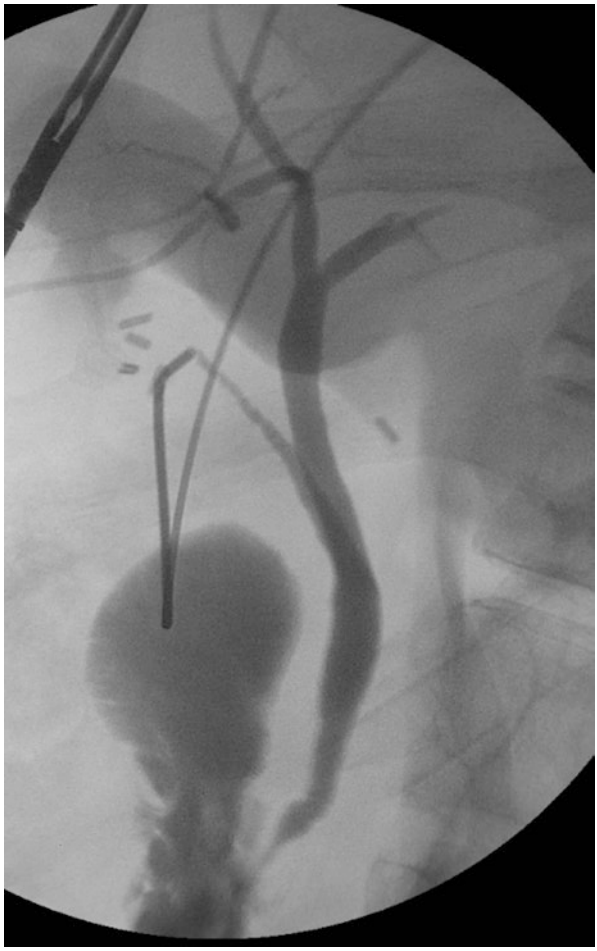

Fig. 4.22 A normal operative cholangiogram. All the intrahepatic ducts are seen, the cystic duct/CHD junction is clearly identified and the CBD is well displayed with no filling defects, a tapered distal end and free flow of contrast into the duodenum. Note there are no instruments across the field to obstruct the view of the bile duct of the biliary tree

gallstones (no biliary pain) is that only 1–2% of patients shall develop symptoms (attacks of biliary pain or complications) each year [13, 14] and that the majority of adults with asymptomatic gallstones shall remain asymptomatic throughout their lives [12]. Using decision analysis techniques to assess the effect prophylactic cholecystectomy compared to nonoperative management, there was a prediction of higher costs (four times) and greater morbidity and mortality if prophylactic cholecystectomy was performed [59]. Two sets of evidence-based guidelines from the Association of Upper Gastrointestinal Surgeons (AUGIS) and the UK National Institution for Health and Care Excellence (NICE) both recommend that patients with asymptomatic gallstones be reassured of the low risk of the development of symptoms and complications and that they should not undergo LC [60, 61]. Therefore, patients with asymptomatic gallstones, that is, gallstones and no episodes of biliary pain, should not proceed to LC.

Patients with other gastrointestinal symptoms (Table 4.5) but no biliary pain need careful consideration but on balance should not proceed to LC. This is due to

the low success rate of resolution of these symptoms after cholecystectomy [27, 36, 62, 63].

An exception for operating on asymptomatic gallstones (no biliary pain) would be in patients who have episodic nausea as their dominant symptom. Patients with episodic nausea and little or no other gastrointestinal symptoms are twice as likely to benefit from LC compared to patients with a spectrum of other gastrointestinal symptoms [64]. In a Dutch meta-analysis, intermittent nausea was seen to resolve in 70% of patients coming to LC where they did not have pain [65]. It is, therefore, reasonable in patients who present with no biliary pain, gallstones and a dominant symptom of intermittent nausea to consider a LC after exclusion of other possible causes for the nausea, including upper gastrointestinal functional disorders such as gastroparesis.

A rare indication in Western counties for LC with asymptomatic gallstones is in a patient identified as being a carrier of *Salmonella typhi*. This is due to the carriage of the *S. typhi* in the gallbladder bile in association with the gallstones and is best managed with LC.

4.7.2 Asymptomatic Gallbladder Polyps

As the majority of gallbladder polyps are non-neoplastic [29], most asymptomatic gallbladder polyps do not require LC. Although less than 5% are neoplastic, the ultrasound has a low accuracy (<20%) for distinguishing between neoplastic and non-neoplastic polyps [66]. Size of less than 10 mm is a very reliable predictor of a benign polyp [67, 68]. As CT scan, MRI and PET all have low predictive values for malignant polyps [69, 70], the common recommendation is to perform LC on asymptomatic polys 10 mm or greater in size on ultrasound [67, 68, 70, 71].

4.7.3 Recurrent Biliary Pain (Colic)

Once gallstones become symptomatic with episodes of biliary pain, LC is recommended. There is only one randomised controlled trial (RCT) in patients with recurrent biliary pain comparing surgery to an observation group, with a 14-year follow-up period [72]. This study reported that in the observational group, 14% of patients developed a significant biliary complication (cholecystitis 9%, complications related to common bile duct stones 4% and biliary pancreatitis 1%). A further 14% developed frequent episodes of biliary colic that resulted in surgical intervention [72]. Although 72% did not require surgery during this 14-year period, there were no reliable predictive factors to determine which patients would develop complications or frequent recurrent pain or which patients would not require surgical intervention. Another longitudinal study of nonoperative observation demonstrated that a 52% of patients with a single episode of biliary colic had no further problems over a 10-year follow-up [10]. Once again there was no single or combination of factors that predicted which patients would go on to develop complications or recurrent biliary pain.

Although there is some evidence to support a nonoperative, observational approach, the UK NICE guidelines recommend that 'laparoscopic cholecystectomy should be offered to patients with symptomatic gallstones' [73]. This is a recommendation based on the balance between a low but definite risk of patients having either recurrent biliary pain or developing a significant complication against the low risk of LC in an elective setting with good outcomes for the cessation of biliary pain (ranging from 92 to 96%) [62, 74, 75]. Although there is no published data, the clinical impression is that most patients with biliary colic would not agree to proceed with nonoperative treatment given the good outcomes associated with LC. Therefore, patients presenting with a single episode of biliary colic can be offered the option of an observational strategy with the provision of the risks and benefits as outlined above. Patients with recurrent episodes of biliary colic should be offered LC.

4.7.4 Acute Cholecystitis

During the open cholecystectomy era, three randomised controlled trials (RCTs) that demonstrated early or urgent open cholecystectomy at the time of clinical presentation had improved outcomes compared with nonoperative management and subsequent delayed surgery at 3 months [76–78]. In these studies, there was a reduced hospital stay, but no associated increase in morbidity or mortality when performing urgent open cholecystectomy. Furthermore, 35% of patients managed nonoperatively were readmitted with further complications of their gallstones prior to their planned elective surgery.

At the commencement of the laparoscopic era in the early 1990s, acute cholecystitis was considered a relative contraindication to LC [79–81]. This was largely based on concerns of an increased risk of bile leak or bile duct injury due to the more difficult dissection in the acutely inflamed state. There were also concerns about increased morbidity and mortality associated with an increased conversion rate in acute cholecystitis [82–84]. This has not proved to be the case with those units that did perform urgent LC for acute cholecystitis with no incidence of CBD injury and a similar incidence of bile leak (0.5–3%) compared to open cholecystectomy for acute cholecystitis [46, 85–87]. In the early experience with LC for acute cholecystitis, the conversion rate was dependent on the severity of the disease: mucocoele (10%), acute cholecystitis (22%), gangrenous cholecystitis (50%) and empyema (87%) [46]. In the last two decades with an increased experience in the technical challenges associated with LC for acute cholecystitis, the conversion rate for all comers with acute cholecystitis ranges between 4.5 and 13.4% [20, 21, 88].

There have been many RCTs comparing early to delayed LC for patients presenting with acute cholecystitis. The majority of these studies have revealed that there is a reduced total hospital stay associated with early LC and that there is no increase in morbidity or mortality. A recent meta-analysis of RCT examined 1548 patients and confirmed that there is a reduced length of stay and demonstrated a tendency towards reduced morbidity in the early LC group [21]. Another recent meta-analysis

Table 4.10 Outcomes of meta-analysis of case controlled studies comparing urgent/early cholecystectomy versus delayed cholecystectomy in patients presenting with acute cholecystitis [22]

	OR (95% CL)	*p* value
Mortality	0.46 (0.33–0.62)	Less than 0.001
Total complications	0.59 (0.50–0.69)	Less than 0.001
CBD injury	0.49 (0.33–0.73)	Less than 0.001
Bile leak	0.51 (0.32–0.8)	Equals 0.001
Wound infection	0.52 (0.35–0.78)	Less than 0.001
Conversion to open	0.66 (0.53–0.81)	Less than 0.001

looking at case-controlled studies examined 40,910 patients revealing a clear benefit with respect to biliary morbidity, general morbidity and mortality when laparoscopic cholecystectomy was performed as an urgent procedure compared to initial nonoperative management and subsequent delayed LC [22]. Furthermore, the conversion rate in the early laparoscopic group was significantly less, and the average length of stay was less than half for the delayed groups (Table 4.10). These results provide clear evidence that where a patient is fit for surgery the best management is an urgent LC.

Percutaneous cholecystostomy using ultrasound or CT guidance has a role in patients with acute cholecystitis that are not fit for a general anaesthetic or surgery. Percutaneous cholecystostomy is successful in resolving the episode of acute cholecystitis in up to 97.5% of cases [89] with a low risk of bile leak (3–6%) when performed transhepatically [90] and a low risk of bleeding (3.3%) [91]. Although drain dislodgement has been reported to be as high as 27% [92], most series have a much lower incidence.

There are three broad categories of patients that may require a percutaneous cholecystostomy rather than proceed to an urgent LC:

1. Acute calculous cholecystitis in a patient who is not currently fit for surgery but may be fit in the future, for example, a patient who has had a myocardial infarction or cerebrovascular accident within the last 6 weeks. In these patients, there is a significant anaesthetic risk that is reduced in 2–4 months' time. These patients may be managed initially with a percutaneous cholecystostomy and consideration given to a delayed LC once their anaesthetic risk is reduced.
2. Acute calculous cholecystitis in someone with multiple comorbidities that shall never be fit for surgery.
3. Acute acalculous cholecystitis in a critically ill patient from another cause (e.g. severe multi-trauma) currently not fit for surgery.

In these scenarios the success rate of percutaneous drainage is high. The drains can be left in for up to 6 weeks for a tract to mature. A percutaneous cholecystogram may help to determine the subsequent management plan with a patent cystic duct having a 21% risk of recurrent acute cholecystitis compared to 36.7% when the cystic duct is occluded [93]. Although delayed LC can be performed, as expected, these are more difficult operations as the gallbladder is often contracted and fibrotic with conversion rates between 23 and 45% [94, 95]. Balancing against this is the risk of recurrent acute cholecystitis or another biliary complication after catheter

removal which ranges from 23% at the 3-month mark up to 49% at 1 year [96]. Apart from a patent cystic duct, there are no other predictive factors for recurrent disease. Therefore, the decision to proceed with an interval LC following an episode of acute calculous cholecystitis treated with a percutaneous cholecystostomy is a balance of risks with no clear decision algorithm available to help in the decision-making process.

Acalculous cholecystitis on the other hand has a much lower incidence of recurrence after removal of the drain (3–14%) [97, 98]. Therefore, in patients with acute acalculous cholecystitis that have a very high operative risk, an initial percutaneous cholecystostomy to resolve the acute cholecystitis and subsequent cholangiogram and removal of the drain with no interval LC is appropriate in the majority of these patients.

4.7.5 Patients at High Risk of Common Bile Duct (CBD) Stone

During the laparoscopic era, there has been debate about the management of patients with a high risk of having common bile duct stones. These patients will have some of the criteria described previously and outlined in Table 4.11. These patients may have presented with recurrent biliary colic, acute cholecystitis, jaundice, mild cholangitis or a recent episode of biliary pancreatitis. The debate largely centres around three options: [1] whether endoscopic clearance of a suspected CBD stone prior to LC should be performed or [2] whether the patient should proceed directly to a LC and subsequent management of stones found at OC at that time or [3] whether the duct is cleared by post-operative ERCP.

Preoperative endoscopic clearance sounds appealing by making the subsequent LC less complicated. However, a meta-analysis comparing preoperative ERCP to initial LC and duct clearance clearly demonstrates that preoperative ERCP and subsequent LC is associated with a higher overall morbidity and an increased mortality. This is in part related to having two separate procedures, with complications being additive. An LC after an ERCP is also associated with an increased conversion rate to open surgery compared to performing the LC as the initial procedure [99]. Therefore, the data indicates that patients with possible CBD stones should proceed directly to a LC and OC and bile duct exploration if indicated. One important provision is that the expertise is available for laparoscopic bile duct exploration, and this is often not as readily available as those with endoscopic (ERCP) expertise. Patients with concomitant cholangitis will require urgent endoscopic bile drainage, if not stone clearance (see Sect. 4.7.6).

Table 4.11 Preoperative risk factors for CBD stones

Recent history of jaundice
Recent history of biliary pancreatitis
Elevated bilirubin
Elevated ALP and/or GGT
Elevated AST and ALT
Dilated (>6 mm) CBD on ultrasound
Stone in the CBD on ultrasound

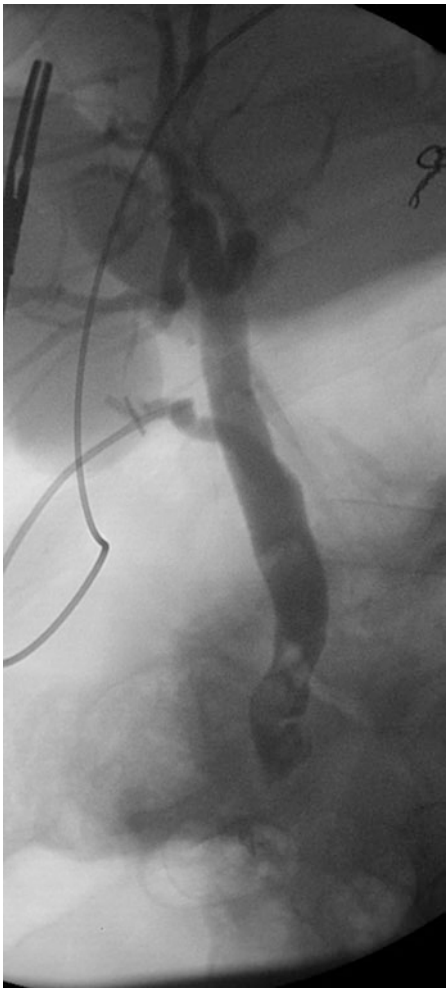

Fig. 4.23 An OC in a 51-year-old man with recurrent biliary colic. The preoperative LFT had a raised AST and ALT during an episode of pain, and the CBD was slightly dilated at 7 mm. At OC there were multiple irregular filling defects in the distal CBD with no flow of contrast into the duodenum and a loss of the tapered distal end of the CBD (compare with Fig. 4.22)

4.7.6 Managment of CBD stones

The next debate concerns the management of the common bile duct stone detected on OC at LC (Fig. 4.23). The options are summarised in Table 4.12.

4.7.6.1 *Sphincter of Oddi (SO) Relaxation and Flushing*

Relaxation of the sphincter of Oddi (SO) with either Buscopan (20 mg IV) or glucagon (1 unit IV) and flushing the CBD via the cholangiogram catheter with saline and then repeating the cholangiogram to check clearance is a technique associated with a success rate of 5–15% [100, 101]. Those cases where it is successful are invariably small stones impacted in the tapered part of the bile duct, or where there is a tapering but no flow. Where there are multiple stones, large stones or stones not impacted in the distal CBD (Figs. 4.23 and 4.24), it is unlikely to be successful. Another technique with a distal stone impacted in the taper of the ampulla is to pass the cholangiogram catheter down the CBD and push the stone into the duodenum. The difficulty

Table 4.12 Options for the management of stones found at operative cholangiography during laparoscopic cholecystectomy

Sphincter of Oddi relaxation and flushing
Transcystic duct exploration
Laparoscopic choledochotomy and common bile duct exploration
Conversion to open surgery for open choledochotomy and CBD exploration
Transcystic biliary stent to facilitate post-operative ERCP
Closure to the cystic duct without inserting a stent and proceeding to post-operative ERCP

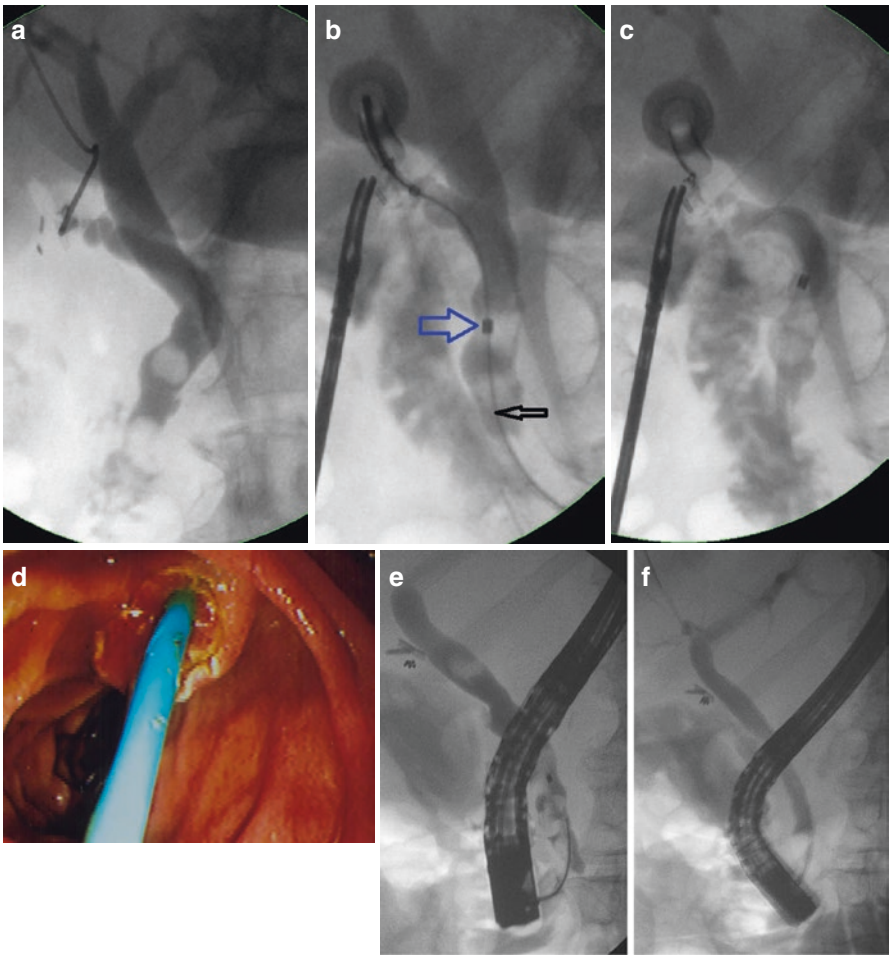

Fig. 4.24 A 64-year-old woman presented with mild (grade I) cholangitis that settled quickly with IV antibiotics. She proceeded to LC 2 days after admission. (**a**) OC demonstrated multiple CBD stones in a dilated (9–10 mm) CBD. (**b**) A wire is passed through the catheter into the duodenum (black arrow) and a 7 Fr. stent deployed (blue arrow) over the wire to lie across the sphincter of Oddi. (**c**) Final position of the transcystic stent with the distal end in the duodenal lumen. (**d**) Endoscopic view of the complete ES over the transcystic stent prior to the removal of a stent with a snare. (**e**) Initial cholangiogram demonstrating the multiple stones. (**f**) The CBD cleared after repeated balloon trawls

with either technique is the possible overlooking of a small stone in the distal CBD on the repeat cholangiogram, the incidence of which has not been assessed in the literature. Any such follow-up studies would need to have at least a 5-year follow-up as the median time for a retained CBD stone to present post LC in 4 years [35].

Laparoscopic transcystic exploration has the advantage of avoiding a choledochotomy or endoscopic sphincterotomy. It has a clearance rate of between 57 and 75% [102, 103]. Failure is usually due to technical issues and/or difficulties in visualising the stone and/or in securing the stone (especially in the CHD and in the liver). When laparoscopic transcystic exploration is unsuccessful, a step-up approach can be considered [103]. *A laparoscopic choledochotomy* when there is a dilated common bile duct (8 mm or greater) will allow a more traditional approach to common bile duct exploration. Once the duct is cleared via the choledochotomy, it is closed either directly or over a T-tube. The former is favoured, especially in the presence of an endoscopic sphincterotomy. Alternatively, the placement of a stent across the ampulla can be readily achieved when transcystic duct extraction fails, and this will facilitate post-operative ERCP, increasing the success rate and reducing the risk of ERCP-associated pancreatitis [100].

Laparoscopic choledochotomy is associated with a higher morbidity including bile leaks and strictures than cases not requiring choledochotomy [103]. A post-operative ERCP in these more difficult cases may involve a separate procedure, but it is associated with a much lower morbidity [100]. A meta-analysis comparing laparoscopic duct exploration to post-operative ERCP could not demonstrate at any statistical difference in outcomes between either approach [99]. However, there is no data to answer the question about whether choledochotomy or transcystic stent is superior after failed transcystic exploration. Therefore, without a direct comparison between laparoscopic choledochotomy and post-operative ERCP, it is difficult to provide an evidence-based approach. However, the increased complexity of performing a laparoscopic choledochotomy with the associated higher morbidity may favour a transcystic stenting and post-operative ERCP.

An alternative strategy to laparoscopic duct exploration via the transcystic approach is to insert a transcystic stent in all patients with common bile duct stones and performing a post-operative ERCP and sphincterotomy in all of these patients with OC-confirmed CBD stones [100] (Fig. 4.24).

In the past, laparoscopic choledochotomy was favoured for very large stones in large dilated ducts, as these large stones were felt to be inappropriate for endoscopic technique. This is no longer as relevant with the availability of techniques such as endoscopic mechanical or laser lithotripsy. During the open era it was felt that such patients required a ‘drainage procedure’ with a choledoch-duodenostomy or hepatico-jejunostomy. This is now considered unnecessary especially in the context of a sphincterotomy which also provides adequate biliary drainage avoiding the need for the biliary bypass.

4.7.7 Cholangitis

The diagnostic criteria and severity of grading have been previously outlined (Sect. 4.6.6, Tables 4.8 and 4.9). Patients with grade III cholangitis should proceed to an urgent biliary drainage. This is usually by an ERCP with sphincterotomy,

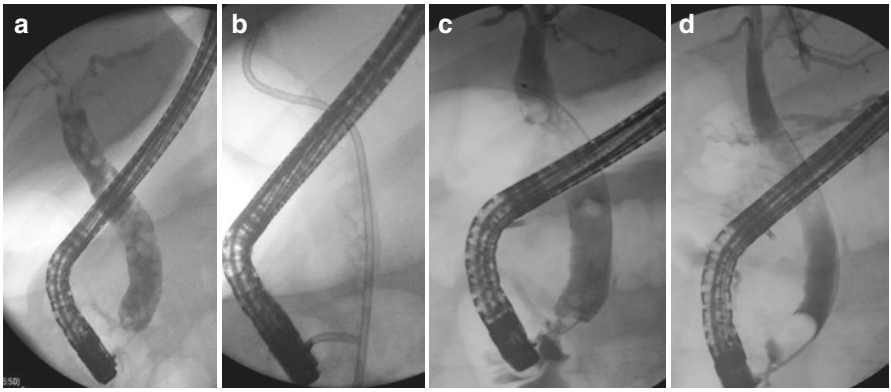

Fig. 4.25 An elderly man presented with grade III cholangitis 25 years after an open cholecystectomy. This was managed with an urgent ERCP. (**a**) The initial ERCP revealed multiple stones in a dilated CBD. (**b**) An ES was performed and some of the stones removed. However, due to being severely septic with hypotension, a stent was deployed to drain the CBD. He was returned to the ICU for ongoing care. (**c**) A repeat ERCP was performed 8 weeks later when fully recovered. The stent was removed and the cholangiogram revealed some residual stones as expected. (**d**) These stones were cleared with repeated balloon trawls

removal of the stones (if possible) and biliary stenting (Fig. 4.25). In patients with a gallbladder still *in situ*, once the cholangitis and sepsis have resolved and the patient is fit for surgery, they should proceed to an early LC, as many of these patients will have associated acute cholecystitis as the ascending infection also involves the gallbladder. Similar to the management of acute cholecystitis, a delayed LC is associated with a much more difficult dissection and, like acute cholecystitis, a higher risk of conversion, biliary morbidity, overall morbidity and presumably mortality [104].

In patients with the gallbladder *in situ* grade I or grade II cholangitis which resolves quickly with nonoperative management, rather than doing an ERCP, these patients should proceed to early LC (within 24–48 h) and any stones in the bile duct managed as described above. Patients having had a previous cholecystectomy that present with grade I or grade II cholangitis should proceed to an early ERCP.

For patients that present with grade I or grade II cholangitis with no prior cholecystectomy that have multiple comorbidities, are frail or are extremely old, it may be reasonable to consider not proceeding to LC and managing the CBD stones with an ERCP and sphincterotomy alone. This is a viable option as there is some evidence that future complications in this group of patients where the CBD stones are managed endoscopically are unlikely to occur during their life [105]. However, the risk is that if they do develop acute cholecystitis, it shall be severe due to the pre-existing contamination of the biliary tree. This decision whether or not to proceed with cholecystectomy in this group of patients requires a careful, considered discussion with the patient and their family.

4.7.8 Mirizzi Syndrome

The treatment of Mirizzi syndrome is dependent on the type (Fig. 4.9) which is determined by the preoperative imaging [24].

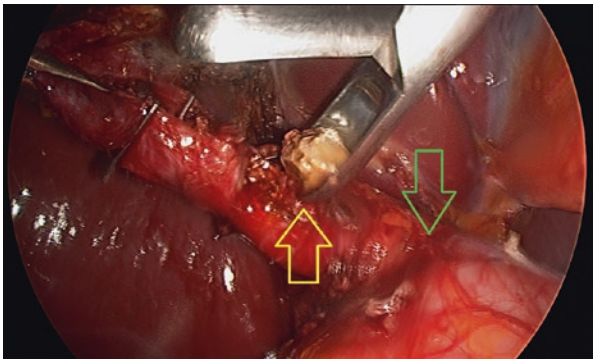

Fig. 4.26 A 69-year-old woman with acute cholecystitis and mild jaundice (bilirubin = 50) was managed with an urgent LC. The cystic duct was dissected and the cystic duct/common hepatic junction noted (green arrow). A 9 mm stone was milked out of the cystic duct and removed with forceps (yellow arrow). The operative cholangiogram was then performed through the hole and this was normal

Type I: This is when the gallstone is impacted in the cystic duct or the neck of the gallbladder (Figs. 4.9 and 4.17). In these patients, it is safe to proceed with LC with careful dissection, being sure to dissect the gallbladder off the cystic plate and dissecting down the cystic duct to obtain the critical view of safety (Fig. 4.21e, f). This may be a difficult dissection due to acute and/or chronic inflammation. Occasionally the stone can be milked out of the cystic duct (Fig. 4.26). More often the stone is impacted at the junction of the cystic duct and the common hepatic duct (Figs. 4.17 and 4.27a) and cannot be milked back into the gallbladder. Dissection down along the cystic duct onto the stone may be performed provided there is a clear margin between the stone and the junction of the cystic duct and common hepatic duct. Where this is no possible conversion, an open surgery may be considered. Another option to manage these difficult cases is transcystic stenting to facilitate post-operative ERCP being performed (Fig. 4.27b). This is certainly appropriate as many of these stones will move into the common hepatic duct allowing withdrawal at the time of ERCP. Stones that do not migrate distally or remain impacted can be managed with endoscopic laser lithotripsy. This combined laparoscopic and endoscopic approach avoids open surgery.

Type II: Here the stone has dilated the cystic duct and is wedged into the common hepatic duct but with no destruction of the duct wall or mucosa (Fig. 4.9). These can be associated with a fibrotic contracted gallbladder. In these situations, the patient can be managed by dissecting down onto the fundus, opening the fundus of the contracted gallbladder, extracting the stone, performing a cholangiogram to demonstrate there are no further stones and then simply closing the fundus, after removing any redundancy. Patients with type II Mirizzi may also present with acute cholecystitis and a distended gallbladder. In these cases, the LC may be attempted by an experienced surgeon. The gallbladder can then be transected distally after the gallbladder has been dissected off the liver. This then allows further dissection down the neck of the gallbladder to then remove the stone. If

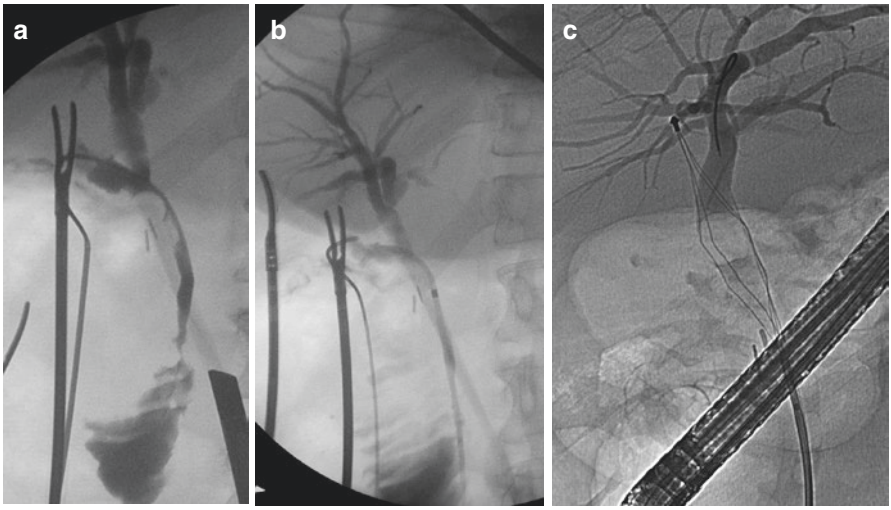

Fig. 4.27 A 58-year-old man with Childs-Pugh A cirrhosis due to hepatitis C presented with acute cholecystitis and raised bilirubin. An ultrasound confirmed multiple gallbladder stones. (**a**) Operative cholangiogram revealed a stone still in the cystic duct or at the junction of the cystic duct and common hepatic duct. The common bile duct had not yet dilated. This stone was not able to be milked out of the cystic duct. Consideration to opening down the cystic duct was given, but decided against due to the concerns about possible bleeding, common bile duct injury and possible vascular injury. (**b**) A transcystic stent was inserted and the cholecystectomy completed. (**c**) An ERCP 4 weeks later found the stone in the common hepatic duct with a still non-dilated common bile duct. The stone was pushed proximally, captured in a lithotripsy basket, crushed and the fragments removed. Had this been unsuccessful an alternative technique would have been endoscopic laser lithotripsy

there is sufficient length on the cystic duct, it can be closed with an endoloop or intra-corporeal suturing. If there is a side hole in the cystic duct and insufficient length, this can be confirmed by inspection and OC; a retrograde biliary stent may be inserted to ensure distal drainage (to reduce biliary pressures and the risk of a leak) and the side hole be closed with sutures (Fig. 4.28).

Types III and IV: Patients with type III or IV Mirizzi syndrome usually present with obstructive jaundice and/or cholangitis. Early imaging with ultrasound will often confirm a contracted gallbladder with a large stone and dilated intrahepatic ducts raising the strong possibility of Mirizzi syndrome. In this clinical setting it is mandatory to obtain more accurate biliary imaging to confirm Mirizzi type III or IV and to plan subsequent treatment. This imaging may be an ERCP where there is associated cholangitis that requires biliary drainage (Fig. 4.9). This would allow confirmation of the diagnosis and treatment of the cholangitis with an endoscopic biliary stent. On the rare occasion that ERCP is not successful, this could be achieved with percutaneous transhepatic cholangiography. In the absence of cholangitis, MRCP usually provides the information required to manage these patients. Type III and type IV Mirizzi syndrome are associated with significant destruction of the common bile duct wall and as such usually require open resection of the distal bile duct and gallbladder and a reconstruction with a hepatico-jejunostomy.

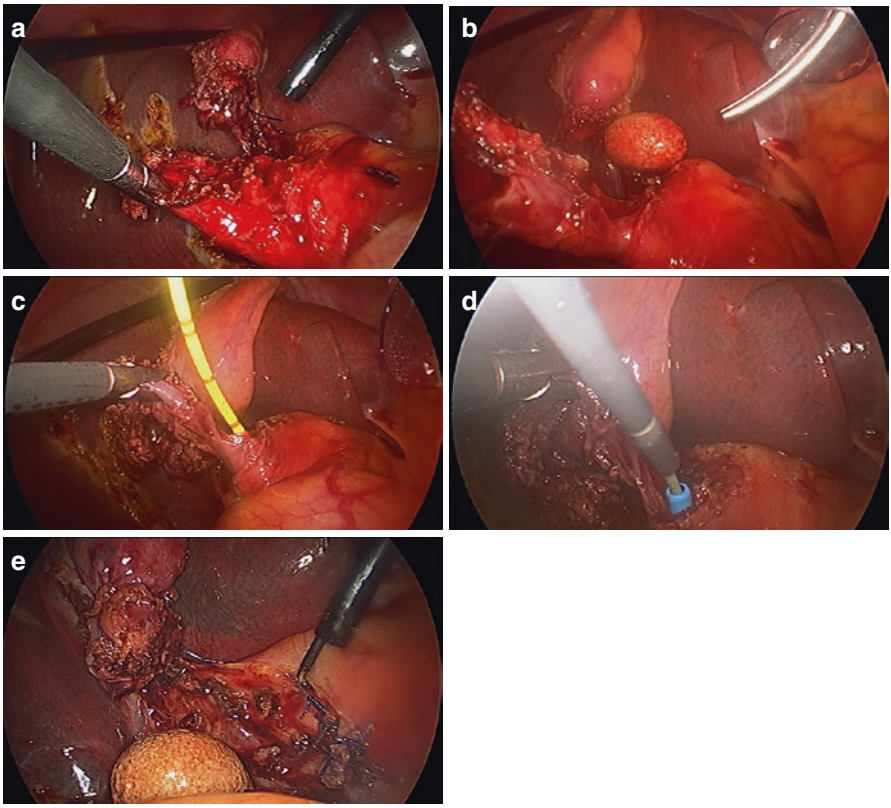

Fig. 4.28 A 36-year-old woman with acute cholecystitis, jaundice and an ultrasound revealing a possible Mirizzi with a stone impacting in the neck of a distended, thick-walled gallbladder close to the common hepatic duct. (**a**) After the gallbladder was dissected off the cystic plate of the liver, it was transected to facilitate more distal dissection. (**b**) The neck of the gallbladder was carefully dissected and opened over the stone away from the common hepatic duct, and the stone removed. (**c**) Operative cholangiogram confirmed the anatomy and that the opening was at the cystic duct/common hepatic duct junction. (**d**) Retrograde stent was inserted across the sphincter of Oddi. (**e**) The side hole was then sutured, post-operatively well with no bile duct, the stent was removed 4 weeks later revealing a normal cholangiogram. Note the diathermy hook is being used only to retract the tissue for better exposure.

4.7.9 Gallstone Ileus

Patients presenting with gallstone ileus (Fig. 4.11) are usually elderly and present with a distal small bowel obstruction (Sect. 4.5.2.3).

The management of gallstone ileus is a laparotomy and enterotomy removal of the obstructing stone and closure of the enterotomy. Occasionally a small bowel resection is required if there is ischaemia and/or perforation associated with the mechanical pressure from the obstructing stone. If the stone is faceted and cylindrical, there may be other stones more proximally. The small bowel proximal to the obstructing stone should be palpated and an endoscopy performed to assess the

stomach and duodenum to look for other stones and prevent the risk of a recurrent episode of gallstone ileus [106–108].

The surgical treatment of the associated cholecysto-duodenal fistula in gallstone ileus is debated. Some advocate a single-stage or two-stage procedure [107]. However, either the primary or the delayed repair of the fistula is associated with the much higher morbidity and mortality compared to the enterotomy alone. Given that many of these patients are elderly with associated comorbidities and that the fistula may spontaneously close and the incidence of recurrent biliary disease following an enterotomy alone is only 15% [106, 108], many surgeons advocate not proceeding with cholecystectomy and closure of the fistula unless there are recurrent biliary symptoms.

4.7.10 Cholecysto-duodenal and Cholecysto-colonic Fistula

Cholecysto-duodenal (Fig. 4.12) and cholecysto-colonic fistula may be suspected or unsuspected and found during LC for a chronically inflamed gallbladder. The clue that there is a fistula is that while dissecting the gallbladder wall away from the adherent surrounding structures, a point is reached where the gallbladder wall and duodenum or colon appear fused. A cholecysto-duodenal fistula can be managed with a cholecystectomy, excision of the fistula tract from the duodenal wall and primary closure of the duodenal wall. This may be done after conversion to open surgery, or an experienced surgeon may not convert and complete the procedure safely with laparoscopic techniques. A cholecysto-colonic fistula also requires a cholecystectomy and excision of the fistula tract from the colon. This normally requires a small formal resection and occasionally a right hemi-colectomy. This is more likely to require conversion to open surgery.

4.7.11 Recurrent Pyogenic Cholangitis (RPC)

The initial treatment to control sepsis when RPC is suspected or known is biliary drainage by either ERCP and stenting or percutaneous transhepatic biliary drainage [109–111]. Most patients will progress to require a formal surgical treatment. The surgical strategy varies depending on the pattern of disease but most commonly involves either a hepatico-jejunostomy with an access limb or stoma for repeated cholangioscopic procedures and/or hepatic resection (frequently segment 2/3) of the dominant component of disease or a combination of both [111, 112].

4.8 Complications of Treatment

The two most frequently performed procedures for the treatment of symptomatic gallstones are LC to treat gallbladder stones and ERCP and ES to treat CBD stones. The discussion regarding complications will concentrate on these two procedures

and discuss the early complications particularly those complications which require early detection and early surgical management to avoid the situation of 'failure to rescue'.

4.8.1 Laparoscopic Cholecystectomy

Early and late complications of laparoscopic cholecystectomy are outlined in Table 4.13.

4.8.2 Bile Leak

Bile leaks occur in between 0.25 and 2% of patients having laparoscopic cholecystectomy. These most frequently occur from either the gallbladder bed (15%) or the cystic duct stump (80%) [113, 114]. These are the type A injuries as classified by Strasberg (Fig. 4.29). Less frequently bile leaks may be associated with type C, D or E injuries to the biliary tree. Bile leaks may be anticipated at the time of surgery.

Table 4.13 Complications of laparoscopic cholecystectomy

Early
Bile leak
Common bile duct injury
Post-operative haemorrhage
Injury to small bowel or colon
Late
Retained common bile duct stones
Common bile duct stricture
Port-site hernias

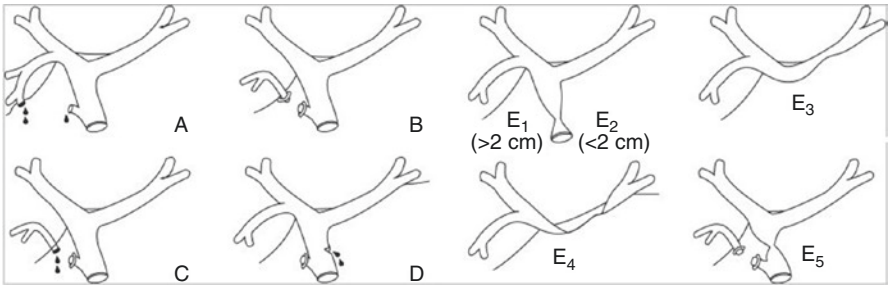

Fig. 4.29 Strasberg classification of CBD injury. (**A**) Bile leak from cystic duct stump or minor biliary radical in gallbladder fossa. (**B**) Occluded right posterior sectoral duct. (**C**) Bile leak from divided right posterior sectoral duct. (**D**) Bile leak from main bile duct without major tissue loss. ($\mathbf{E}_1$) Transected main bile duct with a stricture more than 2 cm from the hilus. ($\mathbf{E}_2$) Transected main bile duct with a stricture less than 2 cm from the hilus. ($\mathbf{E}_3$) Stricture of the hilus with right and left ducts in communication. ($\mathbf{E}_4$) Stricture of the hilus with separation of right and left ducts. ($\mathbf{E}_5$) Stricture of the main bile duct and transection of the right posterior sectoral duct

Table 4.14 Factors that may increase bile leak from gallbladder fossa or cystic duct

Subtotal cholecystectomy for severe acute or chronic inflammation
Cholecystectomy for gangrenous cholecystitis where the cystic duct is necrotic
Difficult dissection of the gallbladder off the liver increasing the likelihood of opening into a subvesical duct
Difficult closure due to cystic duct size, anatomy or severe inflammation

Factors increasing a likelihood of bile leak are listed in Table 4.14. When anticipated, these are best managed and subsequently diagnosed with the insertion of an intraoperative drain into the gallbladder fossa.

Where a drain is not inserted, a post-operative bile leak will present with significant abdominal pain that may be associated with nausea, vomiting and failure to improve following LC. It is absolutely essential that any patient following LC with significant pain must be considered to have a bile leak until proven otherwise. Putting it another way, if the patient is unwell and not able to be discharged within 24 h of LC, consideration should be given to the possibility of a bile leak. Failure to diagnose early leads to delay in treatment with an increased morbidity, length of stay and mortality [115, 116]. It is of utmost importance to diagnose and manage post-operative bile leaks early as 'failure to rescue' has serious consequences.

A less common presentation of a post-operative bile leak is that the patient is well on the first post-operative day, is discharged home but represents 48–96 h after surgery with a sudden (instantaneous) onset of severe generalised abdominal pain associated with signs of peritonitis. These are patients where there has been a diathermy injury either to the sub-vesical ducts in the gallbladder bed, the cystic duct or a hepatic duct. Initially the duct wall was intact, but due to the diathermy injury and subsequent necrosis, there has been a delayed leak some 48–96 h following the surgery. Patients presenting like this need to be treated as bile leaks until proven otherwise for the same reason as early post-operative bile leaks, as delay in diagnosis and treatment is associated with poor outcomes.

The suspected bile leak can be confirmed on imaging. While nuclear medicine scanning (DIDA) has a sensitivity and specificity that approached 100% for bile leaks, it fails to provide any information regarding the site of the leak and any biliary anatomy or other pathology such as bile duct stones contributing to the leak. CT cholangiography (Fig. 4.30) provides a dynamic assessment of the presence of a leak as well as defining the biliary anatomy, the presence of any common bile duct stones and the site and extent of any bile collection. The information obtained with CT cholangiogram is usually all that is required to diagnose and plan management of a bile leak. MRI may be used although this does not provide a dynamic component to prove that the fluid outside the GI tract is from a bile leak.

Once diagnosed, the management of bile leak has three aspects:

1. Treatment of the bile peritonitis
2. Control of the leak
3. Definitive management of the leak

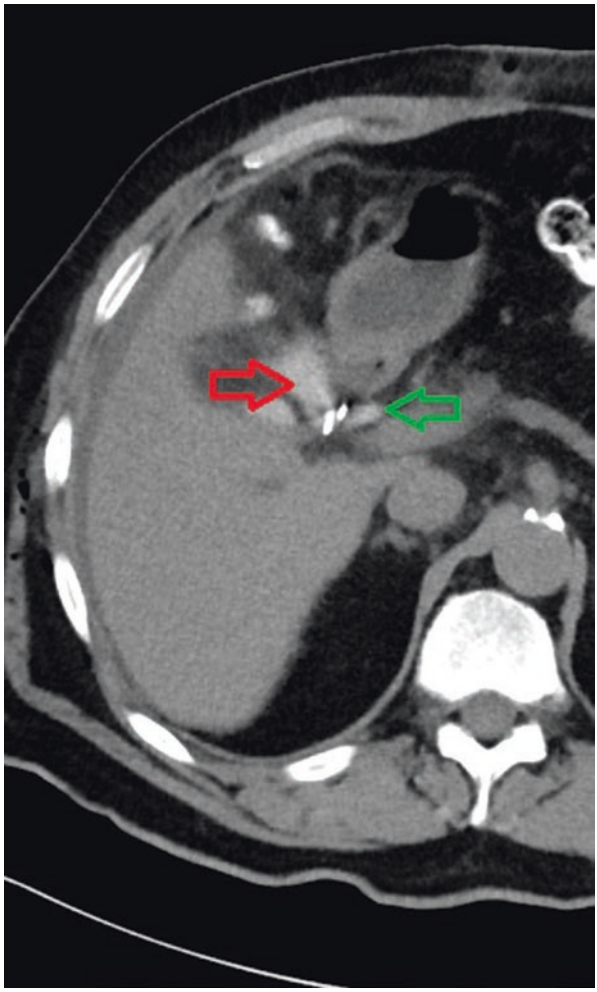

Fig. 4.30 CT cholangiogram in a 45-year-old man with severe abdominal pain 24 h after LC which demonstrates a leak into the gallbladder fossa from the cystic duct (red arrow) lateral to the cystic duct clips and the CBD (green arrow). The remainder of the CT cholangiogram revealed an intact biliary tree with no CBD stones. This was managed with an urgent laparoscopy and peritoneal lavage to manage the biliary peritonitis. The cystic duct stump was easily identified, and it was noted that the clips were not completely across the duct with bile leaking out. The clips were removed and an operative cholangiogram performed that confirmed normal biliary anatomy, no other leak and no CBD stones. The clips were replaced and a drain inserted into the gallbladder fossa. There was no further bile leak

Treatment of Bile Peritonitis The management of bile peritonitis requires an urgent laparoscopy and extensive peritoneal lavage. It is important to do this prior to controlling the bile leak with a drain or proceeding to definitive management. Placement of radiological drain into a bile collection does not necessarily manage the peritonitis. This often results in walling off of collections and ongoing sepsis. The additional advantage of re-laparoscopy and lavage are:

- Ensures optimal placement of the biliary drain
- Allows the site of the bile leak to be defined and confirmed, in most cases
- May allow an operative cholangiogram to be performed
- May offer the possibility of a definitive treatment of the bile leak

Control of the Leak At laparoscopy and following lavage, an intraoperative drain should be placed into the gallbladder fossa, if no definitive treatment is possible. This manages the leak, prevents further episodes of sepsis and can allow for planned definitive treatment which is usually endoscopic.

Definitive Treatment of the Leak The definitive treatment depends on the cause of the leak, the findings at laparoscopy and the skill of the surgeon at the time of laparoscopy. A bile leak from the gallbladder fossa may be confirmed with a repeat OC (Fig. 4.31a) and controlled with laparoscopic suturing of the gallbladder fossa

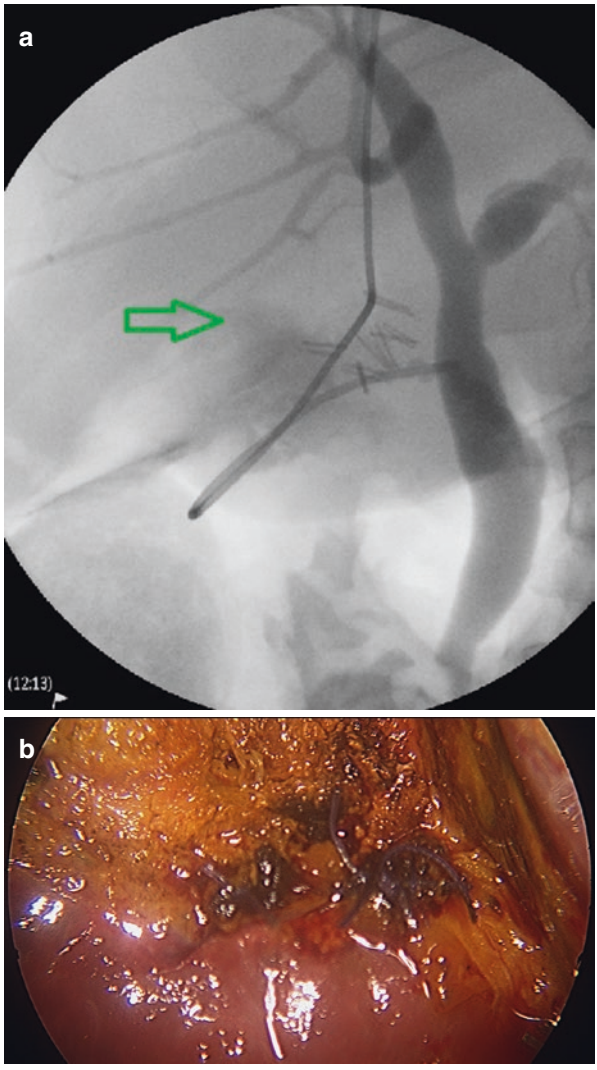

Fig. 4.31 (**a**) A 34-year-old man presented 48 h after discharge (72 h post-operatively) with a sudden onset of severe generalised abdominal pain. At the urgent laparoscopy after the peritoneal lavage, a bile leak from the gallbladder fossa was noted at laparoscopy and confirmed on operative cholangiogram. (**b**) The site of the leak was sutured with two figure-of-eight sutures and the leak controlled. This was confirmed on operative cholangiogram and a drain inserted. Post-operatively he was well with no bile leak and the drain was removed 48 h post-operatively

(Fig. 4.31b). A bile leak from the cystic duct may be visualised at laparoscopy. The clips, if safe to do so, can be removed, and an OC obtained. The OC will confirm the remaining ducts are intact and there is no other cause of the leak. If safe, the cystic duct can be dissected further and then closed by clips, a loop or a suture. A bile leak from a common hepatic duct or right hepatic duct may be noted visually at laparoscopy and either drained or when appropriate converted to open surgery and repaired (Sect. 4.8.3).

In patients where the leak from the cystic duct of the gallbladder fossa is not able to be definitively managed at the time of laparoscopy, the definitive treatment is to obtain drainage of the biliary tree with an ERCP, ES and insertion of a biliary stent (Fig. 4.32). This treatment overcomes the physiological obstruction (sphincter of

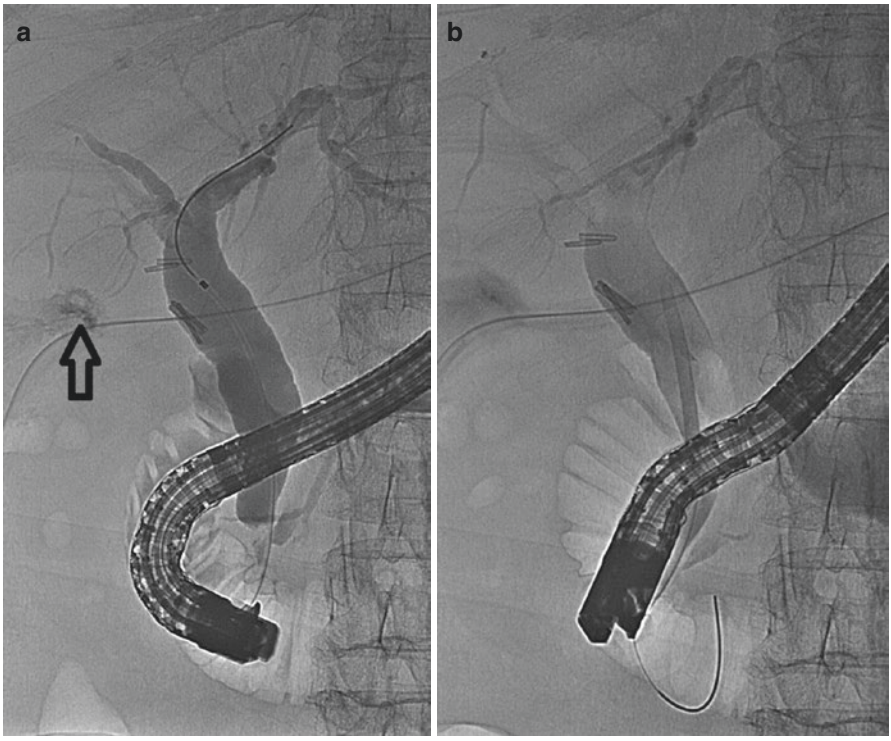

Fig. 4.32 (**a**) ERCP of a patient with post-operative bile leak following LC for gangrenous acute cholecystitis where there was a very difficult dissection getting the gallbladder off the liver. A cholangiogram was performed and the cystic duct noted to be very short (3 mm). It was carefully clipped and a drain inserted in anticipation of a possible bile leak from the cystic duct stump. The subsequent bile leak was controlled by the operative drain but did not resolve after 3 days. The presumed cause was a leak from the cystic duct, but the ERCP demonstrated a leak from the gallbladder bed (arrow). (**b**) A single 10 French stent was inserted after a sphincterotomy was performed. The leak resolved within 12 h and the drain was removed after 48 h. An ERCP to remove the stent was performed 10 weeks later as a day case

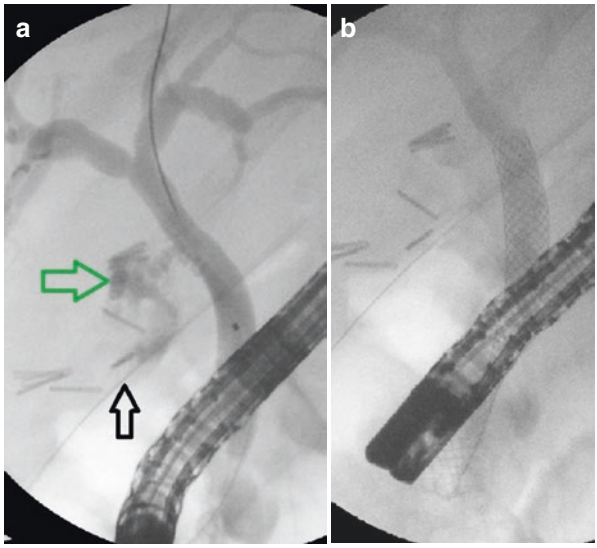

Fig. 4.33 (**a**) An ERCP with a high-volume bile leak (190 mL/24 h) 2 days after a subtotal cholecystectomy for gangrenous cholecystitis. As expected there is a free leak with a small residual component of the gallbladder neck. (**b**) An expandable, fully covered, removable metal stent was deployed. The leak resolved within hours. The stent was removed 3 months later

Oddi) that reduces the leakage of bile into the peritoneal cavity. As with any fistula, removal of the distal obstruction will usually lead to closure of the fistula. The success rate of ERCP sphincterotomy and stenting is between 92 and 100% [117–119]. A completely covered, removable metal stent may be used (Fig. 4.33) for those patients where there is failure to close after an initial ERCP and insertion of a plastic stent or where the risk of failure of closure is higher, for example, in a patient after a subtotal cholecystectomy where there is a residual neck of the gallbladder in situ.

4.8.3 Bile Duct Injury

Bile duct injury can vary in its extent and site and as previously noted has been classified by Strasberg (Fig. 4.29). The bile duct injury may be detected intraoperatively with visual identification or at routine cholangiography. Many, however, are identified post-operatively either as a result of a bile leak or with obstructive jaundice. Once identified, urgent early repair with a hepatico-jejunostomy by an experienced hepatobiliary surgeon provides the best outcomes. There is strong data to demonstrate that repair by an inexperienced surgeon or by the initial primary surgeon results in poorer outcomes.

A bile duct injury may present late as a CBD stricture.

4.8.4 ERCP and ES

The four most common complications associated with ERCP and ES for common bile duct stones are as follows.

4.8.4.1 Acute Pancreatitis

There is a wide range of the incidence of acute pancreatitis following ERCP (1.6–15% with an average of 3.5%) [120, 121]. The risk of post-ERCP pancreatitis is higher in patients with normal bilirubin, sphincter of Oddi dysfunction, multiple cannulations of the pancreatic duct, balloon dilatation of the ampulla and use of precut sphincterotomy [122]. Fortunately, many of these circumstances are less frequent in patients with symptomatic CBD stones, and therefore the risk of acute pancreatitis is lower in this cohort of patients. Treatment for post ERCP acute pancreatitis is the same as for most other causes of acute pancreatitis (Chap. 9).

4.8.4.2 Cholangitis

Incidence of cholangitis is low (less than 1%) [123, 124] following ERCP. When ERCP is for common bile duct stones, the occurrence of cholangitis is usually associated with either pre-existing cholangitis with ongoing poor drainage or subsequent poor drainage due to retained stones. Both of these causes can be predicted at the initial ERCP and managed expectantly with the insertion of a biliary stent at the initial procedure. If cholangitis does occur following ERCP for bile duct stones. It requires early recognition and consideration of an urgent ERCP and stent insertion in addition to antibiotic therapy to avoid 'failure to rescue'.

4.8.4.3 Haemorrhage

Haemorrhage following ERCP is most commonly associated with bleeding from the sphincterotomy site. This has an incidence of 1.3% although 70% of cases are considered mild, resolving spontaneously and not requiring any form of intervention [93]. Most bleeding that does require intervention can be managed endoscopically with a combination of adrenaline injection, diathermy, haemostatic clips or the insertion of an expandable metal stent which tamponades the bleeding point [121, 122].

4.8.4.4 Perforation

The incidence of perforation associated with ERCP and sphincterotomy ranges from 0.1 to 0.6% [122, 124, 125]. Most frequently the perforation occurs from the sphincterotomy extending beyond the lumen of the duodenum and bile duct into the retroperitoneal space. This will present with severe abdominal pain early after the ERCP with an elevated amylase and lipase and is frequently misdiagnosed as postoperative ERCP acute pancreatitis. The failure to recognise this complication may lead to incorrect treatment, delays in operative intervention and subsequent poor outcome. To avoid misdiagnosis and opportunity for early rescue, establishment of the presence of a retroperitoneal duodneal perforation with a CT scan to demonstrate the presence of retroperitoneal gas, with or without leakeage of contrast (Fig. 4.34). If the perforation is excluded, these patients can be managed as with acute pancreatitis. Where the perforation is confirmed, the management is dependent on the clinical assessment as well as the radiological findings. Post-ERCP perforation can be managed nonoperatively with nil orally and IV antibiotics when there is no sepsis, no clinical deterioration and no evidence of oral contrast

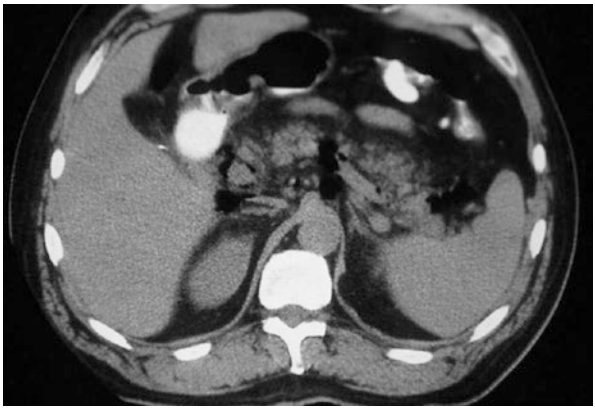

Fig. 4.34 A CT done 8h after an ERCP and ES to remove CBD stones. The patient had severe upper abdominal pain consistent with acute pancreatitis and elevated amylase (2,980) and lipase (5,030) consistent with a diagnosis of acute post-ERCP pancreatitis. The urgent CT revealed extensive retroperitoneal gas, but no contrast leak from the duodenum that was filled with oral contrast. This patient was managed nonoperatively with nasogastric decompression, nil orally and systemic antibiotics. By day 8, they were well and were discharged

leakage on CT scanning. This can occur safely in 63–66% of patients [126, 127]. However at least one-third of patients have sepsis, a clinical deterioration and/or contrast leak at CT scan require early surgical intervention to achieve early rescue. The best outcomes occur when a formal suture repair from within the duodenum is performed. The sphincterotomy located and the bile duct wall and duodenal wall sutured to close the defect in a similar fashion to an open sphincteroplasty [127]. This may be combined with duodenal, retroperitoneal and biliary drainage along with jejunal feeding.

Conclusion

Laparoscopic cholecystectomy (LC) and routine OC is the most frequent treatment for gallbladder stones. The safe dissection technique is based on principles outlined above. Operative cholangiography (OC) should be performed routinely. The main symptom for gallstones requiring an elective LC is biliary pain. Acute cholecystitis requires an urgent LC to achieve the best outcomes. All patients with possible or proven CBD stones, except those with severe cholangitis, should proceed to a LC first and the CBD stones found on OC be managed either with laparoscopic techniques or insertion of an antegrade biliary stent and post-operative ERCP. Patients with severe cholangitis (grade III) require an urgent ERCP and drainage of the CBD. If they have not had a cholecystectomy previously, this should be performed as early as practicable. Patients that have had a previous cholecystectomy with CBD stones should proceed to ERCP.

The complication of bile leak post LC requires early diagnosis and prompt treatment. The major strategy for the prevention of CBD injuries is good surgical

technique. In addition to good technique, CBD injuries are less frequent and less severe when routine OC is performed. Early detection and prompt treatment of CBD injuries is associated with better outcomes. Complications of ERCP and ES for CBD stone disease are acute pancreatitis, cholangitis, haemorrhage and perforation. Of these, perforation is frequently misdiagnosed leading to delay in definitive treatment. This is avoided by performing a CT scan in any patient with abdominal pain post ERCP and ES to exclude a perforation.

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