Chapter 6
Operative Techniques in Laparoscopic Bile Duct Exploration

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Different Scenarios in LBDE

Not all patients with common bile duct (CBD) stones will require the same technique for laparoscopic bile duct exploration (LBDE). It will vary according to whether or not the cystic duct and CBD are dilated and also on whether or not there is hilar inflammation (Fig. 6.1). We have found that all patients fall into one of five different scenarios (Table 6.1).

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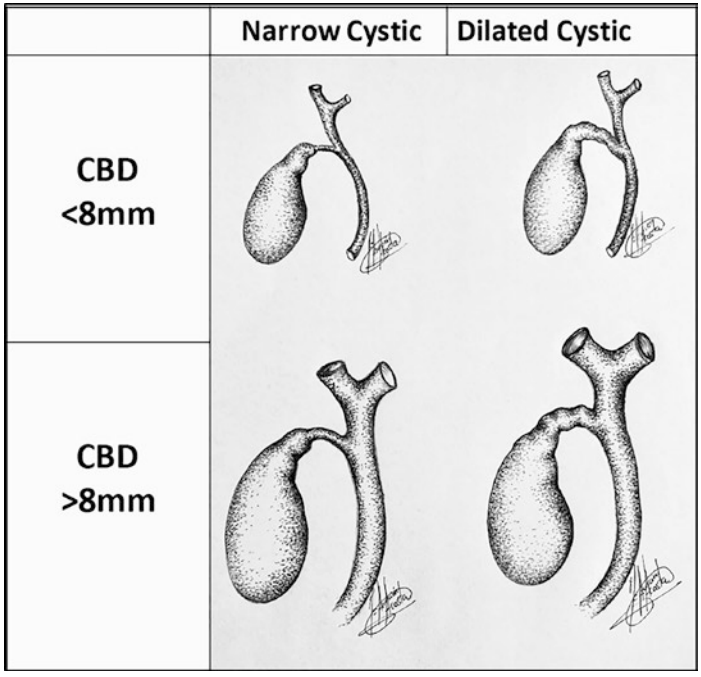

Figure 6.1 Different scenarios in LBDE

Table 6.1 Different scenarios in LBDE

Scenario	Description
1	Both the cystic duct and CBD are not dilated (most challenging situation)
2	The cystic duct is dilated but the CBD is not dilated
3	The cystic duct is not dilated but the CBD is dilated
4	Both the cystic duct and CBD are dilated
5	There is severe inflammation or fibrosis around the hilum making its dissection hazardous

Scenario 1: Both the Cystic Duct and CBD Are Not Dilated

This scenario will occur when neither the cystic duct nor the CBD are dilated (Fig. 6.2). From the first four scenarios outlined in Table 6.1, it is the most difficult scenario and it will demand a very refined surgical technique; luckily it is the least frequent situation.

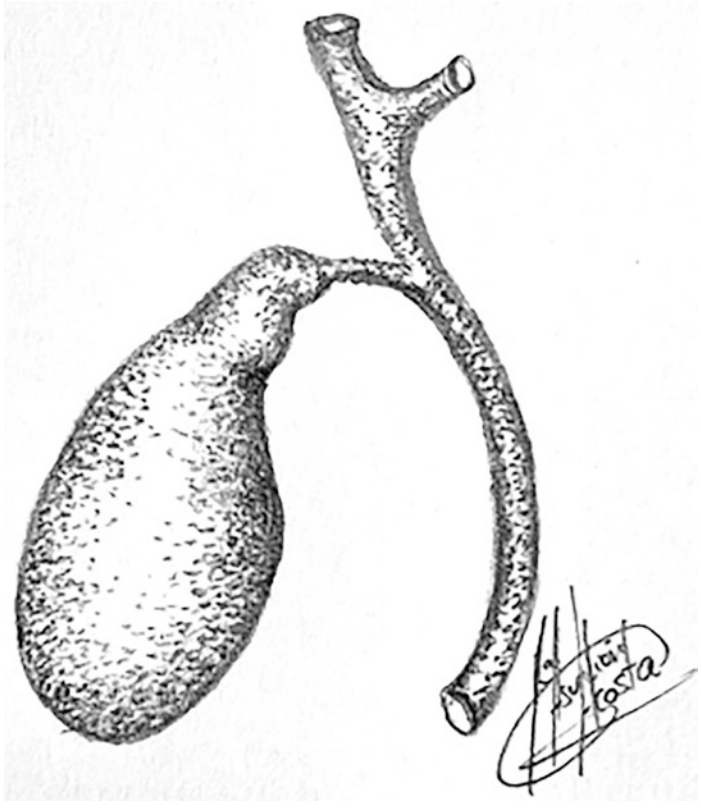

FIGURE 6.2 Both the cystic duct and CBD are not dilated

For the management of this scenario, an ultra-thin 3 mm choledochoscope should ideally be available. The technique described here would typically follow an intra-operative cholangiogram (IOC) and therefore the 5F cholangiogram catheter would already be in situ (see Chap. 4, sections "Intra-operative cholangiogram (IOC)" and "Intra-operative cholangiogram (IOC)"). The first step is to re-introduce the guidewire through the cholangiogram catheter into the CBD, then remove the catheter. The Flexor® Ureteral Access Sheath 9.5-12F (28 cm) (Cook Medical) is railroaded over the guidewire to gain access to the cystic duct. The hydrophilic tip of the sheath-dilator is soft and therefore will follow the guidewire and pass into the CBD, dilating the cystic duct and overcoming the Heister valves (Fig. 6.3). Once this is achieved, the tip of the access sheath (light blue) is removed and you will need to make sure that the sheath (black) is not advanced too far into the cystic duct thereby abutting the tip of the access sheath against the opposite wall of the CBD at the cystic-common bile duct junction. This will preclude the passage of the choledochoscope into the CBD (Fig. 6.4). If we are using a reusable choledochoscope, we always take great care not to manipulate the scope with the forceps as this will cause

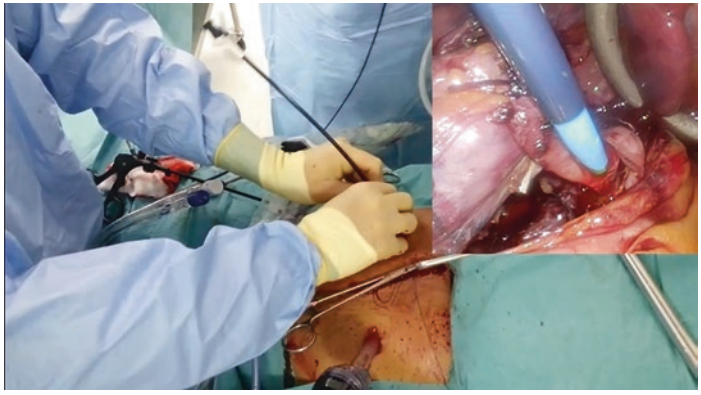

Figure 6.3 Cystic duct dilatation with Flexor® Ureteral Access Sheath 9.5-12F (35 cm) (Cook Medical) for 3 mm choledochoscopy

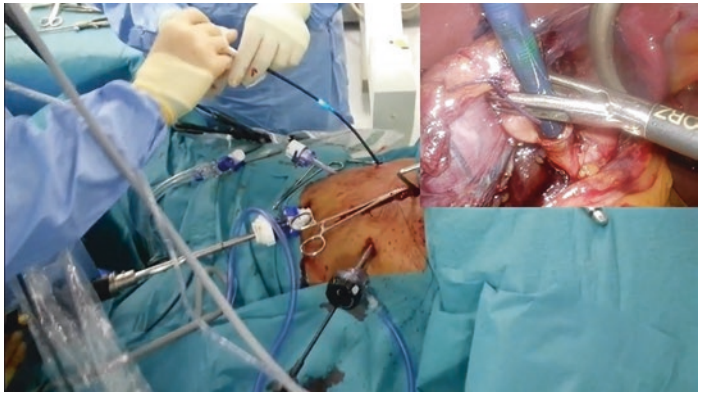

Figure 6.4 Three mm scope advancing through the access sheath introduced into the cystic duct

damage and ultimately scope failure. Reusable choledochoscopes are very expensive and repairs can be very costly which also take several weeks to be returned in working order. Instrumentation to steady the choledochoscope adjacent to the cystic duct entry can be achieved by manipulating the semi-rigid access sheath when the scope is in the CBD (an alternative approach is to pass the choledochoscope through an additional 5 mm laparoscopic port sited in the right upper quadrant). When using 3 mm choledochoscopes, the instrument should be kept as straight as possible because these scopes are fragile which makes it difficult to transmit the torque to the tip. The left hand should control the choledochoscope and the right hand, using the thumb and index finger, will transmit the torque and also direct the access sheath to the cystic duct opening. For this purpose, the access sheath should ideally have a rigid body, and the Flexor® Ureteral Access Sheath 9.5-12F (28 cm) (Cook Medical) works well.

Once the choledochoscope has been introduced into the bile duct, any visualised non-impacted stones can be removed with a stone retrieval basket, of which there are many to choose from. In the authors experience, we prefer to use a 2.4F (120 cm) Dormia basket (Cook Medical) or a 2.4F

(120 cm) Segura Hemisphere™ retrieval basket (Boston Scientific). If a 3 mm choledochoscope is used in combination with laser lithotripsy, we recommend using the 200 μm (smallest) fibre because larger fibres may have a negative impact on the ability of the choledochoscope to fully deflect and therefore successfully navigate the biliary tree. If an ultra-thin 3 mm choledochoscope is not available, and if we face this scenario (both the cystic duct and CBD are not dilated) with a distal filling defect during IOC (Fig. 6.5), we are left with two options. The first option is to dilate the cystic duct to be able to accommodate a 5 mm scope (which is more likely to be available), however, this can be can be dangerous and precipitate a bile duct injury at the junction of the cystic duct and CBD. The second, and safer option, is to employ the basket-in-catheter (BIC) technique as described by Ahmad Nassar and colleagues [1]. This technique involves the introduction of a basket through the 5F cholangiogram catheter, ideally

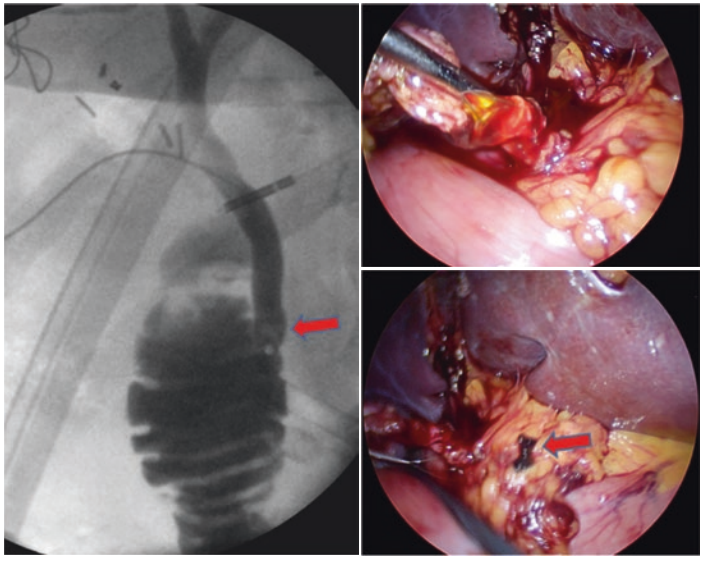

Figure 6.5 Basket-in-catheter (BIC) technique for stone extraction (without choledochoscope)

passed into the duodenum, and under fluoroscopic guidance the tip can be advanced beyond the catheter and opened once in the duodenum. Then the 5F catheter and the opened basket are withdrawn thereby trawling the duct and collecting any stones. Retrieval of proximal and/or multiple and/or impacted stones by this method may prove to be very challenging. If the cystic duct can be dilated and this is thought to be the better and/or only option, this must be performed in a controlled and safe manner. To achieve this, we recommend inserting the guidewire (Chap. 4, Table 4.1 Serial 10) into the CBD, then railroad ureteral dilators gradually increasing in size between 6 to 18F (Ureteral Dilator Set, Cook Medical) (Chap. 4, Table 4.1 Serial 9). This should be done gently and gradually as demonstrated in Fig. 6.6. It should be noted that the 18F dilator is the same size as the 5 mm choledochoscope. Cystic duct dilatation can also be performed with a columnar

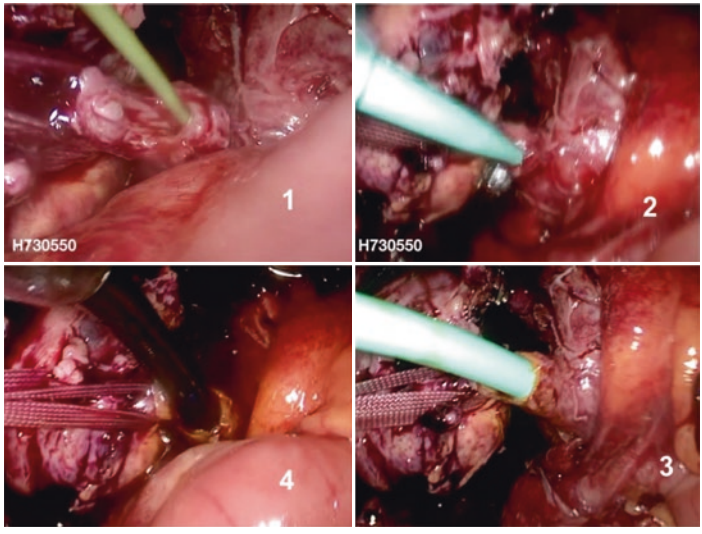

Figure 6.6 Dilatation of the cystic duct in order to accommodate a 5 mm choledochoscope. 1, introducing a guidewire. 2 & 3, progressive dilatation. 4, the cystic duct has been sufficiently dilated to be able to accommodate a 5 mm scope

dilatation balloon; however, the authors have limited experience with this technique [2]. Prior to making a decision to dilate the cystic duct, it is important to recognise the risk of iatrogenic injury to the bile duct, therefore an alternative (bail out) option would be to place a transcystic drain and refer the patient for post-operative endoscopic retrograde cholangiopancreatography (ERCP).

Once all the stones have been extracted from the distal duct (common bile duct) using the choledochoscope, the next step is to assess the proximal ducts (common hepatic duct and intra-hepatic ducts) before completing the procedure. Ideally, this should be done with the choledochoscope, thereby providing direct visualisation of the proximal ducts. To give the choledochoscope a fighting chance of being able to deflect upwards into the proximal ducts, the dissection of the cystic duct-common bile duct junction should ideally be completed as previously described (see Chap. 4, section "Cholecystectomy" and Fig. 4.9). Complete dissection of the cystic duct-common bile duct junction followed by mobilisation of the gallbladder from the liver bed will allow for the correction of the cystic duct-common bile duct angle to a more favourable 90° (Fig. 6.7). The 'windscreen wiper'

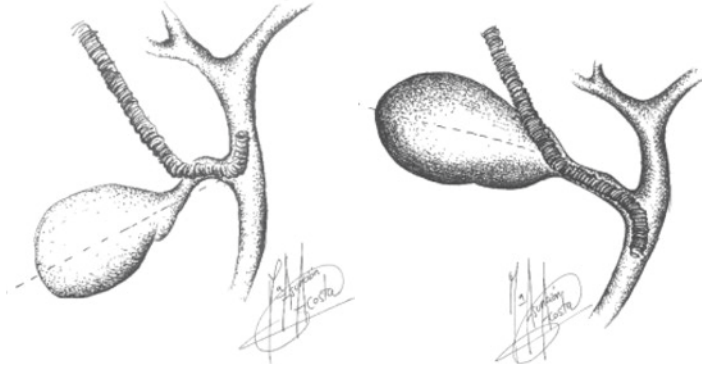

FIGURE 6.7 Complete dissection of the cystic duct-common bile duct junction followed by mobilisation of the gallbladder from the liver bed will allow for the correction of the cystic duct-common bile duct angle to a more favourable 90°

manoeuvre enables the tip of the choledochoscope to move from a distal duct view to a proximal duct view (Fig. 6.8). The manoeuvre begins with the choledochoscope pointing distally, then anti-clockwise torque is applied to the scope using the right thumb and index finger thereby rotating the scope proximally. In the event that proximal choledochoscopy is not possible, a completion cholangiogram should be performed to exclude proximal stones.

There are some situations where transcystic exploration may not be possible. For example, a very low cystic duct insertion into the CBD with a mid-ductal stone may entirely preclude proximal choledochoscopy. Similarly, a proximally facing cystic duct insertion into the CBD, in a double-barrel fashion (which we have experienced only twice), may not permit access to the distal bile duct, and therefore a choledochotomy may be required to achieve distal choledochoscopy. A cystic duct crossing to the other side and draining medially should not be a contraindication if it is dissected properly, however, a thin non-dilated cystic duct may prove to be a very challenging conduit in this scenario [3].

Scenario 2: The Cystic Duct Is Dilated But the CBD Is Not Dilated

The scenario where the cystic duct is dilated and the CBD is not dilated (normal calibre) (Fig. 6.9) is unusual but favourable, because the dilated cystic duct will probably allow the direct transcystic insertion of a 5 mm choledochoscope. Moreover, the stones in a duct that is not dilated should not be too large, and therefore unless they are impacted, would be easy to extract transcystically.

As described in Scenario 1, a similar technique for introduction of the choledochoscope can be used, however, in a cystic duct that is dilated, there is no need for the use of the access sheath. If you are using a 5 mm choledochoscope, this can be introduced from an extra 5 mm laparoscopic port, also inserted in the right upper quadrant. If you are using the

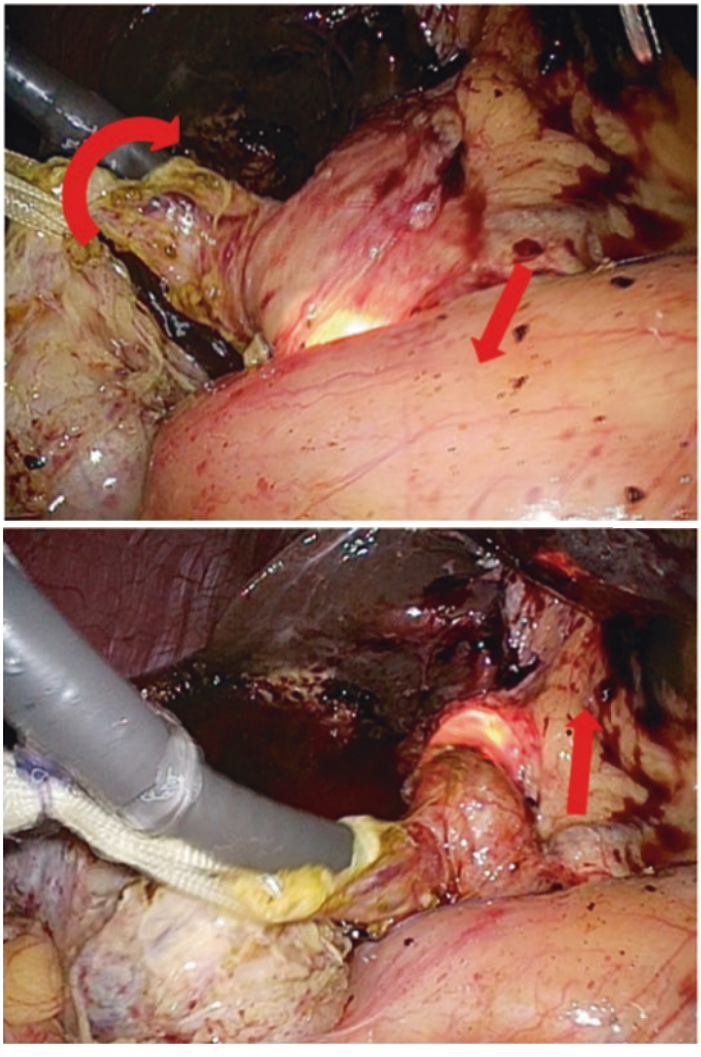

FIGURE 6.8 The 'windscreen wiper' manoeuvre for proximal CBD access

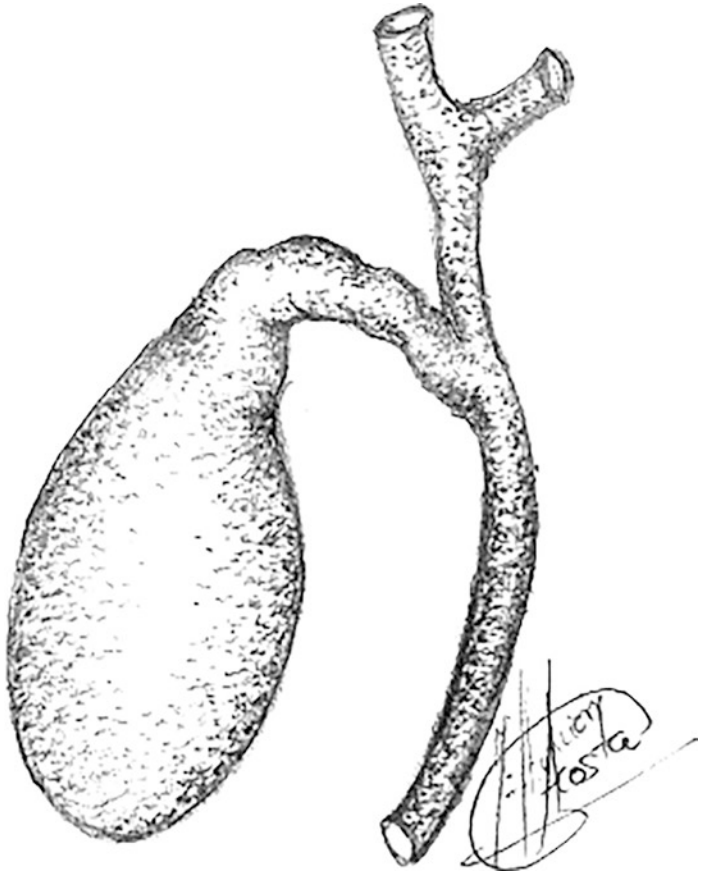

FIGURE 6.9 The cystic duct is dilated but the CBD is not dilated

'American' supine patient position, the mid 5 mm port can be used for choledochoscopic access. The same Endoloop traction technique should be used, but in this scenario, any dilatation of the cystic duct that is required can be achieved using Johan grasping forceps (Fig. 6.10). This manoeuvre will often also overcome any obstructing Heister valves.

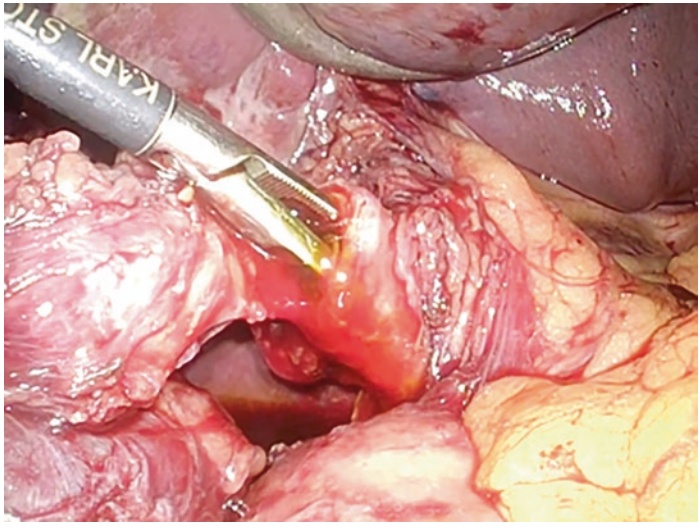

FIGURE 6.10 Cystic duct dilatation using Johan grasping forceps

Scenario 3: The Cystic Duct Is Not Dilated But the CBD Is Dilated

In this scenario, you will find a dilated bile duct with a non-dilated cystic duct (Fig. 6.11). Transcystic access can be achieved using the same technique as described in scenario 1. This should be the first approach, however, if this is not possible, a dilated bile duct will allow for a safe choledochotomy to be performed. The minimal safe diameter of the bile duct when performing a choledochotomy is controversial and has previously been contested. Closure of the bile duct less than 5 mm has been associated with strictures [4]. In general terms, a choledochotomy should not be performed on a bile duct smaller than 7–9 mm [5, 6]. In our practice, we consider a duct as being dilated when it is more than 8 mm.

Generally, large bile ducts harbour large-sized stones, and if the aim is to manage them using a transcystic approach, the Lithotripsy Assisted Bile duct Exploration by Laparoendoscopy (LABEL) technique may be required

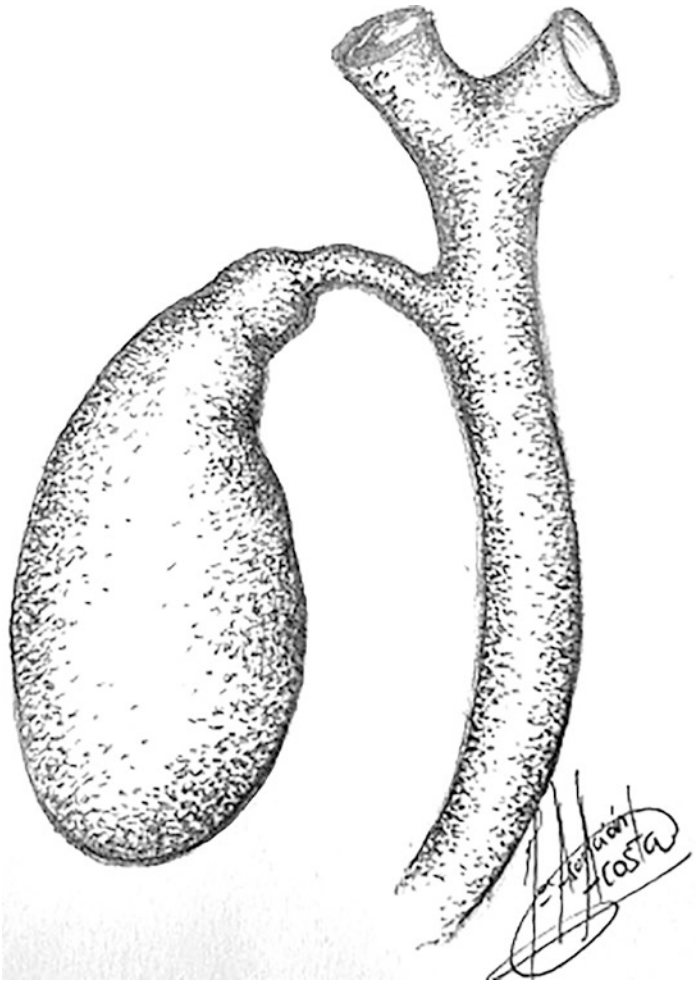

Figure 6.11 The cystic duct is not dilated but the CBD is dilated

[7, 8]. In very rare occasions, when the stones are very large and with a high calcium content (best seen on CT imaging), the LABEL technique is used to powderize the stones into smaller fragments. If the patient has had a previous endoscopic spincterotomy (ERCP-ES), these fragments are

powderized and therefore easily washed down into the duodenum. If there has not been a previous ERCP-ES, and if the fragments cannot be extracted tanscystically, then it may be necessary to complete CBD clearance of these fragments with a post-operative ERCP-ES.

Figure 6.12 demonstrates transcystic extraction of a 10 mm stone through a 5 mm cystic duct. The temptation would be to perform a choledochotomy for easy stone extraction, however, the aim should always be to perform transcystic LBDE where possible. Therefore, in this case we elected to perform lithotripsy (LABEL technique), thereby fragmenting the stone into smaller pieces that are then able to be extracted via the cystic duct using a Dormia basket. It is important to not be too ambitious when extracting large unfragmented stones through the cystic duct. The danger is that if a stone larger than the size of the cystic duct is extracted with a basket, the entire basket-stone complex can get impacted either within the CBD, at the cystic duct-common bile duct junction or the cystic duct itself (Fig. 6.13a). What are your options in this scenario? First, dismount the handle of the basket so that the choledochoscope can be removed. Second, exteriorise the proximal free end of the wire through the abdominal wall close by using a wide bore needle (Fig. 6.13b) or alternatively, leave the free end within the abdomen. Third, re-intubate the cystic duct with the choledochoscope and perform lithotripsy on the impacted basket-stone complex (Fig. 6.13c). Once the basket-stone complex has become disimpacted by fragmenting the impacted stone, the loose wire can safely be removed along with the stone fragments via the cystic duct opening. However, this situation can be avoided altogether if the stone size is assessed from the outset and the LABEL technique applied prior to extraction of the large stone with a basket.

If the transcystic route is not feasible, proceeding to choledochotomy and transductal stone extraction is an appropriate option, taking advantage of the dilated bile duct. This should be performed via a longitudinal (vertical) incision within the supraduodenal portion of the bile duct. In a non-inflamed, thin-walled bile duct, this can be achieved with laparoscopic scissors or a Berci knife® [9] (Fig. 6.14). In a

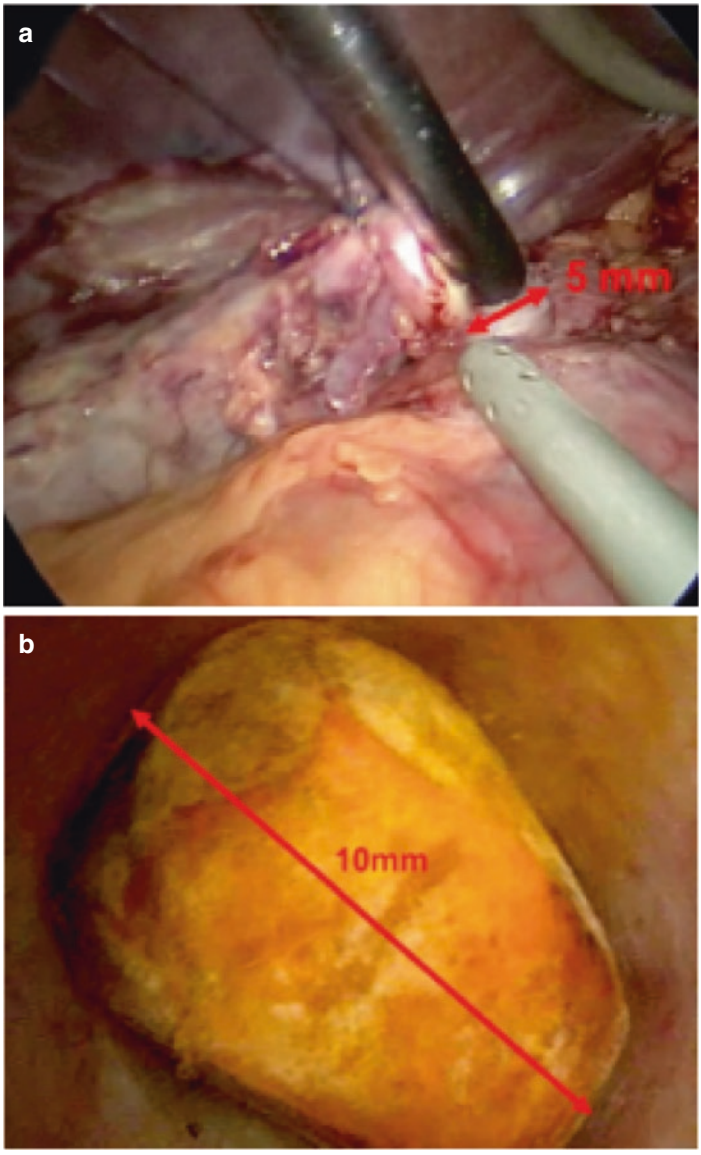

FIGURE 6.12 Transcystic extraction of a large stone. (**a**) transcystic access with 5 mm choledochoscopy. (**b**) 10 mm CBD stone. (**c**) LABEL technique. (**d**) transcystic removal of small fragments

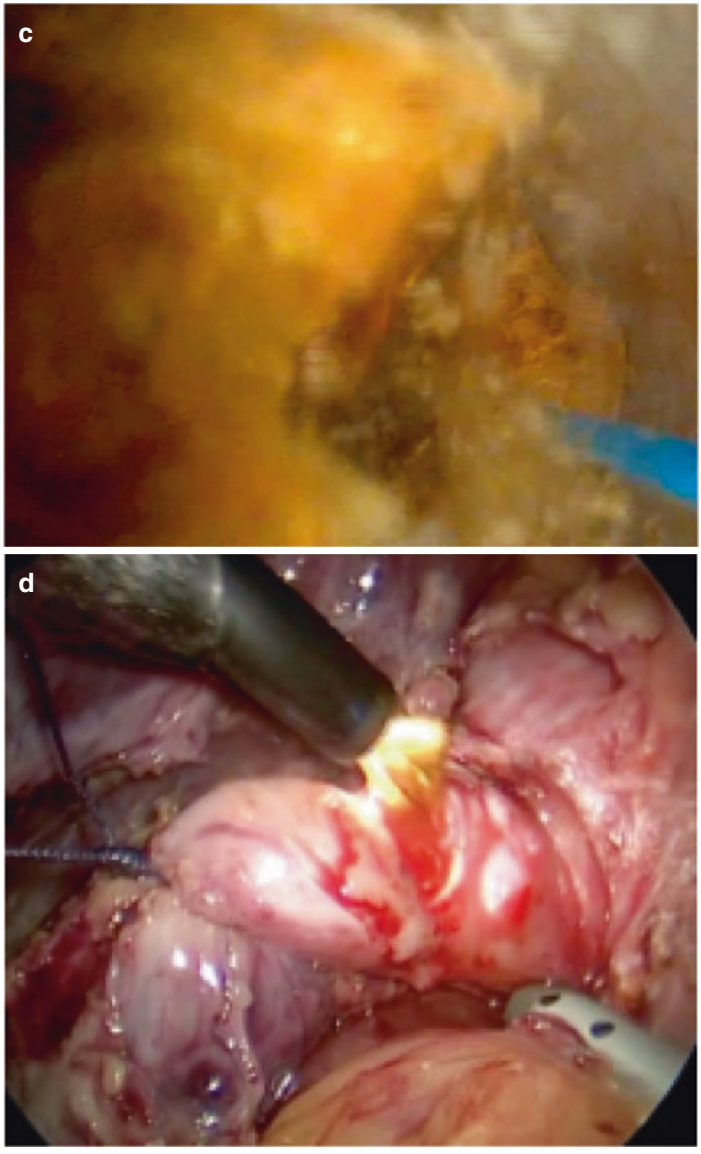

Figure 6.12 (continued)

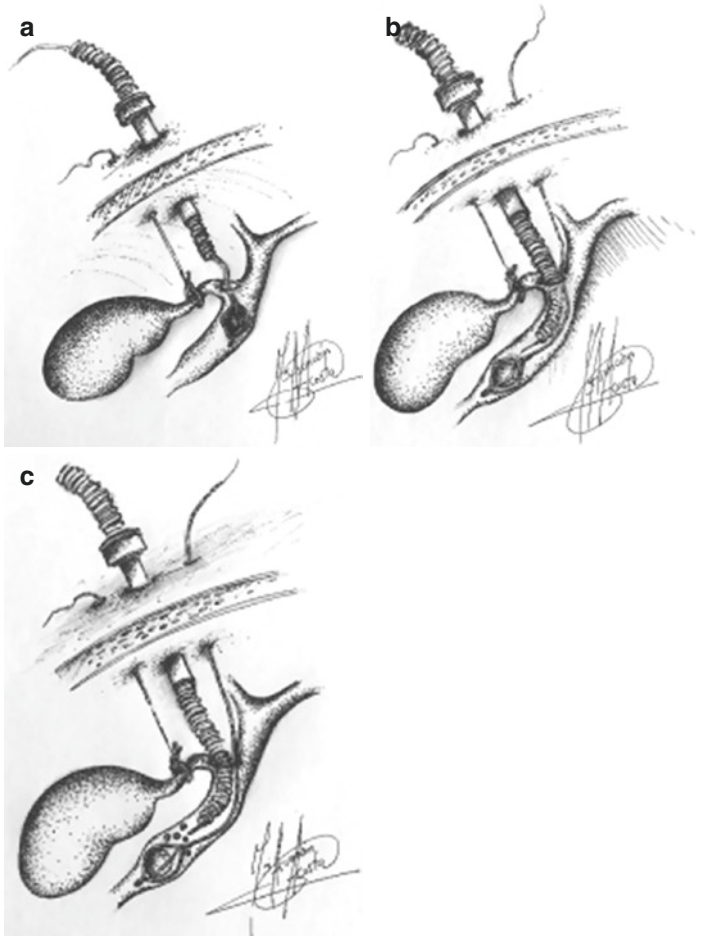

FIGURE 6.13 Impacted basket-stone complex within the bile duct (**a**) and a strategy for getting out of trouble by disconneting the basket handle (**b**) and fragmenting the impacted basket-stone complex using the LABEL technique (**c**)

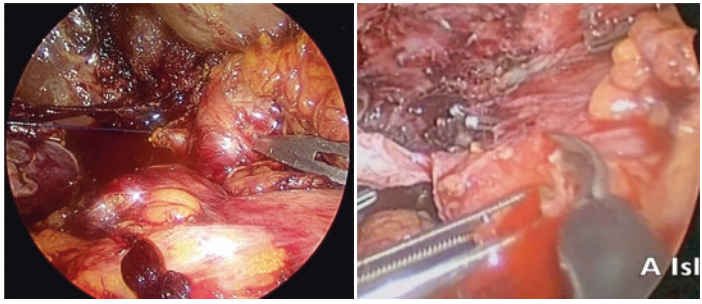

FIGURE 6.14 Choledochotomy incision. Knife choledochotomy (left), scissors choledochotomy (right)

severely inflamed, thick-walled bile duct, the potential danger with scissors or a knife is that cutting into a thickened duct wall can create a false channel and miss the ductal lumen altogether. In such cases, we have controversially used the hook (in pure cut mode) without problems (Fig. 6.15). The size of the choledochotomy should be tailored to the size of the stone. Standard stone extraction techniques include removal with grasping forceps (if the stone is lodged in the mid portion of the duct) (Fig. 6.16) or a Dormia basket. Advanced stone extraction techniques with LABEL may be required for large and/or impacted stones.

Scenario 4: Both the Cystic Duct and CBD Are Dilated

The scenario of a dilated cystic and common bile duct (Fig. 6.17) is an ideal situation, and perfect for the beginner during his or her learning curve. This situation will allow the liberal use of the 3 mm or the 5 mm choledochoscopes for the transcystic route. If a decision is made to adopt the transductal approach, then performing a choledochotomy on a dilated duct should be easy. Less commonly, a massively dilated cystic duct can be difficult to differentiate from a type II Mirizzi syndrome, which can compromise reconstruction of the com-

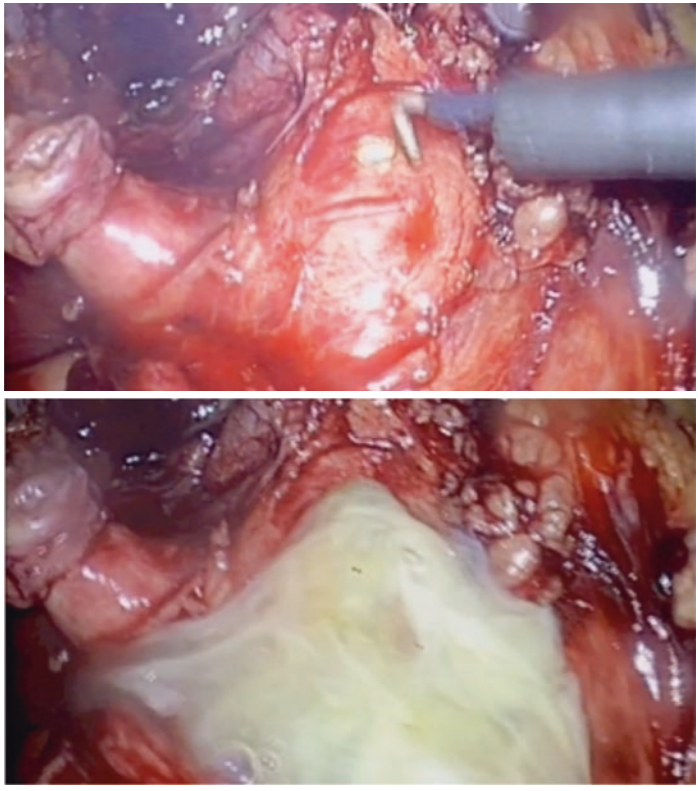

Figure 6.15 Hook choledochotomy in acute cholangitis

mon bile duct. This will be discussed next in section "Scenario 5: The Impossible Hilum: Trans-Infundibular Approach (TIA) to the Bile Duct" and in Chap. 7, section "Management of Type II Mirizzi syndrome".

Scenario 5: The Impossible Hilum: Trans-Infundibular Approach (TIA) to the Bile Duct

After several attacks of inflammation, the hilum becomes fibrotic and can become frozen (Fig. 6.18). In this scenario, it

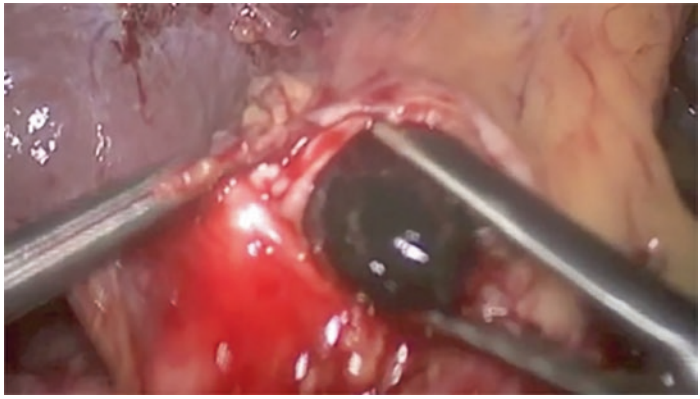

Figure 6.16 Transductal extraction of a stone using grasping forceps

is not safe to continue with dissection in order to obtain the critical view of safety. In such cases we have had to resort to novel techniques, often aided by leveraging access to new technologies such as laser or electrohydraulic lithotripsy. Figure 6.19 demonstrates a frozen hilum which was fibrotic and precluded its safe dissection. A very large stone was impacted in the infundibulum, and in this case, we used the so called 'trans-infundibular approach' (TIA) to the bile duct combined with LABEL to successfully access and clear the bile duct. We have described TIA as the approach to the bile duct in cases of a severely inflamed or fibrotic hilum which precludes safe dissection. The inside of the gallbladder infundibulum is used to gain access to the internal opening of the cystic duct and then onwards to the CBD. This technique often needs to be combined with LABEL [10], because in most cases the offending stones are impacted or too large to be removed through the cystic duct [11, 12]. When TIA is indicated, choledochotomy is often also precluded, not only because the duct wall is inflamed and thickened, but also because identification of the bile duct is often not possible.

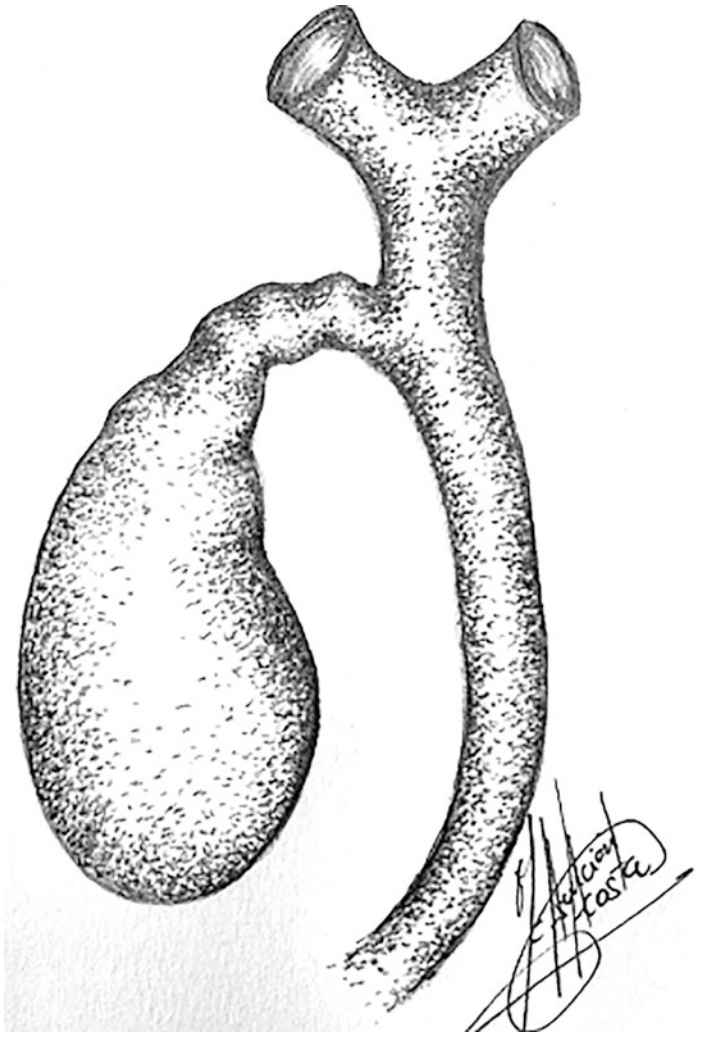

Figure 6.17 Both the cystic duct and CBD are dilated

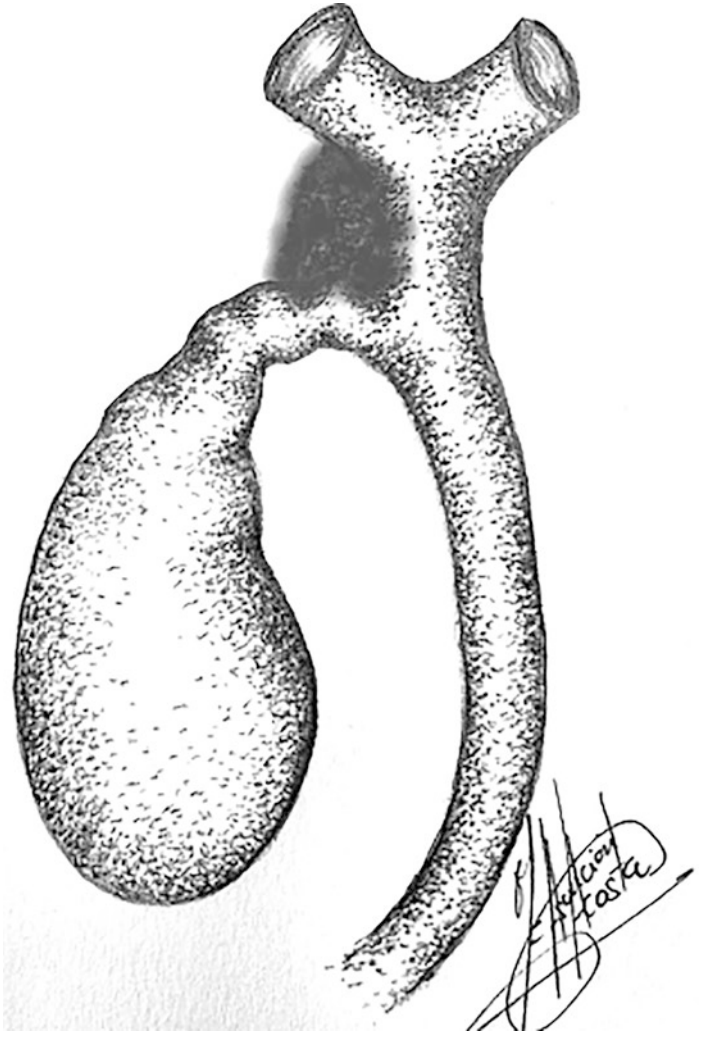

Figure 6.18 The frozen hilum

FIGURE 6.19 The impossible hilum requiring a transinfundibular approach (TIA) to the CBD combined with laser lithotripsy

At the time of describing the technique, we reviewed the last 154 consecutive patients in our series (February 2014–June 2018) and reported nine cases where the bile duct had been accessed through this novel route. For access, a cholecystotomy is performed at the infundibulum where generally a large stone or stones is/are impacted. Once the impacted stones are removed, the choledochoscope is then inserted with the tip directed to the infundibulum, and it often follows into the duct (Fig. 6.20). In our series of patients who underwent TIA, a cholangiogram was performed in only four patients, confirming that a cholangiogram is not necessary to perform this technique. However, we have used this technique more recently to achieve a cholangiogram in complex cases which would not be possible using the standard technique. A cholangiogram can be achieved either by injecting the contrast through the working channel of the choledochoscope or by guiding cystic duct intubation with the cholangiogram catheter during choledochoscopy. The TIA can also be used to clarify the anatomy and appropriately site a choledochotomy (if required). In a difficult hilum, transillumination from the tip of the scope can be used to identify the common bile duct, which in turn can be used to select the correct location for choledochotomy if this is required. In another patient, transillumination via the TIA (Fig. 6.21) was used to identify the entrance of the cystic duct into the CBD, allowing clarification of the anatomy and permitting further safe dissection of the cystic duct to subsequently perform our standard transcystic LBDE.

Figure 6.20 Technique for trans-infundibular approach (TIA) to the CBD. The impossible hilum (left), cholecystotomy (centre), TIA to the bile duct (right) with choledochoscopy (insert)

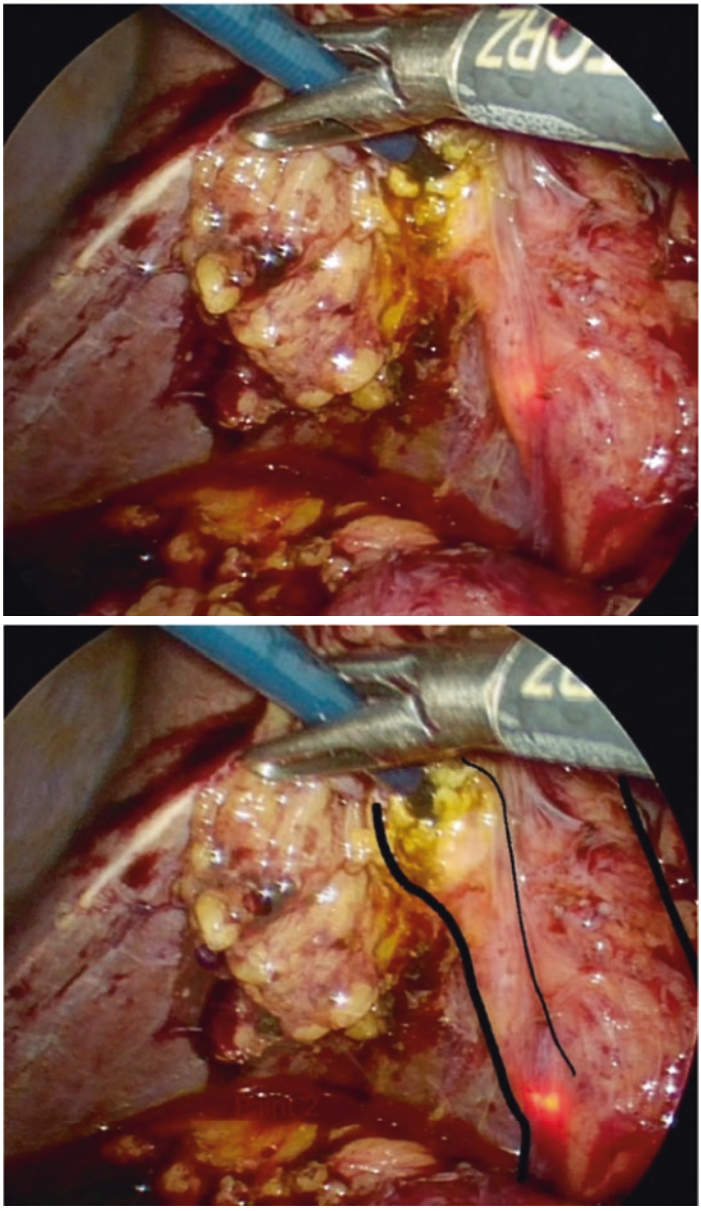

FIGURE 6.21 TIA used to clarify anatomy and delineate the cystic and common bile ducts

The management of complex cases, including type II Mirizzi syndrome, can be achieved laparoscopically using a combination of TIA and LABEL (TIA-LABEL). Type II Mirizzi syndrome (Fig. 6.22) is an uncommon cause of obstructive jaundice caused by an inflammatory response to

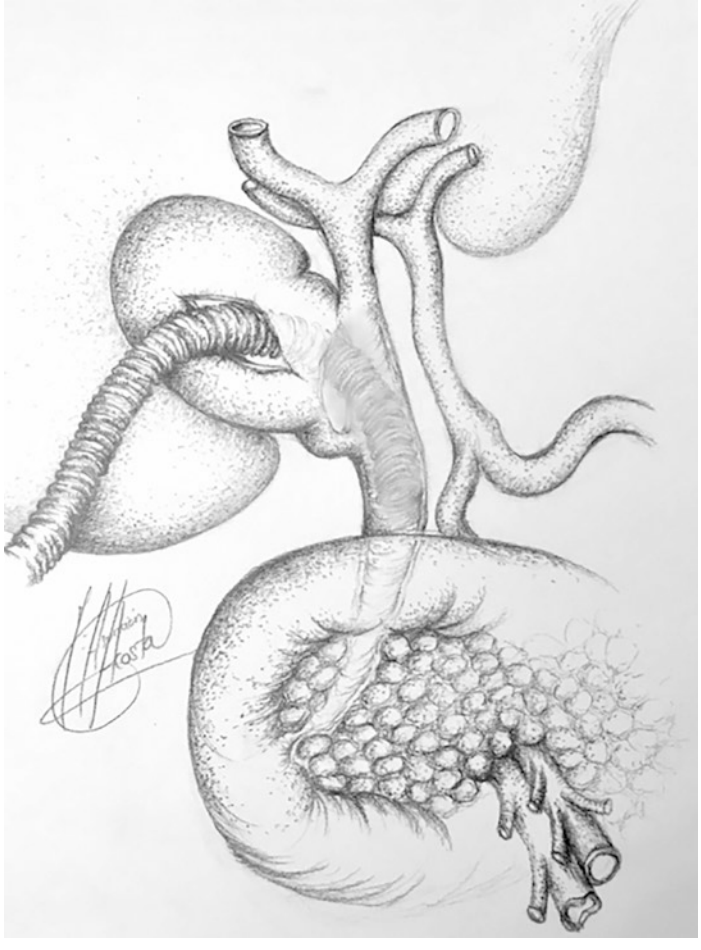

Figure 6.22 TIA in Type II Mirizzi syndrome

an impacted gallstone in Hartmann's pouch or the cystic duct with a resultant cholecystocholedochal fistula, which can sometimes be indistinguishable from a grossly dilated cystic duct. Figure 6.23 demonstrates complex type II Mirizzi syndrome in a patient that required a TIA-LABEL strategy. In this patient, a choledochotomy and bilioenteric anastomosis were considered but were ultimately not feasible options. The size of the stone (35 mm) and the high calcium content (as seen on pre-operative CT imaging) resulted in a prolonged laser lithotripsy time of over 6 h (total operative time 7.5 h). After comprehensive dusting and fragmentation of the stone with basket removal of the majority of fragments, some stone debris remained in the bile duct. After a lengthy procedure, we opted to clear the remaining fragments by a post-operative ERCP which was completed on the 14th post-operative day (the patient had normal LFTs post-operatively). In such cases, a pragmatic decision to complete CBD clearance with post-operative ERCP was appropriate as persisting with basket retrieval would have prolonged an already lengthy procedure.

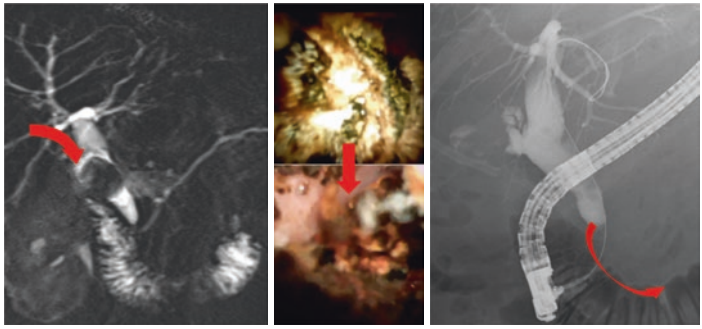

Figure 6.23 Trans-infundibular approach laser assisted bile duct exploration by laparoendoscopy (TIA-LABEL). Type II Mirizzi syndrome (left), lithotripsy of large stone (centre), post-operative ERCP to clear remaining fragments (right)

Closure After Accessing the Bile Duct

Closure of the Choledochotomy

Closure of choledochotomy can be performed in several ways:

1. Closure over a T-tube
2. Closure over an antegrade stent
3. Primary closure (without transcystic drain)
4. Primary closure with transcystic drain
5. Bilioenteric anastomosis

Closure Over a T-Tube

The T-tube should be trimmed in a similar way that is used in open surgery and it can be introduced into the abdominal cavity using the 10–12 mm port. After introducing the short arms into the bile duct proximally and distally (Fig. 6.24 left and centre), it is important to check that the drain moves freely within the duct. The main stem of the drain is exteriorised through the 5 mm right upper quadrant port (the same used for the choledochoscope). The choledochotomy is then closed over the T-tube with interrupted or running 5-0 Vicryl™ (Ethicon, New Brunswick, New Jersey, USA) on a round needle, starting either from the top or the bottom

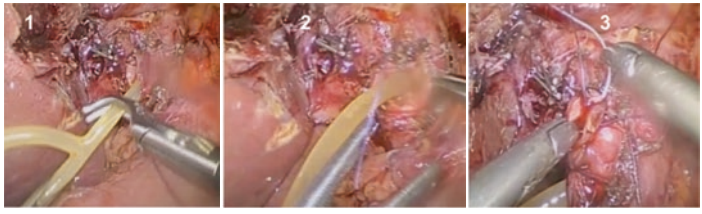

FIGURE 6.24 Closure of choledochotomy over a T-tube. Introduction proximally (left), distally (centre) and closure with interrupted sutures (right)

(Fig. 6.24 right). To test the closure, water can be injected into the T-tube at low pressure to ensure that there is no leak. The exteriorised main stem of the T-tube should be securely fixed to the skin with silk in multiple places to prevent inadvertent misplacement of the drain.

At the beginning of our LBDE series, closure of choledochotomy with T-tube was the favoured technique, however, its routine use was largely abandoned after the early years. Despite this, we still think there are some valid indications for its use: the presence of a choledochoduodenal or cholecystocholedochal fistula (including some instances of type 2 Mirizzi syndrome) and presence of certain types of choledochal cysts. Figure 6.25 illustrates the placement of a T-tube through a choledochotomy with the main stem exiting through a cholecystocholedochal fistula whilst the choledochotomy was closed independently. Figure 6.26 demonstrates reconstruction of the bile duct after resection of a type VI choledochal cyst (isolated dilation of the cystic duct). The technical considerations in this case consisted of resecting the saccular dilatation of the cystic duct (Fig. 6.26 right) and due to the wide implantation of the cystic duct, reconstruction of the bile duct over a T-tube with a subsequent ERCP-ES to address the common bilio-pancreatic channel associated in such cases. The insert (bottom right) in Fig. 6.26 is the choledochoscopic view showing the exit of the distal common bile duct into the common channel with entrance to the pancreatic duct (left) and duodenal papilla (right) [13].

Closure Over an Antegrade Stent

At the author's institution, routine use of T-tube for choledochotomy closure was abandoned in November 2001, and over the next decade or so, closure over an antegrade stent became the preferred choice of choledochotomy closure using a 7F Amsterdam stent. Antegrade insertion of the stent over a PTFE guidewire (0.035-inch diameter, 145 cm length, 3 cm flexible tip) (Cook Medical) (Chap. 4, Table 4.1, Serial

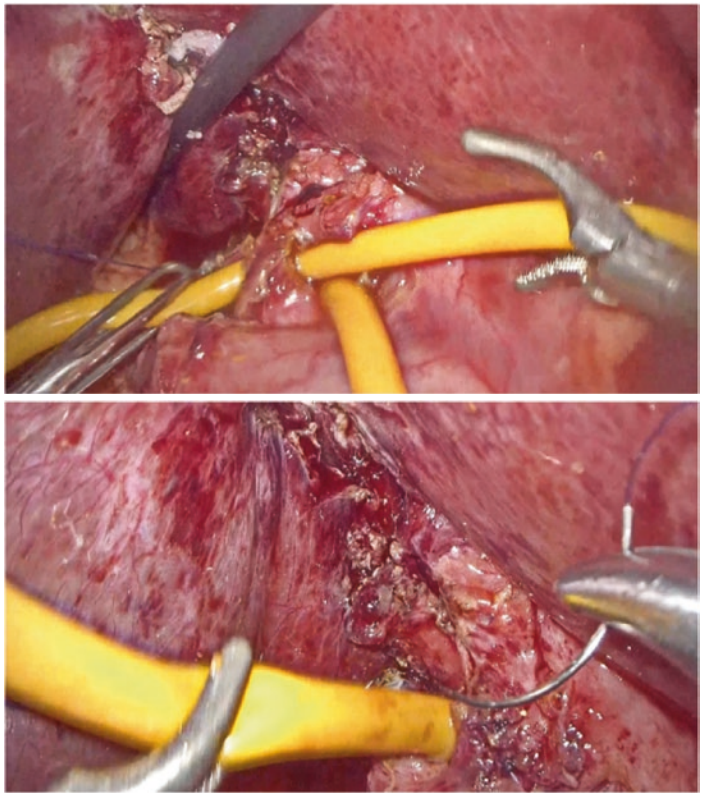

Figure 6.25 Use of a T-tube for a cholecystocholedochochal fistula

10) which was previously inserted into the CBD and duodenum under choledochoscopic view. The choledochoscope can also be railroaded over the guidewire after the stent thereby using the scope as a 'pusher' [14] and allowing direct visual confirmation that the stent has passed the papilla (Fig. 6.27). Following this, the choledochotomy can be closed over the stent with 5-0 Vicryl™. The stent is then removed after 2 or 3 weeks with an standard gastroscope and a snare (Fig. 6.28).

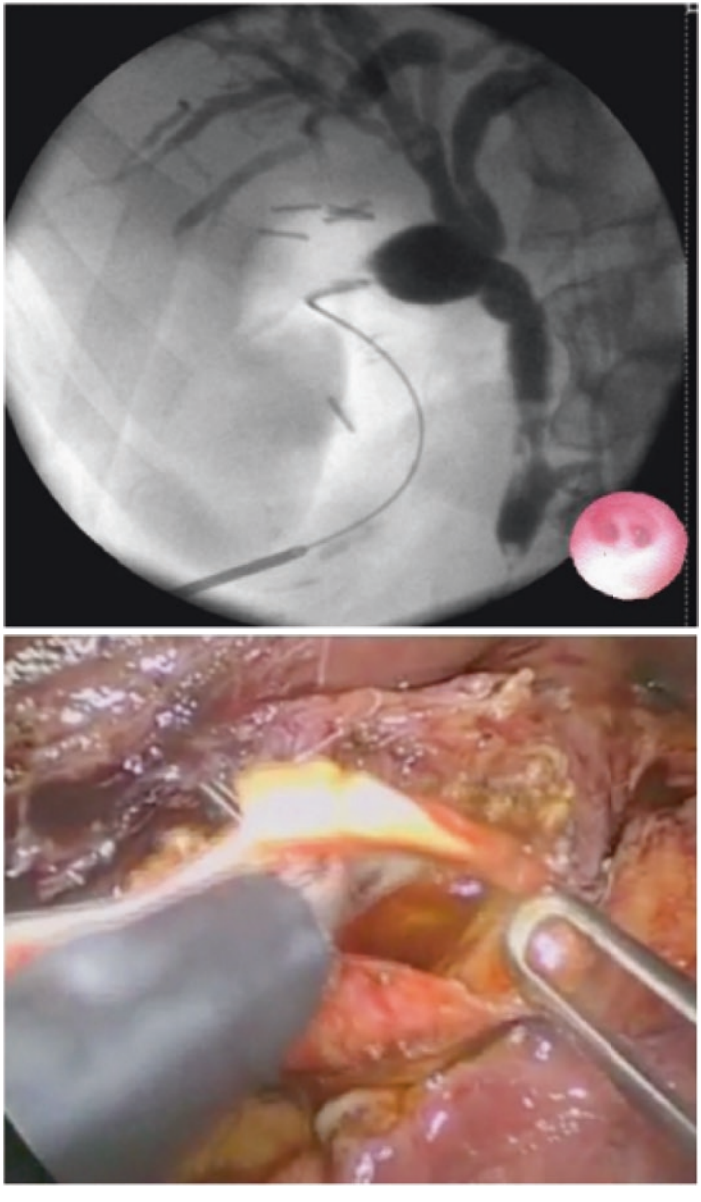

Figure 6.26 Type VI choledochal cyst

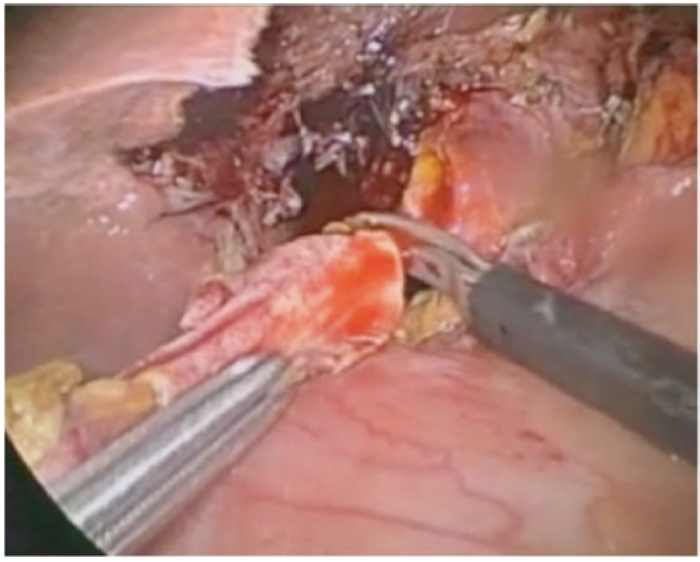

Figure 6.26 (continued)

Primary Closure (Without Transcystic Drain)

Since 2012, primary closure has been our preferred method of closure after choledochotomy. Our technique is performed using 5-0 Vicryl™ and we routinely start the closure by placing a stay suture at the cranial end of the choledochotomy (Fig. 6.29) [15, 16]. The choledochotomy is then closed primarily using a continuous suture on a curved needle starting from the caudal end, which is then tied to the originally placed stay suture (Fig. 6.30). It is important to maintain the tension after each stitch to ensure a water-tight closure.

Even though primary closure after choledochotomy is considered the preferred method of closure, it should only be used without additional biliary drainage when it is safe to do so. This can be checked by performing a completion intraoperative cholangiogram or cholangioscopy. Favourable

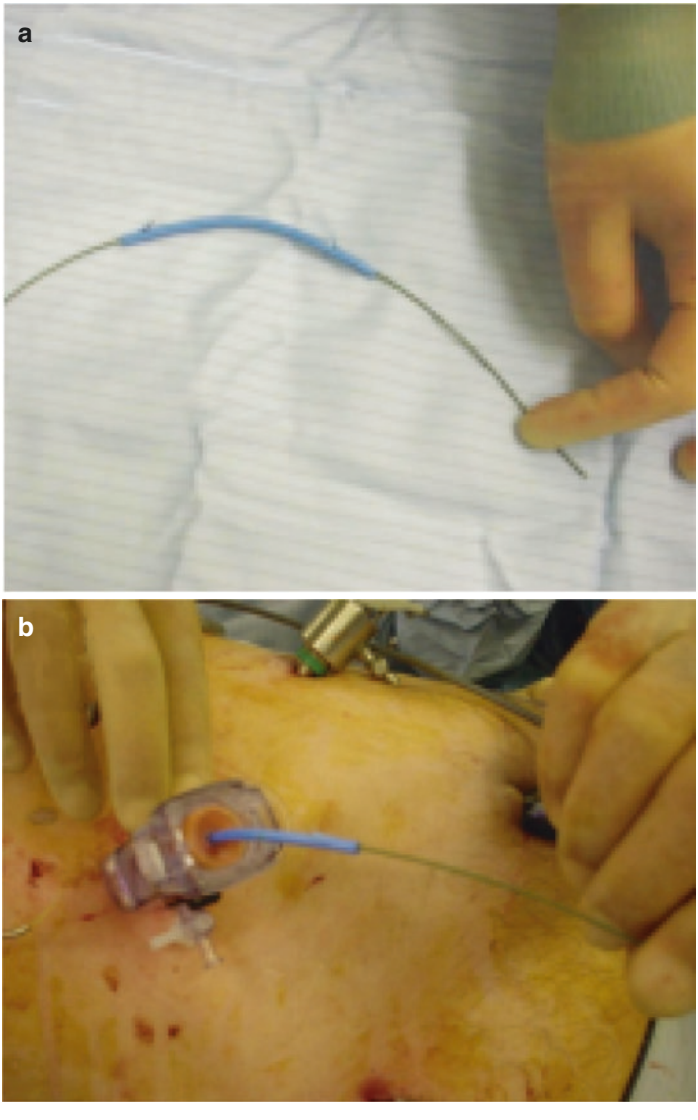

FIGURE 6.27 Insertion of antegrade stent

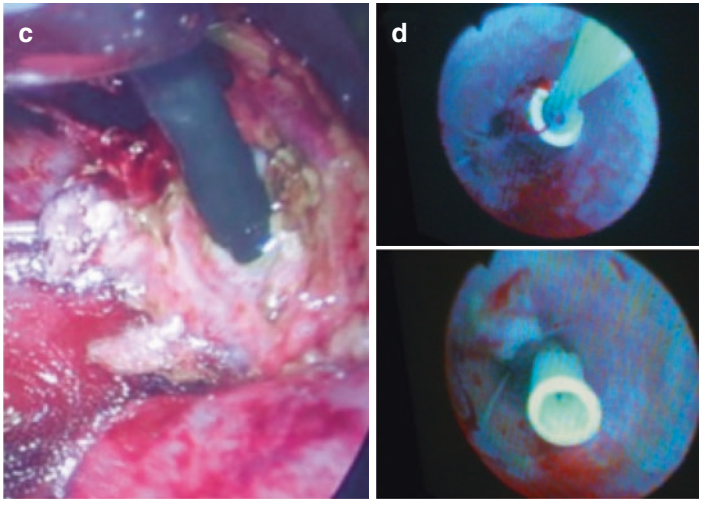

Figure 6.27 (continued)

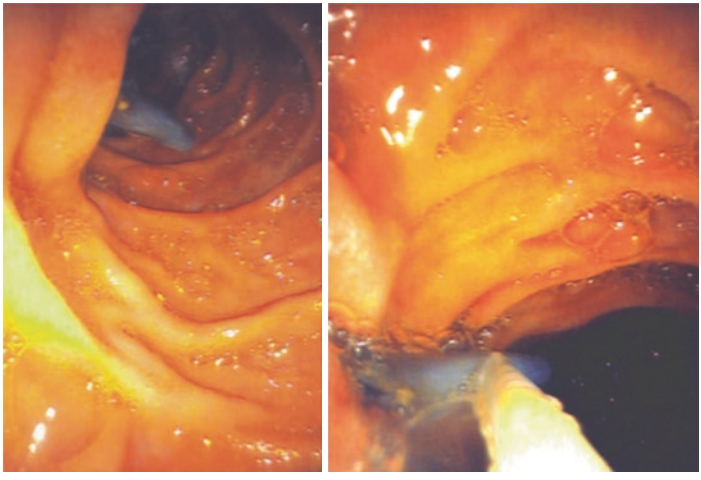

Figure 6.28 Removal of stent with gastroscope

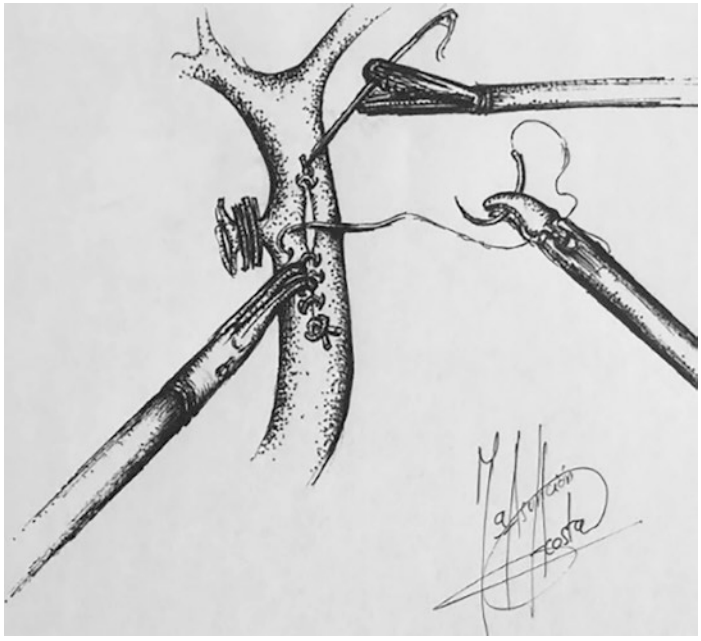

Figure 6.29 Start of the primary closure

observations to be able to proceed with primary closure (without transcystic drain) are that the duct is clear and that there is good passage into the duodenum. This can be seen under direct vision, passing the closed basket into the duodenum and then pulling the opened basket back, whilst watching to see how easily the papilla opens (Fig. 6.31). When we use the 3 mm choledochoscope, we often pass it directly into the duodenum (Fig. 6.32). If drainage into the duodenum is not satisfactory, it would be wise to use some form of bile duct decompression before closing the choledochotomy primarily. For this we favour an 8F drain placed transcystically (transcystic drain).

FIGURE 6.30 Primary closure completed

Primary Closure with Trancystic Drain

Primary closure with transcystic drain is a useful technique when it is highly desirable to protect the ductal closure in high-risk patients where the burden of a bile leak would have serious impact on morbidity and even mortality. It is also used when impaired papillary drainage is suspected rendering the bile duct a high-pressure system until normal outflow is once again established (Fig. 6.33). An 8F infant feeding tube or similar can be used for this and the tube is placed

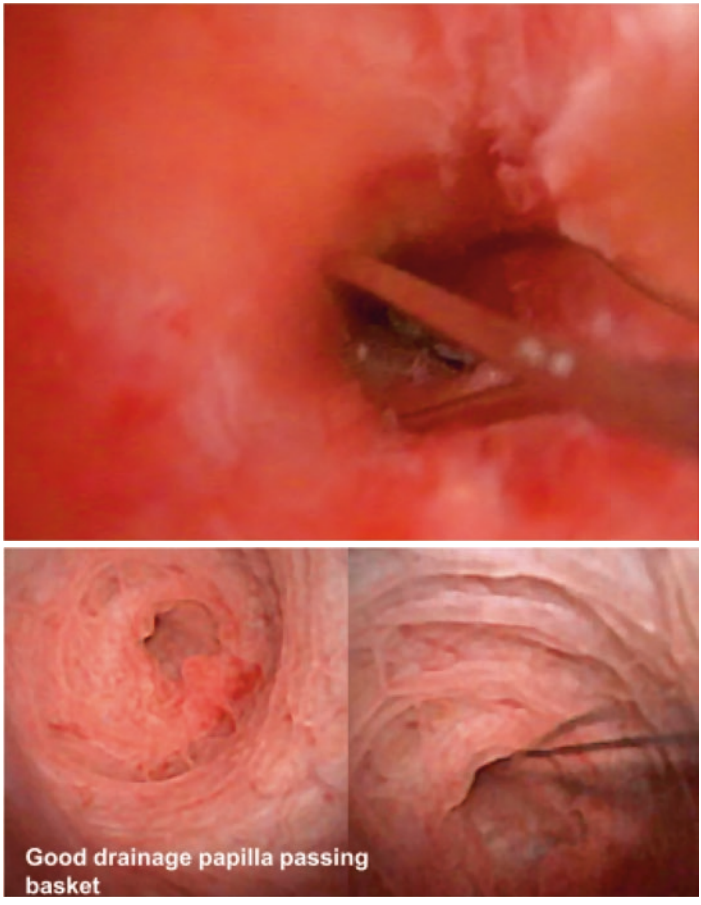

Figure 6.31 Assessing the drainage of the bile duct under direct vision by choledochoscopy

transcystically, often railroaded over a guidewire (once the tip has been cut), so that the tip lies within the common bile duct. The drain should be secured well to the cystic duct stump using a 2-0 Vicryl™ intracorporeal tie. As with the T-tube, the extracorporeal part of the drain needs to be secured well to the skin in multiple places to avoid the drain becoming dis-

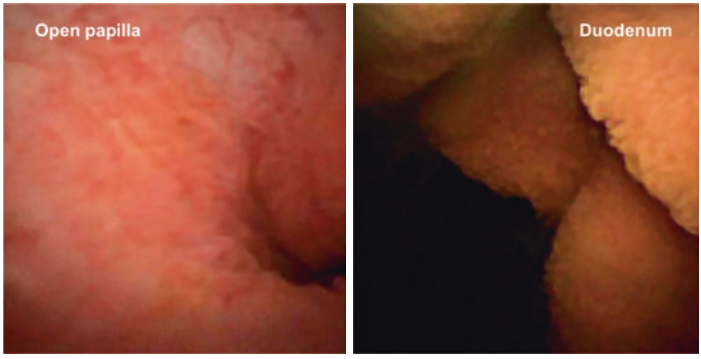

FIGURE 6.32 Passing the 3 mm choledochoscope through the papilla into the duodenum

FIGURE 6.33 Primary closure with transcystic drain in a patient with papillary oedema

lodged. The transcystic drain is better tolerated than the T-tube and is also subject to less complications.

Bilioenteric Anastomosis

Rarely after the choledochotomy and bile duct exploration we need to perform a choledochoduodenostomy. The indications include retained, recurrent and impacted bile duct stones, strictures of the bile duct, stenosis of the sphincter of Oddi, pancreatitis associated with biliary disease, choledochal

cysts, fistulas of the bile duct and biliary obstruction, either benign or malignant. The laparoscopic technique is similar to that performed in open surgery. A vertical incision is made in the supraduodenal portion of the common bile duct and a similar-sized transverse incision in the duodenum. Two stay sutures are placed, one lateral and one medial, bringing the two openings together (Fig. 6.34 left). The stay sutures are then placed under traction and exteriorised using an Endo Close™ (Fig. 6.34 left). The posterior layer of the anastomosis is performed first (Fig. 6.34 right), historically using interrupted 4-0 Vicryl™ but a contemporary alternative would be to use a continuous V-Loc™ suture (Covidien, Mansfield, Massachusetts, USA). Once the posterior layer is completed, the stay sutures can then be tied and then the anterior layer of the anastomosis completed in a similar fashion to the posterior layer (Fig. 6.35).

Closure After the Transcystic Approach

Closure after transcystic exploration is often indistinguishable from that after a laparoscopic cholecystectomy without bile duct exploration. An Endoloop (Ethicon, New Brunswick, New Jersey, USA) or sometimes just a clip is needed to close the cystic duct stump (Fig. 6.36). If a completion cholangiogram is indicated and the cholangiogram catheter is placed once again transcystically, a loose 2-0 Vicryl™ tie can be placed around the cystic duct to prevent leakage of contrast, which can then be tightened once the catheter is removed to achieve secure closure of the cystic duct (Fig. 6.37).

At the junction between the cystic and common bile duct there is often a saccular dilatation. If the cystic duct cannot be cannulated for the standard transcystic approach, then this dilatation may have to be used for access to the bile duct. This can complicate the closure and often requires sutures. The same will occur if a near-total cholecystectomy is performed after the TIA approach (Fig. 6.38). In this scenario, the infundibulum should be closed under direct vision of the entrance

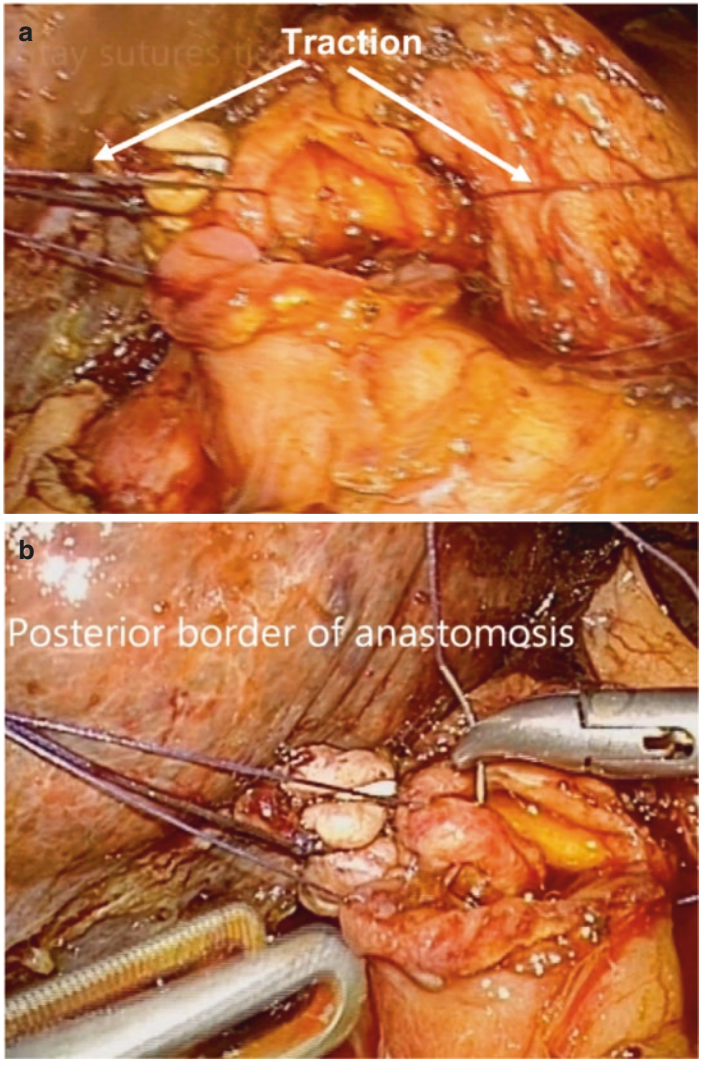

Figure 6.34 Choledochoduodenostomy. (**a**) placement of stay sutures for traction and to bring the two openings together. (**b**) performing the posterior layer of the anastomosis

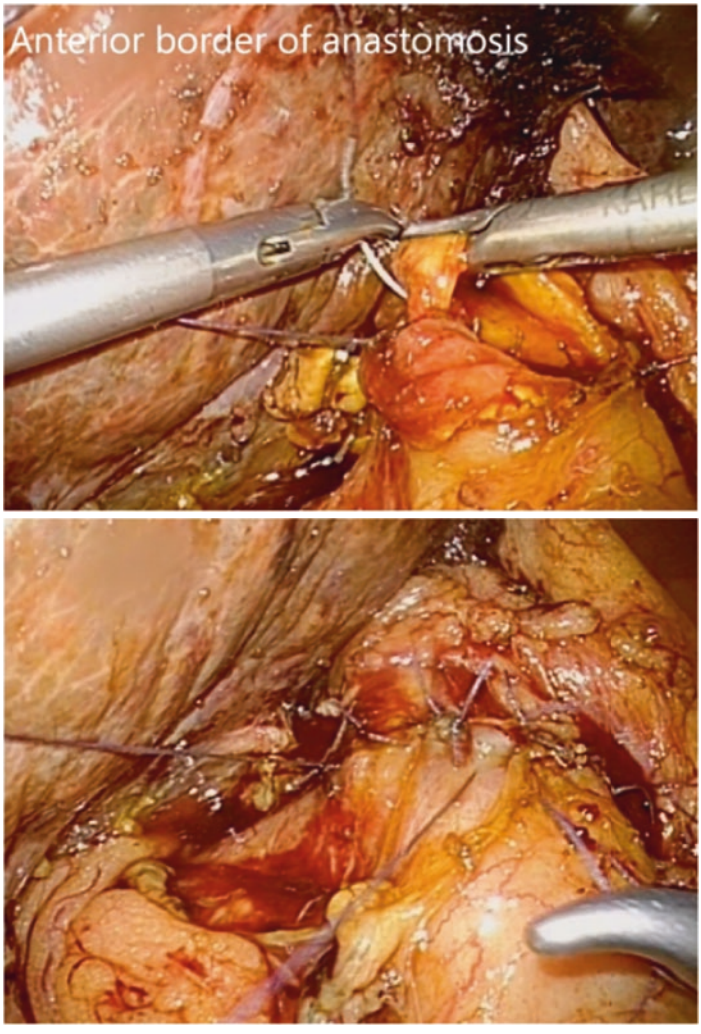

Figure 6.35 Choledochoduodenostomy: anterior layer

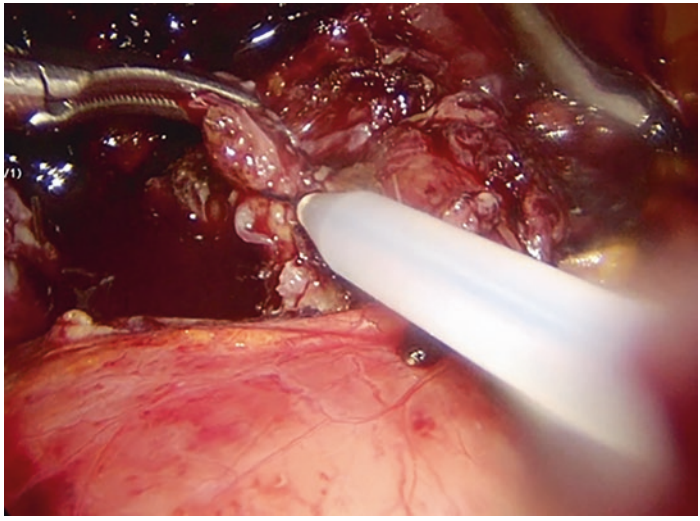

Figure 6.36 Closure of the cystic duct stump with an Endoloop

of the cystic duct (Fig. 6.38 blue arrow) or with the 3 mm disposable choledochoscope inside of the bile duct to avoid stenosis.

Bile Duct Exploration in the Patient with Roux-En-Y Gastric Bypass (RYGB)

Approximately 10–30% of patients develop cholelithiasis (of which about a third are symptomatic) and >1% develop choledocholithiasis after bariatric surgery [17–20]. Following laparoscopic Roux-en-Y gastric bypass (LRYGB) specifically, the incidence is slightly higher. Although it is not our practice, the majority of patients with choledocholithiasis and concomitant gallstones in the UK still receive pre-operative ERCP. Because of surgically altered anatomy, traditional trans-oral ERCP is not possible in patients with RYGB. Various techniques have been described to access the biliary tree in patients with altered anatomy or in situations where tradi-

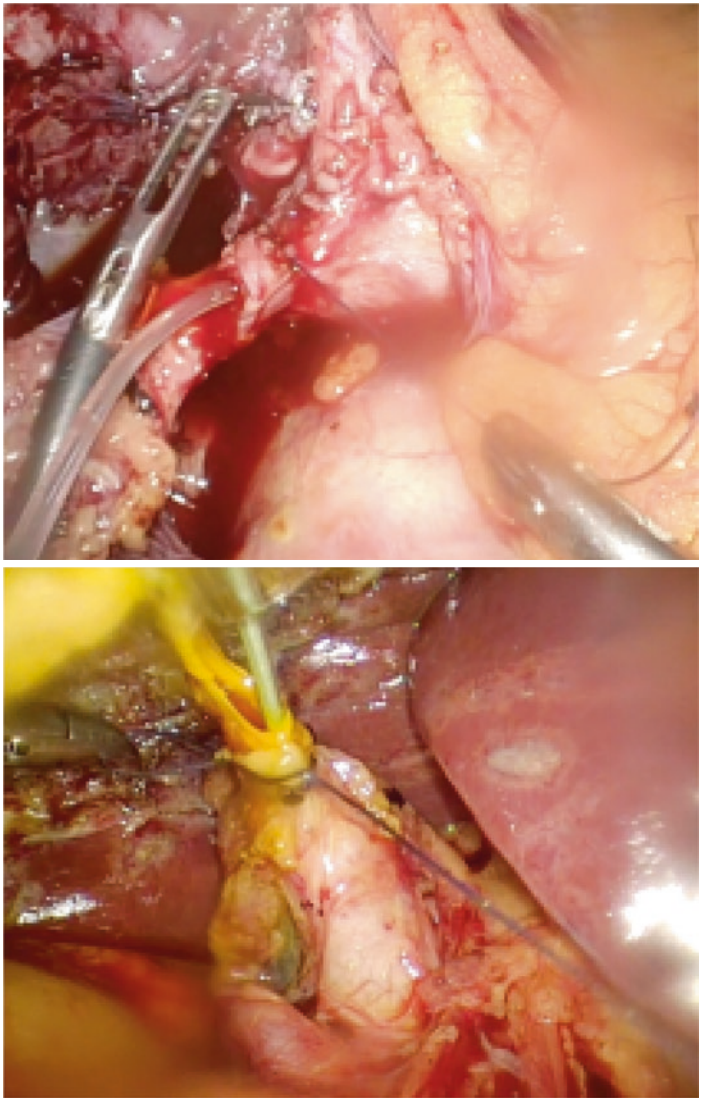

FIGURE 6.37 Completion intra-operative cholangiogram prior to cystic duct closure using an intracorporeal 2-0 Vicryl™ tie

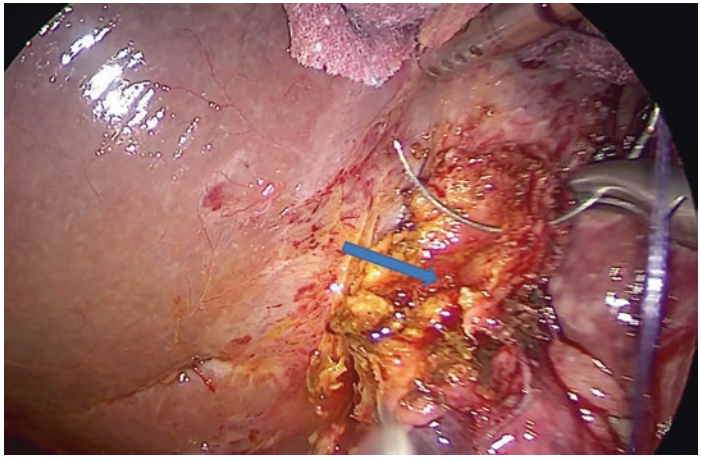

Figure 6.38 Closure after TIA

tional ERCP has failed. Varied results of each technique have been reported. The various options include transcystic and transductal LBDE, laparoscopic choledochoduodenostomy, Laparoscopic Transgastric Endoscopic Retrograde Cholangiopancreatography (LTG-ERCP), single-balloon enteroscopy-assisted ERCP, endoscopic ultrasound (EUS) guided transhepatic ERCP, EUS guided rendezvous and percutaneous transhepatic cholangiography (with or without lithotripsy).

The technique for transcystic or transductal LBDE in patients with surgically altered anatomy in the same as described above. Post-operative adhesions are usually minimal after LRYGB, but the operating surgeon should be cautious upon induction of pneumoperitoneum in these patients. It is our opinion that transcystic LBDE is the optimal management strategy for all patients with choledocholithiasis and concomitant gallstones, including patients with surgically altered anatomy. LTG-ERCP has a post-operative complication rate of 36% [21] compared with lower complication rates of up to 17% for other techniques [16, 22–24] (Table 6.2). Accompanying a very high post-procedure complication rate for LTG-ERCP is a 6% rate of conversion to open surgery

Table 6.2 Various techniques to access the biliary tree in patients with altered anatomy and their respective major post-operative complication rate

Technique	Major post-operative complications (%)
Transcystic LBDE	1
Transductal LBDE	7
Laparoscopic choledochoduodenostomy	9
LTG-ERCP	13
Single-balloon enteroscopy-assisted ERCP	7
Percutaneous transhepatic removal	7

LBDE laparoscopic bile duct exploration; *LTG-ERCP* Laparoscopic Transgastric Endoscopic Retrograde Cholangiopancreatography, *ERCP* endoscopic retrograde cholangiopancreatography

and 10% requiring a further surgical procedure. Regarding single-balloon enteroscopy-assisted ERCP, biliary cannulation and procedural success rates are 90% and 76% respectively [23]. Our own institutional data reports success rates of 99% for transcystic LBDE in all patients and 100% for patients with surgically altered anatomy.

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