Chapter 4
Equipment and Operative Setting for Laparoscopic Bile Duct Exploration (LBDE)

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Equipment

For laparoscopic bile duct exploration (LBDE) at the time of cholecystectomy, the standard laparoscopic cholecystectomy set can be complemented with disposable items listed in Table 4.1 and a 3 mm choledochoscope. Table 4.2 summarises the characteristics, advantages and disadvantages of the various 3 mm choledochoscopes currently available on the market. For complex choledocholithiasis, Lithotripsy Assisted Bile duct Exploration by Laparoendoscopy (LABEL) is

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often required. The equipment required for LABEL will be discussed here, however, patient selection and technical aspects of LABEL will be described elsewhere (see Chap. 5).

Intra-Operative Cholangiogram (IOC)

In reality, transcystic LBDE begins with the cannulation of the cystic duct for intra-operative cholangiography (IOC). For cholangiography, we recommend using an open-end flexi-tip 5F (70 cm) catheter (Table 4.1, Serial 7) which can be introduced through a Horner needle (Table 4.1, Serial 1). Alternatively, if a Horner needle is not available, a disposable ENT suction device can be used to similar effect. An initial

Table 4.1 Disposable equipment

Serial	Item	Description	Picture
1	Steriseal Horner™ perioperative laparoscopic cholecystectomy cholangiogram set (Optech Diagnostic & Surgical)	Used to direct the catheter guidewire to the cystic duct opening	
2	Endoloop® (Ethicon) or Surgitie™ (Covidien)	For retraction of the proximal cystic duct	
3	Endo close™ trocar site closure device (Covidien)	To retract the Endoloop® or Surgitie™ through the anterior abdominal wall	

Table 4.1 (continued)

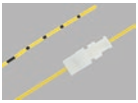
Serial	Item	Description	Picture
4	Adjustable biopsy Port sealing device (Olympus)	Used to make the working channel watertight. Can be connected to [8] if needed	
5	2.4F (120 cm) Dormia basket (cook medical) or 2.4F (120 cm) Segura hemisphere™ retrieval basket (Boston Scientific)	For CBD stone extraction	
6	Flexor® ureteral access sheath 9.5-12F (35 cm) (cook medical)	To introduce 3 mm choledochoscope	
7	Open-end flexi-tip® 5F (70 cm) catheter (cook medical)	To cannulate the cystic duct and perform intraoperative cholangiogram	
8	3-way valve	Allows dual use of the working channel for irrigation and basket instrumentation	
9	Ureteral dilator set 6-18F (cook medical)	To achieve cystic duct dilatation and introduce 5 mm scope	
10	PTFE guidewire (0.035 inch diameter, 145 cm length, 3 cm flexible tip) (cook medical)	The catheter [7] and dilator [6] can be railroaded over the guidewire for access	

Table 4.2 Summary of the characteristics and advantages of the different 3 mm choledochoscopes available

	Cost per case	Diameter	Quality	Sterilization	Steering	Maintenance	Availability	Working channel	Deflection	Additional stack required
SpyGlass™ discover (Boston Scientific)	£££	3.5 mm	+++	N/A	4-way	N/A	+++	3.6F	++++	No
Disposable PUSEN	££	3 mm	++	N/A	2-way	N/A	+++	3.6F	+++	No
Disposable AMBU®	£	3 mm	+	N/A	2-way	N/A	+++	3.6F	+	No
Reusable Fibreoptic	££	3 mm	++	Complex	2-way	Complex	+	3.6F	++	Yes
Reusable Digital	£££	3 mm	+++	Complex	2-way	Complex	+	3.6F	++	Yes

attempt should be made to introduce the catheter directly into the cystic duct. In some patients, the tortuosity of the cystic duct and/or the spiral valves of Heister prevent easy passage of the cholangiocatheter. In such cases, a guidewire (Table 4.1, Serial 10) can be used to railroad the catheter safely into the common bile duct (CBD) [1]. Once the cholangiogram is completed, and if LBDE is indicated, the guidewire is reintroduced through the 5F Cholangiocatheter. The cystic duct can be gently dilated by railroading a 9.5-12F Flexor® Ureteral Access Sheath (Cook Medical, Bloomington, IN, USA) (Table 4.1, Serial 6) over the guidewire. This manoeuvre has dual purpose, as the inner sheath dilates the cystic duct as mentioned, and the outer sheath can introduce the 3 mm choledochoscope. The access sheath is hydrophilic and therefore should be wet prior to its introduction.

Retraction of the Liver

Complex laparoscopic upper gastrointestinal procedures may necessitate the use of the Nathanson retractor for retraction of the left lobe of the liver (Fig. 4.1). We advocate using the French technique (or double-access position) for positioning of the patient during cholecystectomy and LBDE (Fig. 4.2) [2]. In this position, the hook of the Nathanson retractor is introduced through the 5 mm epigastric port incision (after removal of the port). We find that this retraction provides excellent exposure of the hilum when combined with our preferred positioning of the patient (Figs. 4.1, 4.2 and 4.3). If the surgeon is concerned about the risks associated with insertion of the Nathanson liver retractor (bleeding, haematoma formation or creating of false tracts), an alternative technique of safe insertion using a 12F Jacques Nelaton catheter (Teleflex Medical, High Wycomb, UK) as a 'guidewire' has been described [3]; in our experience this has never been necessary but we think that it is an useful trick to know.

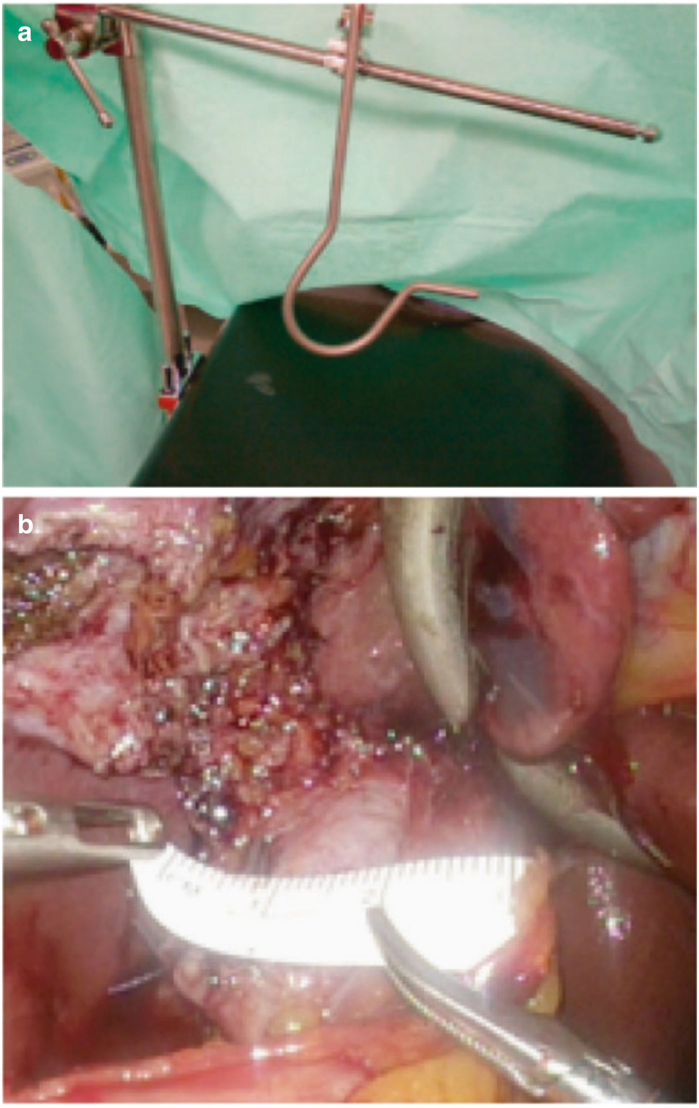


FIGURE 4.1 (**a**) Nathanson liver retractor. (**b**) intraoperative measurement of the CBD

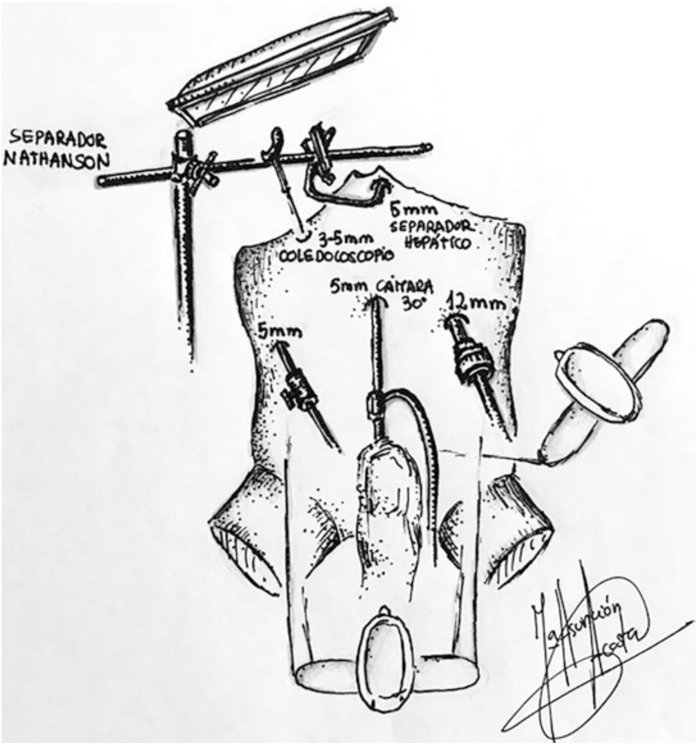


Figure 4.2 Surgical setting

Choledochoscopes

Flexible choledochoscopes are a crucial part of the equipment required for LBDE. Choledochoscopes are available in two sizes: 3 mm and 5 mm, and are similar to cystoscopes and ureteroscopes, but require a different method of sterilisation. The video image can be digital or fibreoptic, the former providing better picture quality and not subject to deterioration due to rupturing of the fibres. Furthermore, an additional camera will not be necessary for digital choledochoscopes. Like other endoscopes, choledochoscopes have a working channel for guidewires, baskets, lithotripsy probes etc. The

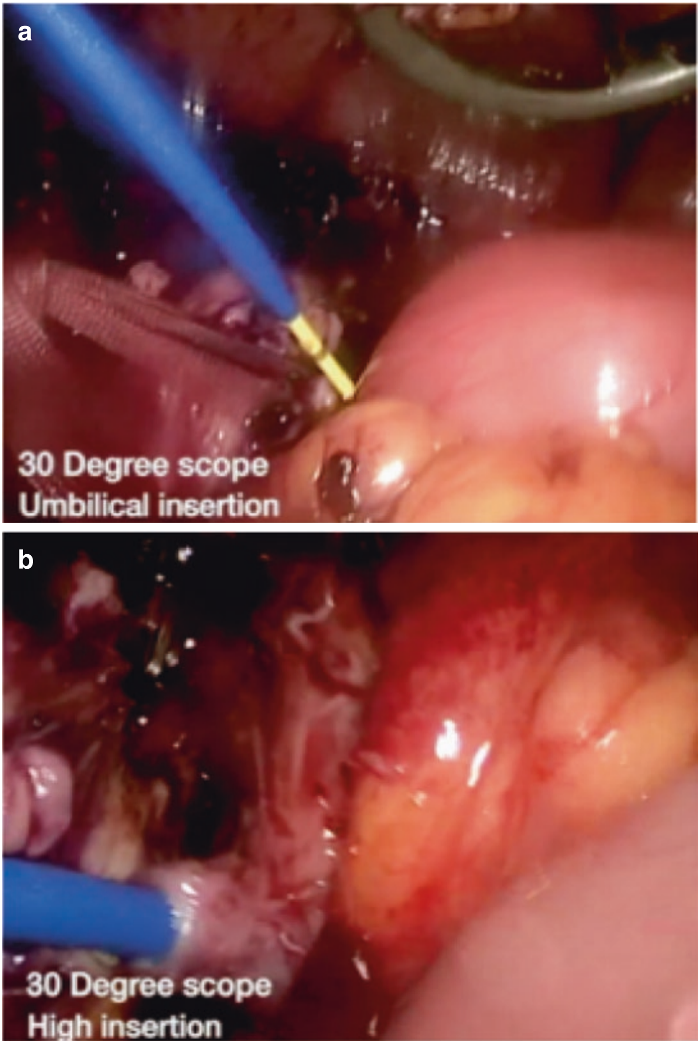


FIGURE 4.3 Views of the CBD with a 30° laparoscope from different port sites. (**a**) At the umbilicus. (**b**) Epigastric

working channel in a 5 mm choledochoscope is up to 6F and 2.5-3.6F in a 3 mm choledochoscope. Choledochoscopes can be reusable or single-use (disposable). Reusable 3 mm scopes, whether digital or fibreoptic, are very delicate and break easily. In the best-case scenario, you can expect a maximum of 20–30 uses before a technical fault which may require costly and lengthy repairs. Reusable scopes also need to be sterilised, which is costly and often needs to be performed on an alternative site. For a relatively busy service, performing one to two LBDEs per week, we recommend stocking a minimum of three choledochoscopes if the institutional preference is for using reusable choledochoscopes. Historically, most disposable scopes were in fact ureteroscopes, not specifically designed for use in the bile duct. Figure 4.4a demonstrates the use of the PUSEN ureteroscope (Zhuhai PUSEN Medical Technology Co., Ltd., China) during LBDE. Recently Boston Scientific has launched the SpyGlass™ Discover (Fig. 4.4b), which is a 3.5 mm specifically designed disposable (single-use) choledochoscope. It has a 3.6F working channel and the two-wheel control offers four-way steering, similar to a gastroscope or colonoscope, allowing superior tip control. This is particularly important during lithotripsy, when precision targeting of the CBD stone is essential for safety and treatment success. The disposable scope also comes equipped with an accessory suction irrigation channel which can be also used as an extra irrigation channel during lithotripsy. The working channel is independent this avoids retrograde fluid spilling during the procedure. The SpyGlass™ Discover can be introduced through a 12F ureteral sheath (refer to table) with the dilator to aid cannulation of the cystic duct once railroaded over the guidewire. We had the opportunity of being the first European team to use the new SpyGlass™ Discover in a live patient. The four-way steering allows precise targeting and relies less on excessive torque and therefore more natural movements. Other disposable scopes (particularly ureteroscopes) equipped with two-way steering require more torque, which can result in detachment of the tip from shaft of the scope thereby breaking it; moreover, the irrigation shares the

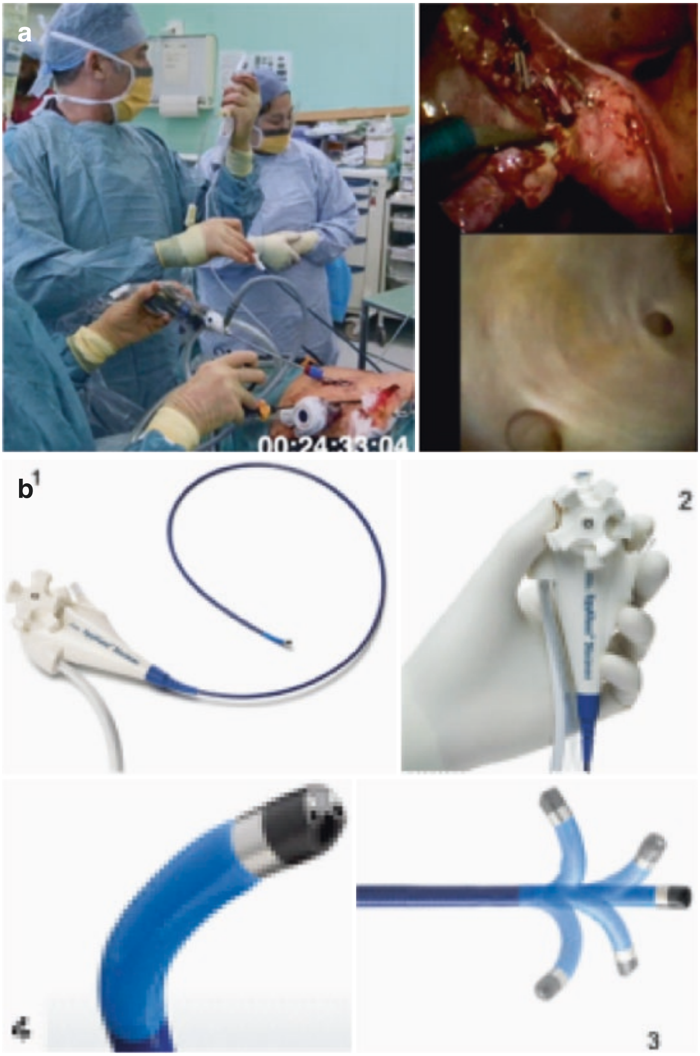


Figure 4.4 3 mm disposable choledochoscopes. (**a**) PUSEN uretero-scope. (**b**) SpyGlass™ Discover Boston Scientific

working channel making necessary the use of a biopsy port to avoid unpleasant fluid spillage on the face during the procedure. Table 4.2 summarises the characteristics, advantages and disadvantages of the various 3 mm choledochoscopes currently available on the market.

Scope Fatigue

With prolonged usage times, the performance of both disposable and reusable choledochoscopes will drop. We describe this phenomenon as *scope fatigue*. Reusable digital choledochoscopes are least likely to become troubled with this, whereas reusable fibreoptic choledochoscopes can show fatigue with use manifested by the appearance of black dots on the video display corresponding to broken optic fibres. In our experience, disposable choledochoscopes are also likely to experience fatigue with prolonged use. The most commonly observed problems are loosening of the junction between the deflecting tip and the shaft of the scope (thereby losing the ability to transmit torque to the tip), general degradation of the deflecting mechanism over time and peeling of the outer plastic cover of the scope shaft. We have also noticed that introducing the laser fibre (stiff) with the scope in deflection has led to perforation of the working channel and exteriorization of the fibre through the lateral side of the scope. Injection of lubrication jelly into the working channel of the choledochoscope may help. When using laser lithotripsy with both disposable and reusable choledochoscopes, it is very important not to activate the laser inside of the working channel as this will damage the scope. Scope fatigue is more likely to affect disposable scopes, however, in the vast majority of cases, a single disposable choledochoscope will be sufficient to do the job.

Scope Failure

Scope failure is the inability to continue a bile duct exploration due to a malfunctioning scope. Possible causes of scope failure include complete disruption of the video display/image, the inability to manoeuvre the scope due to malfunctioning tip deflection, light source failure and damage to the optical fibres by heavy handed grasping of the shaft of a reusable 3 mm choledochoscope. During long procedures it may be necessary to change the scope. We have had to use three disposable choledochoscopes in a single operation for a patient with complex type II Mirizzi syndrome which required more than 7 h of lithotripsy. Scope fatigue and failure appears to affect disposable scopes more frequently, however, the cost effectiveness of using multiple disposable scopes versus sending an expensive reusable choledochoscope for repair (which can be very costly and place the scope out of action for several weeks) needs to be considered when setting up a new service.

Laser Lithotripsy

Light activation by the stimulated emission of radiation (LASER) technology has been utilised for the treatment of urinary stones since the mid-1980s. Two laser devices that are in use today for the endoscopic treatment of CBD stones are the frequency-doubled double-pulse neodymium:YAG (FREDDY) and holmium:YAG (holmium) lasers. The mechanism of action of these lasers differ, thereby producing different safety and efficacy profiles. FREDDY laser lithotripsy causes fragmentation of the stone by the generation of a plasma bubble with mechanical shockwave effects, whereas holmium laser lithotripsy uses a photothermal mechanism of action by creating a vapour bubble that transmits laser energy [4–6]. There have been no studies to date comparing these two modalities during LCBDE. However, in one study comparing FREDDY and holmium lasers during ureteroscopic lithotripsy, the two modalities demonstrated similar stone-free and complication rates, though there was a trend toward a higher complication rate and lower stone-free rate with the FREDDY laser [4]. The two lasers have similar start-up costs

Table 4.3 Description of the costs associated with purchase of the devices and fibres for laser lithotripsy

Laser modality	Device Cost	Fibre cost
Holmium	£50,000	£300–£500 (200 μm)
FREDDY	£45,000	£280–£480 (280 μm)

All fibres are disposable

(i.e., device purchase costs) and laser fibre costs (Table 4.3). At the authors institution, holmium laser lithotripsy is preferred, and due to its widespread use in urological procedures, the laser system (device) should already be available in most hospitals [5, 7]. The laser fibres are disposable and cost approximately £400 (€450) and are available in different diameters. We recommend the 200 μm because it is the smallest and therefore will have less impact on deflecting the tip of the scope. There is no official accreditation to be able to use laser lithotripsy, but several laser safety courses are available to become familiar with the equipment and safety protocols. Figure 4.5 shows a laser safety checklist which is in use at our institution. Use of the laser lithotripsy device (Fig. 4.6a) must be conducted in a laser-amenable operating theatre which has been fitted with the appropriate electrical sockets and blinds (Fig. 4.6b, c). Therefore, when faced with the possibility of managing complex CBD stones (see Chap. 5, section "Which Patients Might Require LABEL?": Which patients might require LABEL?), an appropriate operating theatre should be booked that can cater for use of laser lithotripsy. Additionally, it is important to be aware that different lasers have different wavelengths and each will require the specific protection goggles for that particular wavelength (Fig. 4.6d).

Electrohydraulic Lithotripsy (EHL)

The AUTOLITH® TOUCH (Northgate technologies Inc., Elgin, IL, USA) Bipolar Electrohydraulic Lithotripter (EHL) is a software controlled, electronic device capable of fragmenting biliary calculi of any size and composition (Fig. 4.7).

Laser Safety Checklist

Laser machine pre-checked and calibrated including delivery device?

Yes ☐ No: ....

All doors closed and blinds down?

Yes ☐ No: ....

Laser warning light outside each door of theatre is switched ON?

Yes ☐ No: ....

Protective eyewear warn by all staff in theatre, except for surgeon performing the procedure with filtered microscope laser?
(Only ENT)

Yes ☐ No: ....

Laser mask warn by all staff?

Yes ☐ No: ....

Jug of saline available on scrub trolley?

Yes ☐ No: ....

Patient's eyes protected with laser eye shields?
(Only ENT)

Yes ☐ No: ....

Wet gauze used to protect patient's face and neck?
(Only ENT)

Yes ☐ No: ....

Location of fire extinguisher known?

Yes ☐ No: ....

Laser register book to be completed at the end of the procedure.

Yes ☐ No: ....

FIGURE 4.5 Laser safety checklist

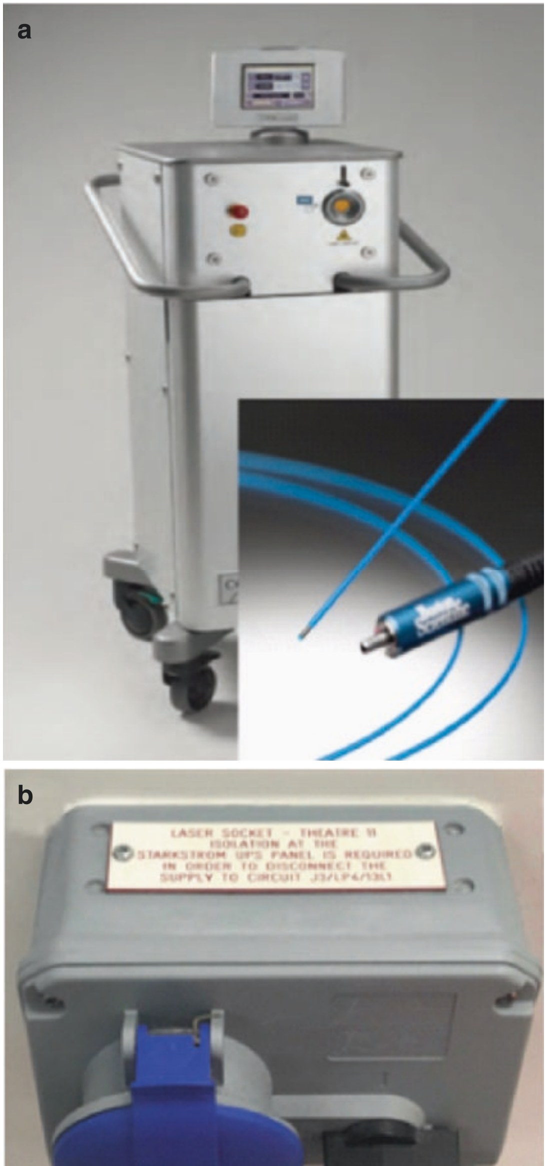


FIGURE 4.6 Equipment required for LABEL. (**a**) laser generator and probe. (**b**) special electrical socket. (**c**) theatre blinds. (**d**) goggles

FIGURE 4.6 (continued)

FIGURE 4.7 The AUTOLITH® TOUCH (Northgate technologies Inc., Elgin, IL, USA) Bipolar Electrohydraulic Lithotripter (EHL) unit

The electronic circuitry generates a single high-voltage pulse or a series of pulses across the tip of a flexible bipolar lithotripter probe. When discharged in 0.9% normal saline solution, these pulses produce sharp, high-amplitude hydraulic shock waves that fragment calculi located within the bile duct. The components of this device are:

- AUTOLITH® TOUCH unit
- Operation/Maintenance Manual
- Extender cable
- Foot Switch
- Detachable Power Cord

The AUTOLITH® TOUCH unit is a software controlled, lithotripter device and will regulate the discharge voltage and repetition rate of a shot delivered to a connected extender cable and probe. The unit will display the relative power delivered to the probe, the number of pulses to be delivered to the probe as requested by the surgeon and the number of pulses delivered. The unit will automatically sense the existence of a plugged-in probe, preset start-up values for power and pulses according to the probe type and scale the power range according to the probe type. The unit will also automatically compare the pulses delivered at the selected power levels and display when to inspect or replace the probe. To ensure proper operation of the EHL unit during the surgical procedure, 0.9% normal saline must be used to irrigate the endoscopic viewing field, and no other irrigating solution should be used. The AUTOLITH® TOUCH 1.9F 375 cm EHL Probe is a single-use device and is to be used with the AUTOLITH® TOUCH EHL unit. The EHL probe has been optimised for use with the SpyGlass™ DS Direct Visualisation System (Boston Scientific, Natick, MA, USA) to help manage large biliary stones. EHL is contraindicated in patients who have an externally connected intra-cardiac catheter or pacemaker.

Operative Setting

Patient Position

Prior to induction of general anaesthesia, all patients should be consented according to local and/or national guidelines (e.g. GMC guidelines in the UK) [8]. For laparoscopic cholecystectomy ± LBDE, we prefer the French position with the surgeon standing between the legs [2]. As previously mentioned, in complex cases or in patients with large fatty livers we may use a Nathanson retractor to retract the liver (Figs. 4.1 and 4.2) [9–12]. During choledochoscopy, the choledochoscope is handled by the surgeon with their left hand and the Dormia basket with their right hand. Opening and closing of the basket is performed by either the first assistant (standing to the patient's left side) or the second assistant/scrub nurse (standing to the patient's right side). The monitors for the choledochoscope and laparoscope are displayed to the right of the head-end of the operating table as shown in Fig. 4.2.

Port Placement

At the authors institution, positioning of the ports has evolved since 1998 when the first LBDE was performed until now (Fig. 4.2) [10, 11]. The most significant change was realised after moving the position of the 5 mm 30° laparoscope. Previously, this was placed at the umbilicus, but a superior view of the CBD is obtained if it is placed more cranially, some 15 cm below the xiphoid (Fig. 4.3). An optimal view of the CBD is especially important in more challenging cases (e.g. fibrotic and/or inflamed hilum) or obese patients with a long xipho-umbilical distance [12]. The improved view of the CBD and hilum is more in keeping with the view experienced during the open era of CBD exploration. The surgeon's right hand provides laparoscopic instrumentation through a 10–12 mm port in the patient's left upper quadrant (approximately in the midclavicular line and horizontally level with the laparoscope port). The surgeon's left hand operates another laparoscopic instrument through a 5 mm port in the patient's right flank. A high 5 mm epigastric port (near the xiphoid) is used for retracting the gallbladder fundus by the assistant's right hand or the Nathanson liver retractor as previously discussed. Finally, if choledochoscopy is indicated, an extra 5 mm port can be inserted in the right upper quadrant for a 5 mm scope or a 12F sheath for a 3–3.5 mm choledochoscope.

Cholecystectomy

Exposure of Calot's triangle and cystic artery ligation should be performed in the standard way. Following dissection of Calot's triangle, we find that there are two key steps that facilitate transcystic intubation. The first step is to mobilise the gallbladder from the liver bed without transecting the cystic duct. The second step is to completely dissect the cystic duct all the way to the cystobiliary junction. The application of an Endoloop® (Ethicon, New Brunswick, New Jersey, USA) or Surgitie™ (Covidien, Mansfield, Massachusetts, USA) at the infundibulum, which is then exteriorised through the abdominal wall in the right upper quadrant using an Endo Close™ (Covidien, Mansfield, Massachusetts, USA), allows a 45° horizontal elevation (Fig. 4.8) and ideally a perpendicular cystic duct relative to the CBD [13]. Figure 4.9 demonstrates our 'gallbladder mobilisation first' approach

Figure 4.8 Retraction of the proximal cystic duct with an Endoloop

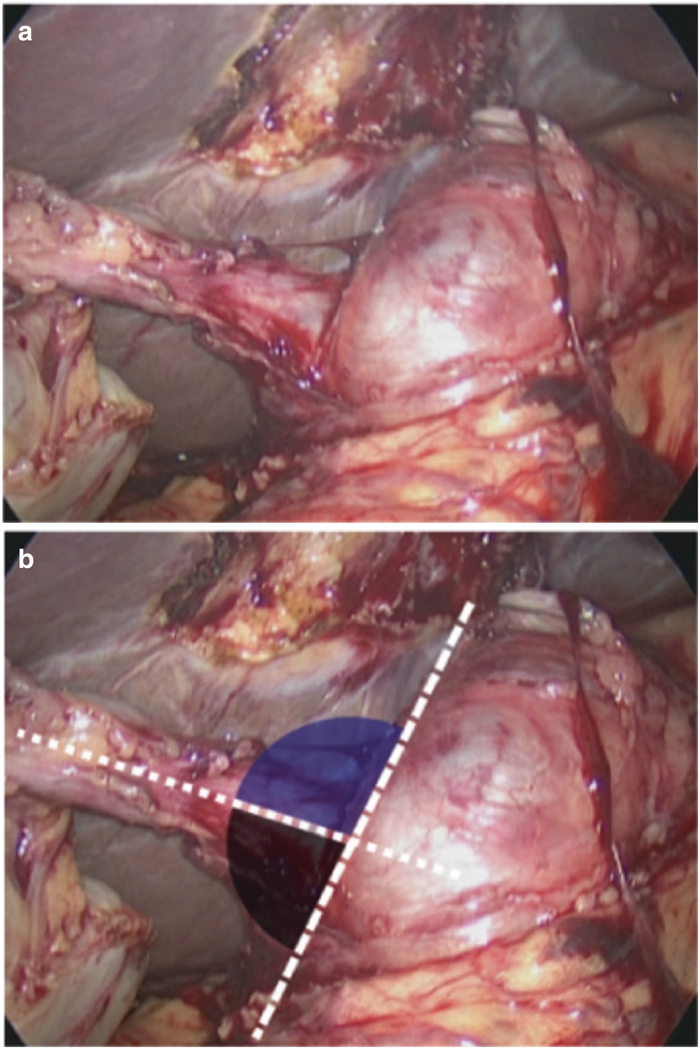


Figure 4.9 Correction of cystic duct-common bile duct angle. (**a**) Dissection of the gallbladder from the liver. (**b**) Creation of ~90° angle. (**c**, **d**) Endoloop retraction. (**e**) Determining optimal angle for traction (white arrow: extracorporeal palpation). (**f**, **g**) Exteriorising the Endoloop. (**h**) Guidewire cannulation of the cystic duct. (**i**) Choledochoscopy with 5 mm scope

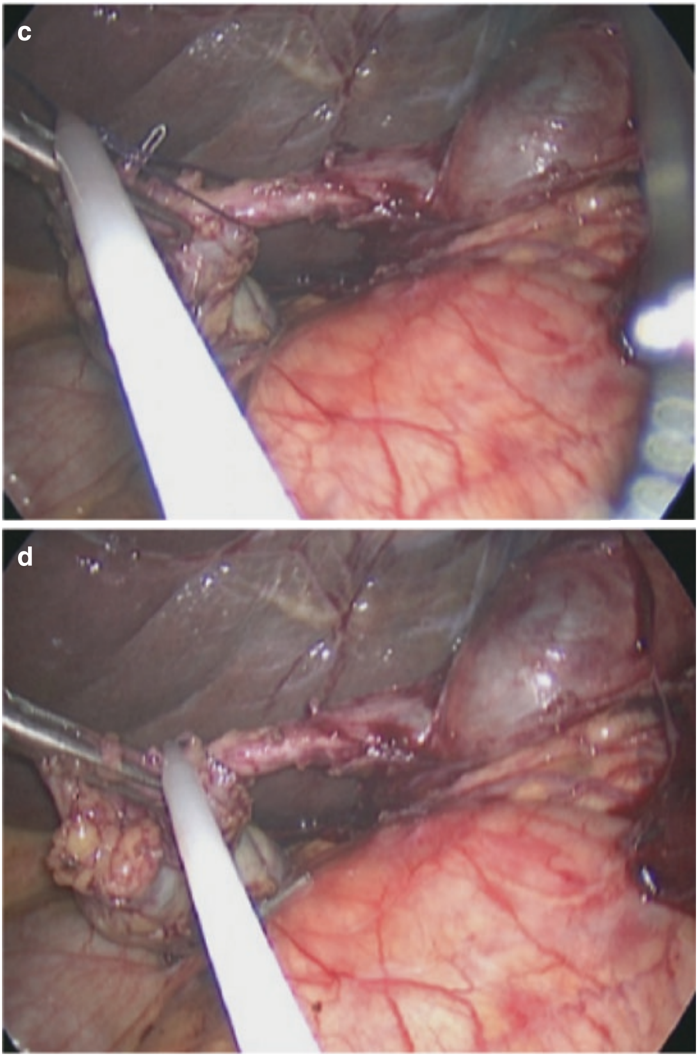


FIGURE 4.9 (continued)

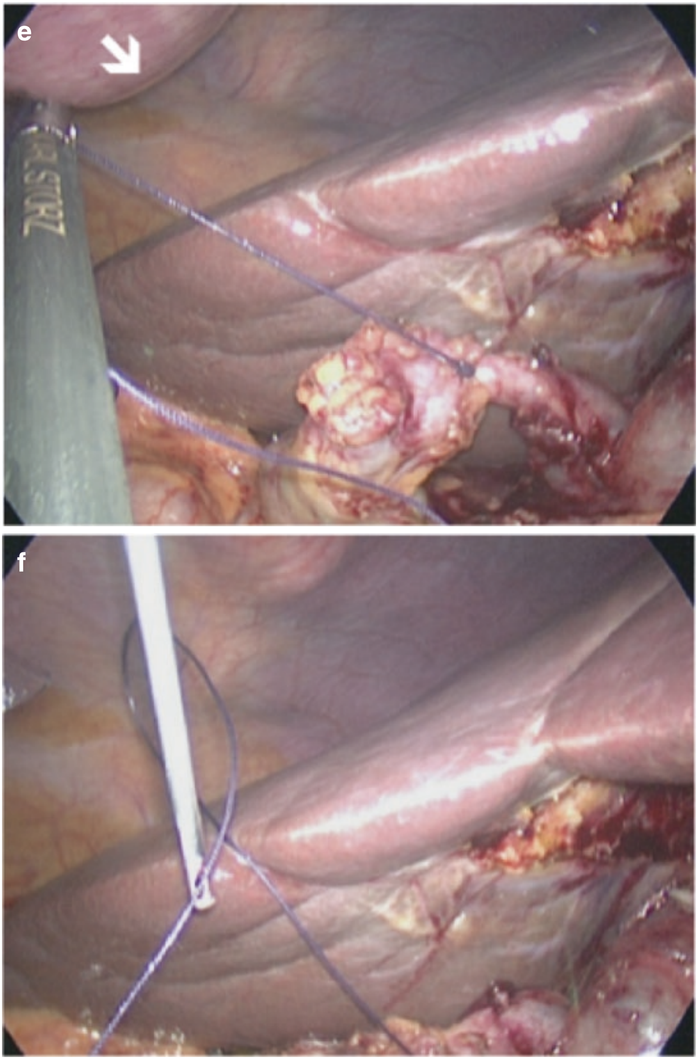


FIGURE 4.9 (continued)

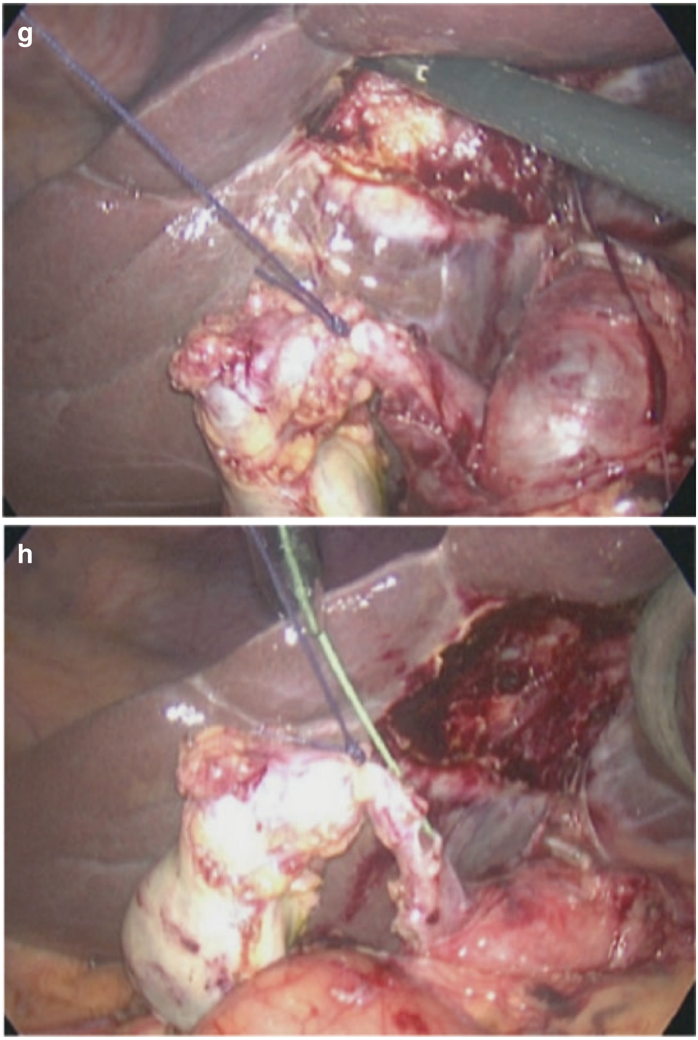


FIGURE 4.9 (continued)

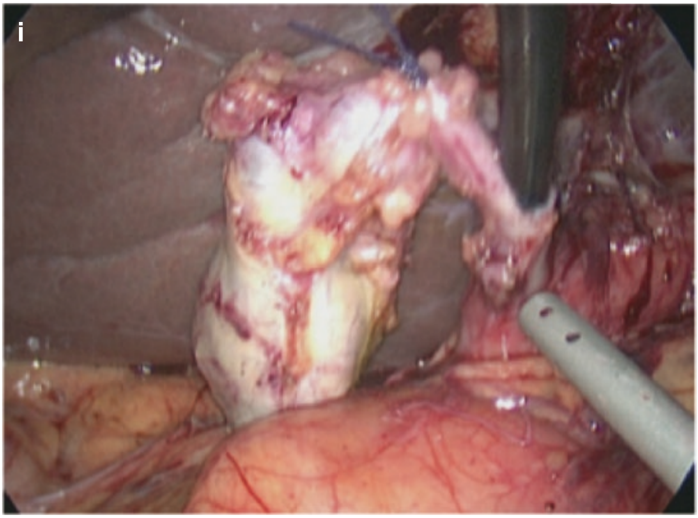


FIGURE 4.9 (continued)

resulting in correction of the cystic duct-common bile duct angle to a more favourable ~90°. A small incision is then made in the cystic duct to provide access for intra-operative cholangiogram and/or transcystic choledochoscopy.

Intra-Operative Cholangiogram (IOC)

Choledocholithiasis is a dynamic disease and as there is constant passage of stone material, we believe that an MRI performed days or weeks before surgical intervention does not guarantee that the bile duct is going to be clear on the day of cholecystectomy. For this reason, the CBD should be assessed intraoperatively with intra-operative cholangiogram (IOC) or laparoscopic intra-operative ultrasound (LIOUS). The need for contemporary imaging is illustrated in Fig. 4.10, which demonstrates pre-operative diagnosis of multiple CBD stones on MRCP (Fig. 4.10a) but normal choledochoscopy (with a widely open papilla) in the same patient at the time

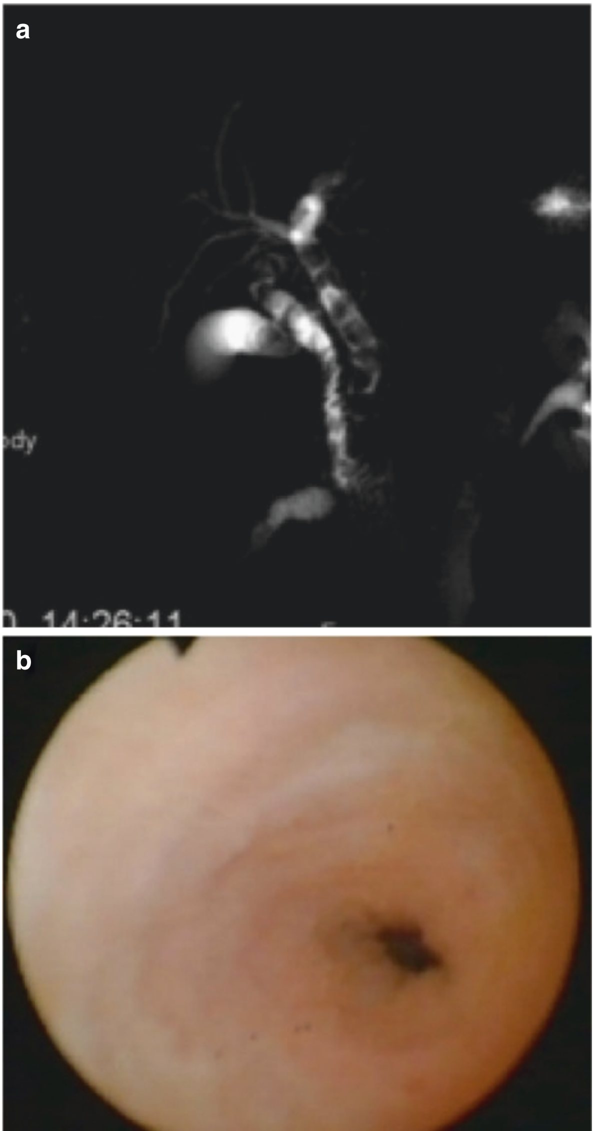


FIGURE 4.10 (**a**) MRCP demonstrating multiple CBD stones. (**b**) cholangioscopy demonstrating no CBD stones

of surgery (Fig. 4.10b). In patients with a high index of suspicion, or in patients who are pregnant or allergic to iodine, a sensible approach is to perform LIOUS or proceed directly to 3 mm transcystic choledochoscopy.

Once an incision has been made in the cystic duct, the cholangiogram needle can be introduced through the abdominal wall in the right upper quadrant. We recommend using the Horner needle (Table 4.1, Serial 1), however, if one is not available then a Belluci style 30° ENT disposable suction tube can be used instead (Fig. 4.11). If an ENT disposable suction tube is used, the 30° angulation in the tube needs to be straightened out, which can be done easily by hand. For easier cannulation, an attempt should be made to align the cholangiogram needle (or ENT suction tube) with the axis of the cystic duct (Fig. 4.12). An open-end Flexi-Tip® 5F (70 cm) catheter (Cook Medical) (Table 4.1, Serial 7) can then be introduced through the needle into the cystic duct. If the cannulation is challenging, a PTFE guidewire (0.035-inch diameter, 145 cm length, 3 cm flexible tip) (Cook Medical) (Table 4.1, Serial 10) can be used to cannulate the cystic duct, and thereafter, the 5F catheter can be railroaded over the guidewire. The catheter can be secured with a single clip, however, it may impede the flow of contrast during the cholangiogram and may also prevent its use as a working channel if the surgeons wants to perform the basket-in-catheter (BIC) technique for transcystic access to the bile duct [14]. Our preference is not to use it.

FIGURE 4.11 Belluci style 30° ENT disposable suction tube

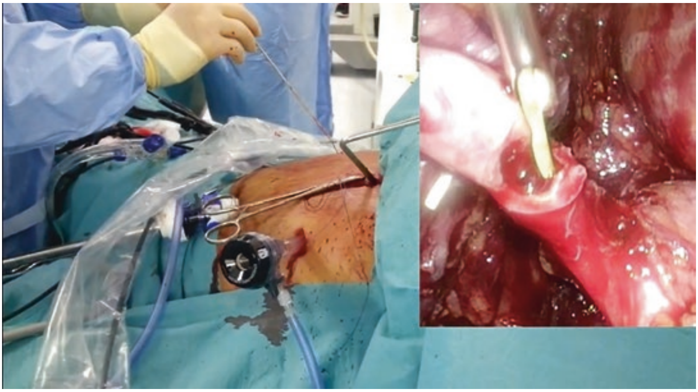


Figure 4.12 Cannulation of a guidewire into the cystic duct using a Horner's needle

For IOC we use Omnipaque™ (iohexol) 300 mg I/ml (GE Healthcare, Oslo, Norway) and a mobile C-arm. The correct sequence for obtaining a cholangiogram can be remembered by the pneumonic '**COAX**'. The first step ('C') ensures that the **C**lips appear in the **C**entre of the image. The second step ('O') involves **O**rientation of the image (Fig. 4.13). The spinous processes of the thoracic spine can be used to instruct the radiographer to rotate the image clockwise or anti-clockwise until the correct orientation has been achieved. The third step ('A') requires the anaesthetist to temporarily stop ventilation (**A**pnoea). Finally, the last step ('X') is to proceed to **X**-ray. Once the IOC has been completed, the image(s) should be saved in the patient's electronic medical record for medico-legal purposes and maintaining accurate documentation. When reviewing the image, it is important to ensure that the whole biliary tree has been included and that there is passage of contrast into the duodenum (Fig. 4.14). The IOC is considered negative or normal when the presence of filling defects have been excluded. Figure 4.15 demonstrates a patient with metal implants, which can obstruct the view of the biliary tree during IOC. In such cases, the tilt of the operating table or C-arm can be adjusted to obtain clear views of the biliary tree.

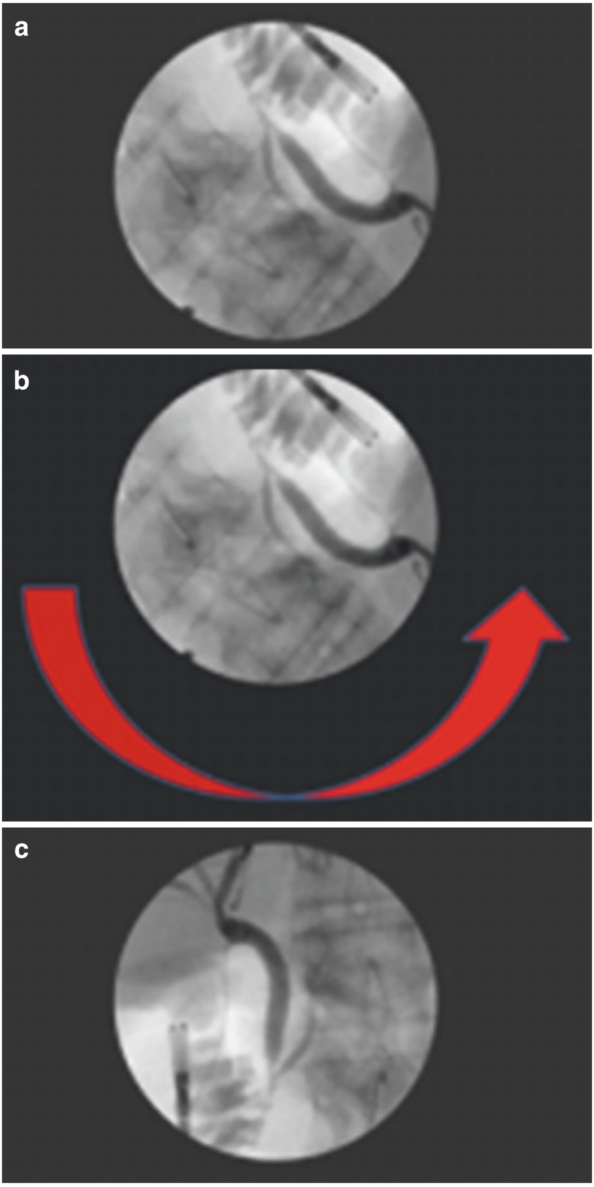


FIGURE 4.13 Orientation during intra-operative cholangiogram (A → B → C)

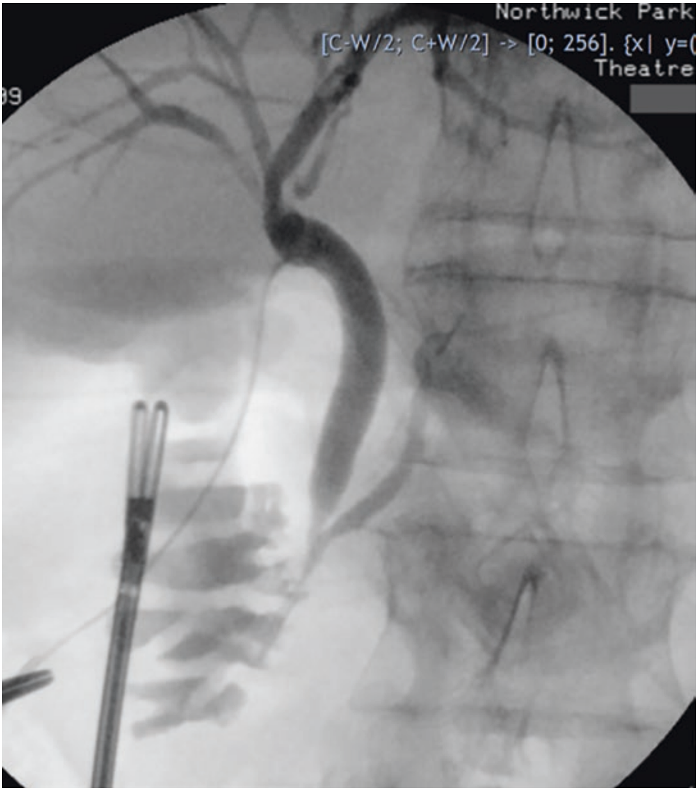


FIGURE 4.14 Intra-operative cholangiogram of the entire biliary tree within view

Not all radiolucent defects represent CBD stones. Filling defects caused by air bubbles are often more rounded, mobile and can change shape. In order to minimise its presence, care should be taken to check the syringe containing contrast to ensure there are no air bubbles that can inadvertently be injected into the biliary tree. More rarely, filling defects can correspond to anatomical artefact. Figure 4.16 displays an IOC with the appearance of a filling defect in the distal CBD in the vicinity of the ampulla (false-positive), caused by a thickened mucosal fold confirmed with 3 mm choledochoscopy.

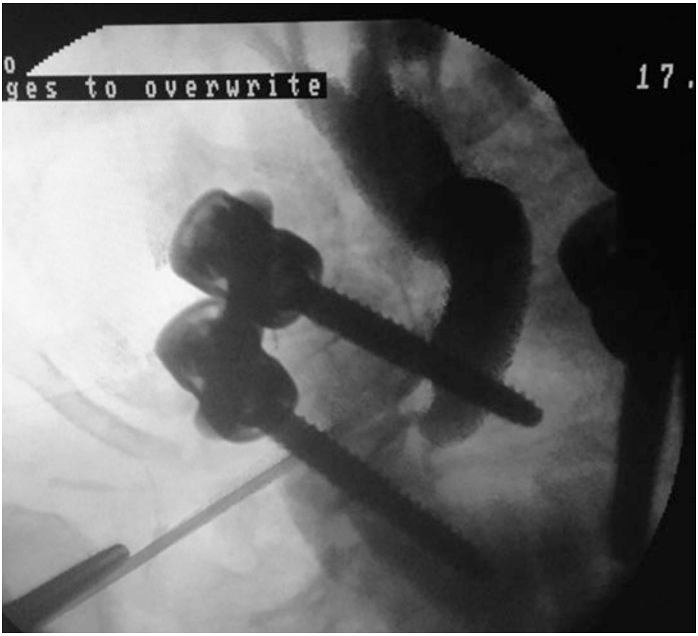


FIGURE 4.15 Metal implants can obstruct the view of the biliary tree during intra-operative cholangiogram

Figure 4.17 demonstrates another false-positive filling defect during IOC caused by a small blood clot, which was confirmed by 3 mm choledochoscopy. In the event of an equivocal IOC, we recommend proceeding to 3 mm transcystic choledochoscopy as this procedure does not add morbidity and is generally simple to perform once the cystic duct has already been cannulated as described previously. If a 3 mm choledochoscope is not available, another less invasive approach that can be used to exclude the presence of small distal stones during an equivocal IOC is the basket-in-catheter (BIC) technique [14]. For the BIC technique, a 5F cholangiogram catheter (Table 4.1, Serial 7) is employed as a working channel and a 2.4F basket is introduced into the duodenum. The basket, whilst in an open configuration, can

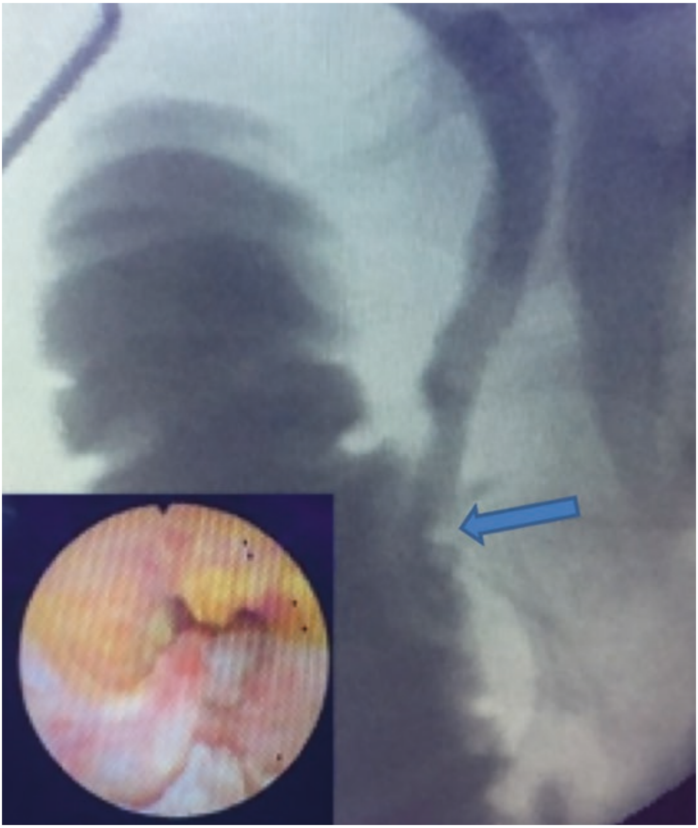


FIGURE 4.16 False-positive intra-operative cholangiogram caused by a thickened mucosal fold confirmed with choledochoscopy (inset)

then be withdrawn thereby trawling the duct. This manoeuvre can be repeated as necessary with or without IOC image guidance.

IOC supported by choledochoscopy can also help to further clarify the anatomy in unusual situations. Figure 4.18 demonstrates a variation in hepatic and cystic duct anatomy (joining duct). The entire biliary tree is filled with contrast from two different ducts, both of which were also communicating with the gallbladder. One was the cystic duct (blue)

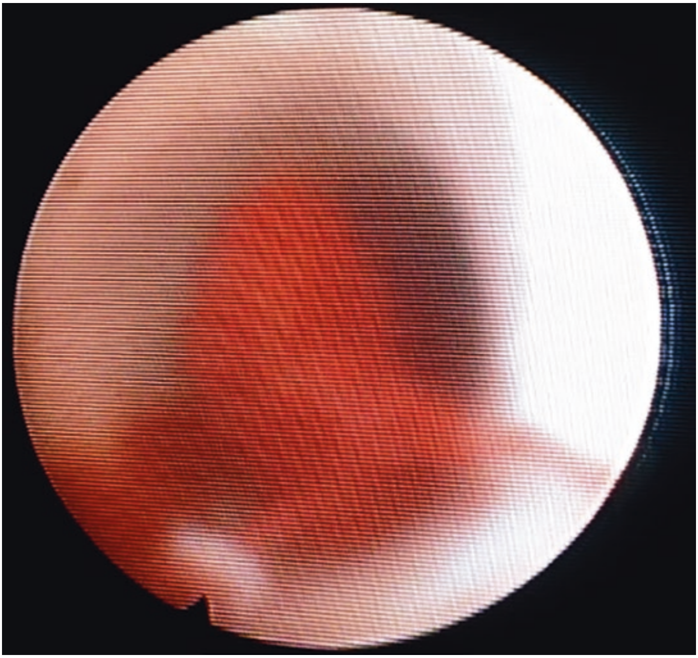


Figure 4.17 False-positive intra-operative cholangiogram caused by a blood clot within the common bile duct confirmed with choledochoscopy

and the other was a joining duct (red) that could have been wrongly classified as double cystic duct; joining ducts are those ducts connecting 2 parts of the biliary tree in this case the duct was connecting the gallbladder with the right posterolateral. Figure 4.19 shows an extrahepatic bifurcation of the common hepatic duct with the cystic duct draining into the right hepatic duct. This anatomical variant did not preclude LBDE via the transcystic route, but certainly would have made impossible the transcystic access to the left hepatic duct. The diameter of the CBD should be known preoperatively with imaging techniques but can also be measured intra-operatively with IOC and using a ruler (Fig. 4.1b).

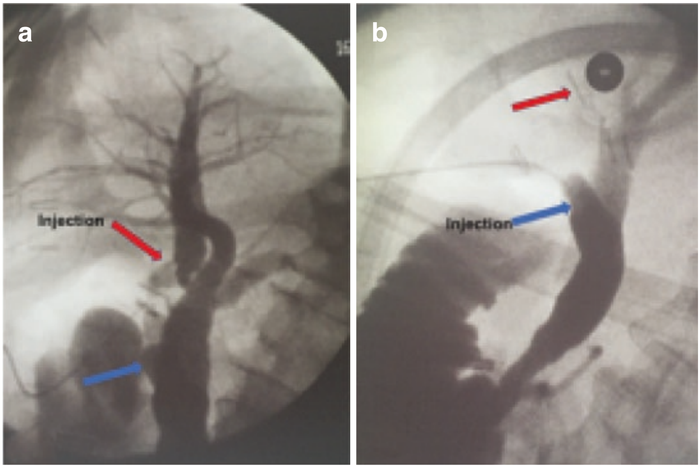


FIGURE 4.18 "Joining ducts"

FIGURE 4.19 Cystic duct draining into the right hepatic duct

Choledochoscopy

Once the cholangiogram has been completed and there is an indication for choledochoscopy, the size of the cystic duct needs to be assessed. If the cystic duct is not overtly dilated to allow the passage of the choledochoscope, a PTFE guidewire (Table 4.1, Serial 10) should be introduced through the cholangiogram catheter so its flexible tip lies within the bile duct or duodenum. The catheter can then be removed leaving the guidewire in situ. Next, the 9.5-12F ureteral access sheath (Table 4.1, Serial 6) is railroaded over the guidewire to gently dilate the cystic duct to allow passage of the 3 mm choledochoscope. Ideally the access sheath should approach the CBD at a right angle (perpendicular), but this may not always be possible in patients with a very narrow costal margin, and this will certainly make the cystic duct intubation more challenging. Figure 4.20 demonstrates the insertion of the 9.5-12F access sheath in the subcostal region of the right upper quadrant (left) and the introduction of the 3 mm choledochoscope through the access sheath, accessing the cystic duct at a right angle to the CBD (right). A full description of the surgical technique for choledochoscopy is provided in Chaps. 5 and 6.

When a proximal view of the intra-hepatic ducts is not possible during choledochoscopy (i.e. unable to intubate the common hepatic duct), then a completion cholangiogram is recommended. If this scenario is encountered during difficult cystic duct intubation, then the cholangiogram can be obtained via the choledochoscope prior to its removal, by injecting contrast through its working channel. This avoids removal of the choledochoscope, which is in a satisfactory position, and a challenging re-intubation that may be subsequently required (Fig. 4.21).

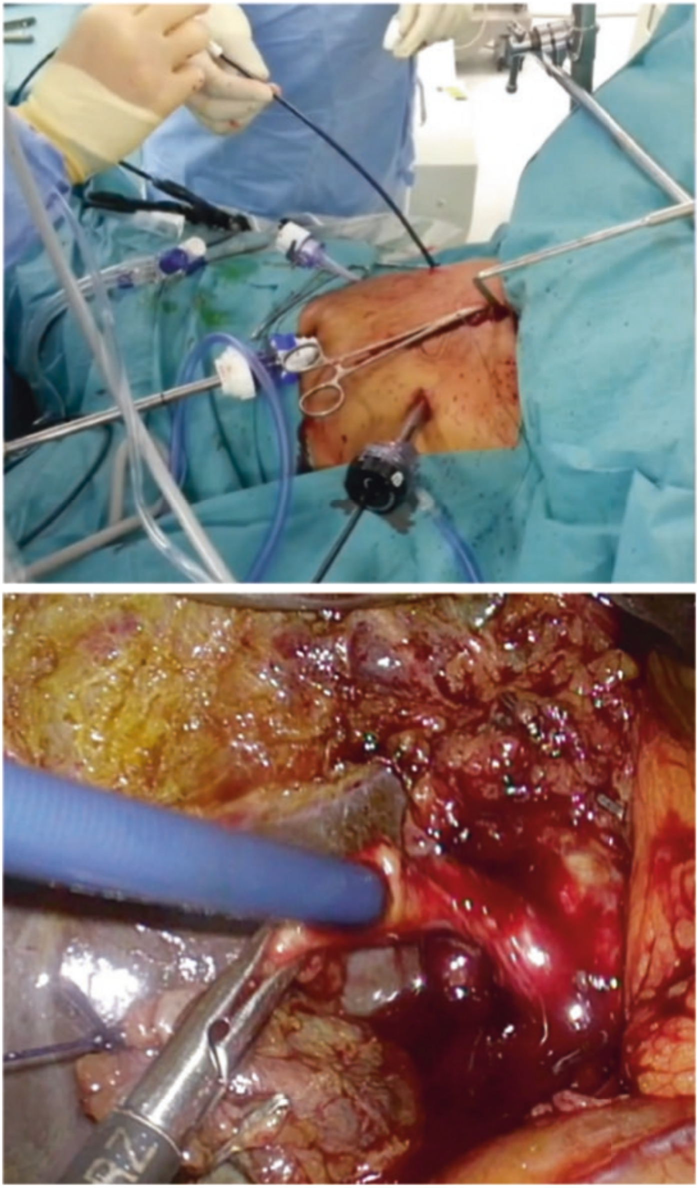


FIGURE 4.20 Transcystic cannulation with 3 mm choledochoscope

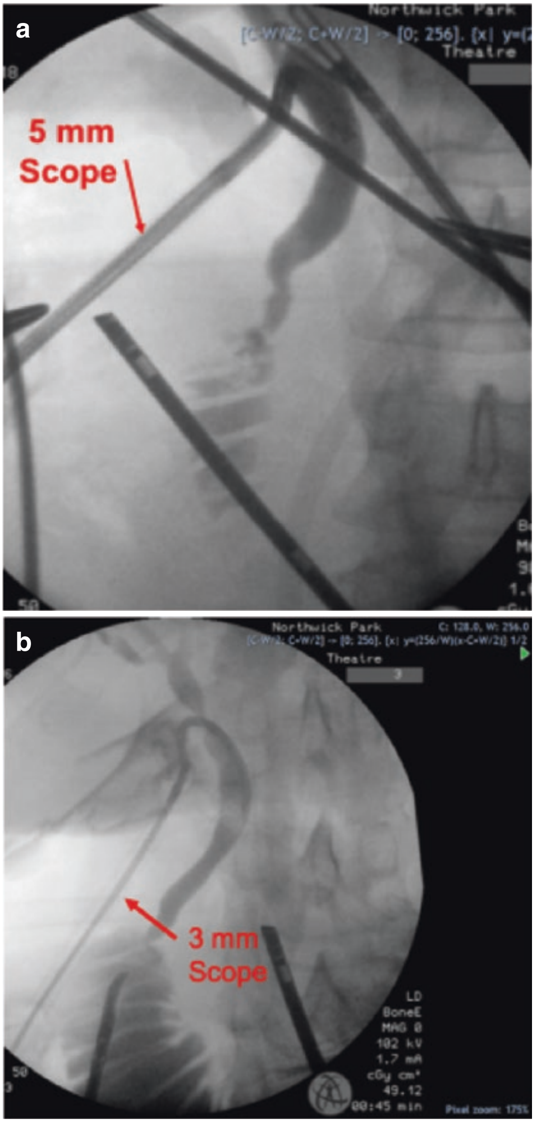


FIGURE 4.21 Transcystic choledochoscopy demonstrated on intra-operative cholangiogram. (**a**) 5 mm choledochoscope. (**b**) 3 mm choledochoscope

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