Chapter 3
Laparoscopic Biliary Ultrasound

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Laparoscopic intra-operative ultrasound (LUS) as a modality for investigating the bile duct in biliary surgery is gaining popularity for a number of reasons. It is rapid, gives accurate and reliable information for treatment and can provide significant advantages in efficiency of patient care.

Evidence shows that LUS is equally as sensitive and specific as MRCP or intra-operative cholangiogram in the detection and exclusion of bile duct stones [1–5]. The process of acquiring images using LUS is significantly quicker than x-ray cholangiogram [6], remains within the surgeon's control and negates the need for potentially dangerous radiation exposure. There is also a growing practice of using intra-operative LUS as an alternative to pre-operative MRCP in those patients who have indices to suggest synchronous common bile duct stones (CBDs) when presenting with symptomatic gallbladder stones. Currently in the UK 1/3 of the 66,000 patients undergoing Laparoscopic Cholecystectomy have a pre-operative MRCP; less than 10% of these patients will have CBDs [7, 8]. LUS can reliably identify and reassure these

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negative CBDs patients, those patients that have CBDs identified can proceed with treatment either with laparoscopic common bile duct exploration (LCBDE) or post-operative ERCP.

For those surgeons providing a LCBDE service, large amounts of information can be acquired from an LUS other than just exclusion of duct stones. When CBDs are identified, they can be measured in size and number, CBD diameter and cystic duct diameter can be measured, which provides decision making information for LCBDE in terms of trans-cystic vs choledocotomy. LUS naturally compliments a LCBDE service and once experienced it is quickly adopted as a standard of practice.

Equipment

Laparoscopic ultrasound machines are compact and mobile (Fig. 3.1). The probes come in two types, a fixed straight type and flexible type (Fig. 3.2), they most commonly use a linear array transducer and operate at a frequency of 4–10 MHz giving a typical tissue penetration of 3–8 cm, ample for detailed scanning of the porta hepatis and views through the pancreas of the intra-pancreatic portion of the CBD. The flexible type can have more applications for liver/pancreatic imaging, however some surgeons prefer the fixed type probe if to be used exclusively for CBD imaging to allow more controlled handling characteristics, although flexible probes have locking levers which emulates this to some degree. Probes all have common characteristics, they are real-time B-mode, providing high quality images, colour doppler capability is necessary in order to identify and navigate anatomy of the porta. A typical probe has a diameter of 10 mm to allow use down a standard size 11 mm epigastric port used in laparoscopic cholecystectomy, if you are using the American technique or the left upper quadrant port for those using the French technique. The probes are typically 40–50 cm long and can be place alongside other laparoscopic instruments making the LUS set-up very ergonomic and space efficient (Fig. 3.3).

FIGURE 3.1
Laparoscopic ultrasound machine

Probe sterility for each patient use can be either with a sheath cover (Fig. 3.4) and probes disinfected between patients, or formally sent away to the hospital sterilisation department between each use (Fig. 3.5). This is an important consideration when purchasing equipment volume, as if a formally sterilisation process is adopted several probes will need to be purchased (at least 5) in order to provide a continuous service for multiple patients on a list and morning/afternoon lists-(approximately 6 h turnaround time). It is important that you agree sterilisation protocols with your infection control department when deciding equipment numbers to purchase in your business case.

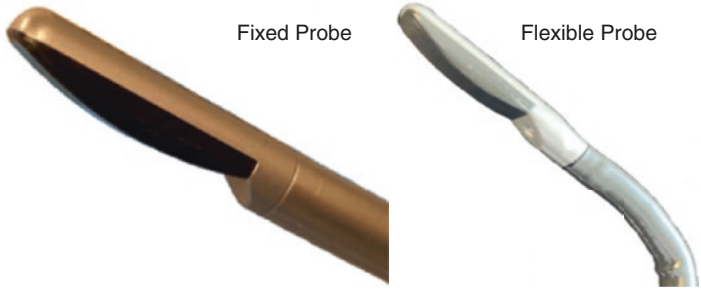


FIGURE 3.2 Laparoscopic ultrasound probes

FIGURE 3.3 Laparoscopic ultrasound used during laparoscopy

Principles of Imaging Acquisition

If using sheaths for probes it is important to remember that ultrasonic gel is placed within the sheath around the transducer head in order to breakdown density interface picture quality problems.

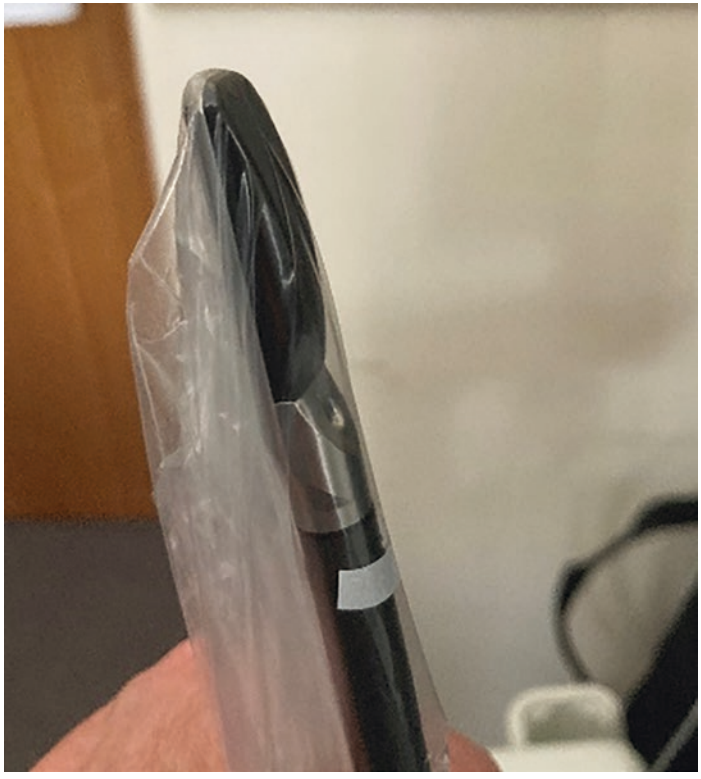


FIGURE 3.4 Laparoscopic ultrasound probe cover

The probe when inserted through the epigastric/left upper quadrant port will naturally rest on the porta hepatis in the short axis view to give cross-sectional view of the porta hepatis structures (Fig. 3.6). The ultrasound machine will rotate the image automatically so giving the user the impression that they are scanning the porta hepatis anteriorly to posterior (Fig. 3.6). This allows easier conceptualisation of imaging for the user.

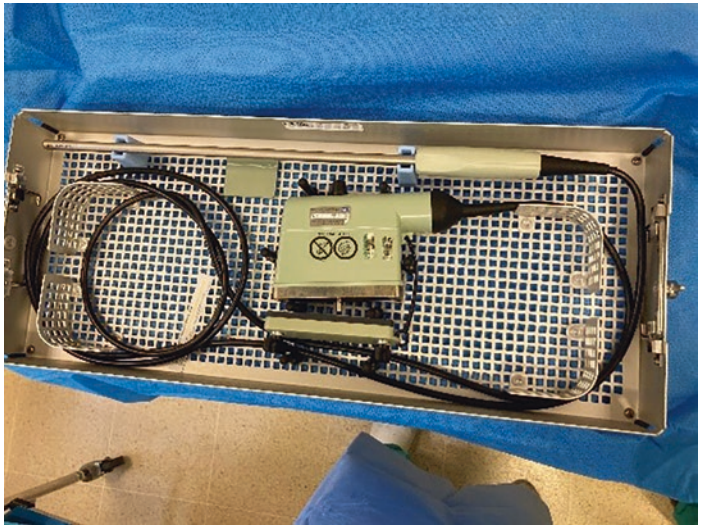


FIGURE 3.5 Laparoscopic ultrasound probe disinfected

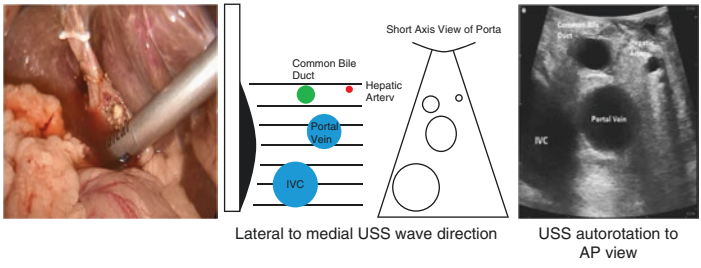


FIGURE 3.6 Laparoscopic ultrasound probe resting on porta hepatis and images obtained. Lateral to medial USS wave direction; USS autorotation to AP view

Principles and Technique of Picture Acquisition

Acquiring information from LUS about the biliary tree that you trust to make decisions about patient care comes from a combination of training and experience in practice. Attending a training course and mentorship is advised.

We would recommend dissection of Calots triangle first, clipping and division of the cystic artery prior to performing the LUS. This allows greater access to the biliary system and manoeuvrability with the ultrasound probe around the porta hepatis structures. LUS is not the best modality for defining unclear biliary anatomy, if there is uncertainty, x-ray cholangiogram provides the best conformation.

Like any ultrasonic device media density interface degrades picture quality due to reflection which you must be mindful of, often there is sufficient moisture from tissue dissection alone for a high-quality image. However poor image quality can be improved with saline infusion intra-peritoneally pooling in sub-hepatic space to breakdown unwanted acoustic reflection (sometimes patient will need to be levelled from head up position). The probe is positioned perpendicular to the hepatoduodenal ligament on the porta hepatis, the linear array probe should immediately produce a cross-sectional image of the porta hepatis, 'the mickey mouse' view (Fig. 3.7). Grasping the gallbladder fundus with the left hand can provide additional manoverability and clarity of porta hepatis by lateral traction. **The vascular structures of the porta provide the navigation markers for clear identification of the CBD**. The colour doppler is activated on the ultrasound machine and doppler signal is confirmed using the doppler signal box in both the larger posterior structure -portal vein (mickey mouse face) and normally in screen right position- hepatic artery (mickey mouse left ear). No significant doppler signal is seen in common bile duct (mickey mouse right ear)

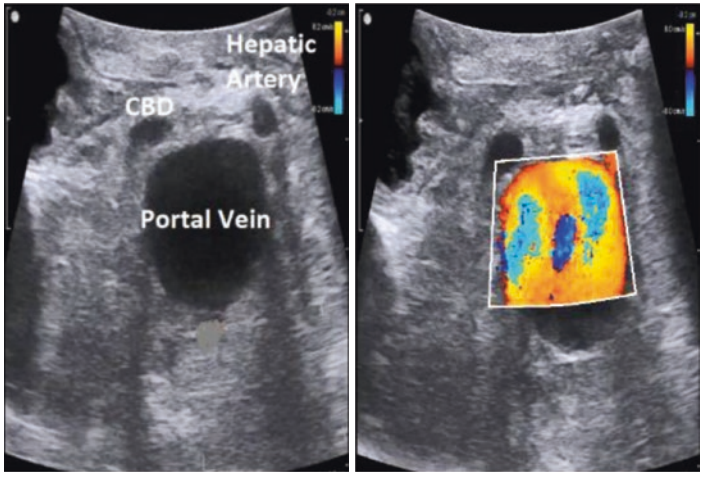


FIGURE 3.7 The 'Mickey Mouse' view

(Fig. 3.8). Structures can vary in size and relative position within the porta hepatis so it is important to start each scan with this orientation procedure to be sure it is the biliary ductal system you are identifying. If you become lost during the scan process then returning to this default start point is advised.

Once the CBD is identified the aim is to travel inferiorly down the supra-duodenal bile duct keeping it central in position on the ultrasound image. The probe should rest gently on the hepatoduodenal ligament otherwise the CBD will be compressed and obscured, to little pressure and the ultrasound window on the porta will narrow.

The aim is to slowly and carefully examine the entire biliary drainage system from hepatic ducts to ampulla. It is important while manoeuvring the probe that you try and stay in the short axis plane producing crisp cross-sectional images to allow accurate interpretation. This is achieved with a combination of probe insertion and withdrawal and wrist rotation and has a learning curve. As the distal CBD passes through

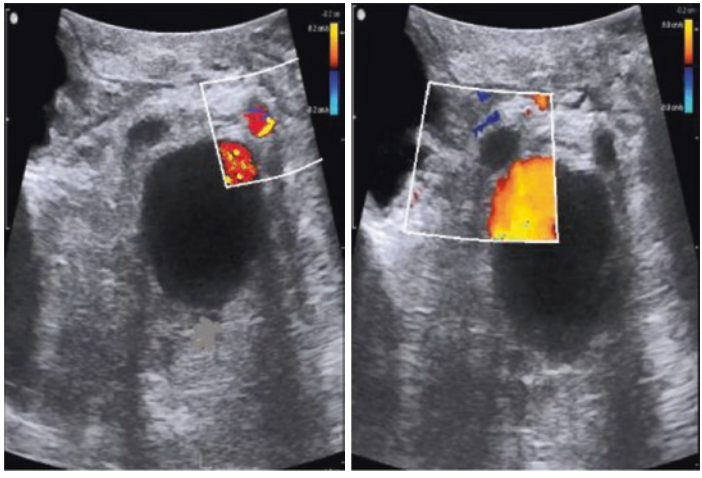


Figure 3.8 Identification of hepatic artery and common bile duct. Doppler Signal on Portal Vein; Doppler Signal Hepatic Artery; No Doppler Signal on CBD

the pancreas it angulates laterally to join duodenum, in order to stay in short axis view of the CBD, reasonably significant supination of the wrist is required in combination with downwards travel of the probe to correctly angle the transducer (Fig. 3.9: a–c).

A complete scan involves several components and anatomical land marks can assist with this, they include right and left hepatic ducts and their confluence to form the common hepatic duct. Cystic duct and common hepatic duct confluence to form the CBD and pancreatic duct confluence with the CBD at the ampulla. The CBD should be followed down to its termination at the ampulla. The intra-pancreatic portion of the bile duct can sometimes be more difficult to interpret due to the echogenic reflectivity of the pancreas which can be made worse in patients with recent pancreatitis. A transduodenal view can sometimes help in this scenario (Fig. 3.10).

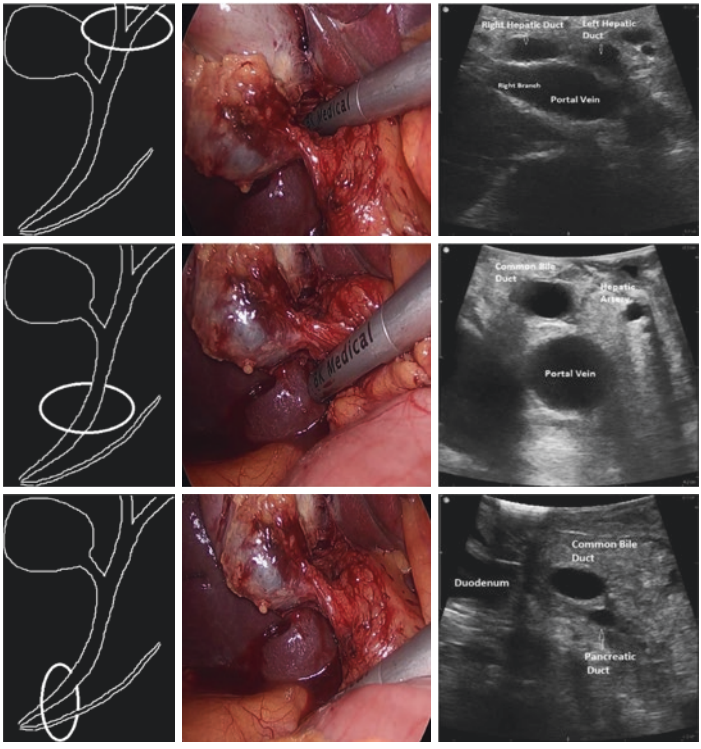


FIGURE 3.9 Downwards travel of the ultrasound probe; (**a**) Identification of left and right hepatic duct; (**b**) Identification of CBD 'Mickey Mouse View' (**c**) Identification of intra-pancreatic common bile duct and pancreatic duct

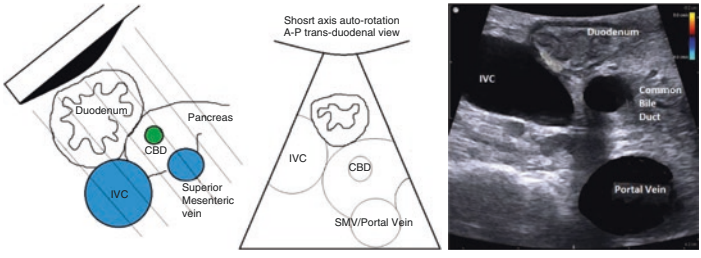


FIGURE 3.10 Trans-duodenal view of the common bile duct

Documentation and Pathology

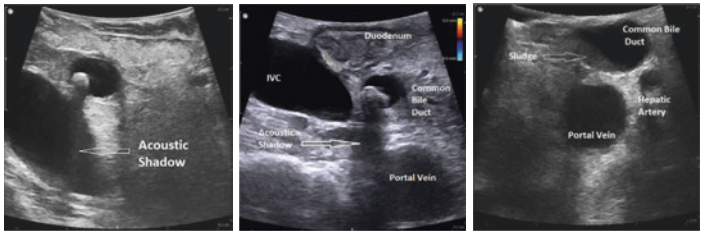
It is good practice to document structures seen and take a standard set of measurements to record in the operation note, this involves using the measurement calliper function of the ultrasound machine to document CBD dimeter distally and proximally. It advisable to discuss with your x-ray department about linking the captured images from the ultrasound machine to the hospital radiology archive system.

Stones within the duct seen are usually very obvious with the casting of an acoustic shadow (Fig. 3.11). Echogenic sludge is sometimes seen within the duct system defined by its more diffuse appearance and lack of acoustic shadow and is usually of little clinical consequence and a CBD flush is recommended.

If using LUS for LCBDE then useful information can be obtained for surgical planning such as size of stone, CBD diameter and cystic duct diameter if attempting trans-cystic exploration (Fig. 3.12).

Business Case

Although the initial cost of equipment can seem high, cost analysis shows that equipment costs are covered after the first 60–70 cases of use based on cost of pre-operative MRCP



Stone in CBD with acoustic shadow

Sludge in CBD without acoustic shadow

Figure 3.11 Stones with and without acoustic shadow. Stone in CBD with acoustic shadow; Sludge in CBD without acoustic shadow

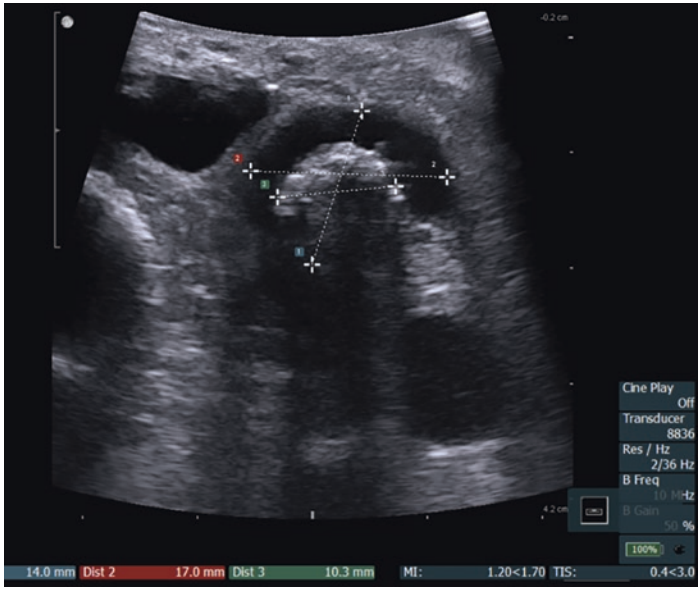


Figure 3.12 Assessing size stone

avoidance in both the inpatient or outpatient setting [9]. As patients presenting with symptomatic gallstones and synchronous deranged LFTs can procedure straight to surgery with the majority accurately reassured the bile duct is clear then emergency bed days can be saved through more efficient patient journey.

References

1. Costi R, Gnocchi A, Di Mario F, Sarli L. Diagnosis and management of choledocholithiasis in the golden age of imaging, endoscopy and laparoscopy. World J Gastroenterol. 2014;20(37):13382–401.
2. Aziz O, Ashrafian H, Jones C, Harling L, Kumar S, Garas G, et al. Laparoscopic ultrasonography versus intra-operative cholangiogram for the detection of common bile duct stones during laparoscopic cholecystectomy: a meta-analysis of diagnostic accuracy. Int J Surg. 2014;12(7):712–9.

3. Halpin VJ, Dunnegan D, Soper NJ. Laparoscopic intracorporeal ultrasound versus fluoroscopic intraoperative cholangiography: after the learning curve. Surg Endosc. 2002;16(2):336–41.
4. Perry KA, Myers JA, Deziel DJ. Laparoscopic ultrasound as the primary method for bile duct imaging during cholecystectomy. Surg Endosc. 2008;22(1):208–13.
5. Machi J, Oishi AJ, Tajiri T, Murayama KM, Furumoto NL, Oishi RH. Routine laparoscopic ultrasound can significantly reduce the need for selective intraoperative cholangiography during cholecystectomy. Surg Endosc. 2007;21(2):270–4.
6. Jamal KN, Smith H, Ratnasingham K, Siddiqui MR, McLachlan G, Belgaumkar AP. Meta-analysis of the diagnostic accuracy of laparoscopic ultrasonography and intraoperative cholangiography in detection of common bile duct stones. Ann R Coll Surg Engl. 2016;98(4):244–9.
7. CholeS Study Group WsMRC. Population-based cohort study of outcomes following cholecystectomy for benign gallbladder diseases. Br J Surg. 2016;103(12):1704–15.
8. Sinha S, Hofman D, Stoker DL, Friend PJ, Poloniecki JD, Thompson MM, et al. Epidemiological study of provision of cholecystectomy in England from 2000 to 2009: retrospective analysis of hospital episode statistics. Surg Endosc. 2013;27(1):162–75.
9. Donoghue S, Jones RM, Bush A, Srinivas G, Bowling K, Andrews S. Cost effectiveness of intraoperative laparoscopic ultrasound for suspected choledocholithiasis; outcomes from a specialist benign upper gastrointestinal unit. Ann R Coll Surg Engl. 2020; https://doi.org/10.1308/rcsann.2020.0109.