Chapter 10
Laparoscopic Biliary Ultrasound

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Introduction

Laparoscopic cholecystectomy has resulted in a dramatic reduction of the medical resources required to treat gallbladder disease. However, the rates of postoperative biliary complications and reintervention remain higher than that seen in the era of open operation [1–4]. Global efforts to reduce bile duct injury (BDI) via education of the Critical View of Safety [5] have mixed results. Survey data indicate that the majority of surgeons do not correctly interpret the Critical View of Safety [6, 7], yet population data suggests that the incidence of major BDI is indeed finally decreasing [8].

An analysis of BDI indicate that surgeon perceptual errors are the leading root cause of injury [9], and the SAGES Safe Cholecystectomy Task Force recognized both performance of the Critical View of Safety and understanding of the relevant

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anatomy as the top factors associated with safety in the laparoscopic cholecystectomy operation [10]. Cholangiography has been associated with improved surgeon recognition of biliary anatomy and is now available via techniques of contrast radiography, near-infrared fluorescence imaging, and ultrasonography, among others. Based on surgeon survey data and population data, contrast cholangiography is performed in approximately 10% of operations nationwide and intraoperative biliary ultrasound performed in less than 1% of cholecystectomy operations nationwide [3, 6, 11].

Approximately 8–10% of patients presenting with gallbladder disease have concomitant symptomatic common duct stones [12], and when prospectively studied, an additional 3–5% have silent common duct stones [13]. The natural history of retained silent common duct stones after cholecystectomy is that approximately half become symptomatic [14, 15]. The wide availability of endoscopic retrograde cholangiopancreatography (ERCP) has decreased the consequences of retained common bile duct stones after cholecystectomy. However, it has been proposed through decision analysis that laparoscopic intraoperative ultrasound is the most effective tool to reduce the incidence of reintervention after cholecystectomy [16].

The effectiveness of intraoperative biliary ultrasound has been examined on many fronts. Intraoperative biliary ultrasound has been found – relative to contrast cholangiography – to be more cost-effective, faster, more specific for identification of common duct stones, less invasive, and without risk of irradiation [17–21]. Additional benefits of biliary ultrasound include identification of aberrant hepatic vascular and biliary anatomy and utility both before and after dissection. However, the utilization of intraoperative biliary ultrasound remains low, largely due to the misperception of a difficult learning curve.

This chapter will describe the technique for ultrasound scanning during cholecystectomy, with emphasis on the fundamentals of scanning technique and the core steps of ultrasound cholangiography. It is the author's and other's experience that the number of intraoperative biliary ultrasound procedure required to achieve proficiency is approximately ten cases [22, 23].

Device Setup

The author prefers the ultrasound device to be located at the patient's left arm, with the ultrasound scanning head draped and placed on a Mayo stand until needed. The ultrasound computer processing unit (CPU) is configured with the tip of the ultrasound probe at the screen left, so that transverse images of the porta hepatis are displayed with the patient's right at the screen left. This image orientation is based on CT scan appearance and should be familiar to all physicians. The B (brightness) mode, or 2D mode, is utilized primarily, although C mode (color flow Doppler) and pulsed-wave Doppler mode are used to confirm vascular structures. It is imperative that – prior to operation – the surgeon rehearse with the surgical support team how to navigate the CPU to freeze and unfreeze, measure with calipers, print or save images, navigate between modes, and adjust the gain and depth of image.

Device scanning heads may be of linear or convex array construction. Linear array is superior for near-field applications, and convex array is superior for far-field imaging, but either may be used successfully for biliary ultrasound. The author prefers to use the scanning head inside a latex rubber sleeve with sterile viscous gel to improve near-field imaging by increasing effective contact surface and allowing more rapid turnover of the device if needed.

Scanning Technique

The author uses a traditional four-port laparoscopic technique, with a 12 mm trocar in the epigastrium to pass the scanning head. Although several reports document effective and accurate biliary ultrasound before any dissection, it is the author's preference to use the ultrasound device after preliminary dissection, including release of the lateral and medial attachments of the gallbladder to expand the hepatocystic triangle. Because ultrasonic waves cannot pass through impacted stones at the gallbladder infundibulum or cystic duct, it is the author's experience that preliminary dissection separates stones at the gallbladder infundibulum from the porta hepatis and enables a more reliable ultrasound image.

Passing the ultrasound device through the epigastric port, the surgeon first obtains a transverse image of the porta hepatis and should identify the so-called Mickey Mouse (Fig. 10.1), with the portal vein representing the head, and the common bile duct (CBD) and proper hepatic artery (HA) representing the screen left and right ears, respectively. Optimal tissue contact occurs with the ultrasound probe at an oblique angle,

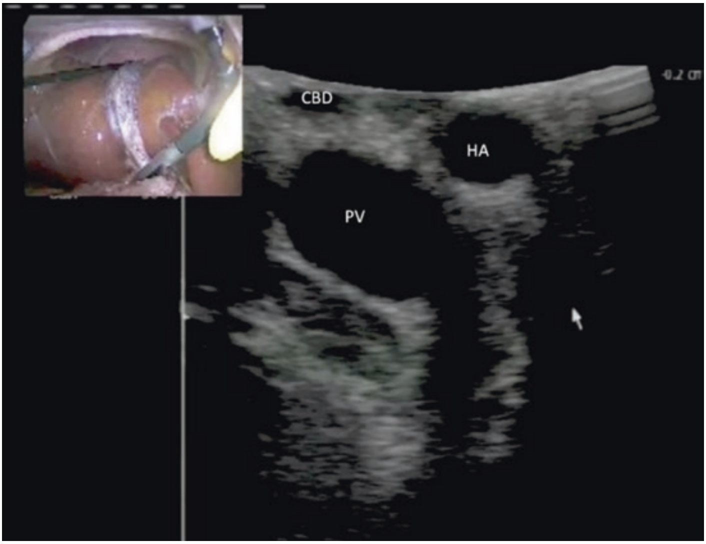

Figure 10.1 Inset demonstrates oblique view of the porta hepatis, yielding a tilted "Mickey Mouse" image. *HA* hepatic artery, *CBD* common bile duct, *PV* portal vein

creating a tilted Mickey image. Color flow mode or pulsed-wave mode is performed to confirm anatomy, with no flow detected in CBD, continuous flow in the portal vein, and pulsatile flow in the hepatic artery (Fig. 10.2). An accessory right hepatic artery appears as an additional screen left ear lateral to the CBD (Fig. 10.3), and a replaced common hepatic artery appears as a right-left reversal of the vascular flow in the ears (no flow in the screen right ear). Variation of vascular anatomy is identified in approximately 15% of patients.

Once the CBD is identified, the CBD can be traced through the intrapancreatic duct down to the ampulla and back up to the hepatic duct-cystic duct junction. The cystic duct is followed to confirm it definitively enters the gallbladder and is not an aberrant right hepatic duct. The hepatic duct is followed up to the biliary bifurcation at the hilum. Scanning technique for following the CBD in the intrapancreatic portion of the duct must be adapted to the quality of the surrounding duodenal and periduodenal fatty tissues.

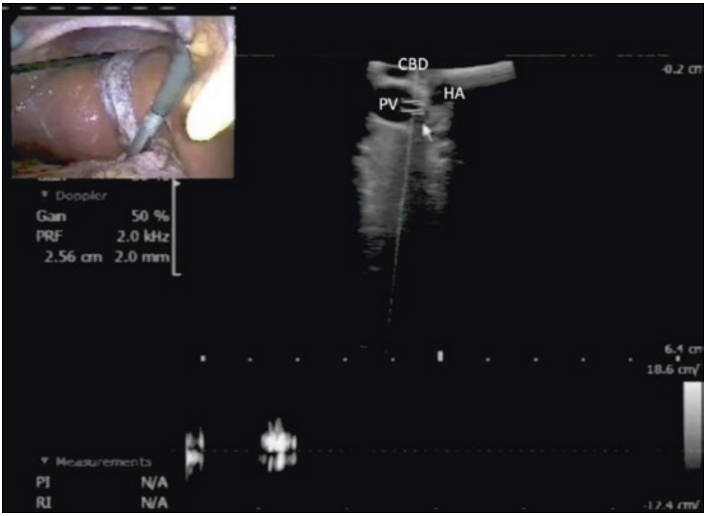

FIGURE 10.2 Pulsed-wave mode imaging demonstrates cursor in the portal vein. Cursor was previously in CBD and showed no flow

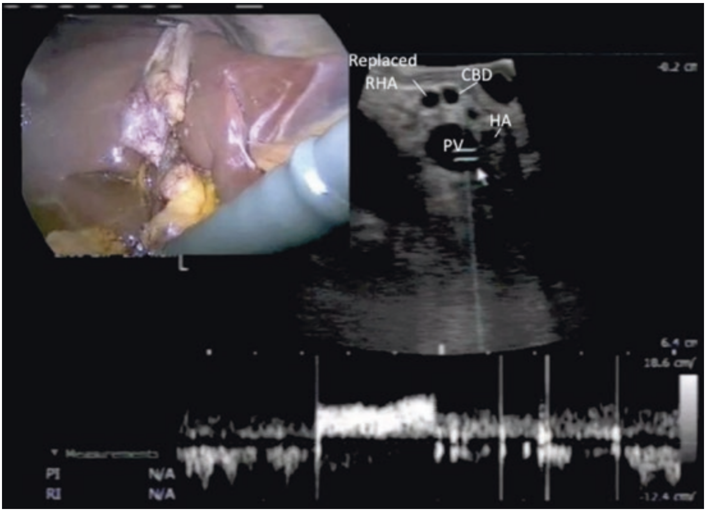

Figure 10.3 Hepatic vascular anatomical variation is identified in approximately 15% of patients at biliary ultrasonography. This image demonstrates replaced right hepatic artery at the level of the porta hepatis. *RHA* replaced right hepatic artery

In the majority of cases, the optimal view is obtained by flattening the tip of the probe to horizontal, sliding the probe tip onto the duodenum and obtaining an axial view of the pancreatic head and CBD. However, in some cases, the anterior duodenum is filled with air, or has inflammatory fat anteriorly, which distorts the imaging of deeper tissues. In such cases, the optimal view is obtained by making the probe tip vertically oriented, placing the probe in the crotch between the duodenal bulb and lateral porta hepatis, and rotating the probe tip to obtain a sagittal view of the pancreatic head and CBD. The surgeon should become familiar with each of these imaging techniques.

Once the biliary tree can be well visualized, the surgeon should confirm or develop the plan for safe division of the cystic duct. The biliary tree should be scanned for anatomical variations and filling defects, which the author has identified in approximately 40% and 12% of cases, respectively. The most common anatomical biliary variation is the insertion of the cystic duct into the hepatic duct. Abnormalities include a short cystic duct, parallel ducts sharing a common wall, and spiral insertion of the cystic duct into the medial wall of the hepatic duct. Filling defects include biliary sludge, stones, endoscopically placed stents, and even soft tissue defects such as neoplasms of the biliary tree.

Biliary sludge creates the ultrasound image of hyperechoic material, which layers posteriorly in the duct and does not cast a sonographic shadow. Sludge can be distinguished from biliary stones, which only leave an image of the leading edge of the stone and which cast a sonographic shadow. The stones can be measured, and if the surgeon and operating room are prepared for laparoscopic duct clearance, this can be performed when the surgeon believes the stone poses a high risk of non-passage (Fig. 10.4). The author prefers to measure the

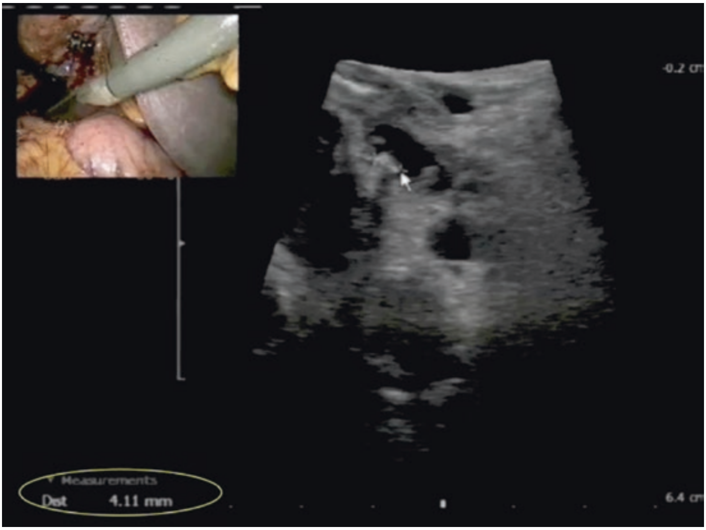

FIGURE 10.4 CBD stone imaged as hyperechoic edge of filling defect with acoustic shadow. Calipers are placed on the edge of stone and stone measured at 4.1 mm. This stone was removed at operation by transcystic choledochoscopy

CBD just caudal to the cystic duct-hepatic duct junction. Photo documentation of images of the biliary ultrasonography, including CBD size and any imaged abnormality, enables billing of the procedure as limited ultrasound exam for guidance of the cholecystectomy procedure.

Conclusion

The major limitation in most major medical centers to surgeon performing biliary ultrasonography is surgeon willingness to learn the scanning technique. Once it is established that the surgeon can have an ultrasound device available for cholecystectomy operations, it should not require additional credentials or training to begin utilizing biliary ultrasonography. Although it is debated whether intraoperative duct clearance, expectant management, or immediate postoperative ERCP is the optimal management for those at risk of symptomatic choledocholithiasis, it should be clear that biliary ultrasonography is the optimal technique for identifying choledocholithiasis during cholecystectomy.

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