Emergency Biliary Ultrasonography
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INTRODUCTION

Hepatobiliary disease is a common cause of abdominal pain in patients evaluated in the emergency department. Cholelithiasis is present in 20 to 25 million of Americans, which represents 10% to 15% of the adult population. Cholecystectomy has become the most common elective abdominal surgery performed in the United States. Significant clinical symptoms, however, do not develop in the majority of patients (up to 80%) with gallstones. Both the prevalence and the complication rate of cholelithiasis increase with age. Biliary infection is a common cause of abdominal sepsis in the elderly.

Ultrasound is the initial imaging modality most commonly used for hepatobiliary evaluation in cases of suspected cholecystitis and biliary obstruction. Timely comprehensive sonographic evaluation is not always available in the emergency setting, and an increasing number of emergency providers use point-of-care biliary sonography to rapidly evaluate symptomatic patients for the presence of cholelithiasis and its complications.

Evaluation of elderly patients with suspected biliary sepsis is frequently complicated by altered mental status. In contrast to younger patients, sepsis from ascending cholangitis may be accompanied by atypical or vague clinical findings. Focused ultrasound is a valuable tool that can quickly evaluate the hepatobiliary tract and expedite appropriate treatment and disposition when signs of biliary infection are found.

Bedside ultrasound is also a useful adjunct to the emergency physician for certain patients with chronic hepatic disease. Ultrasound can quickly evaluate for the presence of ascites and provide procedural guidance for paracentesis.

REVIEW OF LITERATURE ON EVALUATION FOR CHOLECYSTITIS

Clinical findings and laboratory data lack acceptable sensitivity to rule out cholecystitis, which has led to the need for abdominal imaging to aid in determining the patient’s disposition. Commonly used imaging modalities to evaluate for cholecystitis and its complications are ultrasound, computed tomography (CT), and cholescintigraphy or hepatobiliary iminodiacetic acid (HIDA) scanning. The sensitivity and specificity of ultrasound for the detection of cholelithiasis can approach 100% for providers with significant ultrasound experience. CT is much less sensitive than ultrasound for detecting cholelithiasis and misses up to 25% of gallstones. HIDA scanning has been reported to have high sensitivity for acute cholecystitis, but it does not provide an adequate structural evaluation of the hepatobiliary system. HIDA scanning also has limited availability in many locations and is not a practical screening modality in the emergency department setting. These distinctions make ultrasound the imaging modality of choice for the initial evaluation of patients with right upper quadrant pain and suspected cholecystitis.

Emergency physicians have demonstrated the ability to effectively learn to perform point-of-care bedside hepatobiliary ultrasonography. Studies on emergency physician–performed biliary sonography have demonstrated sensitivities and specificities of up to 92% and 87% for the detection of cholelithiasis.
CHAPTER 45  EMERGENCY BILIARY ULTRASONOGRAPHY

BILIARY DUCT EVALUATION

Transabdominal ultrasound is the initial imaging modality used to evaluate for suspected choledocholithiasis and obstruction of the biliary ducts. In the western world, gallstones are the most common cause of both biliary obstruction and cholangitis.\textsuperscript{11,12} Even with the most advanced equipment, the sensitivity of ultrasound in detecting choledocholithiasis is still essentially dependent on the examiner’s proficiency and can range between 22% and 100%.\textsuperscript{3,11,13-15} Specific data on the accuracy of emergency medicine physicians’ performance in detecting choledocholithiasis are not yet available and need further investigation. The overall specificity of transabdominal sonography for detection of common bile duct (CBD) stones is usually very high and ranges between 95% and 100%.\textsuperscript{11}

PATIENT POSITIONING

Imaging begins with the patient in a supine position, but it should be acknowledged that repositioning the patient is required in many cases to obtain the views needed. Rolling the patient to the left lateral decubitus position can help displace the bowel and reduce interference from bowel gas. In some cases, rolling a patient to a semiprone position or having the patient stand up may further facilitate image acquisition. If possible, the patient should elevate the right arm above the head to improve the sonographic accessibility of the inferior liver and for transthoracic scanning.

INSPIRATORY TECHNIQUES

Having patients hold their breath after a full inspiration is also a useful technique. This pushes the liver inferiorly and may aid in displacing the overlying bowel. The liver also provides a friendly imaging window. However, breath-holding can increase air in the antrum, pylorus, and duodenum, which can interfere with the ability to visualize the gallbladder. In general, in the beginning of the examination it is often better to place the probe over the anatomic area of interest and review structures of interest as they are pushed in and out of the sonographic field via the normal respiratory cycle. Once the patient initiates breath-holding, air swallowed into the antrum will quickly move with peristalsis and may obscure areas of interest.

SYSTEMATIC SCANNING APPROACH

Significant anatomic variability, interference from adjacent bowel, and variations in the amount or overlying tissue can make localization of the gallbladder a difficult task. Gallbladder imaging is best approached as a dynamic process, and the sonographer should be prepared to try different imaging windows and repositioning of the patient as needed to obtain the appropriate images.

The authors suggest the following systematic approach:

1. The patient is placed in a supine position with the right arm raised above the head. To begin the examination, the
sonographer should imagine a line that connects the patient’s umbilicus and right shoulder. The probe is placed immediately below the intersection of this line with the right inferior costal margin. The probe is placed parallel to the rib in about 45 degrees of angulation (see Fig. 45.1).

2. If the liver and aspects of the gallbladder are not in the visual field, the probe is fanned cephalad and caudal. If the gallbladder is still not visualized, the probe should be moved slowly along the inferior costal margin while repeating the fanning motion upward and downward and moving the probe laterally and medially.

3. If no liver tissue or gallbladder can be visualized along this inferior margin, the probe is moved one intercostal space up and placed in the same position where the line between the umbilicus and right shoulder intersects with now the last intercostal space. The probe is angled 60 to 90 degrees (Fig. 45.2). Next, the fanning maneuver is repeated and the probe moved within this intercostal space medially and laterally. The process is repeated in next intercostal space if needed.

4. If unsuccessful, the transducer is placed in a modified focused abdominal sonography for trauma (FAST) view. Instead of angling down to the retroperitoneal location of the kidney, the transducer is angled up toward the tip of the liver, and the lateral margin of the liver is scanned until the gallbladder is located.

5. If unsuccessful after steps 1 to 4, the patient is placed in the left lateral decubitus position and steps 1 to 4 are repeated.

6. Finally, if feasible, have the patient stand up, which often drops the liver and gallbladder more caudally and makes them more accessible for sonography.

**GALLBLADDER EVALUATION**

After locating the gallbladder, the probe is rotated clockwise and counterclockwise as needed to obtain a longitudinal (long-axis) view (Fig. 45.3). Next, the probe is moved medially and laterally to evaluate the entire gallbladder in long axis. A normal gallbladder has echogenic walls with an anechoic internal cavity. The gallbladder should be thoroughly evaluated for the presence or absence of cholelithiasis. Special attention should be paid to the gallbladder neck for impacted stones.

Following long-axis evaluation, the probe is rotated 90 degrees to the patient’s right (the indicator is rotated 90 degrees counterclockwise), which will give a transverse or short-axis view of the gallbladder (see Fig. 45.3). The probe should be angled or moved cephalad and caudal to evaluate the entire gallbladder. The gallbladder is scanned from the fundus to the neck. Again, particular attention should be directed to the gallbladder neck. Air artifact can obscure small stones in this area.

The next step should be to measure the thickness of the gallbladder wall (Fig. 45.4). Transmission of ultrasound waves through the fluid-filled gallbladder leads to enhancement of the posterior gallbladder wall, and posterior enhancement can result in overestimation of wall thickness. Hence, measurements are obtained at the anterior wall. Thickness of the anterior wall greater than 3 mm is considered abnormal.18 One should be aware that isolated increased gallbladder wall thickness is not a sensitive finding for detecting acute inflammation because it can be caused by multiple disease processes (e.g., chronic cholecystitis, ascites, hepatitis).19 Next, the area encompassing the gallbladder should be evaluated for the
presence of pericholecystic fluid. This finding will appear as anechoic areas adjacent to the gallbladder. Pericholecystic fluid with septations, internal echoes, or thick walls may suggest perforation of the gallbladder with abscess formation.18

Finally, one should evaluate for a sonographic Murphy sign, which is defined as reproducible tenderness when transducer pressure is applied with the gallbladder in direct view. Correct evaluation for the Murphy sign includes repeating this maneuver on both the left and right sides next to the gallbladder, but with the gallbladder out of the visual field. With a true Murphy sign, tenderness or discomfort in areas away from the gallbladder should be significantly less.18

COMMON BILE DUCT
Locating the Common Bile Duct
The CBD is approximately 4 cm long and intimately associated with the portal vein and hepatic artery in the portal triad. Several approaches can be used to locate this structure. First, one can attempt to find the portal triad. The CBD is located ventral to the portal vein and lacks flow with Doppler imaging. One method to locate the portal triad is to follow the intrahepatic portal vein branches to the liver hilum and main portal vein. The CBD can also be found when following the neck of the gallbladder or the main lobar hepatic fissure toward the hepatic hilum. If the proximal portion of the CBD is difficult to assess, the distal part can be located when scanning the pancreatic head and the duct can then be traced back along the portal vein.

Evaluation of the Common Bile Duct
Once located, the sonographer should interrogate the portal triad with color Doppler to distinguish the CBD from the vessels. The hepatic artery and the portal vein should demonstrate flow, whereas the CBD will not (Fig. 45.5). In patients with sluggish portal flow, the sensitivity of the color or power Doppler settings should be adjusted until the vessels can be distinguished from the CBD. This should be carefully evaluated with a steady hand because motion artifact may produce the illusion of flow with more sensitive Doppler settings. Once the CBD is identified, it should be measured inner wall to inner wall in the transverse plane (Fig. 45.6).

CBD diameter sizes of 1 mm per decade of life and CBD measurements of up to 1 cm following cholecystectomy have traditionally been accepted as normal.20 Measurements of CBD diameter accepted as normal range from 6 to 8 mm, with 7 mm commonly recognized as the upper limit of normal CBD size.21,22

More recent studies, however, do not correlate with the extent of traditionally expected increases in size in elderly and postcholecystectomy patients. A large study of patients older than 60 years found that mean bile duct size increases from

Fig. 45.4 Measuring gallbladder wall thickness. Wall thickness is measured at the anterior wall of the gallbladder in transverse (preferred, A) or longitudinal (B) view.

Fig. 45.5 Common bile duct (CBD) in transverse view (A) showing no flow with Doppler (B, white arrow).
3.6 ± 0.26 mm at 60 years of age to 4 ± 0.25 mm in patients older than 85. Interestingly, 98% of ducts were less than 7 mm in diameter. Additionally, two large studies of patients undergoing cholecystectomy revealed postsurgical mean CBD diameters of 3.96 mm and 6.1 mm, respectively.

**MAIN LOBAR FISSURE**
The gallbladder and the hepatic hilum are connected by the hepatic main lobar fissure (Fig. 45.7). Sonographically, it appears as a bright echogenic structure, relative to the adjacent liver, because of its fibrous content. It is a useful landmark that can be followed away from the gallbladder to locate the portal triad. Conversely, it can be traced from the portal triad to locate obscure gallbladders.

**COMMON OBSTACLES AND TIPS**

**Obesity**
Obesity often increases the depth needed to reach the structures of interest, which decreases the quality of the images. For obese patients, one should consider using a lower-frequency probe or changing to lower-frequency settings to increase tissue penetration.

**Bowel Gas**
The acoustic mismatch that occurs when bowel gas is encountered creates artifacts that prevent the user from visualizing distal structures. If bowel gas interferes with the sagittal imaging technique mentioned earlier, the transducer can be moved laterally to a near-coronal or coronal imaging plane (step 4 above). From this location, the liver can be used as an acoustic window to locate the gallbladder. Imaging from a coronal plane may be complicated by interference from rib shadowing. Having the patient take several sips of water, if possible, may also help displace gas in the small bowel within the upper gastrointestinal tract. After waiting 15 to 30 minutes, peristalsis may create changes in the bowel gas and better imaging windows may be found.

**Postprandial Patients**
Postprandial patients typically have a contracted gallbladder, which makes evaluation of wall thickness unreliable (Fig. 45.8). Contracted gallbladders can also be more difficult to locate.

**IMAGES—NORMAL AND ABNORMAL**

**CHOLELITHIASIS**
Gallstones tend to be rounded, mobile structures found in a dependent position. They have a highly reflective surface, which leads to visualization of a curved echogenic surface and shadowing posterior to the gallstone (Fig. 45.9). An attempt should be made to confirm that the gallstones identified are mobile and not impacted.

**ACUTE CHOLECYSTITIS**
Components of the focused sonographic examination for suspected cholecystitis are listed in Box 45.1. Because no single sonographic finding is diagnostic of cholecystitis, the ultrasound findings must be interpreted in conjunction with the clinical picture and laboratory data. The absence of cholelithiasis combined with a negative sonographic Murphy sign has a negative predictive value of 95%. When cholelithiasis is identified, its positive predictive value is increased in the
The presence of gallbladder wall thickening (95%) or a positive sonographic Murphy sign (92.2%). Pericholecystic fluid is also a common finding in patients with acute cholecystitis (Fig. 45.10).

**Cholecystitis Variants**

Emphysematous cholecystitis occurs when the gallbladder is infected with a gas-producing organism. Focal areas of gas and its characteristic appearance of small, hyperechoic areas with reverberation artifacts can be identified within the gallbladder wall (Fig. 45.11). This can be difficult to differentiate from overlying bowel in some cases. Less than 10% of cases

**BOX 45.1 Components of Focused Hepatobiliary Sonography for Suspected Cholecystitis**

Evaluate for cholelithiasis
Measure the anterior gallbladder wall
Measure the common bile duct
Evaluate for pericholecystic fluid
Evaluate for a sonographic Murphy sign
INTRAHEPATIC BILIARY DUCT DILATION AND COMMON BILE DUCT STONES

Dilation of the intrahepatic biliary ducts (Fig. 45.15) suggests ductal obstruction, although it is not diagnostic of a specific etiology. Obstruction has multiple causes, including choledocholithiasis (most common in the western world; Fig. 45.16), biliary duct stricture, ductal edema (as seen with Mirizzi syndrome), and compression from pancreatic masses.

When dilation of the CBD is found, the duct should be followed as far medially as possible to search for choledocholithiasis. Scanning through the liver may also reveal intrahepatic ductal dilation. Sensitivity is significantly dependent on operator performance and ranges from 25% to 100%.

CHOLANGITIS

Cholangitis is due to a combination of infection and complete or partial biliary obstruction. Choledocholithiasis is the most common cause. Focused ultrasound is a sensitive modality for detection of cholelithiasis and biliary ductal dilation. Identification of these findings should be correlated to the clinical picture. Biliary ductal dilation is not specific for choledocholithiasis and cholangitis, and ultrasound lacks universal high sensitivity for detecting choledocholithiasis, the main cause of cholangitis.

LIVER MASSES

Although use of ultrasound for evaluation of liver masses is beyond the scope of emergency medicine, observation of liver masses with bedside imaging is not uncommon. Common benign liver masses are hemangiomas (Fig. 45.17) and adenomas. Metastatic disease is the most frequent cause of malignant liver masses, and hepatocellular carcinoma is the most common primary malignant liver tumor. The sonographic features of hepatic masses depend on both the composition of the liver mass and secondary factors, such as associated edema, hemorrhage, and necrosis. The findings often mimic a target lesion (Fig. 45.18).

Identification of a liver mass should prompt appropriate referral for further work-up. Liver cysts can also be encountered, and the findings can be quite impressive in patients with polycystic liver disease, which is often combined with kidney disease (Fig. 45.19).
**HEPATITIS AND CIRRHOSIS**

The most common sonographic features of acute hepatitis are increased liver size and decreased echogenicity of the liver (because of increased fluid content as a result of inflammation and edema).

Chronic liver disease and other conditions that elevate portal venous pressure can produce sonographic findings that can mimic acute cholecystitis. Gallbladder wall thickening and ascites are common findings. Ascites may be mistaken for percholecystic fluid. As the disease progresses, the liver will eventually become hyperechoic in comparison with healthy liver tissue with tissue changes manifested as multiple liver nodules surrounded by echogenic fibrotic tissue. As the cirrhosis progresses, the liver typically decreases in size. Occasionally, a transjugular intrahepatic portosystemic shunt can be detected in patients with portal hypertension (Fig. 45.20).

**NORMAL VARIANTS**

Polyps appear sonographically as fixed, pedunculated structures adherent to the gallbladder wall that are unchanged by patient positioning. Gallstones are typically mobile and settle to dependent areas of the gallbladder cavity unless they are impacted. Gallbladder polyps do not normally cause posterior shadowing (Fig. 45.21). Gallbladder folds are commonly encountered normal variants that appear as a bright echogenic line within the gallbladder lumen. A fold at the fundus is commonly seen and is termed a phrygian cap (Fig. 45.22). A fold may appear to divide the gallbladder into two sections.
**Fig. 45.15** Appearance of intrahepatic biliary duct dilation. A-D, Multiple areas of intrahepatic ductal dilation (arrows) can be seen. Intrahepatic biliary ducts have echogenic walls and typically contain anechoic bile within. Color Doppler can be used to differentiate bile ducts (no flow) from vessels (see Fig. 45.16). Prominent dilation of major biliary ducts is sometimes described as a “staghorn” appearance (C).

**Fig. 45.16** Common bile duct dilation and choledocholithiasis. A, Semilongitudinal view of a dilated common bile duct (CBD) (measured at 9.4 mm; stars indicate the ends of the calipers measuring the common bile duct) Long axis (B) and short axis (D) of the dilated proximal CBD. The portal triad consisting of the portal vein (blue circle), hepatic artery (red circle), and dilated common biliary duct (green circle) is seen in D in transverse view. C, Color Doppler image of the distal CBD (no internal flow is seen) with a large stone and posterior shadowing (asterisk).
Careful imaging of the gallbladder in multiple planes can decrease the likelihood of misdiagnosis.

Adenomyomatosis is a common benign condition with a reported incidence of 2.8% to 5% that leads to hyperplastic changes and thickening of the gallbladder wall. Because of differing vascularity, tissue edema, internal hemorrhage, and areas of necrosis, metastatic liver tumors may have multiple sonographic features. The appearance often mimics a target lesion.

GALLBLADDER SLUDGE AND GRAVEL

Gravel is a variant of cholelithiasis that has a distinct ultrasound appearance identified as multiple small individual dependent stones (Fig. 45.24). Sludge produces a homogeneous, hyperechoic area in the gallbladder that does not produce shadowing. Sludge is viscous and settles to the dependent portion of the gallbladder, but it may take longer to settle than larger stones (Fig. 45.25).

HOW TO INCORPORATE EVALUATION OF SUSPECTED CHOLECYSTITIS INTO PRACTICE

Findings should be correlated with the clinical and laboratory picture. The absence of cholelithiasis on focused hepatobiliary imaging makes the diagnosis of cholecystitis much less
likely, and other diagnoses should be entertained. Patients with ultrasound findings suggestive of cholecystitis should be administered antibiotics and undergo surgical consultation. If cholelithiasis is seen without other evidence of cholecystitis, the patient’s laboratory findings and clinical picture should be reviewed. Patients with resolution of pain and without laboratory abnormalities should have close follow-up arranged. Patients with persistent pain or laboratory abnormalities concerning for cholecystitis should undergo appropriate consultation and possibly a HIDA scan.

**BILIARY SEPSIS**

Biliary infection is a common cause of sepsis, and its incidence increases with age. Findings on bedside ultrasound, when suggestive of cholecystitis or cholangitis, can reduce time to appropriate antibiotic administration. Consultation to arrange biliary decompression can be expedited as well.
EVALUATION OF JAUNDICED PATIENTS AND THOSE WITH SUSPECTED BILIARY OBSTRUCTION

In patients with jaundice, focused ultrasound can help differentiate obstructive from nonobstructive causes. Dilation of the CBD and intrahepatic ducts indicates outflow obstruction of the biliary tracts and an obstructive etiology. Identification of biliary obstruction in the setting of acute infection should prompt the physician to consider urgent decompression of the biliary tract.

Discovery of a dilated CBD should prompt the sonographer to follow the CBD as far medially as possible. The most common cause of biliary obstruction is choledocholithiasis, for which transabdominal ultrasound has a specificity of up to 95%. It should be noted, however, that ultrasound is not a specific modality for distinguishing the cause of biliary obstruction with the isolated finding of CBD dilation. Further imaging is often required.

ASCITES EVALUATION AND ULTRASOUND-GUIDED PARACENTESIS

Bedside ultrasound can rapidly identify ascites and visualize the relationship of pockets of ascites to adjacent bowel and other abdominal structures. If paracentesis is required, ultrasound allows the user to choose a location that maximizes the chance for a successful procedure while minimizing the chance of damage to nearby structures.

REFERENCES

References can be found on Expert Consult @ www.expertconsult.com.
REFERENCES


