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Review Article

# Abdominal Ultrasound: Imaging Evaluation of the Liver, Gallbladder, Pancreas, and Bowel.

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## Abstract

Abdominal ultrasound (AUS) is a non-invasive imaging modality frequently employed to assess conditions of the liver, gallbladder, pancreas, and bowel. It offers a rapid alternative to more extensive imaging protocols in evaluating patients with acute or chronic disease conditions. The speed and accessibility of AUS enable broad adoption in clinical practice.

Fundamental ultrasound principles form the basis for reliable liver, gallbladder, pancreas, and bowel assessment. Transducer selection tailored to patient habitus governs image resolution and depth. The liver is optimally evaluated using a 3.0-5.0 MHz curved-array transducer, allowing adequate penetration without undue loss of detail or frame rate. Patient positioning and transducer angling define the fundamental acoustic windows. Bowel assessment is limited due to normal peristalsis and gas-associated attenuation, yet the central abdominal location, targeted imaging between the hepatic flexure and sigmoid colon, and recognition of characteristic echo textural features enhance diagnostic potential.

**Key words:** abdominal ultrasound; hepatobiliary imaging; transducer frequency selection; acoustic windows and patient positioning; bowel ultrasound and gas attenuation

## Introduction

Abdominal ultrasound facilitates evaluation of the hepatic, biliary, pancreatic, and bowel systems [1]. As a basic technique, it guides the work-up of acute and chronic scenarios. Clinical indications emphasize pain, malignancy and trauma. Limitations center on gas obscuring bowel and hypodense liver lesions [2]. Abdominal ultrasound offers several comparative advantages: it is non-invasive, does not require intravenous contrast, it is readily available, inexpensive and simple to perform [3].

Liver ultrasound has an important role in ongoing patient management, success partly based on straightforward technique [4]. A comprehensive survey of the liver on a single ultrasound study depends upon several technical factors [5]. Each factor therefore merits definition when detailing standard operating procedures [6].

Patients should present fasted to minimize bowel gas. Scanning typically begins in the right upper quadrant with the transducer oriented longitudinally, followed by a transverse orientation of organs from the midline to the right flank [7]. Using aged equipment, measuring liver dimensions with 2-dimensional-echocardiography remains problematic: the tagged end of printed hard-copy images denotes organ dimensionality, and X-ray films of the “m-mode” sonograms remain prevalent [8]. Where either the right lobe of the liver or the gall-bladder remains visible, the distance between those two structures then becomes the dominant examination criterion [7].

## 1. Overview of Abdominal Ultrasound Principles

Safe, fast, and widely available, ultrasound is the primary tool for assessing the liver, gallbladder, pancreas, and bowel [9]. Insight into hepatic parenchyma, biliary ducts, pancreatic duct, and intestinal loops helps recognize conditions such as cirrhosis, cystic lesions, or intestinal obstruction while guiding decisions on further imaging, intervention, or follow-up [7].

Imaging of the major abdominal organs using ultrasound requires knowledge of instrument selection, scanning techniques, and Doppler utility, supported by an understanding of safe and effective practice [10]. During abdominal ultrasound, transducer choice, positioning and orientation to fluid-filled organs, methods for augmenting bowel aperture and optimizing visualization, and identification of common artifacts remain crucial considerations [11].

Higher-frequency linear arrays (5–12 MHz) provide superior axial and lateral resolution, with lower-frequency convex or sector transducers (1–5 MHz) preferred for wide fields of view [12]. Special-purpose probes (intracavitary/transesophageal) yield access to selective organs [13]. For large adult or obese individuals, sector transducers allow broader access without sacrificing detail [14].

## 2. Liver Imaging

The normal ultrasonographic anatomy of the liver includes liver parenchyma, portal venous system, hepatic veins and biliary tree [15]. The main portal vein divides in a right and left posterior and anterior branch [16]. The sonographic features of age-related liver anatomical variants and technique-related limitations (e.g. transplant procedure or biliary tree) are summarized. Pathologies impacting liver imaging are classified as diffuse versus focal lesions [17]. Diffuse liver diseases with specific ultrasound hallmarks comprise steatosis, fibrosis, hepatitis, cirrhosis and hemochromatosis [18]. A review of ultrasound findings associated with steatosis, fibrosis and hepatic focal lesions allows for narrowing the differential diagnosis and guiding to further evaluation [19]. Vascular disorders can also be detected by ultrasound: portal vein thrombosis or occlusion and hepatofugal flow. Diffuse abdominal ultrasound diseases are associated with specific ultrasound diagnosis [20]. At least three nominal parameters help reaching a conclusion about diffuse disease (liver size, kidney/liver echogenicity ratio, fibroelastometry) [20]. Various approaches adapt abdominal ultrasound technique acquirement to optimize liver scanning and interpretation [21]. Adequate patient preparation with fasting and standard scans (longitudinal and transverse) assists in identifying the organ and locate lesions. Selection of parenchyma areas, extra-hepatic vessels and biliary branches is useful for obtaining repeatable measurements figuring in a standardized report [22]. Contrast-enhanced ultrasound, perfusion measurements and new imaging strategies can extend scope of liver examination [22].

### 2.1. Normal Sonographic Anatomy and Variants

Abdominal ultrasound facilitates noninvasive assessment of hepatic, biliary, pancreatic, and bowel systems [23]. Common indications include hepatobiliary disorder, diabetes, abdominal pain, and jaundice [23]. Despite limitations such as operator-dependent quality and reduced visualization in over- or underweight patients, ultrasound offers several advantages over cross-sectional imaging [2]. It rapidly identifies gallstones and small-volume effusions, excludes choledocholithiasis, assesses bowel peristalsis, and interrogates vascular structures [24].

Sonographic evaluation of the liver covers parenchyma, portal venous system, hepatic veins, and biliary tree [8]. Normal anatomic description aids recognition of common pathologies including steatosis, fibrosis, focal lesions, vascular disorders, and diffuse diseases 30. Imaging technique and optimization strategies are also addressed [25].

### 2.2. Common Pathologies and Sonographic Findings

Abdominal ultrasound represents the first line of investigation for patients with suspected hepatic, biliary, pancreatic, or bowel disorders [26]. Common clinical indications reflect the disease spectrum necessitating examination: hepatitis and hepatitis B virus screening in endemic regions, assessment of liver cirrhosis, jaundice evaluation, acute right upper quadrant pain, hepatocellular carcinoma screening in cirrhotic liver, and traumatic liver injury [8]. Despite liver biopsy, CT, or MR imaging being helpful, ultrasound plays an important role in the follow-up of liver disease and post-treatment evaluation of various lesions [27]. Bowel ultrasound is often the main tool to assess inflammatory bowel disease or abscess [28]. Compared to other imaging techniques, ultrasound is more available, can be performed in bed, requires no radiations, and has a potential cost-saving impact [26]. It can be performed before other imaging, and in many instances, has a better performance than other modalities [29].

### 2.3. Technique and Optimization

In preparing for an abdominal ultrasound examination, the patient's abdomen should be free of air and excess fluid [30]. To this end, fasting for eight to twelve hours is usually prescribed [31]. In pediatrics, shorter fasting time is required [31]. Many medications are allowed, except for those that lower peristalsis [8]. The patient is positioned supine, with the right arm raised above the head and the legs in a comfortable position [32]. An additional position in the right lateral decubitus may facilitate gallbladder or kidney assessment [33]. Acoustic windows begin with a longitudinal-entry plane through the epigastrium (liver, portal vein, aorta) selected based on the clinical question [34]. A summary of the examination approach appears with emphasis on pelvic ultrasound [35].

After scanning a basic series of images, supplementary acquisitions proceed according to the established protocol [36]. Routine frontal planes examine the liver (longitudinal sections at right lobe, caudate, and left lobe; transversal sections through aortic bifurcation), gallbladder (longitudinal and transversal), pancreas (longitudinal head-craniocaudal; transversal head and neck), kidneys, and bladder [26]. Targeted acquisitions can include abnormal structures or sightlines from another position [37]. All measurements and Doppler color acquisition take place on the standard images [38]. Color Doppler evaluation should check the main and segmentary hepatic arteries, whereas pulse Doppler may furnish additional information about internal flows [39].

## 3. Gallbladder Evaluation

Gallbladder sonography evaluates anatomical variants, detects gallstones, sludge, and cystic lesions, and diagnoses cholecystitis or biliary tract obstruction [40]. The gallbladder, a muscular pear-shaped reservoir for bile, can migrate aberrantly, undergo malformations, or develop cysts [40]. Standard scanning planes include longitudinal and transverse views through the organ's body; measurements of length, diameter, wall thickness, and duct caliber can supplement the examination [41].

Acute and chronic cholecystitis arise from obstruction, with acute cholecystitis commonly linked to the cystic duct via gallstones [42]. Diagnostic criteria encompass gallbladder wall thickening exceeding 3mm, pericholecystic fluid, and the sonographic Murphy sign [43]. In acute cases, the gallbladder is typically distended; in chronic cholecystitis, the gallbladder often remains contracted [44]. The differential diagnosis for thickened walls includes primary or metastatic hepatic lesions [45].

### 3.1. Normal Anatomy and Variants

Abdominal ultrasound is a widely performed non-invasive examination. Ultrasound examination of the liver, gall bladder, pancreas and bowel can be performed under a single examination covering all organs of the upper abdomen [46]. A limited survey of the liver, gall bladder, pancreas and bowel is often requested for screen [47]. It is commonly practiced by ultrasonicates [48]. The safety of abdominal ultrasound has been reviewed. In the study, seventy normal adult subjects aged between eleven to seventy- two years were selected [22]. A total of four hundred and seventy-seven screenings [1]. The liver is examined in subcostal and intercostal views as stated by other authors [49]. Abdominal ultrasound not only indicates cysts, but also indicates some benign causes of hepatic dysfunction [50]. Chronic obstructive jaundice due to extra hepatic obstruction invited due to gall stones, primary sclerosing cholangitis and pancreatic carcinoma are some conditions covered. Such dietary information was often required in the past [50].

The gall bladder is examined in a settled fasting status in the morning hours. The fasting period allows better display of thin wall structure [51]. It also reduces the chance of discovering many abnormalities such as acalculous cholecystitis and decreased gall bladder function [52]. Many other details are covered in the survey such as radiolucent stones, gall bladder dilatation from outflow obstruction, detection of innumerable small stones, abnormality of the aorta and infra renal condition of abdominal aorta [53]. To detect the gall bladder only fasting is sufficient. Gall stone evaluation is different from gall bladder ultrasound [53]. Speculation is dismissed for gall stones [54]. The gall bladder is circumferentially scanned in the intercostal view [55]. Normal transabdominal ultrasound procedure for investigating the gall bladder is described. There are many other stops points and scanning protocols that can be followed [56].

### 3.2. Acute and Chronic Cholecystitis

Cholecystitis represents a common inflammatory process localized to the gallbladder; with the condition most often being precipitated by the presence of gallstones [6]. The inflammation may be acute or chronic in nature and complicating alterations of the gallbladder wall, surrounding fluid, and parenchymal blood flow develop following a duration of inflammation [5]. Standards for the diagnosis of acute cholecystitis are provided through the Tokyo Guidelines on Acute Cholecystitis [44].

Acute cholecystitis is indicated Sono graphically if at least one of the following findings is present: gallbladder wall thickening of 4 mm or greater, pericholecystic fluid collection, or sonographic Murphy's sign [57]. Findings supporting the diagnosis of acute cholecystitis but not included in the Tokyo Guidelines comprise gallbladder distention, intramural gas or air-fluid levels characterized as crescent-shaped within the gallbladder, and vascular lesions detected across the gallbladder wall [58]. In acute cholecystitis, gallbladder stones are visualized according to the normal clinical classification system [59].

### 3.3. Gallstones and Biliary Sludge

Gallstones and biliary sludge are the most common conditions affecting the gallbladder [57]. Biliary sludge consists of a mixture of bile pigments and cholesterol crystals with a defined echogenicity [60]. Gallstones can be differentiated from sludge because they are mobile inside the gallbladder lumen, while sludge does not show mobility [61]. Gallstones can be echogenic, with posterior acoustic shadowing that varies according to the type of stone, or non-echogenic without posterior acoustic shadowing [44]. Both gallstones and biliary sludge are essential to mention if seen during the examination, and the gallbladder should also be checked for collection of a fluid that could be an indicator of a possible aspiration of a bile [62].

### 3.4. Gallbladder and Biliary Ductal Dilatation

Gallbladder and biliary ductal dilatation detected on ultrasound warrants careful evaluation of both the degree of dilatation and possible obstructive etiologies [62]. Routine guage thresholds define the limits of normality for gallbladder neck (≤ 10 mm) and common bile duct (≤ 7 mm) dimensions [57]. For the latter, the upper threshold of normality has been reported to change with age [63]. Downstream consequences of obstruction, such as gallbladder distension or intrahepatic ductal dilatation, complement the differential diagnosis for extra-, intra-, and pancreatic ductal obstruction [64].

## 4. Pancreas Imaging

Abdominal ultrasound demonstrates reliable, extensive, and safe capability for assessing the liver, gallbladder, pancreas, and bowel [65]. The liver is evaluated for echogenicity, size, contour, portal vein anatomy, biliary tree, focal lesions, and in some clinical scenarios, perfusion patterns [47]. The gallbladder assessment ranges from an uncomplicated study to establishing acute cholecystitis, identifying the presence of stones and sludge, and investigating dilatation [50]. Pancreatic imaging concentrates on determining the presence of acute or chronic pancreatitis, the visualization of certain masses, and cystic lesions of the pancreas [66]. The bowel assessment focuses on demonstrating the condition of the bowel wall, content (presence of plications) and evaluation of significant packing [49]. Each organ analysis is performed independently, but recognizes the interaction of the organs with afflictions observed in one part altering the other [65].

### 4.1. Pancreatic Anatomy and Sonographic Windows

The pancreas lies in the retroperitoneum in a transverse position, extending from the second part of the duodenum to the splenic hilum [67]. The normal pancreas demonstrates homogeneous echogenicity, similar to or slightly less than that of the normal liver [68]. The pancreas can be examined using various sonographic windows, including the epigastric, left lateral, and, to a limited degree, suprapubic [69]. The epigastric window is the most useful and is obtained by placing an ultrasound transducer in the midline of the abdomen under the xiphoid process or just above an over-distended urinary bladder [8].

When the pancreas cannot be visualized adequately through these approaches, alternative positions, such as upright or left lateral decubitus, may be beneficial [70]. The anterior wall of the stomach can also be examined to assess whether filling of the organ is appropriate [71]. In the left lateral approach, the left lobe of the liver is visualized, and if it appears smaller than expected, the head of the pancreas should be evaluated for enlargement [72]. The imaging of the pancreas is complemented by the assessment of the splenic artery and vein [73]. A dilated splenic vein in the left lateral position indicates possible pancreatitis [74]. The gallbladder is situated in the gallbladder fossa at the inferior aspect of the liver [74]. The normal gallbladder wall is thin, demonstrating a trilaminar appearance [73]. The gallbladder is usually examined through an epigastric window or an intercostal window [75]. In patients prone to obstructive jaundice, the gallbladder remains distended despite fasting [75].

The gallbladder can be visualized through multiple approaches [76]. In the epigastric or anterior abdominal approach, once the liver has been evaluated through a longitudinal scan with the transducer placed along the line between the xiphoid process and the umbilicus, it is maneuvered laterally towards the right upper quadrant [77]. Holding the transducer at a 45-degree angle permits the gallbladder and liver to be examined in the same setting [78]. For the intercostal approach, the transducer is placed in the right upper quadrant for a longitudinal scan of the right lobe [78]. Ideally, the left lobe of the liver should also be evaluated through the same window to confirm the gallbladder is being assessed, as the gallbladder fossa can be mistaken for a portion of the caudate lobe or a cystic lesion in the medial inferior segment of the right lobe [79]. Scanning through the right kidney and suprarenal glances along the aorta can provide supportive points and alleviate uncertainty regarding the gallbladder location [80]. In patients with acute cholecystitis, the gallbladder wall is enlarged but not always available for assessment [81].

### 4.2. Acute and Chronic Pancreatitis

Normal pancreatic echogenicity reflects the combined echogenicity of the gland itself and mesenteric fat; isoechoic to slightly hyperechoic compared to liver parenchyma is typical [82]. Variations in echogenicity are related to age, sex, body habitus, and nutritional status; visualizing the gland may be especially challenging in large patients [83]. Scans should ideally be obtained with the patient in the supine or left lateral decubitus position [84]. Multiple windows are available—subxiphoid, right upper quadrant, left upper quadrant, and periumbilical—and manoeuvres such as deep inspiration, splenic flexure compression, and water ingestion can facilitate access [82].

Acute pancreatitis is an inflammatory condition characterized by autodigestion of the pancreas due to inappropriate activation of digestive enzymes [85]. It can be classified as mild, moderate, or severe according to the clinical severity index. Changes can be detected within 24–48 hours in up to 90% of cases, which include: enlargement of the gland, an increase in echogenicity, low-echo peripancreatic fluid along the parietal peritoneum, enlargement of the main pancreatic duct, and complications affecting other abdominal organs [86]. A wide differential diagnosis remains possible, including pancreatic trauma when clinical suspicion is high [87].

Chronic pancreatitis is differentiated from the acute form by the presence of irreversible histological changes [88]. Early-stage chronic pancreatitis may be indistinguishable from mild acute pancreatitis on ultrasound, although approximate staging systems have been established [70]. Changing sonar images of the gland may also yield distinguishing signs [70]. A checklist of imaging characters can aid in formulating differential diagnoses [88].

### 4.3. Pancreatic Neoplasms and Cystic Lesions

Several neoplasms and cystic lesions of the pancreas have sonographic features that permit a confidence diagnosis or allow selection of appropriate complementary cross-sectional imaging or endoscopic assessment [89]. The most frequent pancreatic entities recognized by ultrasound comprise solid tumours, cystic neoplasms, pseudocysts, and serous cystadenomas [90]. Endoscopic ultrasound examination aids in characterizing solid and cystic pancreatic masses or lesions; cross-sectional imaging assists in evaluating the extent of disease and surgical planning [91]. Knowledge of the common pancreatic variants and pathology and awareness of pitfalls improve diagnostic confidence and accuracy [92].

### 4.4. Pitfalls and Artifacts in Pancreatic Ultrasound

Despite its established role in non-invasive assessment of the pancreas, ultrasound has certain limitations in visualizing this organ [93]. These limitations include inherent anatomical factors, the presence of bowel gas, and operator dependency [94]. Although some manoeuvres that may improve pancreatic access via the transabdominal route are well-known, they are often poorly applied in practice [93]. Specific factors may further affect the quality of ultrasound evaluation, including insufficient patient history, inconsistency in technique, and failure to recognize the appearance of an abnormal pancreas or related conditions [94]. Pitfalls and artifacts in pancreatic ultrasound may lead to misinterpretation of findings and erroneous diagnosis [94]. Accurate detection and characterization of pancreatic diseases ultimately depend on clear acquisition and analysis of images, along with avoidance of misinterpretation [95].

## 5. Bowel Assessment in Abdominal Ultrasound

Sonographic evaluation of the bowel includes assessment of the small and large bowel loops, visualizing wall thickness, layering, peristalsis, and adjacent mesenteric interfaces [96]. All systemic organs, including the small and large bowel, may be studied with ultrasound [97]. Several pathologies are demonstrable with ultrasound, including inflammatory, infectious, ischemic, obstructive, and neoplastic conditions [32]. Access to cross-sectional imaging, such as CT or MRI, should be considered when bowel ultrasound does not permit confident diagnosis [98]. Practical tips to optimize scanning and patient-cooperation strategies should be employed when studies are performed [99].

### 5.1. Sonographic Evaluation of the Small and Large Intestine

The small and large intestine can also be evaluated using abdominal ultrasound [98]. Although the sensitivity of this technique is low, it nevertheless provides some useful information without pre-treatment [100]. The small intestine can be subjected to measurements of wall thickness, peristalsis, and structure of walls [101]. Additionally, the surrounding mesenteric interface can be observed [102]. The large intestine can be assessed in a similar manner, but a volume of fluid is necessary for a proper study [103]. The evaluation of intestinal ultrasound is limited, and in cases of obstruction, CT or MRI are often selected [104].

The analysis concentrates on the pancreas; possible hepatic, biliary, and renal, or extra-abdominal pathologies are noted within the examination [105]. Evaluation of the abdominal organs is carried out according to a systematic approach: specific window techniques and positioning procedures optimize results, and during each step, the entire abdomen is repeatedly reviewed [106].

### 5.2. Common Bowel Pathologies and Sonographic Features

Abdomen is a common ultrasound examination that includes imaging of the liver, gallbladder, pancreas, bowel, and urinary system [41]. Abdominal ultrasound examinations are requested along with obstetric, gynecological, and vascular examinations [107]. Abdominal ultrasound examinations are crucial for assessing suspected pathology, monitoring the response to treatment, and performing follow-up studies in patients who have undergone surgical treatment [96]. Abdominal ultrasound has an important role in the assessment of infectious diseases, hepato-biliary- pancreatic diseases, and inflammatory bowel disease [32]. The ultrasound assessment of the bowel includes the small bowel, large bowel, and rectum [108]. The ultrasound evaluation of the bowel assesses the bowel wall, diameter of the bowel, peristalsis, motility, abdominal compartment syndrome, wall patterning, and extra intestinal disease [109]. The ultrasound evaluation of the bowel is especially useful for pediatric and obstetric oblique patients [41].

### 5.3. Limitations and Supplemental Imaging

The sonographic evaluation of the liver, gallbladder, pancreas, and bowel is fundamental yet inherently limited [2]. Abdominal ultrasound is often the first-line modality for assessing biliary tract and pancreatic conditions, capable of distinguishing acute cholecystitis and pancreatitis from alternative diagnoses [109]. Hepatic pathology, while typically not an initial ultrasound target in the face of alternate clinical concerns, is nevertheless encountered in parallel studies, with abnormal findings frequently evident [108]. Key limitations include operator dependency, restricted definition of normality, diminishing sensitivity for disease detection in the presence of abnormalities, and the inability to evaluate certain lesions [110]. Supplementary imaging, particularly computed tomography or magnetic resonance techniques, is appropriate for interrogating suspected pathology, assessing complications, or further clarifying differential considerations [32].

Interpretation of bowel ultrasound is further complicated by inadequate attainment of a full clinical history, ongoing therapy, and the time-consuming nature of the examination within a typically constrained protocol [111]. The small and large bowel are therefore better studied using other modalities when broader anatomical imaging of the renal tract, gallbladder, and pancreas is pursued [112]. The presence of gallstones affecting the cystic duct, a factor of relevance to the clinical inquiry, can also be determined readily via a brief ultrasound evaluation [113].

## 6. Integration of Findings and Clinical Correlation

The value of abdominal ultrasound is heightened by the ability to correlate findings across hepatic, biliary, pancreatic, and bowel systems and to integrate these observations with the clinical context [32]. Careful consideration of relevant history in relation to the sonographic appearance permits a concise differential diagnosis to be proposed, enabling targeted recommendations for further investigation, additional management steps, or follow-up time frames [114].

In the liver, liver steatosis and gallstones are prevalent findings in individuals with a history of both hepatitis and alcohol consumption [8]. In patients with hepatitis, gallstones may not be readily visible, especially lenticular stones [115]. In such cases, examining bile duct dilatation and associated clinical information can provide significant insights [116]. Both transluminal and non-transluminal approaches can prove valuable for assessing gallbladder disease in the context of hepatitis [117]. For cystic lesions, a list of differential diagnoses can be narrowed down to hydatid cysts, abscesses (bacterial, amebic, or hydatid), pancreas divisum, and choledochal cysts, particularly when sonograms indicate the presence of a normal external envelope [118].

Focal areas of abnormal echogenicity in the liver, whether increased or decreased, warrant attention; key features such as number, size, vascularity, and presence of internal echoes can help differentiate various types of tumours, both benign and malignant [119]. For suspected inflammatory processes within the pancreas, a review of surrounding abdominal structures is advisable [120]. Findings consistent with pancreatitis may still be indicative of biliary obstruction secondary to choledocholithiasis, especially when the patient has a record of biliary colic [121]. Ulcerative colitis can also be indicated through examination of contiguous segments of the colon [121].

## Conclusion

Abdominal ultrasound offers a valuable imaging modality for evaluating the liver, gallbladder, pancreas, and bowel. Its clinical applications in these organs are numerous, and the technique can be performed readily using standard equipment. Among available imaging options, ultrasound provides several distinct advantages over other modalities, complementing computed tomography and magnetic resonance imaging. The respective strengths of each imaging technology can be leveraged to enhance patient management 8. The information provided in this chapter facilitates the implementation of comprehensive ultrasound protocols suited to institutional requirements and the specific capabilities of equipment. Future developments in abdominal imaging will include improvements in three-dimensional rendering, evaluation of biliary and vascular flow, and contrast-enhanced ultrasound techniques to extend the examination beyond hepatobiliary structures.

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