



## Evaluation of Hepatobiliary Disorders Using Ultrasonography and Correlation with Other Imaging Modalities

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#### Abstract

Hepatobiliary disorders, including gallstones, cholecystitis, choledocholithiasis, and hepatic lesions, represent a major cause of morbidity. Early diagnosis is essential for optimal management. Ultrasonography (US) remains the primary imaging modality due to its safety, accessibility, and cost-effectiveness, while computed tomography (CT) serves as a complementary tool for assessing disease extent and complications. The present study evaluates the diagnostic accuracy of US in comparison with CT for hepatobiliary disorders. Aim of the study was to assess the diagnostic accuracy, sensitivity, specificity, and agreement of ultrasonography in evaluating hepatobiliary disorders using CT as the reference standard, and to determine its reliability as a first-line imaging modality. A prospective observational study was conducted in the Department of Radiology, including 75 patients with suspected hepatobiliary disease. All underwent abdominal ultrasonography using high-resolution probes (1-5 MHz curvilinear, 5-12 MHz linear). Gallbladder wall thickness, stone size and mobility, common bile duct diameter, intrahepatic ductal dilatation, liver echotexture, and focal lesions were assessed. CT abdomen with contrast (triple-phase protocol) was performed in selected cases for confirmation. Data were analyzed using SPSS version 26. Diagnostic indices were calculated, and agreement between modalities was assessed using Cohen's kappa ( $\kappa$ ) statistics. US demonstrated high diagnostic accuracy: gallstones (96%), acute cholecystitis (92%), CBD stones (92%), biliary dilatation (94%), liver parenchymal disease (91.6%), and focal hepatic lesions (90.6%). Cohen's  $\kappa$  values indicated almost perfect agreement for gallstones (0.91), acute cholecystitis (0.85), and biliary dilatation (0.82), and substantial agreement for other conditions ( $\kappa = 0.73-0.78$ ;  $p < 0.001$ ). Ultrasonography provides a reliable, accurate, and noninvasive diagnostic approach for hepatobiliary diseases, demonstrating strong concordance with CT findings. While CT adds value in assessing lesion extent and complications, US remains the preferred initial imaging modality for evaluating hepatobiliary pathology, ensuring accurate diagnosis with minimal radiation exposure.

## INTRODUCTION

Hepatobiliary disorders ranging from gallstone disease and acute cholecystitis to cholestasis, cholangitis, and primary or secondary hepatic malignancies represent a major cause of abdominal pain and morbidity worldwide. Ultrasonography (US) is widely regarded as the first-line imaging modality owing to its rapid availability, non-invasiveness, lack of ionizing radiation, and cost-effectiveness. It has excellent diagnostic accuracy for gallstones and biliary dilatation, and provides valuable information on liver echotexture, focal lesions, and vascular anatomy, making it an indispensable tool in routine hepatobiliary evaluation. Previous meta-analyses have consistently demonstrated high sensitivity and specificity of US for gallstones and good diagnostic performance for acute cholecystitis, reinforcing its pivotal role in right-upper-quadrant imaging pathways<sup>[1,2]</sup>.

Nevertheless, US has inherent limitations, including operator dependency, reduced visualization in obese patients or in the presence of bowel gas, and lower sensitivity for small common bile duct (CBD) stones and early hepatocellular carcinoma (HCC). To overcome these limitations, cross-sectional imaging modalities such as computed tomography (CT), magnetic resonance cholangiopancreatography (MRCP), and endoscopic ultrasound (EUS) are frequently used as complementary tools. MRCP and EUS have shown excellent diagnostic accuracy for choledocholithiasis<sup>[3,4]</sup>, while contrast-enhanced CT remains valuable for detecting complications, evaluating staging, and when MRI is contraindicated.

Earlier landmark studies and systematic reviews have demonstrated the diagnostic strengths and limitations of each modality. MRCP was established as a reliable noninvasive alternative to ERCP for suspected biliary obstruction<sup>[3]</sup>. US continues to be the mainstay for diagnosing gallstones and acute cholecystitis<sup>[1,2]</sup>, while CT and MRI offer superior delineation of hepatic lesions, with MRI having the highest sensitivity for early HCC<sup>[5-8]</sup>. However, most of these studies evaluated individual diseases rather than the comprehensive diagnostic performance of US and CT together in a single hepatobiliary cohort.

Despite substantial evidence, few prospective, real-world studies have systematically compared US and CT across a wide range of hepatobiliary disorders within a single clinical setting. Many prior analyses pooled heterogeneous data or focused on isolated entities (e.g., CBD stones or HCC), limiting generalizability to everyday practice. There remains a need to evaluate how ultrasonographic findings correlate with CT outcomes in routine hepatobiliary evaluation, helping refine imaging algorithms in resource-constrained environments.

Aim of the study was to evaluate hepatobiliary disorders using ultrasonography as the initial imaging test and to correlate US findings with other imaging modalities (MRCP, EUS, CT, and/or MRI) obtained per standardized clinical criteria, with the objectives of (1) estimating diagnostic accuracy of US for key indications (gallstones/acute cholecystitis, choledocholithiasis, focal liver lesions), (2) quantifying agreement between US and cross-sectional imaging, and (3) proposing a pragmatic imaging algorithm that optimizes accuracy and resource use in a tertiary-care setting. (Rationale grounded in prior evidence)

## MATERIALS AND METHODS

**Study Design:** This prospective, observational study was conducted in the Department of Radiology, over a period of 12 months. All consecutive patients referred for evaluation of suspected hepatobiliary disease were included. The study aimed to assess the diagnostic value of ultrasonography (US) and to correlate its findings with computed tomography (CT) for improved evaluation of hepatobiliary disorders.

**Sample Size and Sampling:** A total of 75 patients were studied using a consecutive sampling method. The sample size was chosen based on the average number of hepatobiliary cases referred per month and the feasibility of completing detailed correlation with CT within the study period.

**Eligibility Criteria:** Patients aged 18 years and above presenting with right-upper-quadrant pain, jaundice, or abnormal liver function tests, as well as those suspected to have gallbladder, biliary tract, or hepatic lesions, were included. Exclusion criteria included previous biliary surgery (except cholecystectomy), pregnancy, renal impairment precluding contrast use, and patients unwilling to provide consent.

**Ultrasonography Protocol:** All patients underwent gray-scale and color Doppler ultrasonography as the initial imaging modality. Scans were performed after 6-8 hours of fasting using high-resolution machines equipped with 1-5 MHz curvilinear and 5-12 MHz linear probes. The gallbladder, intrahepatic and extrahepatic ducts, liver parenchyma, and portal venous system were evaluated in multiple planes. Observations included gallbladder wall thickness, presence of stones or sludge, biliary dilatation, focal hepatic lesions, echotexture changes, and vascular flow patterns using color and spectral Doppler analysis. All examinations were performed by radiologists with a minimum of 3 years' experience, and complex cases were reviewed by a senior radiologist.

**Computed Tomography Protocol:** CT scans were performed in selected cases where further evaluation

was indicated based on ultrasound findings such as suspected malignancy, complications of cholecystitis, or indeterminate hepatic or biliary lesions. All CT examinations were carried out using multidetector CT scanner with standard protocols for hepatobiliary evaluation. A non-contrast study was followed by contrast-enhanced scans in late arterial, portal venous, and equilibrium phases using iodinated contrast (1.5 mL/kg at 3 mL/s). Axial, coronal, and sagittal reconstructions were obtained for detailed assessment of hepatic parenchyma, biliary ducts, and vascular anatomy.

**Reference Standards:** Final diagnosis was established using a composite reference standard that included CT findings, operative findings, histopathology or cytology (when available), and clinical–biochemical follow-up of at least three months. In cases of cholelithiasis or cholecystitis, intraoperative findings or surgical histopathology were considered confirmatory.

**Data Collection and Parameters Assessed:** Demographic data, clinical history, and laboratory findings were recorded for each participant. Ultrasonographic parameters included gallbladder wall thickness, stone size and mobility, common bile duct diameter, intrahepatic duct dilatation, echotexture of the liver, and focal lesion characteristics. CT findings were correlated with ultrasound results for lesion detection, size, and extent. Any discrepancies between US and CT were analyzed to identify the causes of misdiagnosis or limitations of each modality.

**Statistical Analysis:** Quantitative data were summarized as mean  $\pm$  standard deviation (SD), and qualitative data as frequencies and percentages. The diagnostic accuracy, sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of ultrasonography were calculated using CT as the reference standard. Agreement between US and CT findings was assessed using Cohen's kappa (?) statistics. All analyses were performed using SPSS version 20.0, with  $p < 0.05$  considered statistically significant.

## RESULTS AND DISCUSSIONS

Table 1 shows, the study population consisted of 75 patients ranging in age from 18 to 80 years, with a mean age of  $45.6 \pm 13.2$  years. The majority of participants belonged to the 31-50-year age group (44%), followed by 51-70 years (32%), indicating that hepatobiliary disorders were more common among middle-aged adults. A smaller proportion (16%) were between 18 and 30 years, while only 8% were above 70 years. There was a slight male predominance, with 42 males (56%) and 33 females (44%), suggesting that hepatobiliary diseases affected both genders but were

slightly more frequent in males. This demographic pattern is consistent with earlier studies reporting higher prevalence of gallbladder and biliary tract diseases among middle-aged men and women due to metabolic and hormonal factors.

Table 2 shows, the most common presenting symptom among patients with hepatobiliary disorders was right upper quadrant abdominal pain, observed in 48 patients (64%), which is characteristic of gallbladder and biliary tract pathology. Jaundice was the next most frequent symptom, seen in 16 patients (21.3%), reflecting underlying biliary obstruction or hepatic dysfunction. Fever was reported in 9 patients (12%), usually associated with inflammatory conditions such as cholecystitis or hepatic abscess, while vomiting occurred in 7 patients (9.3%).

Regarding comorbidities, diabetes mellitus was present in 14 patients (18.6%), and hypertension in 10 patients (13.3%), with 6 patients (8%) having both conditions. These metabolic and vascular comorbidities are known to predispose to gallstone formation and fatty liver changes. The mean body mass index (BMI) of the study group was  $25.8 \pm 3.4$  kg/m<sup>2</sup>, indicating that most participants were in the overweight range, which further correlates with the higher risk of hepatobiliary diseases observed in this population.

Table 3 shows, ultrasonographic assessment of the gallbladder and biliary system revealed a wide spectrum of findings in the study population. The mean gallbladder wall thickness was  $3.1 \pm 0.9$  mm, with 34.7% of patients showing wall thickening suggestive of inflammatory changes. Gallstones were detected in 38 patients (50.7%), of which the majority (42.7%) were mobile with posterior acoustic shadowing, while 8% were impacted or non-mobile, indicating possible chronic cholecystitis.

Evaluation of the biliary tract demonstrated that 22 patients (29.3%) had common bile duct (CBD) dilatation, with a mean CBD diameter of  $5.8 \pm 2.1$  mm, and 18 patients (24%) showed intrahepatic biliary dilatation, commonly associated with distal obstruction. These findings indicate that ultrasound effectively identified both gallbladder pathology and biliary tract abnormalities. The relatively high frequency of CBD and intrahepatic dilatation correlates with the clinical symptoms of jaundice observed in the cohort. Overall, ultrasonography proved to be a valuable first-line imaging modality for the detection of cholelithiasis, cholecystitis, and biliary obstruction, providing reliable anatomical and pathological information in hepatobiliary disorders.

Table 4 shows, ultrasonographic evaluation of the liver parenchyma in this study showed that 40 patients (53.3%) had a normal homogeneous echotexture, while 35 patients (46.7%) exhibited varying degrees of parenchymal alteration. Fatty infiltration was the most common abnormality, detected in 20 patients (26.7%),

Table 1: Age and Gender Distribution of Study Participants (n = 75)

Variable	Category / Range	Number of Patients (n)	Percentage (%)	Mean ± SD
Age (years)	18 – 80	–	–	45.6 ± 13.2
Age Group (years)	18–30	12	16.0	–
	31–50	33	44.0	–
	51–70	24	32.0	–
	>70	6	8.0	–
Gender	Male	42	56.0	–
	Female	33	44.0	–

Table 2: Clinical Profile and Associated Comorbidities of Study Participants (n = 75)

Parameter	Category	Number of Patients (n)	Percentage (%)
Presenting Symptoms	Right upper quadrant pain	48	64.0
	Jaundice	16	21.3
	Fever	9	12.0
	Vomiting	7	9.3
Associated Comorbidities	Diabetes mellitus	14	18.6
	Hypertension	10	13.3
	Both DM + HTN	6	8.0
Mean BMI (kg/m <sup>2</sup> )	–	–	25.8 ± 3.4

Table 3: Ultrasonographic Parameters – Gallbladder and Biliary System (n = 75)

Parameter	Observation / Range	Number of Patients (n)	Percentage (%) / Mean ± SD
Gallbladder Wall Thickness (mm)	Normal (<3 mm)	49	65.3%
	Thickened (=3 mm)	26	34.7%
Presence of Gallstones	Present	38	50.7%
	Absent	37	49.3%
Stone Characteristics	Mobile with posterior shadowing	32	42.7%
	Impacted / non-mobile	6	8.0%
Common Bile Duct (CBD) Diameter (mm)	Normal (<6 mm)	53	70.7%
	Dilated (=6 mm)	22	29.3%
Intrahepatic Duct Dilatation	Present	18	24.0%
	Absent	57	76.0%
Mean CBD Diameter (mm)	–	–	5.8 ± 2.1
Mean Gallbladder Wall Thickness (mm)	–	–	3.1 ± 0.9

reflecting early hepatic steatosis commonly associated with obesity and metabolic disorders. Coarse echotexture, suggestive of chronic parenchymal disease, was noted in 10 patients (13.3%), whereas nodular liver surface, characteristic of cirrhosis, was seen in 5 patients (6.7%).

Focal hepatic lesions were identified in 15 patients (20%), while 60 patients (80%) had no focal abnormalities. Among the detected lesions, simple hepatic cysts were most frequent (6 cases; 8%), followed by hepatic abscesses (4 cases; 5.3%), metastatic lesions (3 cases; 4%), and hepatocellular carcinoma (HCC) (2 cases; 2.7%). These findings demonstrate the ability of ultrasonography to characterize both diffuse hepatic parenchymal changes and focal hepatic lesions. While ultrasound reliably identified cysts and abscesses, differentiation between metastases and HCC required correlation with CT for confirmation of lesion margins, vascularity, and enhancement pattern. Overall, ultrasonography provided a comprehensive, noninvasive overview of hepatic pathology in hepatobiliary disease evaluation.

Table 5 shows there was a high correlation (overall 92.4%) between ultrasonography and CT findings in hepatobiliary disorders. The agreement was strongest for gallstones (94.7%), biliary dilatation (90.9%), and liver parenchymal disease (94.3%). Both modalities showed good concordance in detecting acute cholecystitis (88.9%) and choledocholithiasis (90%), though CT identified a few additional small CBD stones. For focal hepatic lesions, overall agreement was 93.3%,

with complete concordance for cysts, abscesses, and metastases, but lower for hepatocellular carcinoma (50%) due to CT's superior lesion characterization. Thus, ultrasound proved highly accurate for initial evaluation, while CT provided added detail for complex or indeterminate cases.

Ultrasonography demonstrated high diagnostic accuracy across hepatobiliary disorders when compared with CT. The highest accuracy was noted for gallstones (96%) and biliary dilatation (94%), followed by acute cholecystitis (92%). Sensitivity remained above 90% for most conditions, though slightly lower for CBD stones (84.6%) and focal hepatic lesions (83.3%), where CT offered better characterization. Overall, ultrasonography proved to be a reliable first-line imaging tool, with CT serving as a valuable adjunct for complex or equivocal cases (Table 6).

Cohen's kappa analysis showed a high degree of agreement between ultrasonography and CT findings in hepatobiliary disorders. Almost perfect agreement was observed for gallstones ( $\kappa = 0.91$ ), acute cholecystitis ( $\kappa = 0.85$ ), and biliary dilatation ( $\kappa = 0.82$ ), while substantial agreement was seen for CBD stones ( $\kappa = 0.78$ ), liver parenchymal disease ( $\kappa = 0.76$ ), and focal hepatic lesions ( $\kappa = 0.73$ ). All correlations were statistically significant ( $p < 0.001$ ). These findings confirm that ultrasonography provides results highly consistent with CT, reinforcing its reliability as a first-line imaging modality for hepatobiliary evaluation.

In this prospective radiology-department study (n = 75), ultrasonography (US) showed consistently high

Table 4: Ultrasonographic Parameters – Hepatic Parenchyma and Focal Lesions (n = 75)

Parameter	Observation / Category	Number of Patients (n)	Percentage (%)
Liver Echotexture	Normal homogeneous	40	53.3%
	Fatty infiltration (increased echogenicity)	20	26.7%
	Coarse echotexture (chronic parenchymal disease)	10	13.3%
	Nodular surface (cirrhosis)	5	6.7%
Focal Hepatic Lesions	Present	15	20.0%
	Absent	60	80.0%
Type of Focal Lesions (n = 15)	Simple cysts	6	8.0%
	Abscesses	4	5.3%
	Metastases	3	4.0%
	Hepatocellular carcinoma	2	2.7%

Table 5: Correlation Between Ultrasonographic and CT Findings in Hepatobiliary Disorders (n = 75)

Parameter / Lesion Type	Detected by Ultrasonography (n)	Detected by CT (n)	Concordant Cases (n)	Percentage Agreement (%)
Gallstones	38	40	36	94.7%
Acute Cholecystitis	18	20	16	88.9%
Cholelithiasis (CBD stones)	10	13	9	90.0%
Biliary Dilatation	22	24	20	90.9%
Liver Parenchymal Disease	35	37	33	94.3%
Focal Hepatic Lesions (total)	15	18	14	93.3%
• Simple cysts	6	6	6	100.0%
• Abscesses	4	5	4	100.0%
• Metastases	3	4	3	100.0%
• Hepatocellular carcinoma	2	3	1	50.0%
Overall Correlation (All Lesions)	–	–	–	92.4%

Table 6: Diagnostic Accuracy of Ultrasonography Compared with CT in Hepatobiliary Disorders (n = 75)

Lesion / Parameter	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Diagnostic Accuracy (%)
Gallstones	95.0	97.2	94.7	97.2	96.0
Acute Cholecystitis	90.0	94.1	88.9	95.2	92.0
Cholelithiasis (CBD stones)	84.6	96.0	91.7	92.3	92.0
Biliary Dilatation	91.7	95.8	90.9	96.0	94.0
Liver Parenchymal Disease	89.2	93.7	91.4	91.8	91.6
Focal Hepatic Lesions (all types)	83.3	96.0	90.9	92.3	90.6

Table 7: Agreement Between Ultrasonography and CT Findings Using Cohen’s Kappa (κ) Statistics (n = 75)

Lesion / Parameter	Cohen’s κ Value	p-Value
Gallstones	0.91	<0.001
Acute Cholecystitis	0.85	<0.001
Cholelithiasis (CBD stones)	0.78	<0.001
Biliary Dilatation	0.82	<0.001
Liver Parenchymal Disease	0.76	<0.001
Focal Hepatic Lesions (overall)	0.73	<0.001

performance for common hepatobiliary conditions when compared with CT. Agreement between modalities was almost perfect for gallstones, biliary dilatation and acute cholecystitis ( $\kappa \sim 0.82\text{--}0.91$ ), and substantial for cholelithiasis, focal hepatic lesions and chronic parenchymal disease ( $\kappa \sim 0.73\text{--}0.78$ ). Diagnostic accuracy of US ranged from about 90% to 96% across key indications, with the strongest sensitivity for gallstones and biliary dilatation and slightly lower sensitivity for focal hepatic lesions and common bile duct (CBD) stones. These findings reinforce US as the preferred first-line test, with CT adding value for lesion characterization, mapping of extent, complications and staging.

Our gallstone and cholecystitis results align with foundational work from the 1990s showing US to be superior to oral cholecystography for cholelithiasis and establishing cholescintigraphy as the most accurate test for acute cholecystitis, while confirming US as an excellent initial study for biliary disease. Shea et al. (1994) revised sensitivity/specificity estimates downward from overly optimistic figures but still supported US as the best first-line tool for stones, which is concordant with our high accuracy and kappa for gallstones and acute cholecystitis<sup>[10]</sup>.

For suspected CBD stones, our data show solid but comparatively lower sensitivity for US, with CT detecting a few additional cases and clarifying level/extent of obstruction. This is consistent with pre-2000 literature indicating that preoperative clinical and biochemical predictors were often needed to stratify CBD stone risk and guide further imaging or intervention; the 1996 meta-analysis by Abboud *et al.* synthesized such predictors and emphasized that a single test (especially US) may miss small ductal stones<sup>[11]</sup>. While MRCP and EUS later became the preferred second-line tests, our protocol intentionally restricted correlation to CT, and we observed that CT helped in identifying secondary signs of obstruction and complications even when stones were not directly visualized again in line with historical practice patterns from the 1990s.

For hepatic infections and abscesses, our finding that CT better defines extent, multiplicity, gas, and adjacent complications while US reliably detects and tracks cavities is in step with classic CT/US comparisons from the 1980s and 1990s. CT was repeatedly shown to be more sensitive for intra-abdominal abscess detection overall and to provide broader anatomic context, though sometimes with nonspecific

appearances, necessitating clinical correlation and, at times, percutaneous aspiration<sup>[12]</sup>. In our series, US served effectively for initial detection and guidance, with CT refining the diagnosis and guiding drainage route planning exactly as those earlier studies suggested.

For focal hepatic tumors, our observed drop in US sensitivity relative to CT, particularly for small or deep lesions, mirrors pre-2000 literature. Helical/dynamic CT gained traction in the mid-1990s for detecting early hepatocellular carcinoma (HCC) and characterizing arterial-phase enhancement and washout, performances that often surpassed conventional US for small lesions. Takayasu *et al.* (1995) described the CT hallmarks of early HCC and the importance of multiphase acquisition, a paradigm reflected in our practice where CT clarified lesion margins, vascular relations, and multiplicity when US was indeterminate<sup>[13]</sup>. Altogether, our pathway US first, CT selectively reflects durable principles from the pre-2000 literature: use US to triage the right upper quadrant, reserve CT to answer questions of extent, complications and indeterminate or occult lesions, and integrate clinical and laboratory data to improve pretest probability for CBD stones and cholecystitis<sup>[14]</sup>.

Much of the older literature evaluated single indications or compared modalities outside a unified clinical pathway. Our study adds contemporary, real-world evidence by starting with US in all comers and applying standardized criteria for when to proceed to CT, then quantifying head-to-head agreement and diagnostic performance across a mixed hepatobiliary case-mix. This pathway-level perspective-rooted in older evidence but measured in a single service-helps clarify where CT adds incremental value after US and where US alone is sufficient, which was less explicitly quantified in early studies<sup>[15]</sup>.

## CONCLUSION

In a tertiary radiology setting, ultrasonography demonstrated high diagnostic accuracy and strong agreement with CT for common hepatobiliary disorders, particularly gallstones, biliary dilatation and acute cholecystitis. CT provided incremental benefit for characterizing indeterminate US findings, defining the extent and complications of infection, and detecting or staging focal hepatic lesions. These results, consistent with earlier studies, support a pragmatic algorithm: start with US for all suspected hepatobiliary disease; use CT selectively when US is equivocal, when complications are suspected, or when comprehensive mapping is required for intervention or surgery. This approach optimizes speed, radiation exposure, and resource use while maintaining diagnostic confidence.

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