

Research Article

Diagnostic Utility of Abdominal Ultrasonography in Patients Presenting With Right Upper Quadrant Pain: A Prospective Observational Study

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Abstract: **Introduction:** Right upper quadrant pain has a broad differential diagnosis, although biliary disorders are frequent and often require prompt imaging. Abdominal ultrasonography is accessible, radiation-free and commonly used as the first diagnostic investigation. **Objectives:** To evaluate the diagnostic utility of abdominal ultrasonography and determine its accuracy for biliary pathology among patients presenting with right upper quadrant pain. **Methods:** This prospective observational study included 80 adults evaluated at Konaseema Institute of Medical Sciences & Research Foundation, Amalapuram, Andhra Pradesh, India, from April 2021 to December 2022. Consecutively recruited patients underwent clinical assessment, laboratory testing and standardized abdominal ultrasonography. Final diagnoses were established through a composite reference standard comprising clinical course, laboratory findings, follow-up, additional imaging, endoscopic procedures, surgery or histopathology, as applicable. **Results:** The mean age was 42.8 ± 15.6 years, and 44 participants (55.0%) were female. Ultrasonography demonstrated an abnormality in 71 patients (88.8%). Gallbladder calculi were detected in 43 (53.8%), wall thickening in 16 (20.0%) and common bile duct dilatation in seven (8.8%). A final biliary diagnosis was established in 54 patients (67.5%), including uncomplicated cholelithiasis in 26, acute cholecystitis in 14, chronic cholecystitis in eight and choledocholithiasis in six. For overall biliary pathology, ultrasonography showed 92.6% sensitivity, 88.5% specificity, 94.3% positive predictive value, 85.2% negative predictive value and 91.3% accuracy. Agreement with the final diagnosis was strong ($\kappa=0.80$; $p<0.001$). **Conclusion:** Abdominal ultrasonography had high diagnostic utility for biliary causes of right upper quadrant pain and provided clinically relevant findings in most patients. Additional imaging remained necessary when early inflammation, distal ductal obstruction or an alternative diagnosis was suspected.

Keywords: Abdominal pain; biliary tract disease; cholecystitis; cholelithiasis; diagnostic accuracy; right upper quadrant; ultrasonography

INTRODUCTION

Right upper quadrant pain is a frequent clinical presentation in emergency, surgical and medical practice. Its differential diagnosis includes gallstone disease, acute or chronic cholecystitis, choledocholithiasis, cholangitis, hepatitis, liver abscess, pancreatitis, right renal disease, basal pulmonary disorders and gastrointestinal conditions. Biliary and hepatic abnormalities account for a substantial proportion of cases, but symptoms and physical findings overlap considerably. A rapid imaging strategy is therefore required to distinguish uncomplicated biliary colic from inflammatory, obstructive and non-biliary disorders that demand different treatment pathways.¹

Abdominal ultrasonography is generally recommended as the initial imaging examination when biliary disease is suspected. It is widely available, comparatively inexpensive, portable and free of ionising radiation. Real-time imaging permits assessment of gallstones, gallbladder wall thickness, distension, pericholecystic fluid, the sonographic Murphy sign, intrahepatic ducts, common bile duct calibre and adjacent solid organs.

Current appropriateness guidance supports ultrasonography as first-line imaging in most patients with right upper quadrant pain, while computed tomography, magnetic resonance cholangiopancreatography and hepatobiliary scintigraphy are reserved for inconclusive examinations, suspected complications or alternative diagnoses.²

Acute cholecystitis typically presents with persistent right upper quadrant pain, tenderness, fever, nausea and inflammatory laboratory abnormalities. Nevertheless, no single clinical or sonographic feature provides complete diagnostic certainty.³ The Tokyo Guidelines integrate local inflammatory signs, systemic inflammation and characteristic imaging findings to improve diagnostic classification.⁴ Ultrasound findings such as gallstones, wall thickening greater than 3 mm, gallbladder enlargement, pericholecystic fluid and focal probe tenderness are clinically useful, but their performance varies with disease stage, fasting status, body habitus, operator experience and the reference standard used.

Systematic evaluations have demonstrated good, although heterogeneous, performance of

ultrasonography for gallstones and acute cholecystitis.⁵ Earlier pooled estimates also showed that verification bias and differences in patient selection can materially alter sensitivity and specificity.⁶ Transabdominal ultrasonography is less sensitive for small or distal common bile duct calculi because bowel gas, stone composition and duct calibre can obscure direct visualisation. Duct dilatation and abnormal liver biochemistry consequently remain important indirect indicators, and magnetic resonance cholangiopancreatography or endoscopic ultrasonography is often required when clinical suspicion persists despite a negative scan.⁷

Diagnostic performance is influenced by local disease prevalence, referral patterns, reporting expertise and access to confirmatory investigations. Evidence from prospective hospital-based cohorts in coastal Andhra Pradesh remains limited. Evaluating real-world ultrasonographic yield in this setting can inform rational imaging pathways and identify circumstances requiring escalation. The precise objective of this study was to determine the diagnostic utility and accuracy of abdominal ultrasonography for overall biliary pathology, acute cholecystitis and choledocholithiasis among adults presenting with right upper quadrant pain.

MATERIALS AND METHODS

Study design and setting

A prospective hospital-based observational diagnostic-accuracy study was conducted at Konaseema Institute of Medical Sciences & Research Foundation, Amalapuram, Andhra Pradesh, India, from April 2021 to December 2022. Reporting was planned in accordance with the STARD 2015 principles for diagnostic accuracy studies.⁸

Study population

Adults evaluated in the outpatient department, emergency unit or inpatient services for predominant right upper quadrant abdominal pain were screened. The index test was abdominal ultrasonography, and the target condition was biliary pathology identified by a composite final diagnosis.

Inclusion criteria

Patients aged 18 years or older with acute, recurrent or persistent right upper quadrant pain who underwent clinical assessment, relevant laboratory investigations and abdominal ultrasonography were eligible.

Exclusion criteria

Patients with abdominal trauma, previous cholecystectomy, pregnancy, haemodynamic instability preventing standard evaluation, incomplete ultrasonographic assessment, unavailable reference-standard information or refusal of consent were excluded.

Sample size

Assuming 90% sensitivity, a 65% prevalence of biliary disease, 9% absolute precision and a 95% confidence level, the minimum estimated sample was 66 participants. After allowing for approximately 15% incomplete evaluation, the target was rounded to 80 participants.

Sampling and recruitment

Consecutive eligible patients were approached during the study period. Of 86 screened individuals, six were excluded and 80 completed the diagnostic pathway.

Data collection

Age, sex, pain duration, nausea or vomiting, fever, jaundice, right upper quadrant tenderness and clinical Murphy sign were recorded. Laboratory variables included total leukocyte count, serum bilirubin and alkaline phosphatase. Ultrasonography was performed with a curvilinear transducer after fasting whenever clinically feasible. Recorded features included gallstones, sludge, wall thickness, distension, sonographic Murphy sign, pericholecystic fluid, common bile duct calibre and calculi, liver, pancreas and right kidney findings. Gallbladder wall thickness greater than 3 mm was considered abnormal.

Outcome measures

The primary outcome was sensitivity, specificity, positive predictive value, negative predictive value and overall accuracy of ultrasonography for any biliary pathology. Secondary outcomes were abnormal-scan yield, diagnostic performance for acute cholecystitis and choledocholithiasis, agreement with the final diagnosis and clinical factors associated with biliary disease. The final diagnosis incorporated clinical course, laboratory results, follow-up, additional imaging, magnetic resonance cholangiopancreatography, endoscopic procedures, operative findings or histopathology, as applicable.

Statistical analysis

Continuous variables were summarised as mean $\pm$ standard deviation or median with interquartile range; categorical variables were expressed as number and percentage. Groups were compared using the independent-samples t test, Pearson chi-square test or Fisher exact test. Diagnostic estimates were calculated from 2 $\times$ 2 tables with Wilson 95% confidence intervals. Cohen's kappa assessed agreement. Variables with clinical relevance were entered into binary logistic regression, with adjusted odds ratios and 95% confidence intervals reported. Two-sided $p < 0.05$ indicated statistical significance. Analyses were performed using IBM SPSS Statistics version 25.0.

Ethical considerations

Necessary Permissions were obtained before starting the study. Written informed consent was obtained before enrolment. Records were coded, and access to

identifiable information was restricted to the research team.

RESULTS

Participant recruitment and baseline characteristics

During the study period, 86 patients presenting with right upper quadrant abdominal pain were assessed for eligibility. Six patients were excluded: three had incomplete diagnostic evaluation, two declined participation and one did not attend the scheduled follow-up assessment. The remaining 80 patients were included in the final analysis. Complete clinical, laboratory, ultrasonographic and final diagnostic information was available for all participants.

The mean age was 42.8 ± 15.6 years (range, 18–76 years); 44 patients (55.0%) were female. The median duration of pain was 3 days (interquartile range, 1–7 days), and 55 participants (68.8%) presented within seven days of symptom onset. Right upper quadrant tenderness was the most frequent examination finding, while leukocytosis was present in 30.0%. Baseline demographic, symptomatic and laboratory characteristics are summarised in Table 1.

Table 1. Baseline demographic and clinical characteristics of the participants

Characteristic	Value
Age, years	42.8 ± 15.6
Age range, years	18–76
18–30 years	19 (23.8%)
31–45 years	24 (30.0%)
46–60 years	22 (27.5%)
>60 years	15 (18.8%)
Male	36 (45.0%)
Female	44 (55.0%)
Duration of pain, days	3 (1–7)
Acute pain ≤ 7 days	55 (68.8%)
Recurrent or persistent pain	25 (31.3%)
Nausea or vomiting	35 (43.8%)
Fever	22 (27.5%)
Jaundice	8 (10.0%)
Right upper quadrant tenderness	49 (61.3%)
Positive clinical Murphy sign	20 (25.0%)
Leukocytosis	24 (30.0%)
Elevated serum bilirubin	11 (13.8%)
Elevated alkaline phosphatase	14 (17.5%)

Data are presented as mean $\pm$ standard deviation, median (interquartile range), range, or number (percentage).

Abdominal ultrasonographic findings

Abdominal ultrasonography demonstrated at least one abnormal finding in 71 patients (88.8%); nine examinations (11.3%) showed no definite structural abnormality. Gallbladder calculi were the predominant finding, detected in 43 patients (53.8%). Inflammatory gallbladder features included wall thickening in 16, a positive sonographic Murphy sign in 14, distension in 13 and pericholecystic fluid in eight. Common bile duct dilatation was present in seven patients, and a ductal calculus was directly visualised in five. The complete distribution is presented in Table 2.

Table 2. Abdominal ultrasonographic findings among the study participants

Ultrasonographic finding	Number (%)
Gallbladder calculi	43 (53.8%)
Gallbladder wall thickening >3 mm	16 (20.0%)
Positive sonographic Murphy sign	14 (17.5%)
Gallbladder distension	13 (16.3%)
Gallbladder sludge	8 (10.0%)
Pericholecystic fluid	8 (10.0%)
Common bile duct dilatation	7 (8.8%)
Common bile duct calculus	5 (6.3%)
Fatty liver changes	7 (8.8%)
Hepatomegaly	5 (6.3%)
Liver abscess	4 (5.0%)
Right renal abnormality	3 (3.8%)
Pancreatic enlargement or oedema	1 (1.3%)
No definite ultrasonographic abnormality	9 (11.3%)

Individual participants could have more than one ultrasonographic finding; therefore, percentages do not total 100%.

Final clinical diagnoses

A final biliary diagnosis was established in 54 patients (67.5%). Uncomplicated cholelithiasis was most frequent, followed by acute cholecystitis, chronic cholecystitis and choledocholithiasis. Non-biliary diagnoses included fatty liver disease, hepatic infection or enlargement, right renal pathology and pancreatitis. Five patients had nonspecific pain without an identified structural abnormality. Final diagnoses are detailed in Table 3.

Table 3. Distribution of final diagnoses among patients with right upper quadrant pain

Final diagnosis	Number (%)
Uncomplicated cholelithiasis	26 (32.5%)
Acute cholecystitis	14 (17.5%)
Chronic cholecystitis	8 (10.0%)
Choledocholithiasis	6 (7.5%)
Fatty liver disease	8 (10.0%)
Liver abscess	4 (5.0%)
Hepatitis or nonspecific hepatomegaly	4 (5.0%)
Right renal pathology	3 (3.8%)
Pancreatitis	2 (2.5%)
Nonspecific pain without structural abnormality	5 (6.3%)
Total	80 (100.0%)

Final diagnosis was based on the composite clinical reference standard. Categories were mutually exclusive.

Clinical profile according to biliary pathology

Patients with a final biliary diagnosis were more often female and more frequently presented with acute pain, nausea or vomiting and right upper quadrant tenderness than patients with non-biliary diagnoses. Mean age did not differ materially

between groups. Positive clinical Murphy sign, fever and biochemical abnormalities were directionally more frequent in biliary disease, but the differences did not reach conventional statistical significance (Table 4).

Table 4. Comparison of patients with and without final biliary pathology

Characteristic	Biliary pathology (n=54)	Non-biliary diagnosis (n=26)	p-value
Age, years	44.0 ± 15.0	40.3 ± 16.8	0.323
Female sex	34 (63.0%)	10 (38.5%)	0.039
Acute pain ≤7 days	41 (75.9%)	14 (53.8%)	0.046
Nausea or vomiting	29 (53.7%)	6 (23.1%)	0.010
Fever	17 (31.5%)	5 (19.2%)	0.250
Jaundice	7 (13.0%)	1 (3.8%)	0.264
Right upper quadrant tenderness	39 (72.2%)	10 (38.5%)	0.004
Positive clinical Murphy sign	17 (31.5%)	3 (11.5%)	0.054
Leukocytosis	19 (35.2%)	5 (19.2%)	0.145
Elevated serum bilirubin	9 (16.7%)	2 (7.7%)	0.489
Elevated alkaline phosphatase	11 (20.4%)	3 (11.5%)	0.531

Data are mean ± standard deviation or number (percentage). The independent-samples t test was used for age; Pearson chi-square test was used for female sex, acute pain, nausea or vomiting, fever, right upper quadrant tenderness and leukocytosis; Fisher exact test was used for jaundice, clinical Murphy sign, bilirubin and alkaline phosphatase.

Diagnostic performance of ultrasonography

For overall biliary pathology, ultrasonography yielded 50 true-positive, 23 true-negative, three false-positive and four false-negative results. Sensitivity was 92.6% (95% confidence interval [CI], 82.4–97.1%), specificity was 88.5% (95% CI, 71.0–96.0%) and overall accuracy was 91.3%. Agreement with the composite diagnosis was strong (Cohen's $\kappa=0.80$; $p<0.001$). Ultrasonography identified 12 of 14 acute cholecystitis cases and five of six choledocholithiasis cases. Diagnostic estimates are shown in Table 5.

Table 5. Diagnostic performance of abdominal ultrasonography

Diagnostic outcome	Sensitivity, (95% CI) %	Specificity, (95% CI) %	PPV, %	NPV, %	Accuracy, %
Overall biliary pathology	92.6 (82.4–97.1)	88.5 (71.0–96.0)	94.3	85.2	91.3
Acute cholecystitis	85.7 (60.1–96.0)	97.0 (89.6–99.2)	85.7	97.0	95.0
Common bile duct stone	83.3 (43.6–97.0)	98.6 (92.7–99.8)	83.3	98.6	97.5

CI: confidence interval; NPV: negative predictive value; PPV: positive predictive value. Confidence intervals for sensitivity and specificity were calculated using the Wilson method.

Secondary and multivariable analyses

Among the 14 patients with acute cholecystitis, a positive clinical Murphy sign was present in 12 (85.7%), compared with eight of 66 patients without acute cholecystitis (12.1%; $p<0.001$). Fever, leukocytosis, gallbladder wall thickening, sonographic Murphy sign and pericholecystic fluid were also substantially more frequent in acute cholecystitis (all $p<0.001$). Common bile duct dilatation was observed in five of six patients with choledocholithiasis and in two of 74 patients without ductal calculi.

In the multivariable logistic model, female sex and right upper quadrant tenderness remained independently associated with a final biliary diagnosis. Acute presentation and nausea or vomiting retained positive associations, although their confidence intervals crossed unity (Table 6).

Table 6. Multivariable logistic regression for factors associated with final biliary pathology

Variable	Adjusted odds ratio	95% CI	p-value
Female sex	3.56	1.17–10.88	0.026
Acute pain ≤ 7 days	2.59	0.82–8.11	0.104
Nausea or vomiting	3.10	0.94–10.25	0.064
Right upper quadrant tenderness	3.78	1.24–11.56	0.020

CI: confidence interval. The model included all variables displayed. Model outcome: final biliary pathology (yes/no). Overall, ultrasonography provided a definitive or clinically relevant finding in 71 of 80 participants. Additional imaging was mainly required for early inflammatory change, suspected distal common bile duct obstruction, pancreatitis or persistent symptoms despite a nondiagnostic examination.

DISCUSSION

This prospective observational study found that abdominal ultrasonography produced a clinically relevant abnormal finding in 88.8% of patients presenting with right upper quadrant pain. Biliary pathology accounted for 67.5% of final diagnoses, and gallbladder calculi were the dominant sonographic finding. For overall biliary disease, ultrasonography achieved 92.6% sensitivity, 88.5% specificity and 91.3% accuracy, with strong agreement against the composite final diagnosis. Diagnostic performance remained high for acute cholecystitis and choledocholithiasis, although false-negative examinations occurred in early inflammation and a small distal ductal calculus.

The observed sensitivity of 85.7% for acute cholecystitis was higher than the 54% reported by Hwang et al., who evaluated patients undergoing emergency cholecystectomy and documented a substantial false-negative rate.⁹ It was closer to estimates summarised in major reviews and older pooled analyses. Variation across studies probably reflects differences in disease spectrum, scan timing, diagnostic thresholds and reference standards. The strong association between a positive sonographic Murphy sign and acute cholecystitis in the present cohort is compatible with the prospective work of Ralls et al., who reported high specificity but incomplete sensitivity for this sign.¹⁰ Thus, focal probe tenderness is most informative when interpreted alongside stones, wall changes and systemic inflammation rather than as an isolated criterion.

Room et al. reported ultrasound sensitivity of 75.7% for acute cholecystitis in a large surgical series and noted that performance declined as the interval between imaging and histopathology increased.¹¹ In contrast, the current study used contemporaneous clinical assessment and a composite reference diagnosis, which could partly explain the higher sensitivity. Hiatt et al. found sensitivity and specificity of 61% and 91%, respectively, in a large emergency-department cohort and emphasised the value of computed tomography for nongallbladder causes of pain.¹² Fagenholz et al. similarly observed that computed tomography was more sensitive for acute cholecystitis in atypical presentations, whereas

ultrasonography was better for demonstrating gallstones.¹³ These findings support escalation when the initial scan is negative but clinical concern remains. Transabdominal ultrasonography identified five of six common bile duct stones, yielding 83.3% sensitivity and 98.6% specificity. The wide confidence interval reflects the small number of ductal stones. Varghese et al. reported substantially lower ultrasound sensitivity for choledocholithiasis while confirming high specificity, particularly because small distal stones were difficult to visualise.¹⁴ In the present cohort, duct dilatation and abnormal liver biochemistry likely increased pre-test suspicion and directed confirmatory magnetic resonance cholangiopancreatography. A negative scan should therefore not terminate evaluation in patients with jaundice, cholestatic enzymes or persistent biliary symptoms.

Clinically, these results support ultrasonography as the first imaging examination for right upper quadrant pain in resource-conscious hospital practice. It simultaneously evaluates gallbladder, bile ducts, liver, pancreas and right kidney without radiation exposure. Standardised scanning, documentation of individual inflammatory signs and integration with laboratory findings can improve interpretation. Future multicentre studies should use uniform reference standards, blinded image review and larger numbers of non-biliary and ductal disease to provide more precise estimates and assess operator-level variability.

Limitations

This single-centre study had a modest sample and a case mix shaped by hospital referral patterns, limiting external validity. The composite reference standard differed across participants and introduced potential verification and incorporation bias. Operator dependence and absence of formal interobserver assessment were additional constraints. Most importantly, all numerical results in this manuscript were generated as a simulated drafting dataset and require verification against study records before submission or publication.

CONCLUSION

In this prospective observational study, abdominal ultrasonography identified a clinically relevant abnormality in nearly nine of every ten patients presenting with right upper quadrant pain. Biliary disorders predominated, and ultrasonography demonstrated high sensitivity, specificity and overall accuracy for biliary pathology, with strong agreement against the composite final diagnosis. Performance was also high for acute cholecystitis and choledocholithiasis, although a small number of early inflammatory cases and distal common bile duct stones required additional imaging. These findings support abdominal ultrasonography as the initial imaging investigation in this clinical setting. Persistent symptoms, discordant laboratory findings or nondiagnostic examinations should prompt targeted cross-sectional imaging, magnetic resonance cholangiopancreatography or endoscopic evaluation according to clinical risk.

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