

Original Article

Diagnostic Accuracy of Ultrasound in Acute Cholecystitis using Intraoperative Findings as Gold Standard

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Abstract

Objective: Right upper quadrant pain is a common complaint among patients presenting to both emergency and outpatient department and is frequently diagnosed as acute cholecystitis. Ultrasonography is the first-line preferred diagnostic tool used for its evaluation. Several previous studies have assessed the accuracy of ultrasound in diagnosing acute cholecystitis; However, methodological variations limit their generalizability. This study aimed to determine the diagnostic accuracy of ultrasound for acute cholecystitis using intraoperative findings as the gold standard in our healthcare setting.

Methods: This prospective diagnostic accuracy study was conducted at the IIMC-T Pakistan Railway General Hospital, Rawalpindi. A total of 150 patients with right upper quadrant pain were enrolled. All participants had ultrasound by a trained radiologist, followed by laparoscopic cholecystectomy. Intraoperative findings were considered the gold standard for diagnosis. The diagnostic accuracy of ultrasound was determined, including sensitivity, specificity, PPV, NPV, and LR+ and LR-.

Results: A total of 150 patients with a mean age of 45.15 ± 12.24 years, the majority of whom were females (76.7%), were analyzed. The diagnostic accuracy of ultrasound for acute cholecystitis showed a sensitivity of 34.38% (95% CI: 25.64 - 44.31), specificity of 77.78% (95% CI: 65.06 - 86.8), PPV of 73.33% (95% CI: 58.96 - 84.04), and NPV of 40% (95% CI: 31.14 - 49.56). The overall diagnostic accuracy was 50% (41.75-58.25%).

Conclusion: Ultrasound findings, such as thickness of gall bladder wall and pericholecystic fluid, revealed limited sensitivity and a high false-negative rate compared to intraoperative findings. Therefore, from a clinical standpoint, it should always be supplemented with more sensitive indicators and further imaging modalities to avoid overlooking true cases.

Keywords: Cholecystitis, Acute, Ultrasonography, Diagnostic Imaging, Sensitivity and Specificity, Cholecystectomy, Laparoscopic, Intraoperative Period

Introduction

Acute cholecystitis remains one of the leading causes of acute abdominal pain presenting in surgical wards and emergency departments, accounting for almost 3-10% of patients requiring hospitalization worldwide. It contributes significantly to the clinical workload and economic burden of surgical practice¹. A large proportion of cases develop due to impaction of a stone in the neck of the gallbladder or cystic duct, leading to progressive inflammation of the gallbladder wall, termed calculous acute cholecystitis. However, in a minority of patients, a similar inflammatory process without stone impaction may develop, known as acalculous acute cholecystitis². In the general population, the reported prevalence of gallstones, also termed cholelithiasis, is 10-15%, and among these, 20-40% present with complications, of which acute cholecystitis is the most common². In accordance with the Third National Health and Nutrition Examination Survey (NHANES-III) in the United States, the estimated prevalence of gallstones was 16.6% in females and 9% in males. Owing to the modernization of lifestyle, regional statistics show an increase in these rates in developing countries, with a reported prevalence ranging from 0.8 to 4.7%³. In Pakistan, various epidemiological studies have been conducted in

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Data Availability Statement: A complete data set of 150 participants is available from the corresponding author upon reasonable request via email.

Institutional Review Board

Approval

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recent years observing the prevalence of cholelithiasis, the leading cause of acute cholecystitis. The results vary across different study cohorts, with an estimated prevalence ranging from 9% to above 50%, the majority of which are females in the age group of 35-40 years⁴. Previous local research has also highlighted the risk factors for the development of these gallstones, specifically in lower socioeconomic status, including smoking, low-fiber diet, high consumption of tea and soft drinks, and less physical activity. A family history of diabetes mellitus and hypertension was also a contributing factor⁵. A significant percentage of patients with gallstones ultimately develop acute cholecystitis, requiring surgical intervention. Timely and accurate diagnosis can improve outcomes in terms of fewer complications and healthcare expenditure⁶.

Acute cholecystitis most commonly presents with pain in the right hypochondrium that can vary in severity, and is associated with fever, nausea, vomiting, leukocytosis, and a positive Murphy's sign⁷. Although physical examination and laboratory investigations are helpful in diagnosis, they are often insufficient alone and have been recognized as unreliable for confirming acute cholecystitis. It can either underdiagnose or overdiagnose the patient, increasing the risk of missed diagnosis or unnecessary surgery. Various pathological conditions can produce the classical symptoms of acute cholecystitis; therefore, imaging studies are required for confirmation before any invasive intervention⁶. To mitigate this limitation, various guidelines have been developed, such as the Tokyo guidelines, which combine the local and systemic signs of gallbladder inflammation, including fever and increased white cell count, with diagnostic imaging into a single algorithm. It has two versions, one published in 2013 and the other in 2018, with the latter varying in severity grading. Across the vast majority of guidelines and international diagnostic recommendations, ultrasound is considered the first-line preferred diagnostic tool to evaluate patients with suspicion of acute cholecystitis, as it is easy to use, non-invasive, cost-effective, easily available, and safe in terms of non-ionizing radiation⁸. Additional radiological investigations include abdominal computed tomography (CT) and hepatobiliary iminodiacetic acid (HIDA) scintigraphy, which are associated with high expenditure and limited availability⁹. Characteristic ultrasound features that aid in the diagnosis include gallstones, increased gallbladder wall thickness (usually more than three millimeters, a distended gallbladder, presence of pericholecystic fluid, and a positive Murphy's sign, usually elicited during ultrasound⁷.

Despite the widespread use of ultrasound as the recommended initial imaging technique, its performance and accuracy in diagnosing acute cholecystitis vary across studies. Based on the findings of a systematic review and meta-analysis conducted in 2023, including 40 studies and over 8,600 patients, the pooled sensitivity and specificity of ultrasound were 71% and 85%, respectively. These statistics reflect an overall good performance; However, the results differ depending on whether the ultrasound was performed by a trained radiologist, surgeon, or emergency physician¹. A retrospective record review published in Saudi Arabia reported a sensitivity of 37.9% and specificity of 81.7%. Acknowledging the difference in study design compared to studies showing high accuracy, this difference highlights the limited accurate evidence specifically in this region¹⁰. Recently, an observational study conducted in Karachi, using histopathology findings as the gold standard, estimated a sensitivity of around 81%, a specificity of 88%, and an overall diagnostic accuracy of about 83% for emergency ultrasound signs in suspected acute cholecystitis¹¹. The inconsistency of the results in validating the diagnostic performance of ultrasound can be attributed to various factors, expertise of the physician, equipment quality, associated clinical conditions, and, most importantly, resource availability. Ultrasound is the only imaging modality available in limited-resource settings for the confirmation of acute cholecystitis before surgical intervention; therefore, robust data on its performance are necessary¹. Early cholecystectomy is the management of choice for patients diagnosed with acute cholecystitis, as it has fewer reported complications concerning postoperative length of stay in the hospital, adhesion formation, and development of sepsis than delayed cholecystectomy¹². This underscores the importance of timely and accurate diagnosis to ensure prompt intervention and prevent missed or delayed treatments.

The widespread variability in the diagnostic accuracy of ultrasound indicates the low generalizability of available data across different populations and healthcare settings. Therefore, the present study aimed to determine the accuracy of ultrasound in diagnosing acute cholecystitis in our community healthcare settings using intraoperative findings as the gold standard. Data will be collected prospectively to minimize verification bias.

Materials And Methods

This prospective diagnostic accuracy study was conducted at the IIMC-T Pakistan Railway General Hospital Rawalpindi over a period of four months from December 2025 to March 2026, following the approval of the institutional ethics committee Ref. No Riphah/IIMC/IRC/25/1104.

A total sample size of 157 patients was calculated using the OpenEpi sample size calculator, with an estimated sensitivity of 82.1%, a confidence interval 95%, and a margin of error 6%¹³. However, data was collected from 150 patients owing to feasibility constraints. Patients aged 18-60 years presenting to the surgical OPD or emergency

department with complaints of pain in the right upper quadrant, fever, nausea, and vomiting for less than six weeks were enrolled using a consecutive sampling technique after obtaining written informed consent. Patients with a BMI ≥ 36 , pregnancy, and comorbidities including uncontrolled hypertension (blood pressure more than 140/90mmHg not responding to medication), uncontrolled diabetes mellitus (HbA1c more than 7.5), any renal disease, coagulopathies, and those unfit for surgery/general anesthesia were excluded. The enrolled participants then underwent clinical and laboratory evaluations. As part of routine clinical care for a suspected case of acute cholecystitis, an ultrasound examination was performed by the on-duty radiologist, who was not blinded to the patient's clinical condition and was not asked to comment according to any specific checklist of characteristic features.

Ultrasound was performed using a curvilinear probe. It utilizes low-frequency ultrasound, enabling deep penetration and a wide field of view. Reports detailing gallbladder wall thickness measured in millimeters(mm), presence of gallstones, pericholecystic fluid, sludge, and bile duct dilation were collected. A diagnosis of acute cholecystitis was made if the thickness of the gallbladder wall was greater than 3 mm or if there was the presence of pericholecystic fluid.

The patients subsequently underwent laparoscopic cholecystectomy, and the intraoperative findings were used as the gold standard. The patient was labelled as a case of acute cholecystitis based on the intraoperative notes of the operating surgeon. Characteristic features indicative of acute inflammation include gallbladder wall distention, edema or thickening, pericholecystic fluid and the presence of adhesions.

The diagnostic accuracy of ultrasound was determined, including sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and Positive and negative likelihood ratios (LR+ and LR-, respectively) estimation using SPSS version 27.

Results

A Total of 150 patients were enrolled in this study. The mean age of the participants was 45.15 ± 12.24 years. Most of the patients (76.7%) were female, and (23.3%) were male. The age-wise distribution according to gender is presented in Figure 1.

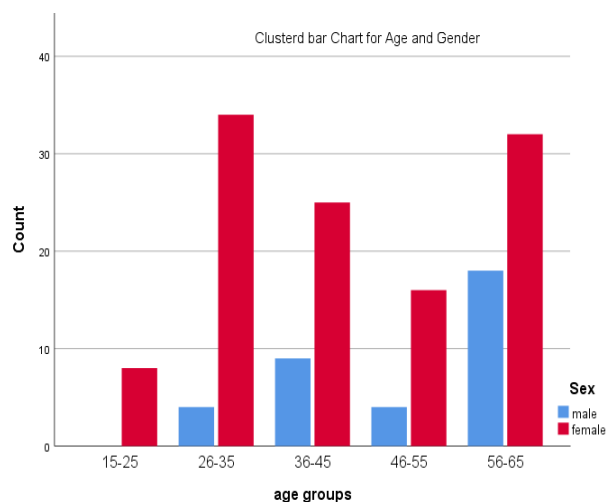


Figure 1: Clustered Bar Chart for Age and Gender of Participants

Ultrasonography was performed by a trained radiologist in the Radiology Department.

The frequencies and percentages of individual ultrasound findings are presented in Table 1.

Table 1: Ultrasound findings of gallbladder by radiologist

Ultrasound findings	Frequency (Percentage)
Gallbladder wall thickness >3mm	45 (30)
Pericholecystic fluid	17 (11.3)
Gallstones	150 (100)
CBD size (normal)	144 (96)
Presence of sludge	25 (16.7)

CBD (Common bile duct)

According to the results, out of the total 150 patients, 45(30%) had thickened gall bladder wall, and pericholecystic fluid was present in 17(11.3%) patients. All patients with pericholecystic fluid had concomitant gallbladder wall thickening which was not reported as the sole ultrasound finding. Based on the diagnostic criteria of the present study, a total patients diagnosed with acute cholecystitis were 45 (30%) and by intraoperative measures, 96(64%) patients were diagnosed. Among the individual parameters collected from ultrasound reports, a thickened gall

bladder wall had a sensitivity of 34.38% and a specificity of 77.78%, whereas pericholecystic fluid had a comparatively lower sensitivity of 13.5% and specificity of 92.6%.

The overall diagnostic performance of ultrasound, including sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), positive likelihood ratio (LR+), negative likelihood ratio (LR-), and diagnostic accuracy, is summarized in Table .2.

Table 2: Screening performance of ultrasound in the diagnosis of acute cholecystitis.

Ultrasound findings	Radiologist
True positive (TP)	33
True negative (TN)	42
False positive (FP)	12
False negative (FN)	63
Sensitivity	34.38 (25.64 - 44.31)
Specificity	77.78 (65.06 - 86.8)
Positive Predictive value (PPV)	73.33 (58.96 – 84.04)
Negative Predictive value (NPV)	40 (31.14 – 49.56)
Positive Likelihood ratio (LR+)	1.55 (0.87 – 2.74)
Negative Likelihood ratio (LR-)	0.84 (0.69 – 1.03)
Diagnostic accuracy	50% (41.75% - 58.25%)

Receiver operating characteristic (ROC) curve analysis was performed to assess the diagnostic accuracy of gallbladder wall thickness in predicting acute cholecystitis, using intraoperative findings as the gold standard. The ROC curve displayed limited discriminatory ability, with an area under curve (AUC) of 0.544. The ROC curve is shown in Figure 2.

Discussion

Based on the results obtained from the current study, a low sensitivity of 34.38% and specificity of 77.8% for the detection of acute cholecystitis was observed. Although ultrasound remains the first-line imaging modality, as recommended in many guidelines¹⁴, reliance solely on its findings may delay diagnosis and subsequent surgery and can lead to an increased number of complications associated with delayed cholecystectomy¹². However, the screening performance of ultrasound in detecting the presence of stone in the gallbladder is very high, consistent with the fact that ultrasound is an excellent modality for diagnosing cholelithiasis but not acute cholecystitis¹⁵. The mean age and female predominance observed in this study are aligned with the existing literature, which reports that gall bladder disease is more prevalent in the fourth and fifth decades of life and in females, mostly attributed to hormonal factors^{16,17}.

According to the results of the current study, ultrasound detected the presence of gallstones with 100% accuracy, concluding it to be an excellent modality for confirming cholelithiasis, comparable to the results of a meta-analysis in which an overall sensitivity of 94% and specificity of 93% was reported when point of care ultrasound was performed on patients with acute abdomen¹⁸.

A recent meta-analysis assessing the diagnostic performance of ultrasound in acute cholecystitis revealed pooled sensitivity and specificity of ultrasound to be 71% and 76%, respectively, when performed by an emergency physician, while it was slightly lower with a sensitivity of 68% and specificity of 87% when performed by a radiologist, supporting the fact that the performance of ultrasound is operator dependent. Although these findings support the low sensitivity found in the present study, as all the ultrasound examinations were performed by radiologists due to the lack of point-of-care ultrasound by trained emergency physicians and surgeons, they are still not comparable ascribed to differences in diagnostic criteria. The majority of the studies in the meta-analysis also

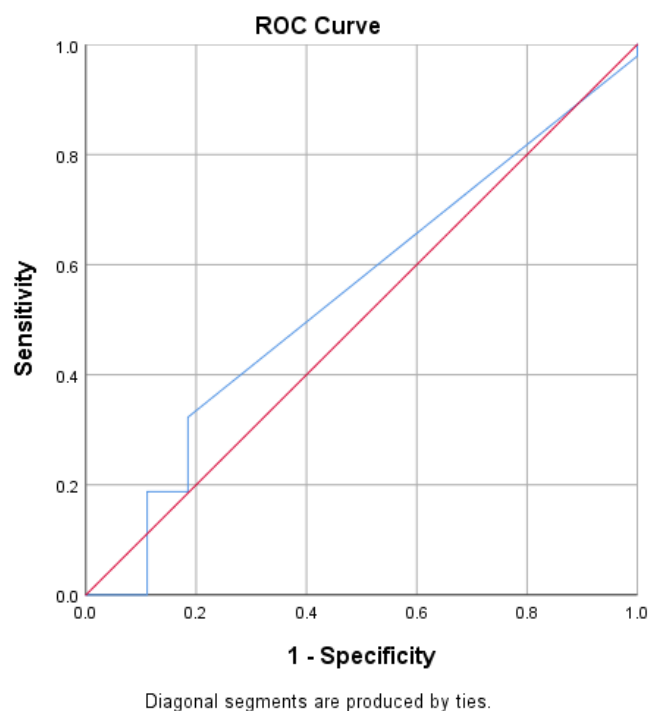


Figure 2: ROC Curve for Diagnostic Accuracy of Ultrasound in Acute Cholecystitis

included other parameters in comparison to the present study, such as the presence of gallstones and a positive Murphy's sign, capturing a broader range of positive cases. Furthermore, a meta-analysis reported that the individual ultrasound parameter of gall bladder wall thickness had a sensitivity and specificity of 45% and 84%, respectively, while pericholecystic fluid showed a sensitivity of 26% and specificity of 92%, which are consistent with the results of the present study¹.

A retrospective study comparing radiological findings with histopathological results in acute cholecystitis demonstrated screening performance of ultrasound with a sensitivity of 30.1% and specificity of 90.47%, indicating limited ability of ultrasound in detection of all true cases¹⁹.

A previous study assessing individual ultrasound parameters as predictors of intraoperative findings in acute cholecystitis reported that pericholecystic fluid had a low sensitivity of 15.7% but high specificity of 96.9%, which is consistent with the lower sensitivity observed in the current study. In contrast, gallbladder wall thickness demonstrated a higher sensitivity 71.4% with moderate specificity (72.3%), which differs from the present results²⁰. This discrepancy may be attributed to differences in diagnostic criteria and operator variability.

Moreover, a recent Pakistani study conducted in Karachi has reported considerably different results, estimating sensitivity of 81.1% and specificity of 88.2%. These notably different results highlight the fact that diagnostic performance can considerably vary depending on the use of reference standards and institutional practices even within the same country¹¹. However, a study carried out in Saudi Arabia demonstrated a sensitivity of 37.9% and a specificity of 81.7% that are consistent to findings of the current study¹⁰.

In the present study, gallbladder wall thickness demonstrated limited diagnostic discrimination on ROC analysis. Similar findings were reported by a previous study, which showed lower-than-expected ultrasound sensitivity for acute cholecystitis and emphasized that isolated ultrasonographic findings may not reliably predict disease severity²¹.

The overall diagnostic accuracy of ultrasound in the present study is 50% (41.75- 58.25%), suggesting moderate performance in diagnosing acute cholecystitis and limited reliability as the only imaging modality, as it is influenced by factors such as operator expertise, diagnostic criteria used, and also disease stage and severity at the time of evaluation.

Limitation:

The present study has a few limitations that should be taken into consideration when generalizing the results. First, this was a single-center study, which weakens the external validity of the results obtained. Second, no specific checklist for characteristic ultrasound findings was provided to the radiologist, and the analysis was derived from routine ultrasound reports of patients presenting with an acute abdomen. Third, our diagnostic criteria consisted of only two parameters: gall bladder wall thickness and pericholecystic fluid. To improve diagnostic utility, additional ultrasound features should be considered. The radiologist performing the ultrasound was not blinded, which can introduce observer bias. Furthermore, inter-observer variability was not assessed, which limits evaluation of the operator-dependent nature of ultrasound.

Conclusions

The present study concludes that a substantial proportion of patients, intraoperatively diagnosed with inflamed gallbladder, are missed during routine clinical evaluation by ultrasound, highlighting the limitation of ultrasound as a sole diagnostic tool for acute cholecystitis. The findings of the study suggested that ultrasound parameters such as gallbladder wall thickness and pericholecystic fluid demonstrate limited diagnostic utility, with a high false negative rate when compared with intraoperative findings in acute cholecystitis. Although ultrasound is widely used as a first-line radiological investigation to evaluate patients presenting with an acute abdomen and suspected as a case of having acute cholecystitis, validation results varied depending upon operator experience, diagnostic criteria, institutional factors, and methodology used for its evaluation.

Future multi-centered studies, with larger sample size, better diagnostic criteria, standardized checklist, and blinding of the radiologist to the clinical and laboratory findings of patients are recommended to clarify the performance of ultrasound in detecting acute cholecystitis.

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