VOLUME - 14, ISSUE - 08, AUGUST - 2025 • PRINT ISSN No. 2277 - 8160 • DOI : 10.36106/gjra

Original Research Paper

Radio-Diagnosis

# UTILITY OF ULTRASONOGRAPHY IN GALL BLADDER PATHOLOGIES

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## ABSTRACT

**Background:** Gallbladder diseases are a significant health burden worldwide, with higher prevalence in women and in Indian populations. Ultrasonography (USG) is considered the first-line imaging modality owing to its accessibility, cost-effectiveness, and high diagnostic accuracy. This study was undertaken to evaluate the role of ultrasonography in the diagnosis of gallbladder pathologies with clinicopathological correlation. **Methods:** A cross-sectional observational study was conducted in the Department of Radiodiagnosis, Sri Aurobindo Institute of Medical Sciences, Indore, over 18 months (June 2023–November 2024). Forty patients with clinically suspected gallbladder disease underwent ultrasonographic evaluation using high-resolution transabdominal scanners. Findings were correlated with histopathology and clinical follow-up. Statistical analysis included descriptive measures and Chi-square testing, with $p < 0.05$ considered significant. **Results:** The mean age of patients was 46.2 ± 7.5 years (range 30–70), with a female predominance (65%). The most common symptom was right upper quadrant pain (75%), followed by nausea/vomiting (45%) and fever (25%). USG identified cholelithiasis in 57.5%, acute cholecystitis in 15%, chronic cholecystitis in 10%, benign lesions in 7.5%, and carcinoma in 10% of cases. Histopathology confirmed 21/23 gallstone cases, 5/6 acute cholecystitis, 3/4 chronic cholecystitis, and 3/4 carcinomas. One carcinoma was missed (false negative), and one was overdiagnosed (false positive). The diagnostic efficacy of USG for carcinoma showed sensitivity 75%, specificity 97.2%, PPV 75%, NPV 97.2%, and overall accuracy 95%. Stage-wise, 75% of carcinomas presented in advanced stages (III/IV). **Conclusion:** Ultrasonography remains a highly effective, non-invasive modality for diagnosing gallstones and inflammatory gallbladder disease. While its sensitivity for early carcinoma detection is limited, it demonstrates high accuracy in advanced disease, making it indispensable in resource-limited settings. These findings reaffirm USG as the cornerstone for initial evaluation and management of gallbladder pathologies.

**KEYWORDS :** Gallbladder disease, ultrasonography, cholelithiasis, cholecystitis, gallbladder carcinoma, diagnostic accuracy.

## INTRODUCTION

Gallbladder diseases are a major health concern worldwide, affecting about 10–20% of adults [1]. They represent a wide spectrum of inflammatory, infectious, obstructive, and structural abnormalities of the gallbladder, with a higher prevalence in middle-aged women and in Western populations. In India, prevalence ranges from 2% to 29%, with Northern regions showing up to sevenfold higher rates [2]. Although most gallstones remain silent, nearly 20% of cases develop symptoms requiring medical attention [3].

Anatomically, the gallbladder is a pear-shaped organ beneath the liver that stores and concentrates bile, essential for fat digestion. Common pathologies include cholelithiasis, cholecystitis, choledocholithiasis, biliary dyskinesia, gallbladder perforation, gallstone pancreatitis, and gallbladder polyps, most of which are benign [4–7]. Risk factors are both non-modifiable (female sex, age, pregnancy, family history, genetics) and modifiable (obesity, high-fat diet, diabetes, dyslipidemia, sedentary lifestyle). Estrogen contributes to disease by increasing cholesterol saturation and impairing gallbladder motility, especially in pregnancy [8,10].

Clinically, patients may present with nonspecific abdominal discomfort, biliary colic—classically sharp postprandial right upper quadrant pain radiating to the back or shoulder—along with nausea and vomiting [4,5,8]. Acute cholecystitis manifests with fever, jaundice, and a positive Murphy's sign [5]. Other features include dyspepsia, bloating, and intolerance to fatty meals [4,5,8].

Ultrasonography (USG) is the gold standard for diagnosis due to its high sensitivity (up to 96%) and specificity (up to 93%), accessibility, and cost-effectiveness [11,12]. Cholelithiasis is detected as echogenic foci with posterior acoustic shadowing [13]. Acute cholecystitis shows wall thickening >3 mm, distension, pericholecystic fluid, and sonographic Murphy's sign [14]. Chronic cholecystitis typically reveals a contracted fibrotic gallbladder [15]. Gallbladder polyps appear as echogenic projections without shadowing, with lesions >1 cm warranting malignancy work-up [14]. Carcinoma may be suspected with irregular wall thickening or intraluminal masses [14].

USG offers several advantages—non-invasive, radiation-free, inexpensive, and safe even in pregnancy [16, 17]. It also guides procedures like percutaneous drainage and biopsy. Limitations include operator dependency, reduced accuracy in obese patients, and difficulty assessing adjacent organs, sometimes necessitating CT, MRI, or MRCP [11].

Despite these, ultrasonography remains invaluable not only for diagnosis but also for detecting complications such as empyema and perforation. In resource-limited settings like India, its role is amplified. With ongoing innovations such as contrast-enhanced and 3D/4D ultrasound, its diagnostic utility is expected to expand further. Thus, ultrasonography continues to serve as a cornerstone in the detection and management of gallbladder diseases, enabling early intervention and improved outcomes.

## MATERIAL AND METHODS

After obtaining approval from the Institutional Research and Ethics Committee, this cross-sectional observational study was conducted in the Department of Radiodiagnosis, Sri Aurobindo Institute of Medical Sciences (SAIMS) and Postgraduate Institute, Indore (Madhya Pradesh). The study was carried out over 18 months, from June 1, 2023 to November 30, 2024. Written informed consent was obtained from all

participants following explanation of the study protocol in their vernacular language.

A total of 40 patients, irrespective of age and gender, diagnosed with gallbladder pathology and undergoing ultrasonographic evaluation during the study period were enrolled. Patients with histopathological correlation or clinical follow-up confirming the diagnosis were included, while those unwilling or unable to provide consent were excluded.

### Methodology

For each patient, a detailed clinical history was obtained and a thorough physical examination performed to correlate presenting complaints with imaging findings. Ultrasonographic evaluation was carried out using General Electric LOGIQ E9 and LOGIQ F8 ultrasound systems equipped with a 3.5 MHz convex array transducer for transabdominal scanning. Real-time gray-scale imaging was employed to assess gallbladder size, wall thickness, luminal contents, sludge, calculi, polyps, or masses, along with pericholecystic collections and associated features. Patient positioning or scanning technique was modified when necessary to improve visualization.

Relevant laboratory parameters, including liver function tests and complete blood counts, were documented wherever available. All scans were performed and interpreted by experienced radiologists. Imaging findings were systematically recorded in a structured proforma, and when available, histopathological examination or treatment response served as the reference standard.

### Statistical Analysis

Data were compiled in Microsoft Excel to create master charts. Descriptive statistics, including mean, standard deviation, frequencies, and percentages, were applied. Associations between clinical and sonographic findings were assessed using Chi-square tests, with a p-value $<0.05$ considered statistically significant.

## RESULTS

A total of 40 patients with gallbladder pathologies were evaluated using ultrasonography. The age of patients ranged from 30 to 70 years, with a **mean of 46.2 ± 7.5 years**. Females (26; 65%) predominated over males (14; 35%). The most common presenting symptom was right upper quadrant abdominal pain (75%), followed by nausea/vomiting (45%), positive Murphy's sign (30%), fever (25%), dyspeptic complaints (20%), and jaundice (15%). With respect to final diagnosis, ultrasonography identified **cholelithiasis in 57.5%**, acute cholecystitis in 15%, chronic cholecystitis in 10%, benign lesions in 7.5%, and carcinoma in 10% of patients. Importantly, carcinoma was detected more frequently in advanced stages, with no Stage I cases and 75% of patients diagnosed in Stage III/IV. [Table 1]

**Table 1. Demographic, Clinical Profile And Final Diagnosis Of Patients (n=40)**

| Characteristic | Statistic (%) |
|---|---|
| Mean age ± SD (years), range | 46.2 ± 7.5 (30–70) |
| Gender (Male: Female) | 14 (35.0): 26 (65.0) |
| Presenting complaints | |
| – Right upper quadrant pain | 30 (75.0) |
| – Nausea/Vomiting | 18 (45.0) |
| – Fever | 10 (25.0) |
| – Jaundice | 6 (15.0) |
| – Dyspepsia/Flatulence | 8 (20.0) |
| – Positive Murphy's sign | 12 (30.0) |
| Final diagnosis (based on USG & HPE/Follow-up) | |
| – Cholelithiasis | 23 (57.5) |
| – Acute cholecystitis | 6 (15.0) |
| – Chronic cholecystitis | 4 (10.0) |
| – Gallbladder polyps/benign lesions | 3 (7.5) |
| – Gallbladder carcinoma (total) | 4 (10.0) |
| Stage distribution of carcinoma (n=4) | |
| – Stage I | 0 (0.0) |
| – Stage II | 1 (2.5) |
| – Stage III | 2 (5.0) |
| – Stage IV | 1 (2.5) |

Ultrasonography findings revealed that gallstones were the most frequent abnormality (57.5%). Gallbladder wall thickening was seen in 25%, pericholecystic fluid in 15%, and distension in 20%. Polyps or intraluminal masses were visualized in 7.5%, and carcinoma was suspected in 10%. Other associated findings included sludge (12.5%), choledocholithiasis (5%), empyema (5%), perforation (2.5%), and gallstone-induced pancreatitis (2.5%). [Table 2]

**Table 2. Ultrasonographic Findings And Associated Complications (n=40)**

| USG Feature / Complication | No. of Cases | Percentage (%) |
|---|---|---|
| Gallstones with shadowing | 23 | 57.5 |
| Gallbladder wall thickening (>3 mm) | 10 | 25.0 |
| Pericholecystic fluid | 6 | 15.0 |
| Distension of gallbladder | 8 | 20.0 |
| Polyps/Intraluminal mass | 3 | 7.5 |
| Carcinoma | 4 | 10.0 |
| Sludge | 5 | 12.5 |
| Choledocholithiasis | 2 | 5.0 |
| Gallstone pancreatitis | 1 | 2.5 |
| Empyema of gallbladder | 2 | 5.0 |
| Perforation | 1 | 2.5 |

When compared with clinical diagnosis, ultrasonography consistently demonstrated superior yield (Table 3). While only 16 patients were clinically suspected of gallstones, USG confirmed 23 cases. Acute and chronic cholecystitis were detected in 6 and 4 cases, respectively, compared to 4 and 2 cases clinically. Carcinoma was suspected clinically in just one patient, whereas USG identified 4 patients.

**Table 3. Clinical Vs. Ultrasonographic Correlation**

| Condition | Clinical Diagnosis (n) | USG Diagnosis (n) |
|---|---|---|
| Gallstone disease | 16 | 23 |
| Acute cholecystitis | 4 | 6 |
| Chronic cholecystitis | 2 | 4 |
| Polyps/Carcinoma | 1 | 7 (3 polyps + 4 Ca) |

Correlation with histopathology and follow-up confirmed the diagnostic accuracy of ultrasonography (Table 4). Of 23 gallstone cases, 21 were confirmed, along with 5/6 acute and 3/4 chronic cholecystitis cases. Out of 4 suspected carcinomas, 3 were confirmed malignant, while 1 was a false positive. Additionally, one carcinoma (Stage III) was missed on USG and detected on histopathology, making it a false negative.

**Table 4. Ultrasonography vs. Histopathology/Follow-up Correlation**

| Condition | USG Diagnosis (n) | HPE/Follow-up Confirmed (n) |
|---|---|---|
| Gallstone disease | 23 | 21 |
| Acute cholecystitis | 6 | 5 |
| Chronic cholecystitis | 4 | 3 |
| Polyps/Carcinoma | 7 (3 + 4) | 4 (3 Ca + 1 polyp) |

Based on these outcomes, the diagnostic efficacy of ultrasonography for carcinoma was high, with a sensitivity of 75%, specificity of 97.2%, PPV of 75%, NPV of 97.2%, and an overall accuracy of 95% (Table 5).

**Table 5. Diagnostic Efficacy Of Ultrasonography For Carcinoma**

| Parameter | Value |
|---|---|
| True Positive (TP) | 3 |
| False Positive (FP) | 1 |
| False Negative (FN) | 1 |
| True Negative (TN) | 35 |
| Sensitivity (%) | 75.0 |
| Specificity (%) | 97.2 |
| PPV (%) | 75.0 |
| NPV (%) | 97.2 |
| Accuracy (%) | 95.0 |

Stage-wise analysis demonstrated that the majority of carcinomas (75%) were advanced at diagnosis, with 2 cases in Stage III and 1 in Stage IV, while only 1 case was Stage II and none were Stage I. Ultrasonography correctly identified all Stage II and IV cases, but missed one of the two Stage III cases, reflecting its stronger performance in advanced disease (Table 6).

**Table 6. Stage-wise Detection Rate Of Carcinoma By USG**

| Stage | HPE Confirmed (n) | USG Confirmed (n) | Sensitivity (%) |
|---|---|---|---|
| Stage I | 0 | 0 | – |
| Stage II | 1 | 1 | 100.0 |
| Stage III | 2 | 1 | 50.0 |
| Stage IV | 1 | 1 | 100.0 |

## DISCUSSION

The present study assessed the diagnostic utility of ultrasonography in gallbladder pathologies in 40 patients. The findings highlight the significant role of ultrasonography as a first-line, non-invasive modality with high diagnostic accuracy, particularly for cholelithiasis and inflammatory conditions, while also underlining its limitations in early carcinoma detection.

In this series, the mean age of patients was 46.2 years, with a predominance of females (65%). This gender distribution is consistent with prior literature done by Vadthya G et al. [15] and Khanduri S et al. [18] which reports a higher frequency of gallbladder disease among women, likely related to estrogen-induced cholesterol supersaturation and hypomotility of the gallbladder. Similar demographic profiles have been reported in both Indian and Western studies, with the highest incidence noted in the 40–60 year age group.

Clinically, the majority of patients presented with right upper quadrant pain (75%), nausea/vomiting (45%), and fever (25%) (Table 1). These features are in line with classical descriptions of gallbladder disease, including biliary colic and dyspeptic symptoms. However, clinical diagnosis alone was often insufficient; ultrasonography consistently identified more cases of cholelithiasis and cholecystitis than clinical suspicion, underscoring its indispensable role in routine evaluation.

Ultrasonography detected gallstones in 57.5% of cases, with 21 of 23 cases confirmed histologically, reaffirming its high diagnostic accuracy. Findings such as wall thickening, pericholecystic fluid, and distension were reliable indicators of acute cholecystitis, confirmed in 5/6 cases, consistent with prior studies reporting sensitivity between 85–95%. Thus, USG continues to serve as the gold standard for gallstone disease and inflammatory conditions.

A notable finding of the present study was the detection of gallbladder carcinoma in 10% of patients. Importantly, 75% of these were in advanced stages (III/IV), reflecting the epidemiological trend of late diagnosis in Indian patients. Ultrasonography detected 3 out of 4 carcinoma cases, with one false positive and one false negative, yielding a sensitivity of 75%, specificity of 97.2%, PPV of 75%, NPV of 97.2%, and an overall accuracy of 95%. Stage-wise analysis revealed that USG identified all Stage II and IV cases, but missed one Stage III lesion. This stage-specific variation emphasizes that while USG performs well for advanced disease, its sensitivity for early carcinoma remains suboptimal.

Our findings align with Khanduri et al. (2018), who reported an overall accuracy of 91.3% and sensitivity of 82.8% for gallbladder carcinoma using USG, with better yield in advanced stages. [18] Similarly, Kim JH et al. (2015) demonstrated the utility of HR-USG in differentiating gallbladder polyps and various stages of carcinoma, with reported accuracies between 65–92%. [19] Bach et al. (1998) [20] documented 94% sensitivity for resectable gallbladder lesions, while Cho et al. (2009) [21], using endoscopic ultrasonography, reported a higher PPV (85%) compared to the transabdominal USG PPV in our study (75%) and that of Khanduri et al. (57.1%) [18]. The discrepancy can be attributed to differences in patient selection and technique-transabdominal USG being broader in scope but more prone to false positives.

Older studies had reported USG sensitivity as low as 44% before the advent of high-resolution transducers. Both our study and that of Khanduri et al. (2018) & Kim et al. 2015[9] confirm that modern HR-USG, aided by harmonic frequency modulation and appropriate probe selection, can reliably visualize mural stratification and tumor invasion, substantially improving sensitivity in resource-limited settings. The Indian Council of Medical Research also endorses patient-specific use of low- and high-frequency probes, citing diagnostic accuracies above 90%.

In its consensus document, the Indian Council of Medical Research also recommends patient specific low-/high-frequency transducer use for the detection of gall-bladder carcinoma and proposes its accuracy to be as high as 90.5%.[16] In the present study, we utilized a harmonic frequency modulation as suggested by Kim et al. 2015 [19] and thus were able to determine the depth of tumor invasion in most patients as this technique enabled detailed visualization of the layers of the gall bladder, however, we must admit that this was the reason for slight overdiagnosis of gall-bladder carcinoma, thus resulting in relatively lower positive predictive value (57.1%). However, this approach was successful in visualizing deep-seated lesions efficiently, thus increasing the overall sensitivity

The strengths of ultrasonography reaffirmed in this study include its accessibility, affordability, absence of radiation, and high diagnostic accuracy for gallstones and cholecystitis. However, limitations include operator dependence, reduced sensitivity in obese patients, and difficulties in distinguishing early carcinoma from benign wall thickening. The relatively small sample size and low carcinoma case numbers limited the statistical power of stage-wise analysis, which is a key limitation of the present study.

Despite these constraints, the present findings, in conjunction with those of Khanduri et al. and others, establish ultrasonography as a reliable, cost-effective, and widely available modality for the evaluation of gallbladder disease. While its role in early carcinoma detection remains limited, ultrasonography continues to be the cornerstone in both diagnosis and initial management planning, particularly in regions where advanced imaging is neither practical nor affordable.

## CONCLUSION

The present study reaffirms the pivotal role of ultrasonography as the first-line imaging modality in the evaluation of gallbladder diseases. USG demonstrated

excellent diagnostic accuracy for gallstones and inflammatory conditions such as acute and chronic cholecystitis, correlating well with clinical and histopathological findings. Its non-invasive nature, wide availability, affordability, and absence of ionizing radiation make it particularly valuable in resource-limited settings like India. Importantly, while USG showed high specificity and overall accuracy in detecting gallbladder carcinoma, its sensitivity was reduced in early stages, with most malignancies being diagnosed at advanced stages. This highlights both its utility and its limitation—USG can reliably exclude carcinoma and detect advanced disease, but subtle early lesions may require supplementary imaging with CT, MRI, or MRCP.

In summary, ultrasonography remains the cornerstone in the diagnostic pathway of gallbladder pathology, offering a reliable, economical, and widely accessible tool for early intervention and management. Strengthening operator expertise and integrating USG with complementary imaging techniques when needed can further improve diagnostic outcomes and aid in reducing the morbidity and mortality associated with gallbladder disease.

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