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Diagnostic Accuracy of Abdominal Ultrasonography in Gallbladder Disease: Correlation with Histopathology

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Abstract: Background: Imaging of the biliary tract has evolved considerably and plays a central role in the diagnosis of gallbladder diseases. Among available diagnostic tools, ultrasonography, serum bilirubin assessment, and histopathological examination are widely used for the evaluation of cholecystitis and cholelithiasis
Aim: This study aimed to assess the diagnostic correlation between ultrasonographic findings, serum bilirubin levels, and histopathological outcomes in patients presenting with gallbladder pathology.
Methods: This cross-sectional clinical study included 208 patients who underwent preoperative abdominal ultrasonography followed by cholecystectomy and histopathological examination. Demographic and clinical data were collected, and serum bilirubin levels were measured. Statistical analysis was performed to evaluate diagnostic agreement between ultrasonography, serum bilirubin, and histopathology.
Results: Of the 208 patients, 162 were diagnosed with cholecystitis associated with cholelithiasis, while 46 had cholecystitis without gallstones. No significant differences were observed between groups with respect to age or gender distribution. Serum bilirubin levels were significantly higher in patients with gallstone-associated cholecystitis ($p = 0.0004$). Ultrasonography demonstrated excellent agreement with histopathological diagnosis ($\kappa = 0.918$), while serum bilirubin showed substantial agreement ($\kappa = 0.893$). The combined use of ultrasonography and serum bilirubin further enhanced diagnostic concordance.
Conclusion: Abdominal ultrasonography is a reliable and accurate first-line diagnostic modality for gallbladder disease, particularly when combined with serum bilirubin assessment. This integrated, non-invasive diagnostic approach supports early diagnosis, improves preoperative evaluation, and facilitates timely clinical decision-making

Keywords: Bilirubin; Cholecystitis; Cholelithiasis; Histopathology; Ultrasonography.

1. Introduction

Gallbladder diseases, particularly acute cholecystitis, represent one of the most common causes of acute abdominal pain encountered in emergency departments. It has been reported that approximately 9% of patients admitted with abdominal pain are ultimately diagnosed with acute cholecystitis, many of whom require urgent surgical intervention [1]. Although fever and leukocytosis are frequently observed clinical indicators, their absence does not exclude the

diagnosis, as a substantial proportion of patients with gallbladder inflammation may present with normal white blood cell counts [2].

Acute biliary colic typically presents as a sudden onset of pain in the right upper quadrant or epigastric region, often occurring within 30–60 minutes after meals. This pain results from gallbladder contraction against an obstructed cystic duct, commonly due to gallstones [3]. If left untreated, symptomatic biliary disease may progress to serious complications, including gallbladder perforation, empyema, and sepsis, which significantly increase patient morbidity and mortality. Therefore, timely and accurate diagnosis is essential.

Cholecystectomy remains the definitive treatment for confirmed acute cholecystitis [4]. In routine clinical practice, abdominal ultrasonography is considered the first-line imaging modality for suspected gallbladder disease due to its non-invasive nature, wide availability, cost-effectiveness, and ability to provide real-time imaging [5]. Ultrasonography is particularly effective in identifying gallstones, gallbladder wall thickening, pericholecystic fluid, and a positive sonographic Murphy's sign, all of which are key diagnostic features of acute cholecystitis.

Previous studies have demonstrated that ultrasonography achieves a diagnostic sensitivity and specificity approaching 90% in detecting gallbladder inflammation [6]. Common sonographic findings include gallbladder distension, wall thickening greater than 3 mm, echogenic bile or sludge, impacted gallstones in the gallbladder neck or cystic duct, and pericholecystic fluid collections. However, differentiation between acute and chronic cholecystitis remains challenging due to overlapping imaging.

Despite its diagnostic utility, ultrasonography has several limitations. Image quality may be affected by posterior acoustic shadowing, limited penetration in obese patients, or obscuration by overlying bowel gas. Additionally, diagnostic accuracy may be reduced in atypical clinical presentations or in the early stages of inflammation [7]. In such cases, correlation with clinical findings, laboratory markers such as elevated bilirubin levels, and histopathological examination becomes essential.

Given these considerations, there is increasing interest in evaluating the diagnostic performance of ultrasonography in comparison with histopathological findings, which remain the definitive standard for diagnosis. Establishing this correlation may improve diagnostic accuracy and facilitate early identification of patients who require surgical intervention. Accordingly, the present study aims to assess the diagnostic correlation between ultrasonographic findings and histopathological results in patients undergoing cholecystectomy for suspected gallbladder disease.

Materials and Methods

This cross-sectional clinical study was conducted to evaluate the diagnostic concordance between abdominal ultrasonography (US) and histopathological examination in patients presenting with gallbladder disease. The primary objective was to assess the diagnostic utility of ultrasonography in detecting features of cholelithiasis and cholecystitis and to correlate these imaging findings with postoperative histopathological results, which are considered the diagnostic gold standard.

A total of 208 patients who underwent preoperative abdominal ultrasonography followed by cholecystectomy and subsequent histopathological examination of gallbladder specimens were included in the study. Demographic characteristics, clinical presentations, and laboratory findings—including serum bilirubin levels—were systematically recorded for all participants.

-Ultrasonography Protocol

Abdominal ultrasonographic examinations were performed using a standardized protocol with high-resolution real-time ultrasound scanners. Evaluation of the gallbladder focused on the assessment of

the following parameters: presence of gallstones (defined as echogenic foci with posterior acoustic shadowing), gallbladder wall thickening greater than 3 mm, pericholecystic fluid collection, gallbladder distension, a positive sonographic Murphy's sign, and the presence of biliary sludge or impacted stones at the gallbladder neck.

These ultrasonographic findings were considered suggestive of acute or chronic cholecystitis based on the pattern, combination, and severity of the observed features. The diagnostic role of ultrasonography within the clinical workflow was critically evaluated, with particular emphasis on its concordance with histopathological diagnosis.

-Inclusion Criteria

Patients were included in the study if they met the following criteria:

- Age between 21 and 70 years
- Clinical diagnosis of cholelithiasis or cholecystitis
- Underwent preoperative abdominal ultrasonography
- Subsequently underwent cholecystectomy with histopathological examination of the gallbladder
- Availability of recorded serum bilirubin levels

-Statistical Analysis

All collected data were entered and analyzed using the Statistical Package for the Social Sciences (SPSS), version 24.0. Appropriate statistical tests were applied to evaluate the relationship and diagnostic concordance between ultrasonographic findings and histopathological results. A p-value of less than 0.05 was considered statistically significan

Results

Study Population

This cross-sectional clinical study included a total of 208 patients who underwent preoperative abdominal ultrasonography followed by cholecystectomy and histopathological examination. The analysis aimed to evaluate the diagnostic correlation between ultrasonographic findings, serum bilirubin levels, and histopathological diagnosis

1. Demographic Characteristics

Based on histopathological diagnosis, patients were classified into two groups: cholecystitis without cholelithiasis (n = 46) and cholecystitis with cholelithiasis (n = 162). In the group without gallstones, 69.5% were male and 30.4% were female, while in the group with gallstones, 71.6% were male and 28.4% were female. No statistically significant difference in gender distribution was observed between the two groups ($p = 0.82$). Similarly, the difference in mean age between the groups was not statistically significant ($p = 0.31$).

Table (1): Demographic Characteristics of Study Subjects.

Parameter	Cholecystitis Without Stones (n = 46)	Cholecystitis With Stones (n = 162)	p-value
Male, n (%)	32 (69.5%)	116 (71.6%)	0.82
Female, n (%)	14 (30.4%)	46 (28.4%)	
Mean Age (21-70years)	46(22.1%)	162(77.9%)	0.31

2. Serum Bilirubin Levels

Serum bilirubin levels were categorized as normal or elevated. In the cholecystitis without stones group, 82.6% of patients had normal bilirubin levels, whereas 17.3% showed elevated levels. In contrast, among patients with cholecystitis and gallstones, 39.5% had normal bilirubin levels and 60.4% had elevated levels. This difference was statistically significant (p = 0.0004).

Table (2): Serum Bilirubin Levels Among Study Subjects.

Group	Cholecystitis without stones	Cholecystitis with stones	p-value
Normal <0.3	4 (8.7%)	4 (2.4%)	0.36
Abnormal (0.3–1.9 mg/dL)	42 (91.3%)	158 (97.6%)	

Table (3): Total Bilirubin Abnormalities.

Group	Without Stones (n = 46)	With Stones (n = 162)	p-value
Normal Total Bilirubin	38 (82.6%)	64 (39.5%)	
Abnormal Total Bilirubin	8 (17.3%)	98 (60.4%)	0.0004

3. Correlation between Ultrasonography and Histopathology

A very strong diagnostic agreement was observed between ultrasonographic findings and histopathological diagnosis. The overall kappa agreement coefficient was 0.918 (95% CI: 0.833–1.000), indicating almost perfect agreement, particularly in patients with cholelithiasis.

Table (4): Correlation of USG and Histopathology.

Group	Concordant Cases (n)	Kappa Agreement (95% CI)
Without Stones	0	0.918 (0.829–1.000)
With Stones	156	

4. Correlation between Serum Bilirubin and Histopathology

A substantial agreement was also observed between serum bilirubin levels and histopathological findings, with a kappa value of 0.893 (95% CI: 0.792–0.993). Elevated bilirubin levels were more frequently associated with histopathologically confirmed cholecystitis in patients with gallstones.

Table (5): Correlation of Serum Bilirubin with Histopathology.

Bilirubin Level	Without Stones (n)	With Stones (n)	Kappa Agreement (95% CI)
Normal	38	64	0.893(0.792–0.993)
Abnormal	8	98	

5. Overall Diagnostic Agreement

Comparison of diagnostic modalities demonstrated that ultrasonography showed the highest agreement with histopathology, followed by serum bilirubin. Combined use of ultrasonography and serum bilirubin further enhanced diagnostic reliability in the preoperative evaluation of gallbladder disease.

Table (6): Overall Diagnostic Agreement Summary.

Diagnostic Comparison	Kappa Agreement (95% CI)
USG vs. Histopathology	0.918 (0.833–1.000)
USG vs. Serum Bilirubin	1.000 (1.000–1.000)
Serum Bilirubin vs. Histopathology	0.893 (0.792–0.993)

6. Ultrasonographic Findings

Ultrasonographic examination demonstrated characteristic gallbladder abnormalities. Gallstones were detected in 162 patients (77.9%) and appeared as echogenic foci with posterior acoustic shadowing, with some stones impacted at the gallbladder neck. Gallbladder wall thickening greater than 3 mm was observed in 89.1% of patients without stones and 87.6% of patients with stones. Pericholecystic fluid was identified in 17.3% of cases, predominantly in acute inflammatory

conditions. A positive sonographic Murphy's sign was observed in 32.6% of patients. Gallbladder distension and biliary sludge were detected in 21.1% and 13.9% of patients, respectively.

Figure 1. Gray-scale ultrasonography demonstrating a distended gallbladder with an anechoic lumen and smooth walls.

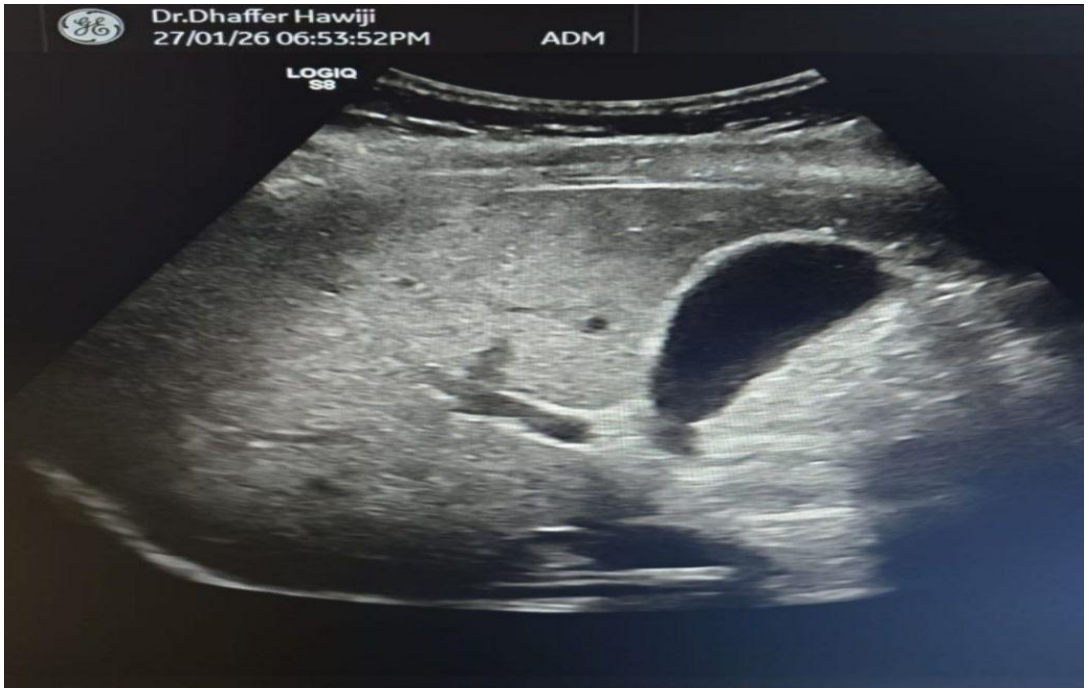

Figure 2. Ultrasonographic image showing intraluminal echogenic material with dependent layering, consistent with biliary sludge.

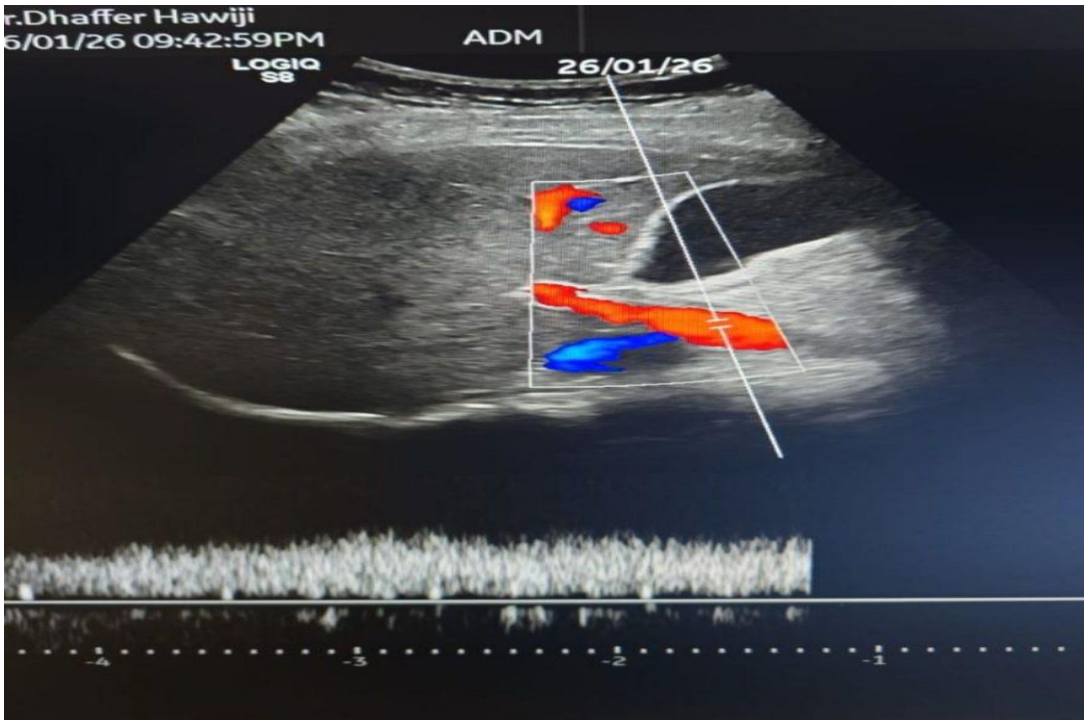

Figure 3. Color Doppler ultrasonography revealing increased gallbladder wall vascularity, suggestive of inflammatory hyperemia.

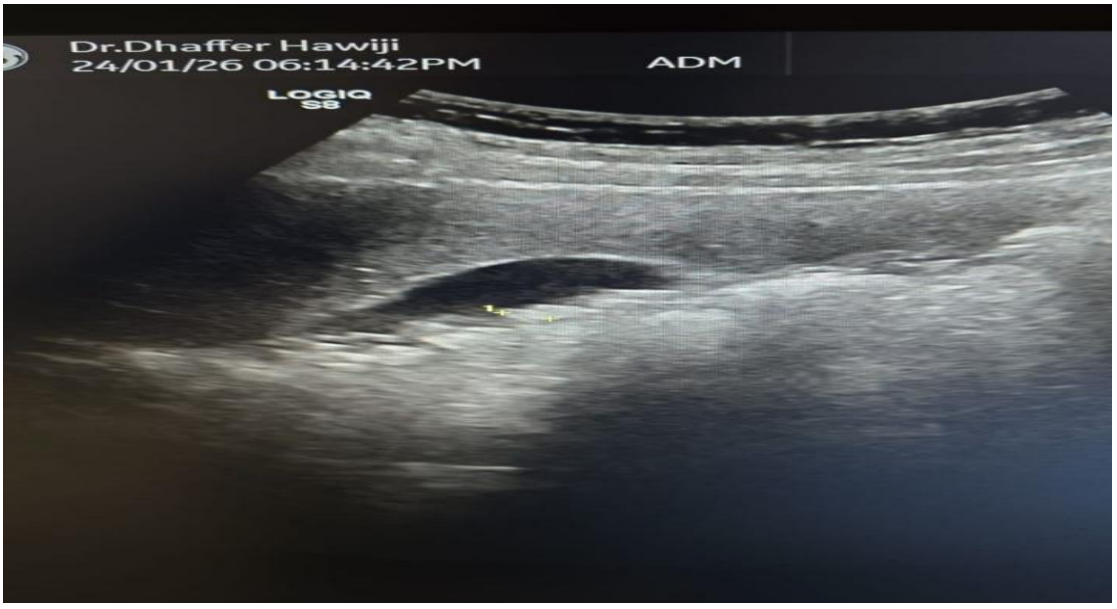

Figure 4. Longitudinal gray-scale ultrasonographic image demonstrating an echogenic gallstone casting posterior acoustic shadowing.

Discussion

This study was conducted to evaluate the diagnostic reliability of abdominal ultrasonography in comparison with histopathological findings in patients with gallbladder diseases, particularly cholecystitis and cholelithiasis. By analyzing data from 208 patients who underwent preoperative ultrasonography, serum bilirubin assessment, and subsequent histopathological examination following cholecystectomy, the present findings underscore the substantial clinical value of ultrasonography in preoperative diagnostic evaluation and surgical decision-making.

The demographic analysis demonstrated no statistically significant differences in age or gender distribution between patients with cholecystitis with and without cholelithiasis. This finding is consistent with previous studies by Malik et al. and Bekele et al., which reported comparable demographic profiles among patients undergoing cholecystectomy [8][9]. These observations suggest that gallbladder disease affects a broad patient population regardless of age or sex.

In the present study, serum bilirubin levels were significantly higher in patients with cholecystitis associated with cholelithiasis compared with those without gallstones ($p = 0.0004$). This observation supports earlier findings by Mazlum et al. and Kushwah et al., who highlighted that elevated bilirubin levels are frequently associated with gallstone-related biliary obstruction or inflammatory processes [10][11]. Accordingly, serum bilirubin may serve as a useful adjunctive biochemical marker in the diagnostic assessment of gallbladder pathology

A key finding of this study was the very high level of agreement between ultrasonographic findings and histopathological diagnosis, as reflected by a kappa coefficient of 0.918. This indicates excellent diagnostic reliability of ultrasonography in detecting gallbladder pathology. Ultrasonography was particularly effective in identifying gallstones, gallbladder wall thickening, and pericholecystic fluid, all of which demonstrated strong concordance with histopathological evidence of acute or chronic cholecystitis. These findings are in agreement with previous reports by Mahajan et al. and Wadhwa et al., who similarly demonstrated high diagnostic concordance between sonographic and histopathological evaluations [12][13].

Additionally, a substantial agreement was observed between serum bilirubin levels and histopathological findings, with a kappa value of 0.893. This reinforces the diagnostic relevance of bilirubin as a supportive marker, particularly in patients with gallstone-related disease. Notably, the combined assessment of ultrasonography and serum bilirubin demonstrated perfect agreement in certain analyses (kappa = 1.000), highlighting the complementary role of imaging and biochemical parameters in enhancing diagnostic accuracy.

The findings of the current study are further supported by reports from Bundgaard et al. and Kaur et al., who demonstrated a strong correlation between preoperative ultrasonographic findings and postoperative histopathological outcomes in patients undergoing cholecystectomy [14][15]. Collectively, these studies emphasize the role of ultrasonography as a cornerstone diagnostic modality in biliary tract diseases due to its non-invasive nature, accessibility, and high diagnostic yield [16].

Despite certain limitations, including operator dependency and occasional difficulty in differentiating acute from chronic inflammatory changes, ultrasonography remains the first-line imaging modality for gallbladder evaluation. When integrated with clinical assessment and biochemical markers, such as serum bilirubin, ultrasonography provides a comprehensive and reliable diagnostic approach for patients with suspected gallbladder disease.

Conclusion

Based on the findings of the present study, abdominal ultrasonography demonstrates high diagnostic accuracy in the detection of gallbladder pathology, particularly cholecystitis associated with cholelithiasis. When combined with serum bilirubin assessment, the diagnostic performance is further enhanced. The strong agreement observed between ultrasonographic findings and histopathological results supports the role of ultrasonography as a reliable, non-invasive, and readily available first-line diagnostic modality in both emergency and elective clinical settings.

This integrated diagnostic approach facilitates early diagnosis, appropriate surgical planning, and timely intervention, thereby contributing to improved clinical outcomes. However, future prospective and longitudinal studies involving larger and more diverse patient populations are warranted to validate these findings and further optimize diagnostic algorithms for gallbladder disease.

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