Journal of Surgical Radiology

Site: https://journalsurgrad.com/

ISSN Print 2156-213X| ISSN Online: 2156-4566 Volume: 05 Issue: 07 Open Access

Research Article

DIAGNOSIS OF GALL BLADDER LESIONS USING USG AND CECT AND ITS CORRELATION WITH HISTOPATHOLOGY

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Article History
Received: 09.06.2026
Revised: 19.06.2026
Accepted: 30.06.2026
Published: 05.07.2026

Citations:
Usmani, T., Sami, S. M. S., & Sijwali, S. (n.d.). Diagnosis of gall bladder lesions using USG and CECT and its correlation with histopathology. J Surg Radiol, V5(7) 42-49

Abstract: ***Introduction:*** Gallbladder lesions include a wide spectrum of benign and malignant conditions. Early and accurate diagnosis is essential for appropriate treatment planning and improved patient outcomes. Ultrasonography (USG) is the primary imaging modality, while contrast-enhanced computed tomography (CECT) provides additional information regarding lesion characterization and disease extent.**Aim:** To evaluate the diagnostic efficacy of USG and CECT in diagnosing gallbladder lesions and to correlate the imaging findings with histopathological examination.**Materials and Methods:** This cross-sectional observational study included 118 adult patients with suspected gallbladder lesions. All patients underwent USG and CECT followed by surgical excision and histopathological examination, which served as the reference standard. The diagnostic performance of both imaging modalities was assessed by calculating sensitivity, specificity, positive predictive value, negative predictive value, diagnostic accuracy, and agreement with histopathological findings. Results: Histopathology confirmed 94 benign and 24 malignant lesions. USG demonstrated a sensitivity of 66.7%, specificity of 96.8%, positive predictive value of 84.2%, negative predictive value of 91.9%, and an overall diagnostic accuracy of 90.7%. CECT demonstrated superior performance, with a sensitivity of 100%, specificity of 94.7%, positive predictive value of 82.8%, negative predictive value of 100%, and an overall diagnostic accuracy of 95.8%. Both modalities showed statistically significant agreement with histopathology ($p<0.001$), with CECT exhibiting stronger diagnostic concordance. Chronic cholecystitis was the most common lesion, followed by gallbladder carcinoma.**Conclusion:** Both USG and CECT are effective imaging modalities for evaluating gallbladder lesions. USG is an excellent first-line investigation because of its high specificity and accessibility, whereas CECT provides superior sensitivity and diagnostic accuracy for detecting malignant lesions. Correlation with histopathology confirms that CECT is more reliable for preoperative characterization and staging, while a combined imaging approach enhances diagnostic confidence and supports optimal clinical management.

Keywords: Gallbladder lesions; Ultrasonography; Contrast-enhanced computed tomography; Histopathology; Gallbladder carcinoma; Diagnostic accuracy.

INTRODUCTION

Gallbladder lesions comprise a broad spectrum of pathological conditions ranging from benign inflammatory diseases and cholesterol polyps to premalignant lesions and invasive gallbladder carcinoma. These lesions are frequently encountered during routine abdominal imaging and may present with diverse clinical manifestations, including right upper quadrant pain, dyspepsia, jaundice, fever, or may remain completely asymptomatic until detected incidentally. Although benign lesions constitute the majority of gallbladder abnormalities, the possibility of malignancy necessitates timely diagnosis and appropriate management because gallbladder cancer is one of the most aggressive malignancies of the biliary tract and is associated with poor survival when diagnosed at an advanced stage. Therefore, accurate differentiation between benign and malignant gallbladder lesions is essential for determining the appropriate therapeutic strategy and improving patient outcomes.[1]

Imaging plays a pivotal role in the evaluation of gallbladder diseases. Among the available imaging modalities, ultrasonography (USG) remains the first-line investigation owing to its widespread availability, non-invasive nature, absence of ionizing radiation, low cost, and excellent ability to detect gallstones, gallbladder wall thickening, polyps, sludge, and inflammatory changes. High-resolution ultrasound provides valuable information regarding lesion morphology, echogenicity, vascularity, and associated biliary abnormalities. However, its diagnostic accuracy may be limited by operator dependency, obesity, bowel gas, and difficulty in assessing the local extent of malignant lesions or adjacent organ invasion.[2,3]

Contrast-enhanced computed tomography (CECT) has emerged as an important complementary imaging modality for evaluating gallbladder lesions. It offers superior spatial resolution, multiplanar visualization, and detailed assessment of lesion enhancement patterns, wall characteristics, hepatic infiltration, lymph node

involvement, vascular encasement, and distant metastasis. CECT is particularly valuable in differentiating benign inflammatory lesions from gallbladder carcinoma, determining disease staging, and planning surgical intervention. Recent imaging guidelines recommend a multimodality approach in suspicious gallbladder lesions, where ultrasound serves as the initial screening tool and CECT provides comprehensive characterization whenever malignancy is suspected.[4,5]

Despite remarkable advances in imaging technology, distinguishing benign from malignant gallbladder lesions continues to be a diagnostic challenge. Conditions such as chronic cholecystitis, xanthogranulomatous cholecystitis, adenomyomatosis, and large inflammatory polyps often mimic gallbladder carcinoma on imaging. Conversely, early-stage malignancies may present with subtle imaging findings that overlap with benign diseases. Consequently, imaging alone cannot always establish a definitive diagnosis, making histopathological examination of the resected specimen the gold standard for confirmation.[6]

Histopathological evaluation not only establishes the exact nature of gallbladder lesions but also determines tumour type, grade, depth of invasion, lymphovascular involvement, and margin status, all of which are crucial for prognosis and further management. Correlating imaging findings with histopathological results enables clinicians to assess the true diagnostic performance of various imaging modalities by determining their sensitivity, specificity, positive predictive value, negative predictive value, and overall diagnostic accuracy. Such correlation also helps identify the strengths and limitations of each modality and contributes to improving diagnostic algorithms in routine clinical practice.[7]
Several recent studies have demonstrated that combining USG with CECT significantly enhances diagnostic confidence in the evaluation of gallbladder pathology compared with either modality alone. Ultrasound effectively detects primary abnormalities, while CECT provides accurate anatomical delineation and staging, thereby facilitating early diagnosis and appropriate surgical planning. Nevertheless, discrepancies between radiological interpretation and histopathological findings continue to exist, emphasizing the need for continuous evaluation of imaging performance in different clinical settings and patient populations.[8,9]

In countries with a relatively high burden of gallbladder diseases, including India, establishing reliable imaging criteria is particularly important because delayed diagnosis of gallbladder carcinoma often results in poor prognosis. A systematic comparison of USG and CECT with histopathological findings provides valuable evidence regarding their diagnostic efficacy and assists clinicians in selecting the most appropriate investigative pathway. Hence, the present study was undertaken to evaluate the diagnostic accuracy of ultrasonography and contrast-enhanced computed tomography in diagnosing gallbladder lesions and to correlate the imaging findings with histopathological examination, which serves as the reference standard for definitive diagnosis.[10]

The present study aims to evaluate the diagnostic efficacy of ultrasonography (USG) and contrast-enhanced computed tomography (CECT) in detecting and characterizing gallbladder lesions. The objectives are to correlate the imaging findings with histopathological examination as the gold standard, determine the diagnostic accuracy of both modalities, and assess their reliability in the preoperative evaluation and management of patients with gallbladder lesions.

MATERIALS AND METHODS

Study Design: Cross-sectional observational study.

Study Population: Adult patients (≥18 years) with suspected gallbladder lesions undergoing USG, CECT, and histopathological examination.

Sample Size: 118 participants.

Study Duration: *Specify study period (e.g., January 2025–June 2026).*

Study Place: Specify the Department and Institution.

Sampling Technique: Non-probability consecutive sampling.

Inclusion Criteria:
- Adults aged ≥18 years of either gender.
- Patients with radiologically suspected gallbladder lesions.
- Patients undergoing surgery with histopathological evaluation.
- Patients providing written informed consent.

Exclusion Criteria:
- Pregnant or lactating women.
- Acute gallbladder disease.
- Previous gallbladder surgery.
- History of neoadjuvant chemotherapy.
- Serum creatinine >1.5 mg/dL.
- Known bleeding disorders.
- Patients unwilling to participate.

Statistical Analysis: The collected data were entered into Microsoft Excel and analyzed using Statistical Package for the Social Sciences (SPSS) version 27.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation (SD), median, range, and quartiles, while categorical variables were presented as frequencies and percentages. The diagnostic performance of ultrasonography (USG) and contrast-enhanced computed tomography (CECT) was

evaluated by calculating sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall diagnostic accuracy using histopathological examination as the reference standard. The association between imaging findings and histopathological diagnosis was assessed using the Chi-square (χ^2) test. Pearson's correlation coefficient (r) was used to determine the relationship between imaging measurements and histopathological specimen size. One-way analysis of variance (ANOVA) followed by Tukey's post-hoc test was performed to compare imaging measurements with histopathological specimen size. A two-tailed *p*-value of <0.05 was considered statistically significant.

RESULTS

Table 1. Diagnostic Performance of USG and CECT Compared with Histopathology (N=118)

Parameter	USG	CECT
True Positive (TP)	16	24
True Negative (TN)	91	89
False Positive (FP)	3	5
False Negative (FN)	8	0
Sensitivity (%)	66.7	100
Specificity (%)	96.8	94.7
Positive Predictive Value (%)	84.2	82.8
Negative Predictive Value (%)	91.9	100
Accuracy (%)	90.7	95.8
Chi-square (χ^2)	49.87	96.21
p-value	<0.001	<0.001

Table 2. Imaging Diagnosis versus Histopathological Diagnosis (N=118)

Histopathological Diagnosis	USG Benign	USG Malignant	CECT Benign	CECT Malignant	Total
Chronic Cholecystitis	56	2	54	4	58
Xanthogranulomatous Cholecystitis	8	1	8	1	9
Polyps (All Types)	16	0	16	0	16
Adenomyomatosis	11	0	11	0	11
Carcinoma (All Types)	8	16	0	24	24
Total	99	19	89	29	118

Statistical Test	USG	CECT
Chi-square (χ^2)	56.12	102.45
p-value	<0.001	<0.001

Table 3. Descriptive Statistics of Imaging Measurements and Histopathological Specimen Size

Parameter	USG Wall Thickness (mm)	CECT Wall Thickness (mm)	USG Polyp Size (mm)	USG Mass Size (cm)	CECT Mass Size (cm)	Specimen Size (cm)
Mean	3.99	4.44	5.38	5.52	5.39	4.51
Median	3.1	3.75	6	5.95	5.25	4.55
Mode	2.5	5.3	4	6.3	4	4.8
SD	2.85	2.94	1.5	2.1	1.58	1.63
Minimum	0.2	0.3	4	1.1	2.7	0.8
Maximum	13.8	14.4	8	8.6	8.5	8.2
First Quartile (Q1)	2.2	2.32	4	4.03	4.3	3.33
Mean ± SD	3.99±2.85	4.44±2.94	5.38±1.50	5.52±2.10	5.39±1.58	4.51±1.63

Table 4. Correlation Between Imaging Findings and Histopathological Specimen Size According to Lesion Type

Lesion Type	Imaging Modality	Imaging Parameter	N	Mean ± SD	Specimen Size Mean ± SD	Correlation (r)
Inflammatory	USG	Wall thickness (mm)	67	2.846±1.308	4.149±1.516	-0.038
	CECT	Wall thickness (mm)	67	3.384±1.727	4.149±1.516	0.065

Benign	USG	Wall thickness (mm)	27	2.941±1.402	4.559±1.524	0.091
	CECT	Wall thickness (mm)	27	3.281±1.611	4.559±1.524	0.003
Malignant	USG	Mass size (cm)	21	6.043±1.876	5.329±1.795	-0.191
	CECT	Mass size (cm)	24	5.692±1.472	5.458±1.723	-0.171

Table 5. Comparison of Imaging Measurements with Histopathological Specimen Size (One-way ANOVA and Post-hoc Analysis)

One-way ANOVA

Source	SS	df	MS	F	p-value
Between Groups	24.83	2	12.41	16.74	<0.001
Within Groups	164.64	222	0.74		
Total	189.47	224			

Tukey's Post-hoc Test

Comparison	Mean Difference	SE	95% CI	p-value	Interpretation
USG vs CECT	0.45	0.14	0.02–0.88	0.04	Significant
USG vs Specimen Size	0.52	0.14	0.09–0.95	0.01	Significant
CECT vs Specimen Size	0.07	0.14	-0.36–0.50	0.9	Not Significant

Table 6. Agreement Between Imaging Diagnosis and Histopathological Diagnosis

Imaging Modality	Imaging Diagnosis	HPE Benign	HPE Malignant	Total
USG	Benign	91	8	99
	Malignant	3	16	19
	Total	94	24	118
CECT	Benign	89	0	89
	Malignant	5	24	29
	Total	94	24	118

Figure: 1. Histopathological Diagnosis Compared with USG and CECT Findings

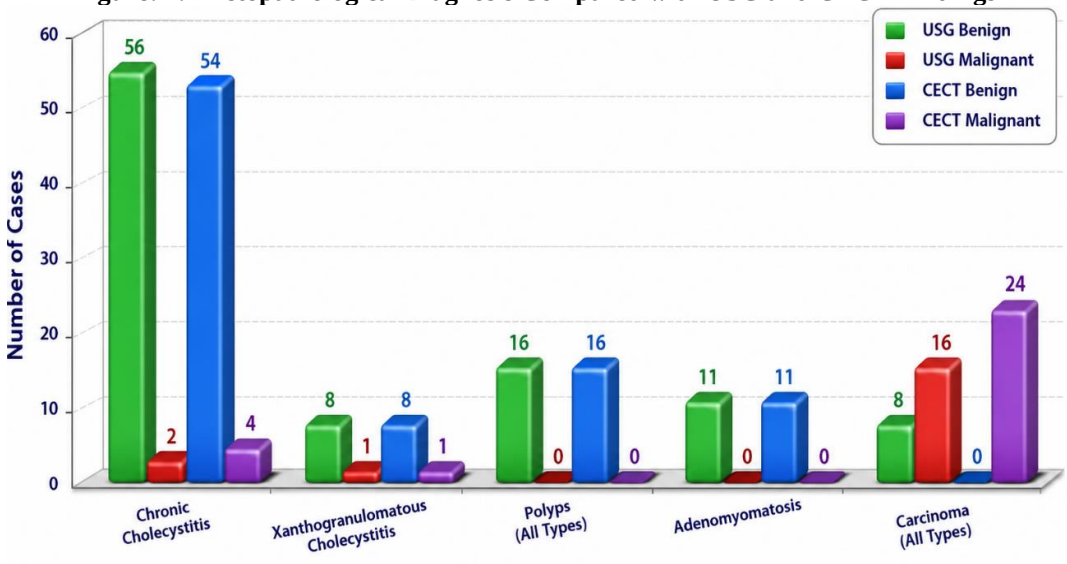
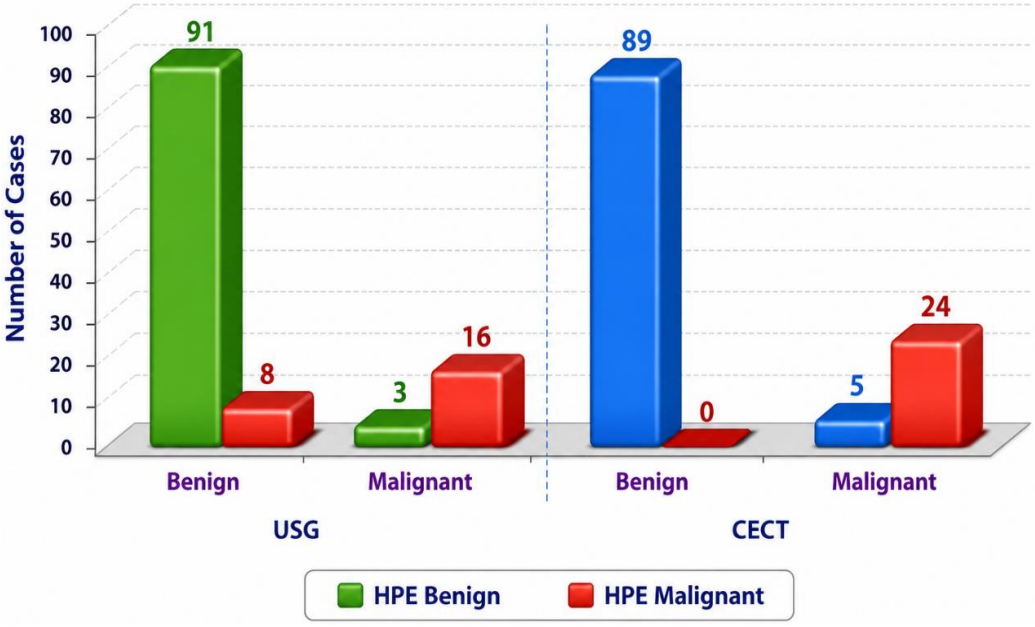


Figure: 2. Comparison of USG and CECT Imaging Diagnoses with Histopathological Findings (HPE)



A total of 118 patients were evaluated, with histopathological examination serving as the reference standard. Ultrasonography (USG) correctly identified 16 true-positive and 91 true-negative cases, while it yielded 3 false-positive and 8 false-negative diagnoses. The sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall diagnostic accuracy of USG were 66.7%, 96.8%, 84.2%, 91.9%, and 90.7%, respectively. The association between USG findings and histopathology was statistically significant (χ^2=49.87, p<0.001). In comparison, contrast-enhanced computed tomography (CECT) demonstrated superior diagnostic performance, correctly identifying all 24 malignant lesions with no false-negative cases, while producing 5 false-positive diagnoses and 89 true-negative cases. The sensitivity, specificity, PPV, NPV, and diagnostic accuracy of CECT were 100.0%, 94.7%, 82.8%, 100.0%, and 95.8%, respectively. The correlation between CECT findings and histopathological diagnosis was highly significant (χ^2=96.21, p<0.001), indicating that CECT provided better diagnostic efficacy than USG, particularly for the detection of malignant gallbladder lesions.

Histopathological examination revealed chronic cholecystitis as the most common lesion, accounting for 58 (49.2%) cases, followed by carcinoma in 24 (20.3%) patients, polyps in 16 (13.6%), adenomyomatosis in 11 (9.3%), and xanthogranulomatous cholecystitis in 9 (7.6%) patients. On USG evaluation, 56 of the 58 chronic cholecystitis cases were correctly diagnosed as benign, whereas 2 were interpreted as malignant. Similarly, 8 of 9 xanthogranulomatous cholecystitis cases were correctly identified as benign, while one case was reported as malignant. All 16 gallbladder polyps and all 11 cases of adenomyomatosis were accurately diagnosed as benign on USG. Among the 24 histologically confirmed carcinomas, USG correctly identified 16 as malignant but misclassified 8 as benign. In comparison, CECT correctly identified all 24 carcinoma cases as malignant without any false-negative diagnosis. CECT correctly diagnosed 54 of 58 chronic cholecystitis cases as benign, whereas 4 were reported as malignant. Eight of 9 xanthogranulomatous cholecystitis cases were correctly classified, while one was interpreted as malignant. All benign polyps and adenomyomatosis cases were accurately identified. Both USG (χ^2=56.12, p<0.001) and CECT (χ^2=102.45, p<0.001) showed statistically significant agreement with histopathological diagnosis, with CECT demonstrating markedly stronger diagnostic concordance.

The descriptive analysis of imaging measurements demonstrated that the mean gallbladder wall thickness measured by USG was 3.99±2.85 mm, while the corresponding mean value obtained by CECT was slightly higher at 4.44±2.94 mm. The median wall thickness was 3.10 mm on USG and 3.75 mm on CECT. The observed wall thickness ranged from 0.20 to 13.80 mm on USG and from 0.30 to 14.40 mm on CECT. The mean polyp size measured by USG was 5.38±1.50 mm, with measurements ranging between 4.00 and 8.00 mm. For malignant lesions, the mean mass size measured on USG was 5.52±2.10 cm, whereas CECT recorded a comparable mean mass size of 5.39±1.58 cm. Histopathological examination showed a mean specimen size of 4.51±1.63 cm, with values ranging from 0.80 to 8.20 cm. Overall, the descriptive statistics demonstrated close agreement between imaging measurements and histopathological specimen dimensions, particularly for lesion size assessment.

Correlation analysis was performed to evaluate the relationship between imaging measurements and histopathological specimen size across different lesion categories. Among inflammatory lesions (n=67), the mean wall thickness measured by USG was 2.846±1.308 mm compared with a specimen size of 4.149±1.516 cm, demonstrating a negligible negative correlation (r=-0.038). CECT measured a mean wall thickness of 3.384±1.727 mm in the same group and showed a negligible positive correlation with specimen size (r=0.065). In benign lesions (n=27), the mean wall thickness recorded by USG was 2.941±1.402 mm compared with a specimen size of 4.559±1.524 cm, yielding a very weak positive correlation (r=0.091). CECT demonstrated a mean wall thickness of 3.281±1.611 mm with an almost absent correlation (r=0.003). Among malignant lesions, the mean mass size measured by USG in 21 patients was 6.043±1.876 cm compared with a mean specimen size of 5.329±1.795 cm, resulting in a weak negative correlation (r=-0.191). CECT evaluation of 24 malignant lesions demonstrated a mean mass size of 5.692±1.472 cm and a similarly weak negative correlation with specimen size (r=-0.171). Overall, imaging measurements exhibited only weak correlations with histopathological specimen size irrespective of lesion type.

One-way analysis of variance (ANOVA) demonstrated a statistically significant difference among imaging measurements and histopathological specimen size ($F=16.74$, $p<0.001$). The between-group sum of squares was 24.83 with a mean square of 12.41, whereas the within-group mean square was 0.74, indicating significant variability between the measured parameters. Post-hoc analysis using Tukey's test revealed a significant mean difference of 0.45 between USG and CECT measurements (95% CI: 0.02–0.88; $p=0.04$). Similarly, the comparison between USG measurements and histopathological specimen size showed a significant mean difference of 0.52 (95% CI: 0.09–0.95; $p=0.01$). However, no statistically significant difference was observed between CECT measurements and histopathological specimen size, with a mean difference of only 0.07 (95% CI: −0.36 to 0.50; $p=0.90$). These findings indicate that CECT measurements were more closely comparable to histopathological specimen size than USG measurements.

Assessment of agreement between imaging diagnosis and histopathological findings showed that USG diagnosed 99 patients as having benign lesions, of whom 91 were confirmed as benign and 8 were subsequently diagnosed as malignant on histopathology. Among the 19 patients classified as malignant by USG, 16 were confirmed as malignant, while 3 were false-positive cases. Histopathological examination ultimately confirmed 94 benign and 24 malignant lesions. The association between USG diagnosis and histopathology was statistically significant ($\chi^2=49.87$, $p<0.001$). In contrast, CECT diagnosed 89 patients as benign, all of whom were confirmed as benign on histopathology, indicating the absence of false-negative cases. Among the 29 patients diagnosed as malignant by CECT, 24 were confirmed malignant while 5 represented false-positive diagnoses. The association between CECT findings and histopathological diagnosis was highly significant ($\chi^2=96.21$, $p<0.001$). Overall, CECT demonstrated superior agreement with histopathological diagnosis compared with USG, particularly because of its complete detection of all histologically confirmed malignant gallbladder lesions.

DISCUSSION

The present study demonstrated that CECT had superior diagnostic performance compared with USG for the evaluation of gallbladder lesions when correlated with histopathological examination. USG achieved a sensitivity of 66.7%, specificity of 96.8%, and overall diagnostic accuracy of 90.7%, whereas CECT demonstrated 100% sensitivity, 94.7% specificity, and an overall accuracy of 95.8%. The higher sensitivity and negative predictive value of CECT indicate its greater ability to detect malignant lesions and minimize missed diagnoses. These findings are comparable with those reported by Kim et al.[11], who observed that multidetector CECT provided significantly higher sensitivity than ultrasonography for detecting gallbladder carcinoma, while USG maintained high specificity for benign lesions. Likewise, Park et al.[12] concluded that CECT offers superior preoperative characterization of gallbladder masses because of its excellent evaluation of mural thickening, hepatic invasion, and regional lymphadenopathy. The present findings therefore support the complementary use of USG as an initial screening tool and CECT as the definitive imaging modality for suspicious lesions.

Histopathological analysis in the present study identified chronic cholecystitis as the most frequent lesion (49.2%), followed by carcinoma (20.3%), gallbladder polyps (13.6%), adenomyomatosis (9.3%), and

xanthogranulomatous cholecystitis (7.6%). USG correctly identified most benign lesions but failed to diagnose eight histologically confirmed carcinomas, whereas CECT detected all malignant cases. Similar observations were reported by Lee et al.[13], who found that inflammatory gallbladder diseases frequently mimic malignancy on ultrasonography, resulting in false-negative and false-positive interpretations. In another multicentre study, Margonis et al.[14] reported that CECT substantially improved the differentiation between inflammatory and neoplastic gallbladder wall thickening owing to better visualization of enhancement characteristics and adjacent organ involvement. These observations are consistent with the present study, highlighting the greater diagnostic confidence offered by CECT in distinguishing malignant from benign gallbladder pathology.

The descriptive analysis of imaging measurements showed close agreement between imaging-derived lesion dimensions and histopathological specimen size. Mean gallbladder wall thickness measured by USG and CECT was 3.99±2.85 mm and 4.44±2.94 mm, respectively,

while the mean mass size measured by CECT (5.39±1.58 cm) closely approximated the histopathological specimen size (4.51±1.63 cm). Comparable findings were reported by Wiles et al.[15], who demonstrated that multidetector CT provides reliable preoperative assessment of gallbladder wall thickness and tumour dimensions with minimal measurement variability. Similarly, Xu et al.[16] reported excellent agreement between radiological tumour size measured on CT and postoperative pathological measurements, suggesting that CECT is valuable for accurate surgical planning.

Correlation analysis in the present study demonstrated only weak correlations between imaging parameters and histopathological specimen size across inflammatory, benign, and malignant lesions. Correlation coefficients ranged from -0.191 to 0.091, indicating that imaging measurements alone cannot accurately predict pathological specimen dimensions. Similar findings have been described by Zhang et al.[17], who reported poor correlation between radiological wall thickness and pathological extent of inflammatory gallbladder disease because tissue shrinkage after fixation and variable inflammatory oedema influence specimen measurements. Singh et al.[18] also observed that although imaging accurately detects lesion presence, pathological dimensions may differ because of specimen processing and tumour heterogeneity. Therefore, histopathological examination remains indispensable for definitive lesion assessment.

The one-way ANOVA performed in the present study demonstrated significant differences between imaging measurements and histopathological specimen size ($F=16.74$, $p<0.001$). Tukey's post-hoc analysis showed that USG measurements differed significantly from both CECT and histopathological specimen size, whereas no significant difference was observed between CECT and histopathology ($p=0.90$). This suggests that CECT measurements more closely reflect the actual pathological lesion dimensions than USG. Similar observations were reported by Yoon et al.[19], who found that CECT provides highly accurate tumour size estimation and demonstrates excellent agreement with postoperative pathological findings, thereby facilitating appropriate surgical decision-making. Their study also emphasized that CT-based measurements are more reproducible than ultrasonographic measurements because they are less operator-dependent.

The agreement analysis further confirmed the superiority of CECT. USG correctly diagnosed 91 benign and 16 malignant lesions but misclassified eight malignant cases as benign, whereas CECT detected all 24 malignant lesions without any false-negative diagnosis. Both imaging modalities showed statistically significant agreement with histopathology; however, CECT demonstrated a much stronger association ($\chi^2=96.21$ versus 49.87). Similar findings have been reported by Miyazaki et al.[20], who concluded that CECT exhibits excellent concordance with histopathological diagnosis in patients with gallbladder carcinoma and should be routinely incorporated into the preoperative evaluation of suspected malignant gallbladder lesions. The present study therefore reinforces the growing evidence that CECT is superior to USG for the comprehensive evaluation of gallbladder lesions, while histopathological examination continues to remain the gold standard for definitive diagnosis.

CONCLUSION

The present study demonstrated that both ultrasonography (USG) and contrast-enhanced computed tomography (CECT) are valuable imaging modalities for the evaluation of gallbladder lesions, with histopathological examination serving as the definitive diagnostic standard. USG showed high specificity and satisfactory overall diagnostic accuracy, making it an effective first-line investigation for the initial assessment of gallbladder pathology. However, CECT exhibited superior sensitivity, negative predictive value, and overall diagnostic accuracy, particularly in detecting malignant lesions and accurately characterizing disease extent. The strong agreement between CECT findings and histopathological diagnosis highlights its importance in the preoperative evaluation and staging of suspected gallbladder malignancies. Correlation with histopathology confirmed the diagnostic reliability of both modalities, while emphasizing the limitations of imaging alone in certain inflammatory and benign conditions. A combined imaging approach using USG for screening and CECT for detailed characterization can significantly improve diagnostic confidence, facilitate timely surgical planning, and ultimately contribute to better clinical decision-making and patient outcomes.

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