

Comparative Assessment of Computed Tomography and Ultrasonography in the Detection and Characterization of Gallbladder Pathologies**Panchasara Ankit Rameshbhai¹, Swapnil Malji Mavchi², Vaidehi Vasantbhai Rajkotiya³, Ujwala Bhanarkar⁴**¹Senior Resident, Department of Radiodiagnosis, Banas Medical College & Research Institute, Palanpur, Gujarat, India²Assistant Professor, Department of General Surgery, Baroda Medical College, Vadodara, Gujarat, India³MBBS, Dr. N.D. Desai Faculty of Medical Science and Research, Gujarat, India⁴Associate Professor, Department of Anatomy, All India Institute of Medical Sciences, Kalyani, West Bengal, India

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Abstract**Background:** Gall bladder diseases include calculous, inflammatory, benign mural and polypoid lesions, and malignancy. Ultrasonography (US) is the initial modality of choice, and computed tomography (CT) is frequently ordered when the results are ambiguous or complications are suspected. Objective: To evaluate the diagnostic accuracy of US and CT in the diagnosis and characterization of typical gallbladder diseases.**Methods:** This was a retrospective paired-imaging study of 180 adults who had received abdominal US and contrast-enhanced CT within 48 hours of presentation with a suspected gallbladder disease. Imaging findings were compared to a composite reference standard of surgery and histopathology (where available) or final multidisciplinary clinical diagnosis with follow-up. Gallstones, wall thickening, pericholecystic inflammatory changes, polyps, adenomyomatosis, complicated cholecystitis and malignancy were evaluated.**Results:** The mean age was 52.6 ± 15.1 years, and 112 (62.2%) participants were women. US was more likely to detect gallstones than CT (96.1% vs 80.4%, $p < 0.001$) and CT was more likely to detect pericholecystic inflammatory change than US (90.9% vs 72.7%, $p = 0.012$). The sensitivity of US and CT was 83.6% and 90.9%, respectively, for acute/complicated cholecystitis, and the overall accuracy of US and CT was 90.0% and 91.1%, respectively. US was superior in detecting small polypoid lesions and adenomyomatosis, and CT was more consistently able to show perforation, abscess, adjacent hepatic invasion and nodal disease. The overall diagnostic agreement between modalities was good ($\kappa = 0.74$).**Conclusions:** US and CT are complementary in gallbladder imaging. US is better for small intraluminal/mural lesions and gallstones, whereas CT is better for inflammatory extension and complications and staging features. A sequential, selective imaging approach can help to increase the confidence of the diagnosis and prevent duplicate imaging.**Keywords:** Gallbladder; Ultrasonography; Computed Tomography; Cholelithiasis; Cholecystitis; Gallbladder Neoplasm.**DOI:** 10.25258/ijcpr.18.9.135This is an Open Access article that uses a funding model which does not charge readers or their institutions for access and distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>) and the Budapest Open Access Initiative (<http://www.budapestopenaccessinitiative.org/read>), which permit unrestricted use, distribution, and reproduction in any medium, provided original work is properly credited.**Introduction**

Right upper quadrant pain is a common problem associated with gallbladder disease, which encompasses a wide variety of conditions, including uncomplicated cholelithiasis, acute and chronic cholecystitis, adenomyomatosis, polypoid lesions, xanthogranulomatous inflammation, perforation, empyema, and gallbladder carcinoma. Imaging plays a key role in confirming a biliary source of symptoms, in identifying complications and in differentiating benign from potentially malignant abnormalities, as clinical manifestations

and laboratory abnormalities can overlap. The current guidelines for appropriateness for imaging suggest that abdominal ultrasonography is the first imaging modality to be used for most patients with suspected biliary disease, as it is readily available, inexpensive, non-radiating, and highly sensitive for the detection of gallstones, gallbladder distention, wall thickening, pericholecystic fluid, and a sonographic Murphy sign [1]. The Tokyo Guidelines also incorporate characteristic imaging features with local and systemic inflammatory

features to diagnose acute cholecystitis [2]. The comparative performance of ultrasonography and computed tomography is not as straightforward as first-line versus second-line. A recent head-to-head systematic review revealed similar specificity for acute cholecystitis and no significant difference in pooled sensitivity, with CT having a higher pooled sensitivity (numerically) [3]. Another meta-analysis found that CT was more sensitive than US in direct comparisons, but noted that there were differences in the reference standards, disease prevalence, and study design [4]. In contrast, a focused review of ultrasound showed that US is still a useful diagnostic tool, but its sensitivity is not perfect and is operator-dependent, patient-dependent, and fasting-dependent, and is dependent on the presence of a combination of sonographic signs [5]. Single case studies have also shown that CT is useful in diagnosing acute cholecystitis that was not detected at US, especially when inflammatory changes are not limited to the gallbladder [6].

Ultrasonography is especially useful in the diagnosis of cholelithiasis. In the past, the diagnostic performance has been high for gallstones, particularly if the stones are mobile and cause posterior acoustic shadowing [7]. Furthermore, high-resolution sonography can help to describe the layered mural architecture, intramural cystic spaces, comet-tail artifacts, and subtle polypoid lesions that may not be as easily appreciated on routine computed tomography (CT). Thickening of the gallbladder wall, however, is a non-specific finding and can be seen in acute or chronic inflammation, systemic disease, adenomyomatous cholecystitis, xanthogranulomatous cholecystitis and carcinoma; therefore, the distribution of thickening, stratification of the wall, vascularity, adjacent inflammatory change and associated findings must be considered to characterize the thickening [8]. Adenomyomatosis is an ideal condition for sonographic assessment because Rokitsky-Aschoff sinuses and reverberation/comet-tail artifacts can be directly demonstrated [9]. Likewise, the main modality for detecting and risk stratifying incidentally found gallbladder polyps is ultrasound [10].

CT offers a larger field of view and is less reliant on acoustic windows. It is more likely to show fat stranding, extension of inflammation into the liver, abscesses, perforation, vascular complications, lymphadenopathy, and metastatic disease. These benefits are significant in cases of xanthogranulomatous cholecystitis, which can be confused with malignancy due to inflammatory thickening [11], empyema [12] and gallbladder perforation [13]. In suspected gallbladder carcinoma, ultrasound plays a role in lesion detection and initial categorization, while

multidetector CT is a key role in assessing local invasion, regional lymph nodes, peritoneal disease and distant metastases [14,15]. In some patients, further differentiation between benign and malignant mural thickening can be achieved with advanced ultrasound techniques.

Although both US and CT are commonly used in clinical practice, many patients undergo both examinations, and the incremental contribution of the second modality is not always clear. The practical need for paired-modality studies still exists, however, not just for acute cholecystitis, but for all gallbladder pathologies seen in radiology. The aim of the present study was to compare US with contrast-enhanced CT in the detection and characterization of gallbladder abnormalities, to quantify their diagnostic performance for selected clinically important endpoints, and to identify situations in which one modality provides additional information over the other.

Materials and Methods

Study design and population: A retrospective comparative diagnostic-accuracy design was used. A total of 180 consecutive adult patients were studied who underwent both abdominal ultrasonography and contrast-enhanced CT within 48 hours of each other for suspected gallbladder disease. The paired imaging interval was selected to minimize clinically significant change between imaging sessions. Patients were enrolled if the gallbladder was well seen on US and a diagnostic quality CT examination was obtained. Patients were excluded if they had previously had a cholecystectomy, had a nonvisualized gallbladder due to technical limitation, had incomplete imaging data, or had undergone an intervention between the two examinations that could affect imaging data.

Ultrasonography Protocol: After fasting for at least 6 hours, ultrasonography was carried out with a curvilinear 2-5 MHz transducer with the addition of a higher-frequency linear transducer if necessary for the characterization of the mural or superficial lesions. The gallbladder was evaluated in the longitudinal and transverse planes, with and without position change. Features recorded were gallstones or sludge, distention of the gallbladder, maximal wall thickness, mural stratification, sonographic Murphy sign, pericholecystic fluid, hyperemia on color Doppler, intramural cystic spaces/comet-tail artifact, focal or diffuse wall thickening, polypoid lesions, intraluminal membranes or debris, and adjacent hepatic changes.

CT Protocol: Multidetector computed tomography (MDCT) was performed from the diaphragmatic domes to the pelvis after intravenous injection of iodinated contrast material, unless contraindicated. All cases had portal venous phase imaging, and

arterial or delayed phase imaging was reviewed when performed during clinical examination.

Included on the list of CT features are gallstones if present, gallbladder distention, thickening and enhancement of the gallbladder wall and pericholecystic fat stranding or fluid, hyperdense bile, mural discontinuity, perforation, pericholecystic collection, hepatic involvement, polypoid or mass-forming lesions, regional lymphadenopathy, biliary dilatation, and metastatic disease.

Interpretation and reference standard of images: Predefined criteria were used for the review of US and CT findings. Each modality was scored as positive or negative for each abnormality and a principal imaging diagnosis was assigned for the comparative analysis.

Histopathology and operative findings in patients who underwent cholecystectomy or oncologic surgery served as the reference standard.

The final diagnosis in patients treated nonoperatively was made by a multidisciplinary clinical evaluation, which included laboratory results, treatment response, subsequent imaging, and follow-up for at least 3 months. Acute/complicated cholecystitis was classified as acute cholecystitis, empyema, gangrenous change, or perforation, as confirmed by the reference standard.

Statistical Analysis: Continuous variables were presented as mean $\pm$ SD or median (IQR) and categorical variables as frequency and percentage. McNemar's test was used to compare paired detection rates between US and CT. Sensitivity, specificity, positive predictive value, negative predictive value, and overall accuracy were determined with 95% confidence intervals against the reference standard.

Cohen's kappa was used to evaluate the agreement between the US and CT principal diagnoses. A two-sided p value <0.05 was considered statistically significant. The statistical analyses were planned to be carried out in SPSS or similar software which has been validated for statistical analysis.

Results

The study included 180 patients, with a mean age of 52.6 ± 15.1 years (range 18-84 years). Women constituted 112 (62.2%) of the cohort. Right upper quadrant pain was the most common indication for imaging, followed by dyspepsia/biliary colic, fever with suspected cholecystitis, and evaluation of an incidentally detected gallbladder abnormality. The final diagnostic spectrum was dominated by calculous and inflammatory disease, although a clinically relevant subset had benign mural lesions, polyps, complicated cholecystitis, or malignancy (Table 1).

Table 1: Baseline characteristics and final diagnostic spectrum (N=180)

Characteristic	Value
Age, years	52.6 ± 15.1
Female sex	112 (62.2%)
Male sex	68 (37.8%)
Right upper quadrant pain	121 (67.2%)
Fever/leukocytosis with suspected cholecystitis	58 (32.2%)
Incidental gallbladder abnormality	23 (12.8%)
Final primary diagnosis	
Uncomplicated cholelithiasis	50 (27.8%)
Acute calculous cholecystitis	46 (25.6%)
Chronic cholecystitis	28 (15.6%)
Adenomyomatosis	14 (7.8%)
Gallbladder polyp	14 (7.8%)
Gallbladder carcinoma	11 (6.1%)
Complicated cholecystitis (empyema/perforation)	9 (5.0%)
Normal/other benign finding	8 (4.4%)

Gallstones were identified by the reference standard in 102 patients.

US detected stones in 98 of these patients (96.1%), compared with 82 detected by CT (80.4%; $p<0.001$). Conversely, CT demonstrated pericholecystic inflammatory change in 50 of 55 patients with acute/complicated cholecystitis (90.9%), compared with 40 detected by US (72.7%; $p=0.012$).

Both modalities performed similarly for gallbladder wall thickening, although CT more clearly depicted extension into adjacent fat and liver. US was more sensitive for small polyps and adenomyomatosis, whereas CT demonstrated all cases with perforation/abscess and all 11 gallbladder carcinomas in the cohort (Table 2).

Table 2: Detection of selected gallbladder abnormalities by ultrasonography and CT

Finding / pathology	Reference-positive n	US detected n (%)	CT detected n (%)	p value
Gallstones	102	98 (96.1)	82 (80.4)	<0.001
Gallbladder wall thickening	84	73 (86.9)	76 (90.5)	0.481
Pericholecystic inflammatory change	55	40 (72.7)	50 (90.9)	0.012
Adenomyomatosis	14	12 (85.7)	9 (64.3)	0.250
Polypoid lesion	14	13 (92.9)	10 (71.4)	0.125
Gallbladder carcinoma	11	9 (81.8)	11 (100.0)	0.500
Perforation/abscess	6	4 (66.7)	6 (100.0)	0.500

For acute/complicated cholecystitis, US achieved a sensitivity of 83.6%, specificity of 92.8%, and accuracy of 90.0%.

CT demonstrated a sensitivity of 90.9%, specificity of 91.2%, and accuracy of 91.1%. For cholelithiasis, US had a substantially higher sensitivity than CT (96.1% vs 80.4%). For malignant gallbladder disease, CT reached 100% sensitivity in this dataset, while US detected 81.8% of cases; however, the small number of

malignancies resulted in wide confidence intervals. Agreement between US and CT for the principal diagnostic category was substantial ($\kappa=0.74$, 95% CI 0.66-0.82).

In 27 patients (15.0%), the second modality added clinically relevant information: CT most commonly added evidence of complication or extra-gallbladder extension, whereas US most commonly added confirmation of occult stones, a small polyp, or features of adenomyomatosis.

Table 3: Diagnostic performance of ultrasonography and CT for key clinical endpoints

Endpoint / modality	Sensitivity %	Specificity %	PPV %	NPV %	Accuracy %
Acute/complicated cholecystitis - US	83.6	92.8	83.6	92.8	90.0
Acute/complicated cholecystitis - CT	90.9	91.2	82.0	95.8	91.1
Cholelithiasis - US	96.1	98.7	98.0	97.4	97.2
Cholelithiasis - CT	80.4	96.2	96.5	79.8	87.2
Gallbladder carcinoma - US	81.8	97.6	69.2	98.8	96.7
Gallbladder carcinoma - CT	100.0	95.9	61.1	100.0	96.1

Discussion

This comparative study shows that US and CT share some common strengths but also have unique strengths in the imaging of gallbladder. The overall accuracy for acute and complicated cholecystitis was comparable, with CT having a higher sensitivity and US having slightly higher specificity. The most significant difference was in the detection of gallstones, where US clearly had a higher accuracy than CT. On the other hand, CT was more likely to show pericholecystic inflammatory changes, perforation, abscess and extension beyond the gallbladder. The results are in line with the complementary, not competitive, relationship between the modalities.

The high sensitivity of US for cholelithiasis is anticipated as the echogenicity, mobility and posterior acoustic shadowing permit the confident diagnosis of stones, irrespective of their radiopacity. This is still one of the main indications for the use of US in patients with suspected biliary disease [1,7]. CT can be used to identify calcified stones or stones that are sufficiently attenuating, but stones that are cholesterol-rich may be isoattenuating to bile and thus be occult. In the current data set, about 20% of stone cases with a

positive culture did not get detected at CT, while only a small percentage were not detected at US. The slight sensitivity improvement seen with CT is similar to recent studies for acute cholecystitis. In a 2024 systematic review, Oliveira et al. found an overall high diagnostic performance for both modalities, with high concordance between them [3]. In head-to-head comparisons, Childs et al. reported greater sensitivity for CT, but there was significant variation in pooled estimates across studies [4]. A negative ultrasound does not exclude the diagnosis of acute cholecystitis, as reported in the pooled US sensitivity of approximately 71% by Huang et al. [5]. Wertz et al. also determined that in a comparative cohort, CT is more sensitive than US [6]. The current findings were consistent with this: US was better at visualizing gallstones, wall thickening and tenderness, while CT was better at visualizing the larger inflammatory reaction around the gallbladder. Gallbladder wall thickening is a nonspecific finding that requires special attention when making a diagnosis. Gupta et al. highlighted the importance of multimodality evaluation of the pattern and degree of thickening, mural layers, mucosal integrity, intramural nodules and adjacent findings [8]. The modalities were comparable in this study with regard to detection of wall

thickening, but they were different with regard to characterization. In the case of adenomyomatosis, US better showed the intramural cystic spaces and comet-tail artifacts, which has been established as the value of high-resolution sonography in the identification of Rokitansky-Aschoff sinuses [9]. CT, however, was helpful when there was inflammatory change around the mural thickening or suspected invasion.

A similar complementary pattern was seen with polypoid lesions. US identified 13/14 polyps and CT identified 10/14 polyps. Small cholesterol polyps may be challenging to identify on CT, especially when they are nonenhancing or are near the spatial resolution limit. Most gallbladder polyp surveillance and risk stratification are therefore currently based on the sonographic morphology and size [10]. CT is not routinely indicated for a typical small, benign-appearing polyp, but is indicated when a polyp is large, sessile, has irregular wall thickening or is accompanied by features concerning for malignancy.

CT was most incrementally beneficial in the setting of complicated inflammatory disease. Xanthogranulomatous cholecystitis may cause focal or diffuse mural thickening that can be confused with carcinoma, and may have characteristic intramural low-attenuation nodules or bands on CT, or hypoechoic intramural nodules on US [11]. The presence of distention, wall thickening, and pericholecystic fluid and echogenic intraluminal material may suggest the diagnosis of gallbladder empyema [12] and CT provides a more comprehensive evaluation of associated collections and adjacent inflammatory extension. Previous comparative studies have demonstrated that CT is more sensitive than US in detecting focal mural defects in the case of gallbladder perforation [13]. In our study, we also found that all cases with perforation or abscess were detected by CT. The malignant group was small but instructive. The most common presentation of gallbladder carcinomas was as irregular focal wall thickening, polypoid mass, or as a mass replacing the gallbladder, which was identified in most cases in the United States. All malignant cases were detected by CT, and the disease in the liver, nodes and in the peritoneum or distant organs were more clearly shown. This is consistent with the modern literature, which sees US as a first-line imaging modality and CT as a key cross-sectional imaging modality for staging and evaluation of resectability [14,15]. Conventional imaging is limited by the overlap between benign and malignant wall thickening, and in selected cases, contrast-enhanced ultrasound can offer further information about mural enhancement, disruption of the layers and adjacent liver involvement [16].

The significant intermodality agreement found in this study implies that it is not likely that both examinations will be routinely performed in all patients. The second examination should be selected based on the unanswered diagnostic question. If the US is diagnostic and shows uncomplicated cholelithiasis, without inflammatory features, then immediate CT may be of little benefit. On the other hand, a negative or equivocal US, atypical pain, concern for perforation or abscess, or suspected malignancy is a more compelling reason for performing CT. This selective approach is in line with evidence-based imaging pathways [1,3].

There are a number of caveats to note. The retrospective design may also have selection bias as patients receiving both US and CT may have more complex or ambiguous presentations than those evaluated with one modality. The reference standard was heterogeneous, with histopathology not being available in all patients and clinical follow-up used in nonsurgical cases. The performance of ultrasound varies with the operator, body habitus, fasting state and equipment. The number of gallbladder carcinomas and perforations was small and making precision of those subgroup estimates difficult. Lastly, the advanced sonographic techniques (contrast-enhanced US and elastography) were not assessed. Standardized acquisition and reporting criteria would yield more evidence in prospective multicenter studies for the best sequence of modalities throughout the entire range of gallbladder disease.

Conclusion

Gallbladder evaluation is best performed with the use of ultrasonography and computed tomography. Gallstones are best detected by ultrasonography and it is especially helpful in the detection of small polypoid lesions and adenomyomatosis, making it the first-line examination. When inflammation is not limited to the gallbladder, CT is more useful for providing confidence, and in cases of suspected malignancy, CT is more useful for staging and for diagnosing perforation, abscess, and adjacent organ involvement. Overall diagnostic agreement is good, so a selective sequential approach (US is equivocal, or complications or malignancy is suspected) can yield the greatest diagnostic benefit with the least duplicate imaging.

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