Natural Resources for Human Health

eISSN: 2583-1194

Original Research

Received 22 May 2026
Revised 26 June 2026
Accepted 22 July 2026

Natural Resources for Human Health 2026, Vol. 6 (8s): 891–899

KEYWORDS: Transabdominal Ultrasound; Endoscopic Ultrasound; Gallstones; Choledocholithiasis; Biliary Dilatation.

Diagnostic Accuracy of Transabdominal Ultrasound (TAUS) Compared to Endoscopic Ultrasound (EUS) in the Diagnosis of Gallbladder and Biliary Diseases

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ABSTRACT: Background: Transabdominal ultrasound (TAUS) is the first-line imaging modality for gallbladder (GB) and biliary diseases, however, its diagnostic performance may decline for microlithiasis, and distal biliary and pancreatic lesions where endoscopic ultrasound (EUS) could superior.

Aim: To compare the diagnostic accuracy of TAUS versus EUS in the detection and characterization of GB and biliary lesions.

Patients and Methods: This cross-sectional observational study included 201 adults (mean age 47.8 ± 11.9 years; 53.2% female) evaluated with TAUS and EUS (single expert operator for each modality). Diagnostic indices (sensitivity/specificity/PPV/NPV/accuracy) and agreement (kappa) were calculated using EUS as reference.

Results: Transabdominal ultrasonography (TAUS) demonstrated high diagnostic performance for common gallbladder (GB) pathology, with a sensitivity of 75% and specificity of 99.5% ($\varkappa = 0.817$) for overall GB stones. For stones measuring 5–10 mm, sensitivity was 95.1% ($\varkappa = 0.969$), while stones >10 mm were detected with 100% sensitivity ($\varkappa = 0.884$). The sensitivity for GB sludge was 78.6% ($\varkappa = 0.843$). TAUS demonstrated perfect diagnostic concordance for common bile duct (CBD) dilatation ($\varkappa = 1$) and high sensitivity for intrahepatic biliary radicle dilatation (89.3%; $\varkappa = 0.914$).

In contrast, TAUS demonstrated markedly limited sensitivity for lesions that are frequently occult on conventional ultrasonography, including GB microlithiasis (4.35%), CBD stones (9.09%; $\varkappa = 0.159$), and pancreatic head masses (11.76%; $\varkappa = 0.164$). Among patients with CBD dilatation (n = 42), TAUS identified an underlying etiology in only 28.5% of cases, compared with 85.7% with EUS ($P < 0.001$). EUS also demonstrated significantly higher detection rates for CBD stones (26.1% vs. 2.4%, $P = 0.002$) and pancreatic head masses (23.8% vs. 7.1%, $P = 0.035$).

Conclusion: TAUS provides reliable diagnostic assessment of GB wall thickening, gallstones ≥5 mm, biliary sludge, and biliary ductal dilatation. However, EUS substantially enhances the detection of small gallstones and microlithiasis, CBD stones, and pancreatic lesions, while providing superior etiological delineation in patients with otherwise unexplained CBD dilatation.

1. INTRODUCTION

In evaluating the gallbladder (GB), a variety of imaging modalities are useful including transabdominal ultrasonography (TAUS), computed tomography (CT), magnetic resonance (MR) imaging, endosonography and nuclear scintigraphy [1].

Transabdominal ultrasound (TAUS) is used as a primary screening modality for GB lesions because it is a relatively inexpensive, minimally invasive, and simple examination [2].

However, the sensitivity and accuracy of TAUS are highly dependent on the diagnostic skill of sonographers and conditions of patients. In addition, both detection and differentiation of lesions become more challenging in complicated conditions of GB [3, 4].

Despite these limitations, the routine use of other imaging modalities is not recommended but can be considered to aid decision making in certain circumstances with appropriate expertise [3, 5].

Endoscopic ultrasound (EUS) is an invasive procedure that facilitates close contact with the GB to produce higher resolution images due to the use of high frequency transducer. EUS enables the visualization of the mucosa, muscularispropria, and subserosa of the GB wall, and allows assessment of the morphology and surface of GB polyps, and can differentiate neoplastic and non-neoplastic polyps [1]. Currently, EUS is considered superior to TAUS and CT in terms of GB examination [6].

However, the invasiveness of EUS procedures, their low tolerability, high cost, longer duration, and need for sedation makes it not routinely used for evaluation of the GB [5].

This study aimed to compare the diagnostic accuracy of TAUS to that of EUS in GB and biliary diseases.

PATIENTS AND METHODS

Study Design and Population

This cross-sectional observational study enrolled 201 patients referred to Kasr Al-Ainy Internal Medicine Hospital and Emergency Department with any complain related to GB and biliary system necessitating TAUS and endosonography during the period between May 2023 and August 2024.

Eligibility criteria

Patients of both genders, above 18 years of age, presenting with abdominal pain, biliary pain or recurrent acute pancreatitis, with GB lesions detected by TAUS or CT scan of the abdomen, with no definite diagnosis, and patients with biliary obstruction in whom the cause of obstruction could not be identified by other imaging modalities (CT or MRI). Patients were excluded from the study if they were not fit for deep sedation, contraindicated for EUS, had bleeding tendency with PC < 60% or platelets < 60,000/mm3, or pregnant.

Sample size estimation

Based on previous study by Wennmacker al. [2], a total sample size of 185participants with abdominal pain or biliary pain was needed to provide a two-sided 95% confidence interval for a single proportion using the large sample normal approximation with confidence limits 5%. Sample size estimation was performed by Epi Info 7 statistical package.

Pre-operative assessment

Patients' Assessment

All enrolled participants completed a standardized evaluation, including a detailed medical history and a full clinical examination, with particular attention to the abdominal examination. Routine laboratory testing included a complete blood count, bilirubin, alanine aminotransferase, aspartate aminotransferase, alkaline phosphatase, gamma-glutamyl transferase, international normalized ratio, creatinine, and urea, serum amylase and lipase. All patients under went transabdominal ultrasonography and EUS to assess the GB and biliary system. Before endoscopic ultrasonography, patients were assessed for suitability for deep sedation, after which EUS was performed for detailed evaluation of the GB and biliary system.

Procedure Steps

Transabdominal Ultrasound (TAUS)

TAUS was performed by a single certified sonographer with ≥10 years of experience to limit inter-observer variation. All patients fasted before the examination to reduce GB contraction. With the abdomen exposed, the patient was positioned in the left lateral decubitus position to improve GB visualization. The probe was disinfected before scanning, and ultrasound gel was applied to the examination area.

The scan followed a consistent sequence. The probe was placed first at the midline epigastrium with the marker oriented toward the patient's head, then advanced laterally along the costal margin toward the right side until the portal triad was clearly identified and the GB could be fully assessed. Patients were asked to take a deep breath and hold it when needed to optimize the acoustic window. Images were acquired in longitudinal, transverse, and oblique planes using slow, controlled rocking movements. Across all examinations, organ size, parenchymal homogeneity, echogenicity, and contours were evaluated.

Endosonography (EUS)

EUS was performed by a single certified endoscopist with ≥10 years of experience to reduce inter-observer variability. Patients fasted before deep sedation (≥8 hours for solids and ≥2 hours for clear liquids), which also helped minimize GB contraction. The procedure was carried out with the patient in the left lateral decubitus position. Pulse, blood pressure, and oxygen saturation were monitored continuously, and deep sedation was administered by an anesthesia specialist.

Examinations were performed using an oblique-viewing linear Pentax (J-10) video endoscope connected to a Hitachi ultrasound system. The probe position was adjusted to obtain multiple views of the biliary system and allow a complete assessment. Biliary findings—including sludge, stones, microlithiasis, and other pathologies—were identified and recorded.

Statistical analysis

Data were analyzed using SPSS version 26. Categorical variables were summarized as counts and percentages and compared using Pearson's chi-square test. Numeric variables were summarized as mean ± SD and assessed for normality using the Kolmogorov–Smirnov test; paired t-test was used for normally distributed related data and Wilcoxon signed-rank test for non-normal related data. Diagnostic performance (sensitivity, specificity, PPV, NPV, and overall accuracy) was calculated using crosstabs. All tests were two-tailed, with $p \leq 0.05$ considered statistically significant.

RESULTS

Demographics and indications for EUS in the studied group were presented in Table 1.

There was a slight difference in the frequency of detection of GB wall thickening (GBWT), large stones (>5mm), and GB mud, while common bile duct (CBD) dilatation was detected with the same frequency by both modalities. EUS demonstrated higher frequency in the overall detection of GB stones, particularly small stones (<5mm), and microlithiasis. EUS also showed higher detection frequencies for GB polyps, CBD stones and pancreatic head masses. It can also be noted that CBD microlithiasis, CBD mud, pancreatic body masses, pancreatic cysts, ampullary and papillary lesion could only be detected by EUS. Table 2

TAUS has a high sensitivity for the detection of GBWT, GB stones 5-10mm, GB stones >10 mm, GB mud, CBD dilatation, and intrahepatic biliary radicle dilatation (IHBRDs). There was a perfect agreement between the two modalities for the detection of these lesions with kappa values of 0.817, 0.969, 0.884, 0.843, 1 and 0.914 respectively. It can thus be concluded that TAUS can be a reliable modality for the detection of these lesions. In addition, TAUS showed moderate sensitivity for GB stones 3-5 mm with moderate agreement between it and EUS. For GB polyps, TAUS showed moderate sensitivity, however there was fair agreement between it and EUS. TAUS was also found to have very low sensitivity in detection of GB microlithiasis, CBD stones, and pancreatic head masses. The kappa values for the previously mentioned lesions demonstrate a slight agreement between the two modalities. Table 3

In patients with CBD dilatation (N=42), patients showed a mean age of 54.5±10 and 52.4% were males. Table 4

In patients with CBD dilatation, TAUS identified a detectable cause in 12 patients (28.5%) compared with 36 patients (85.7%) by EUS ($p<0.001$), showing a significantly higher diagnostic yield for EUS in determining the etiology of CBD dilatation.

EUS was able to detect more lesions than TAUS in cases of CBD dilatation. There was a statistically significant difference between the frequency of detection of CBD stones and pancreatic head masses between TAUS and EUS. On the contrary, CBD mud, CBD microlithiasis, CBD benign distal stricture, papillary lesions and ampullary masses were detected only by EUS. Table 5

Table 1: Demographics and indications for EUS in the studied group

Variable		n=201
Gender	Male	94 (46.8%)
	Female	107 (53.2%)
Age (years)		47.8 ± 11.9
Indication for EUS	Right upper quadrant pain	136 (67.6%)
	Jaundice	42 (20.8%)
	Pancreatitis	12 (5.97%)
	Post cholecystectomy symptoms	4 (1.99%)
	Pancreatic lesions detected by CT (total)	7 (3.48%)
	Pancreatic body cyst	1 (0.49%)
	Pancreatic head mass	5 (2.48%)
	Swollen pancreas	1 (0.49%)

Data was presented as Mean±SD or n (%).

Table 2: Comparison between the frequency of detection of different lesions by TAUS and EUS.

Lesions	TAUS	EUS
Gall bladder wall thickening	16 (7.96%)	20 (9.95%)
GB Stones	51 (25.4%)	75 (37.5%)
Microlithiasis<3mm	3 (1.5%)	46 (22.9%)
Stones (3-5mm)	17 (8.5%)	28 (13.9%)
Stones (5-10mm)	41 (20.3%)	43 (21.4%)
Stones (>10mm)	24 (10.4%)	17 (8.5%)
GB mud	23 (11.4%)	28 (13.9%)
GB polyps	11 (5.5%)	23 (11.4%)
CBD stones	1 (0.49%)	12 (5.9%)
CBD microlithiasis	0	11 (5.47%)
CBD mud	0	7 (3.5%)
CBD dilatation	42 (20.9%)	42 (20.9%)
IHBRD	26 (12.9%)	28 (13.9%)
Pancreatic head mass	4 (2%)	17 (8.5%)

Pancreatic body mass	0	3(1.5%)
Pancreatic cysts	0	3(1.5%)
Ampullary mass	0	3 (1.5%)
Papillary mass	0	1(0.5%)

Data was presented as n (%), TAUS: transabdominal ultrasound, EUS: endoscopic ultrasound, GB: gallbladder, mm: millimeter, IHBRD: intrahepatic biliary radical dilatation.

Table 3: The validity of transabdominal ultrasound (TAUS) in the detection of different lesion in comparison to endoscopic ultrasound (EUS).

Parameter	Sensitivity (95% CI)	Specificity (95% CI)	PPV	NPV	Overall Accuracy	Kappa value
GBWT	75 % (50.9 – 90.34)	99.5 % (96.96 – 99.99)	93.75 %	97.27 %	97.01 %	0.817
GB stones	69.3 % (55 – 78)	100 % (97 – 100)	100 %	85.8 %	89.5 %	0.748
GB microlith.	4.35 % (0.53 – 14.84)	99.35 % (96.46 – 99.98)	66.67 %	77.78 %	77.6 %	0.055
GB stone (3-5mm)	46.43 % (27.51 – 66.13)	97.69 % (94.19 – 99.37)	76.4 %	91.85 %	90.55 %	0.528
GB stone (5-10mm)	95.12 % (83.47 – 99.4)	100 % (97.72 – 100)	100 %	98.77 %	99 %	0.969
GB stone (>10 mm)	100 % (80.49 – 100)	97.83 % (94.53 – 99.4)	80.9 %	100 %	98.01 %	0.884
GB mud	78.57 % (59 – 91)	99.42 % (96.82-99.99)	95.65 %	96.63 %	96.52 %	0.843
GB polyps	47.8 % (43 – 48)	98.96 % (94 – 99)	100 %	96.46 %	91.54 %	0.220
CBD stones	9.09 % (0.23 – 41)	100 % (98 – 100)	100 %	95 %	95.02 %	0.159
CBD dilatation	100 % (91.59 – 100)	100 % (97.71 – 100)	100 %	100 %	100 %	1.00
IHBRD	89.3 % (0.71 – 0.97)	99.4 % (0. 96 – 0.99)	96.1 %	98.3 %	98.1 %	0.914
Pancreatic Head mass	11.76 % (1.4 – 36)	98.91 % (96.15 – 99.87)	50 %	92.39 %	91.54 %	0.164

C.I: confidence interval, PPV: positive predictive value, NPV: negative predictive value, GBWT: gallbladder wall thickening, GB: gallbladder, microlith: microlithiasis, mm: millimeter, CBD: common bile duct, IHBRD: intrahepatic biliary radicals dilatation, Kappa value is the test of agreement between two methods with; slight agreement (0.0-0.2-), fair agreement (0.21-0.4), moderate agreement (0.41-0.6), substantial agreement (0.61-0.8), perfect agreement (0.81-1).

Table 4: Gender and age distribution of patients with biliary obstruction (n=42).

Number		n= 42
Sex	Male	22 (52.4%)
	Female	20 (47.6%)
Age		54.5±10

Data was presented as Mean±SD or n (%).

Table 5: Lesions detected by TAUS and EUS in cases with CBD dilatation.

Lesions	TAUS (n=42)	EUS (n=42)	P-value
GB stones	9 (21.42%)	11 (26.1%)	0.2
CBD stone	1 (2.4%)	11 (26.1%)	**0.002***
CBD mud	0	6 (14.3%)	--
CBD microlith	0	5 (11.9%)	--
CBD benign distal Stricture	0	12 (28.6%)	--
papillary lesion	0	1 (2.4%)	--
Pancreatic head mass	3 (7.1%)	10 (23.8%)	**0.035***
Ampullary mass	0	2 (4.8%)	**--**

TAUS: transabdominal ultrasound, EUS: endoscopic ultrasound, GB: gallbladder, CBD: common bile duct, p-value <0.05 is considered significant.

DISCUSSION

The present study included 201 patients with GB and biliary-related symptoms, with a female predominance (107/201; 53.2%) and an age range of 17–70 years (mean 47.8 ± 11.9 years). In terms of demographic characteristics and indications for EUS examination, the current findings align with two recent studies by Metwally et al., [7] and Hashim et al. [8], both conducted for similar clinical purposes and reporting comparable patient profiles and referral patterns.

The indications for EUS in the current study were also consistent with those described by Beyna and Gerges [9], who emphasized diagnostic EUS for indeterminate biliary strictures and detection of biliary stones, as well as the review by Prager et al. [10] highlighting EUS in choledocholithiasis evaluation and in pancreatitis-related assessment when conventional imaging is non-diagnostic. In our cohort, EUS detected several GB and biliary lesions more often than TAUS, most notably small stones, microlithiasis, and abnormalities involving the distal biliary tree and pancreas.

TAUS, however, performed strongly for a number of frequent findings. It showed high sensitivity and strong agreement with EUS for GB wall thickness, large gallstones (≥5 mm), GB sludge, common bile duct dilatation, and intrahepatic biliary radicle dilatation, which supports its role as a first-line test for these indications. This aligns with recommendations that abdominal ultrasound remains the initial imaging modality for routine GB and biliary evaluation [11]. When the clinical question requires finer anatomic detail, EUS provides clear added value because of its close proximity to the target structures and high-resolution imaging, particularly for wall assessment and lesion definition [12]. Chang et al. [13] also discussed that high-frequency ultrasound may approach EUS performance in selected settings [13], which supports a stepwise strategy based on clinical suspicion and available expertise.

For GB polyps, EUS identified polyps more frequently than TAUS in the current study, while TAUS demonstrated only moderate sensitivity with relatively weaker agreement compared with EUS. This aligns with observations that polyps are commonly reported on TAUS [14], but that diagnostic difficulty increases with smaller lesions and in complex GB conditions. In the meta-analysis by Wennmacker et al. [2], TAUS showed good overall performance for polyp detection, while other reports including Wu et al. [15] support TAUS as the most used modality for diagnosis and follow-up. Nevertheless, multiple authors including Kim [16], Kalbi et al. [17], Chavan and Rathi [18], Hashim et al. [8], and Metwally et al. [7] have emphasized that EUS can be particularly helpful when TAUS is inconclusive or when better characterization is required, which fits the pattern observed in our cohort.

Gallstones were among the most frequently detected lesions in this study. While TAUS showed strong performance for larger stones (>5 mm) with very high sensitivity/specificity and excellent agreement with EUS, its sensitivity decreased for smaller stones (<5 mm) and was markedly low for microlithiasis, where EUS demonstrated clear superiority. This pattern mirrors prior work showing that TAUS is reliable for typical gallstones but can miss very small stones and microlithiasis [12, 19, 20]. Other studies have also reported a higher diagnostic yield with EUS for GB and common bile duct microlithiasis, including Khurshid et al. [21] , with similar conclusions reported by Hashim et al. [8] and Metwally et al. [7].

A clinically important finding in our study concerned CBD dilatation. Among patients with CBD dilatation (n=42), TAUS reported no abnormality in 71% of cases, whereas EUS reported no abnormality in only 14.2%. Conversely, TAUS identified a detectable cause in 28.5% compared with 85.7% by EUS ($p<0.001$), indicating a significantly higher diagnostic yield for EUS in determining the etiology of CBD dilatation. This is consistent with prior work highlighting the role of EUS in obstructive jaundice or biliary dilatation when cross-sectional imaging is inconclusive, including studies by Hantour et al. [22], Abou Bakr et al. [23], and Mahajan et al. [24].

Overall, the findings of the current study support that TAUS remains reliable as a first-line modality for common GB and biliary findings particularly GBWT, large stones, mud, and ductal dilatation while EUS offers clear added value in lesions that are frequently missed by TAUS, especially small stones, microlithiasis, CBD stones, and pancreatic lesions, and in clarifying the cause of CBD dilatation when TAUS does not provide an explanation.

This study was limited by its relatively small sample size, which may reduce the generalizability of the findings, and the potential for selection bias due to the lack of randomization. In addition, the higher cost and limited availability of EUS particularly in resource-limited settings may restrict its routine use and affect the broader applicability of these results.

CONCLUSION

In conclusion, TAUS demonstrated reliable performance with strong agreement versus EUS for detecting GB wall thickening, large gallstones (>5 mm), GB mud, CBD dilatation, and intrahepatic biliary radicle dilatation. In contrast, EUS was superior for identifying lesions commonly missed on TAUS, particularly small GB stones (<5 mm), GB microlithiasis, CBD stones, and pancreatic head masses. Among patients with CBD dilatation, EUS provided a significantly higher diagnostic yield in determining the underlying cause, supporting its use when TAUS is nondiagnostic.

DECLARATIONS

Ethics approval and consent to participate

Study was done after obtaining the approval from the Ethical Committee at Cairo University Hospitals in Cairo, Egypt, which was assigned the approval code (M.D-178-2023), and the study was conducted in accordance with the principles of the Declaration of Helsinki. All participants provided written informed consent before enrollment. Informed consent was formally obtained from the patients after they were adequately informed.

COMPETING INTERESTS

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

FUNDING

The authors received no financial support for the research, authorship, and/or publication of this article.

CLINICAL TRIAL NUMBER

Not applicable.

DATA AVAILABILITY

The data that support the findings of this study are available on request from the corresponding author.

LIST OF ABBREVIATIONS

ALP: Alkaline Phosphatase

ALT: Alanine Aminotransferase

AST: Aspartate Aminotransferase

CBC: Complete Blood Count

CBD: Common Bile Duct

CI: Confidence Interval

CT: Computed Tomography

EUS: Endoscopic Ultrasound

GB: Gallbladder

GBWT: Gallbladder Wall Thickening

GGT: Gamma-Glutamyl Transferase

IHBRD: Intrahepatic Biliary Radicle Dilatation

INR: International Normalized Ratio

MR: Magnetic Resonance

MRI: Magnetic Resonance Imaging

NPV: Negative Predictive Value

PC: Prothrombin Concentration

PPV: Positive Predictive Value

SD: Standard Deviation

SPSS: Statistical Package for Social Sciences

TAUS: Transabdominal Ultrasound

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