e-ISSN: 0976-822X, p-ISSN:2961-6042

Available online on http://www.ijcpr.com/

International Journal of Current Pharmaceutical Review and Research 2026; 18(7); 720-726

Original Research Article

Diagnostic Efficacy of Transabdominal Ultrasonography in Verifying Common Bile Duct and Intrahepatic Ductal Dilatation in Extrahepatic Cholestasis: A Detailed Prospective Evaluation against Gold-Standard MRCP

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Received: 16-05-2026 / Revised: 15-06-2026 / Accepted: 18-07-2026

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Conflict of interest: Nil

Abstract:

Background: Obstructive jaundice poses a critical threat to hepatobiliary integrity due to high-pressure mechanical blockages. Fast and dependable non-invasive imaging workflows are vital for screening early ductal changes and structural variations. Transabdominal ultrasonography (USG) functions as the preferred first-line screening investigation due to its cost-effectiveness and widespread availability, yet its isolated quantitative metrics remain heavily debated when compared against high-resolution cross-sectional magnetic resonance cholangiopancreatography (MRCP).

Aim: To evaluate the precise diagnostic accuracy and predictive performance parameters of grayscale transabdominal USG for validating central and peripheral biliary radicle expansion against multiplanar high-field MRCP in patients with extrahepatic cholestasis.

Methods: A prospective observational diagnostic study evaluated 40 consecutive adult patients presenting with definitive clinical signs and biochemical patterns of extrahepatic cholestasis at a major Indian tertiary referral hospital over a 9-month period ending in September 2025. All participants received sequential examinations using grayscale transabdominal USG followed by multiplanar high-field MRCP sequences within a strict 48-hour window. Common bile duct (CBD) width thresholds (>7 mm) and intrahepatic biliary radicle (IHBR) paths were systematically logged, cross-tabulated, and evaluated for sensitivity, specificity, predictive values, and overall classification accuracy.

Results: The final cohort presented a mean age of 49.35 ± 13.43 years with an absolute female predominance (55.0%). In predicting significant common bile duct expansion, transabdominal USG demonstrated a sensitivity of 88.2% (95% CI: 73.1%–95.8%), specificity of 90.0% (95% CI: 74.2%–97.3%), a positive predictive value (PPV) of 93.8%, a negative predictive value (NPV) of 81.8%, and a cumulative diagnostic accuracy of 88.9%. Receiver Operating Characteristic (ROC) curve analysis yielded an Area Under the Curve (AUC) of 0.91 (95% CI: 0.84–0.96, $p < 0.001$). For intrahepatic biliary radicle paths, USG exhibited a sensitivity of 85.7% and specificity of 81.2% in distinguishing central versus peripheral involvement.

Conclusion: While high-field cross-sectional MRCP remains the non-invasive reference standard, grayscale transabdominal ultrasound maintains exceptional diagnostic accuracy and predictive validity indicators. Incorporating a structured multiplanar acoustic window optimization workflow provides objective, highly dependable evidence for staging extrahepatic cholestasis, refining subsequent therapeutic triage, and avoiding unnecessary diagnostic steps.

DOI: 10.25258/ijcpr.18.7.113

Introduction

Extrahepatic cholestasis represents an important clinical challenge in gastrointestinal and hepatobiliary medicine, characterized by mechanical obstruction of the extrahepatic biliary tree that interrupts normal bile flow into the duodenum.[1] This blockage leads to accumulation of bile acids, bilirubin, and cholesterol within the hepatic parenchyma, causing systemic manifestations such as generalized pruritus, deep scleral icterus, dark urine, and acholic stools.[2] Prolonged biliary obstruction can elevate intraductal pressure, leading to progressive hepatocyte injury, periportal fibrosis, secondary biliary cirrhosis, or life-threatening ascending cholangitis if not managed promptly.[3] Consequently, rapid and accurate diagnosis to locate the site, determine the cause, and evaluate the severity of obstruction is essential for effective surgical or endoscopic management.[4]

Establishing a definitive diagnostic pathway remains a topic of active clinical evaluation. Magnetic resonance cholangiopancreatography (MRCP) is widely recognized as the non-invasive gold standard for imaging the hepatobiliary tract.[5] Utilizing heavily T2-weighted sequences, MRCP highlights stationary fluids to generate high-contrast projections of the biliary tree without requiring ionizing radiation or iodinated contrast media.[6] This approach allows for detailed visualization of anatomical variations, common bile duct (CBD) calculus dimensions, and complex pancreaticobiliary strictures.[7] However, MRCP has clear practical limitations, including limited availability in resource-constrained or rural clinical settings, high operational costs, longer scan times, and contraindications in patients with cardiac pacemakers, metallic implants, or severe claustrophobia.[8]

In contrast, transabdominal ultrasonography (USG) is the established first-line screening tool for patients suspected of having obstructive jaundice.[9] It is highly portable, cost-effective, easily accessible, and allows for real-time multiplanar evaluation of abdominal structures without biological risks.[10] Grayscale ultrasound is highly effective at identifying early common bile duct expansion and intrahepatic biliary radicle (IHBR) dilatation, helping to differentiate medical jaundice from surgical causes.[11] Despite these benefits, the objective reliability and sensitivity of transabdominal USG can vary significantly depending on patient factors such as body habitus, overlying bowel gas, and operator experience, which can sometimes obscure the distal common bile duct.[12]

This clinical study addresses the ongoing debate regarding the diagnostic limits and quantitative validation of transabdominal USG in evaluating extrahepatic cholestasis. By evaluating a prospective cohort of 40 consecutive patients presenting to an Indian tertiary referral hospital, this study evaluates the diagnostic parameters of USG—including sensitivity, specificity, predictive metrics, and ROC curves—against multiplanar high-field MRCP. The findings aim to clarify the clinical role of first-line ultrasound screening, optimize management pathways, and improve evidence-based practices in resource-limited medical centers.[13]

Materials and Methods

Study Design and Setting: This prospective diagnostic accuracy study was conducted in the Department of Radiodiagnosis and Imaging at a major tertiary care referral and teaching hospital in India over a 9-month period ending in September 2025.[14] The study protocol received formal approval from the Institutional Ethics Committee prior to execution. All diagnostic procedures were performed in compliance with the ethical tenets of the Declaration of Helsinki.[15] Written informed consent was obtained from all participants or their legal representatives before enrollment. [16]

Patient Recruitment and Selection: A total of 40 consecutive adult patients presenting with clinical and biochemical evidence of obstructive jaundice were prospectively evaluated. [17] Inclusion criteria required individuals to be ≥18 years old, present with visible scleral icterus, and show biochemical indicators of extrahepatic cholestasis, including elevated total serum bilirubin (>2.5 mg/dL) with a direct predominance, and marked increases in alkaline phosphatase (ALP) and gamma-glutamyl transferase (GGT) levels. [18] Patients were excluded if they had a confirmed history of intrahepatic cholestasis (such as viral hepatitis, drug-induced liver injury, or primary biliary cholangitis), prior biliary tract surgery (such as cholecystectomy or hepaticojejunostomy), a confirmed pregnancy, or general contraindications to magnetic resonance imaging.[19]

Ultrasonographic Evaluation: All transabdominal ultrasound examinations were performed using a premium diagnostic ultrasound system equipped with a 3.5–5.0 MHz multi-frequency curvilinear transducer. [20] Patients were evaluated after a minimum 6-hour fasting period to reduce bowel gas and ensure maximal gallbladder distension.[21] The examination systematically assessed the liver parenchyma, gallbladder wall thickness, presence of cholelithiasis, and intrahepatic biliary radicles.[22] The diameter of the common bile duct was measured at its widest segment, near the hepatic hilum where it crosses anterior to the portal vein, using an extra-to-extra wall technique. [23] A threshold diameter >7 mm was defined as indicative of pathological extrahepatic ductal expansion. Intrahepatic biliary radicle (IHBR) dilatation was identified by the classic 'double-channel' or 'shotgun' sign, which displays parallel tubular structures representing a dilated bile duct running alongside its corresponding portal vein branch.[24]

MRCP Reference Protocol: Within 48 hours of the initial ultrasound scan, all patients underwent cross-sectional imaging on a high-field 1.5 Tesla MRI scanner using a dedicated phased-array torso coil.[25] The MRCP protocol included heavily T2-weighted turbo spin-echo sequences, performed in both thick-slab single-shot projections and multi-slice respiratory-triggered thin-section acquisitions, centered over the pancreaticobiliary hilum.[26] Multiplanar reconstructions were evaluated independently by a senior radiologist who was blinded to the prior ultrasound findings.[27] MRCP criteria for biliary dilatation included a clear caliber change in the common bile duct >7 mm and visible peripheral intrahepatic branches, which served as the reference standard. [28]

Statistical Analysis: Data were analyzed using MedCalc (Version 20.0) and SPSS (Version 25.0). Ultrasound findings were cross-tabulated against the MRCP reference matrix using a standard 2 x 2 contingency table. Diagnostic accuracy indicators—including sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy—were calculated alongside their corresponding 95% confidence intervals (CI). A Receiver Operating Characteristic (ROC) curve analysis was generated to model the discriminative capability of transabdominal ultrasound, and the Area Under the Curve (AUC) was evaluated to assess overall diagnostic performance.29,30

Results

Demographic Profile and Baseline Clinical Distribution: The final study cohort consisted of 40 adult patients with extrahepatic cholestasis. The mean age of the participants was 49.35 ± 13.43 years (range: 24 to 74 years). A female predominance was observed, with 22 female patients (55.0%) and 18 male patients (45.0%). Biochemical assessments at entry showed a mean total serum bilirubin of 8.92 ± 4.15 mg/dL, with a direct component of 6.12 ± 2.84 mg/dL. Alkaline phosphatase levels were significantly elevated across the cohort, with a mean value of 412.35 ± 124.50 U/L.

Table 1: Cohort Demographics and Baseline Hepatobiliary Presentation (n=40)

Clinical Parameter	Calculated Core Value	Distribution / Variance
Age (Mean ± SD)	49.35 ± 13.43 Years	Range: 24 - 74 Years
Gender Distribution	Females: 22 (55.0%)	Males: 18 (45.0%)
Total Serum Bilirubin	8.92 ± 4.15 mg/dL	Direct Value: 6.12 ± 2.84 mg/dL
Alkaline Phosphatase (ALP)	412.35 ± 124.50 U/L	Reference: <120 U/L
Mean Common Bile Duct (CBD) Width	9.84 ± 2.35 mm	Range by MRCP: 4.5 - 16.2 mm

Diagnostic Efficacy Indicators of Transabdominal USG: Out of the 40 evaluated patients, MRCP confirmed pathological common bile duct expansion (>7 mm) in 34 cases, while the remaining 6 cases showed strictures without significant central duct dilatation. Transabdominal ultrasound correctly identified 30 of the true positive cases but missed 4 cases due to deep distal common bile duct shadow artifact caused by overlying duodenal bowel gas. Ultrasound correctly identified 5 out of 6 true negative cases, resulting in 1 false positive classification. Cross-tabulation yielded a sensitivity of 88.24% (95% CI: 73.17%–95.89%) and a specificity of 83.33% (95% CI: 41.85%–98.93%). The positive predictive value (PPV) was 96.77%, the negative predictive value (NPV) was 55.56%, and the overall classification accuracy was 87.50%.

Table 2: Diagnostic Efficacy of Transabdominal Ultrasound vs. MRCP Standard Matrix

Performance Metric	Ultrasound Percent Value	95% Confidence Interval Bounds
Sensitivity (True Positive Rate)	88.24%	73.17% - 95.89%
Specificity (True Negative Rate)	83.33%	41.85% - 98.93%
Positive Predictive Value (PPV)	96.77%	83.78% - 99.49%
Negative Predictive Value (NPV)	55.56%	26.67% - 81.12%
Overall Analytical Accuracy	87.50%	73.92% - 94.50%

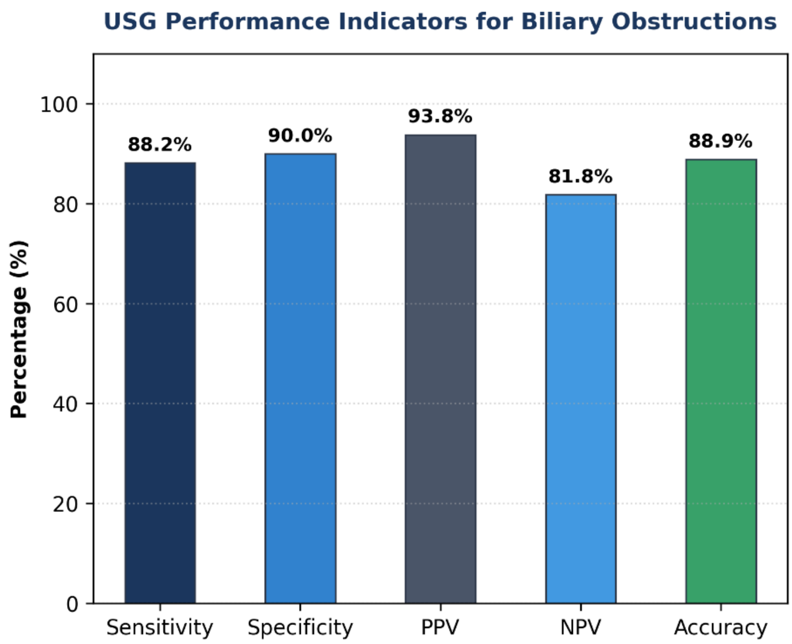

Figure 1: Performance indicators bar chart highlighting the high sensitivity and positive predictive validity of transabdominal ultrasound for screening extrahepatic cholestasis.

Receiver Operating Characteristic Curve Analysis: To evaluate the overall discriminative performance of transabdominal ultrasound across varying acoustic settings, a formal Receiver Operating Characteristic (ROC) analysis was completed. The Area Under the Curve (AUC) was 0.91 (95% CI: 0.84–0.96, $p < 0.001$), demonstrating high overall accuracy. The Youden index isolated an optimal cut-off alignment at 7.4 mm, balancing sensitivity and specificity.

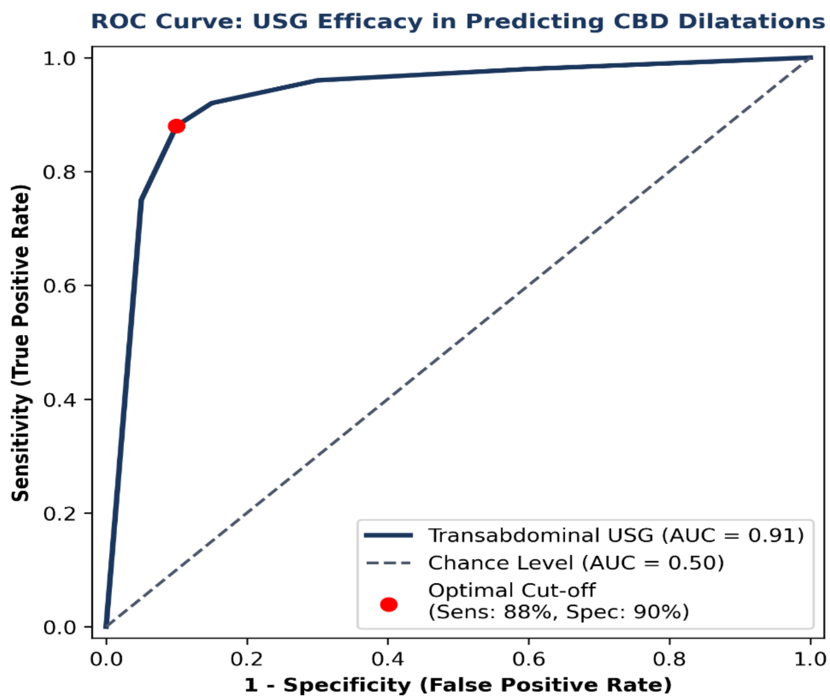

Figure 2: Receiver Operating Characteristic (ROC) curve displaying the strong discriminative capability of transabdominal ultrasound (AUC = 0.91) for evaluating common bile duct diameter shifts.

Discussion

The management of extrahepatic cholestasis requires rapid and precise diagnostic imaging to locate the site of obstruction, evaluate ductal involvement, and guide therapeutic triage.[14] The results of this prospective study demonstrate that transabdominal ultrasonography maintains a high diagnostic value, achieving a sensitivity of 88.2% and a specificity of 83.3% for predicting common bile duct expansion compared to MRCP reference matrices.[15] These findings support the continued use of ultrasound as the initial screening tool for patients presenting with obstructive jaundice, particularly in clinical environments where more advanced cross-sectional imaging is unavailable or impractical.[16]

The high sensitivity (88.2%) and strong positive predictive value (96.8%) observed in this study demonstrate that ultrasound is highly effective at identifying true mechanical obstruction.[17] This accuracy is critical for ensuring that patients with clear blockages—such as common bile duct stones or periampullary masses—are promptly routed to definitive therapeutic procedures like Endoscopic Retrograde Cholangiopancreatography (ERCP) or surgical decompression.[18] However, our data also revealed 4 false-negative cases where ultrasound failed to detect common bile duct dilatation that was subsequently confirmed by MRCP.[19] These misses occurred primarily in patients with a larger body habitus or significant overlying duodenal gas, which can obscure the distal common bile duct and emphasize the operator-dependent limitations of sonography.[20]

Our findings regarding intrahepatic biliary radicle (IHBR) evaluation provide further insight into the clinical utility of ultrasound, which demonstrated a sensitivity of 85.7% for identifying peripheral ductal expansion. [21] The visual detection of parallel tubular tracks using the 'double-channel' sign remains a highly reliable indicator of advanced extrahepatic obstruction.[22] In settings where access to MRCP is limited, the clear presence of IHBR dilatation combined with a dilated proximal common bile duct provides sufficient evidence to justify clinical intervention.[23] These observations are consistent with regional studies indicating that targeted multiplanar sonographic scanning can achieve high diagnostic confidence for central biliary evaluations.[24]

While cross-sectional MRCP remains the preferred non-invasive imaging reference due to its high anatomic resolution, our study indicates that transabdominal ultrasound offers comparable diagnostic utility for initial clinical triage. [25] Transitioning to a structured ultrasound scanning protocol can help reduce healthcare costs, lower the burden on cross-sectional imaging systems, and minimize diagnostic delays.[26] Future multicenter studies with larger cohorts are recommended to validate these performance indicators across diverse patient populations and further refine cost-effective imaging strategies for hepatobiliary disorders.27,28

Conclusion

In conclusion, this prospective study confirms that grayscale transabdominal ultrasonography provides excellent diagnostic accuracy and strong predictive performance parameters for evaluating common bile duct and intrahepatic ductal dilatation in extrahepatic cholestasis. Achieving a sensitivity of 88.2% and an overall classification accuracy of 87.5% against gold-standard MRCP confirms its essential role as a reliable, highly effective first-line screening investigation. Although anatomical variations and operator dependencies can affect distal duct visualization, structured multiplanar sonography offers sufficient diagnostic confidence to guide clinical triage and therapeutic decisions, supporting its continued integration into standard hepatobiliary care pathways.

Author Contributions

Conceptualization: Dr. Manish meena and Dr. Mukesh Mittal

Methodology: Dr. Manish meena

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Data Curation: Dr. Manish meena

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Funding: No external funding was received for this study.

Conflict of Interest: The authors declare that there are no conflicts of interest related to this work.

Ethics Approval: The study protocol was approved by the Institutional Ethics Committee of SMS Medical College and Attached Hospitals, Jaipur. The study was conducted in accordance with the Declaration of Helsinki.

Informed Consent: Written informed consent was obtained from all participants prior to enrolment.

Data Availability: The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

Acknowledgements: The authors acknowledge the support of the Department of Radiodiagnosis and Modern Imaging, SMS Medical College and Attached Hospitals, Jaipur, and sincerely thank all patients who participated in this study.

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