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Correlative Evaluation of Transabdominal Ultrasonography and Magnetic Resonance Cholangiopancreatography Findings in Patients with Periampullary and Biliary System Pathologies

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ABSTRACT

Background: Periampullary and biliary pathologies are common causes of obstructive jaundice, requiring timely and accurate imaging for effective diagnosis and management. Transabdominal ultrasonography (USG) is widely available and cost-effective, while magnetic resonance cholangiopancreatography (MRCP) provides superior anatomical visualization of the biliary system.

Objective: To compare the diagnostic accuracy of USG and MRCP in detecting periampullary and biliary pathologies, using endoscopic retrograde cholangiopancreatography (ERCP) as the reference standard.

Materials and Methods: This prospective observational study was conducted over 18 months (May 2023 to November 2024) in the Department of Radiodiagnosis at the Integral Institute of Medical Sciences and Research, Lucknow. A total of 45 patients with clinical and laboratory evidence of obstructive jaundice were enrolled. All patients underwent USG followed by MRCP. Imaging findings were assessed for choledocholithiasis, common bile duct (CBD) dilatation or obstruction, gallbladder pathology, and periampullary lesions. ERCP findings served as the gold standard. Diagnostic performance parameters, including sensitivity, specificity, accuracy, and positive predictive value (PPV), were calculated using SPSS v20.0.

Results: MRCP identified all 17 cases of choledocholithiasis confirmed by ERCP, whereas USG missed three distal CBD stones. MRCP also detected more biliary and periampullary malignancies. USG showed 77.5% sensitivity, 60% specificity, 75.6% accuracy, and 93.9% PPV. MRCP showed superior performance: 92.5% sensitivity, 80% specificity, 91.1% accuracy, and 97.4% PPV.

Conclusion: USG remains a valuable first-line screening modality for evaluating biliary obstruction due to its accessibility and cost-effectiveness. However, MRCP offers significantly greater diagnostic accuracy, especially in detecting distal CBD stones and periampullary malignancies. Owing to its non-invasive nature and high diagnostic yield, MRCP serves as a reliable alternative to ERCP in the preoperative evaluation of obstructive jaundice.

Keywords: *MRCP, Obstructive jaundice, Choledocholithiasis, Ultrasonography, ERCP, Biliary obstruction, Periampullary carcinoma*

1. INTRODUCTION

Obstructive jaundice is a common and clinically significant condition that necessitates prompt imaging evaluation and timely intervention. [1] It accounts for approximately 30–40% of all surgical jaundice cases and is most frequently caused by gallstones, benign biliary strictures, or malignancies affecting the biliary tract. [2] In patients presenting with clinical and biochemical indicators of biliary obstruction, the key diagnostic objectives are to confirm the presence of obstruction, identify its underlying cause, and determine its precise location and extent.

Among the available imaging modalities, transabdominal ultrasonography (USG) and magnetic resonance cholangiopancreatography (MRCP) are widely utilized for evaluating pancreaticobiliary disorders. [1] USG is typically the initial investigation of choice due to its accessibility, non-invasiveness, cost-effectiveness, and reasonably high diagnostic accuracy in detecting biliary ductal dilatation. [3] However, its diagnostic performance may be limited in certain scenarios, such as distal common bile duct (CBD) obstruction, obesity, or when bowel gas obscures the view. Additionally, USG has limited sensitivity for evaluating the distal CBD and periampullary region, particularly in cases of choledocholithiasis or periampullary tumors. [4]

Cross-sectional imaging modalities like computed tomography (CT) and multislice CT offer excellent anatomical detail with three-dimensional reconstruction capabilities. Despite this, their ability to detect radiolucent biliary calculi is constrained due to the isodense nature of these stones relative to bile, often requiring indirect diagnostic signs such as proximal biliary dilatation. [5,6] While endoscopic retrograde cholangiopancreatography (ERCP) provides high diagnostic accuracy along with therapeutic potential, its invasive nature and associated risks restrict its use primarily to therapeutic interventions. [7,8]

In contrast, MRCP is a non-invasive imaging modality that enables a comprehensive assessment of the hepatobiliary and pancreatic systems. It provides high contrast resolution, multiplanar imaging capabilities, and accurate delineation of the biliary and pancreatic ducts without the need for intravenous contrast agents. [9] Unlike USG, MRCP is not affected by bowel gas and offers near artifact-free imaging, making it especially useful in evaluating complex cases of biliary obstruction. [10] It has demonstrated excellent sensitivity and specificity in detecting biliary calculi, strictures, and periampullary lesions, often matching or exceeding the diagnostic accuracy of other modalities. [11,12]

This study compares the diagnostic performance of transabdominal ultrasonography and MRCP in determining the cause, site, and extent of biliary obstruction. ERCP findings, surgical outcomes, or histopathological analysis will serve as the reference standards to evaluate the clinical utility of these imaging techniques in assessing periampullary and biliary system pathologies.

2. MATERIALS AND METHODS

Study Setting and Design

A prospective observational study was undertaken in the Department of Radiodiagnosis at the Integral Institute of Medical Sciences and Research (IIMS&R), Lucknow, over a duration of 18 months, from May 2023 to November 2024.

Study Population

The study included a total of 45 patients, aged 16 years and above, of either sex, who presented with clinical and laboratory findings indicative of obstructive jaundice and were referred for MRCP.

Eligibility Criteria

Inclusion Criteria:

- Age ≥ 16 years
- Clinical and laboratory evidence of obstructive jaundice

Exclusion Criteria:

- Contraindications to MRI (e.g., pacemakers, MR-incompatible implants, claustrophobia)
- Age < 16 years
- Refusal to provide informed consent or unwillingness to participate

Ethical Approval

Ethical approval for the study was obtained from the Institutional Ethics Committee (IEC) of the IIMS&R, Lucknow (Approval No. IEC/IIMSR/2023/25). Written informed consent was obtained from all participants prior to enrolment. Patient confidentiality was strictly maintained, and all data were anonymized to ensure privacy and compliance with ethical standards.

Imaging Protocol and Data Collection

All participants underwent both USG and MRCP following a fasting period of 6–8 hours to optimize hepatobiliary visualization. Imaging findings were independently interpreted and subsequently compared with ERCP results, which served as the diagnostic gold standard.

Demographic and clinical information, including age, gender, and presenting symptoms, was recorded using a structured data form. All imaging examinations were conducted by experienced radiologists who were blinded to the results of the alternate imaging modality, in order to reduce interpretation bias.

Ultrasonography (USG)

USG was conducted using a Samsung HS50 ultrasound system with a 2–5 MHz curvilinear transducer. Scanning was performed in sagittal, transverse, and subcostal oblique planes to obtain comprehensive views of the liver, gallbladder, biliary ducts, and adjacent structures.

Magnetic Resonance Cholangiopancreatography (MRCP)

MRCP was performed using a Philips Intera Achieva 1.5 Tesla MRI scanner (Philips Medical Systems, Best, The Netherlands) equipped with a phased-array body coil. All patients were instructed to fast for 6–8 hours prior to imaging to reduce bowel peristalsis and enhance biliary tract visualization. The MRCP protocol comprised the following sequences:

- Axial T1-weighted images
- Transverse and coronal T2-weighted turbo spin echo (TSE)
- Transverse T2-weighted SPAIR
- Balanced turbo field echo (BTFE)
- Diffusion-weighted imaging (DWI)
- Single-shot 3D MRCP
- High-resolution 3D MRCP

Diagnostic Parameters Assessed

Both USG and MRCP were evaluated for the following:

- Presence of bile duct calculi
- Common bile duct (CBD): diameter, obstruction, calculi, or mass lesions
- Gallbladder: size, wall characteristics, calculi or masses
- Ampullary region: periampullary masses
- Evidence of local invasion into adjacent organs or fascial planes

Statistical Analysis

Data were analyzed using SPSS version 20.0 (IBM Corp., Armonk, NY, USA). Diagnostic performance metrics—sensitivity, specificity, accuracy, and positive predictive value (PPV)—were calculated for both USG and MRCP, using ERCP findings as the reference standard. Comparative analysis between the two modalities was performed, with $p < 0.05$ considered statistically significant.

3. OBSERVATION & RESULTS

Table 1: Gender distribution of the study cases

Gender	**Frequency. (n=45)**	**Percentage. (%)**
Male	19	42.22
Female	26	57.78
Total	45	100.0
Age Group (Years)	**Frequency (n=45)**	**Percentage (%)**
17-30	06	13.33

31-40	10	22.22
41-50	12	26.67
51-60	08	17.78
>60	09	20.00
Total	45	100.0

Table 1 presents the demographic distribution of the study participants based on gender and age. Out of a total of 45 cases included in the study, 19 were male (42.22%) and 26 were female (57.78%), indicating a slight female predominance in the sample population.

The age distribution shows that participants were spread across a wide age range. The majority of participants were in the 41–50 years age group (26.67%), followed by 22.22% in the 31–40 years group, and 20% were aged over 60 years. Additionally, 17.78% of the participants were between 51–60 years, and the youngest age group, 17–30 years, comprised 13.33% of the sample.

Table 2: Location of calculi in 17 cases of choledocholithiasis.

Location.		**USG.**	**MRCP.**
No. of cases diagnosed		14	17
Common hepatic duct		1	1
Common bile duct	**Proximal**	7	7
	Middle	5	5
	Distal	1	4

Table 3 presents the distribution of calculi locations in 17 confirmed cases of choledocholithiasis as detected by ultrasonography (USG) and MRCP. USG identified calculi in 14 cases, while MRCP detected all 17 cases, indicating its higher sensitivity. Both imaging modalities detected one calculus in the common hepatic duct. In the common bile duct, calculi were found in the proximal segment in 7 cases and in the middle segment in 5 cases by both USG and MRCP. However, in the distal segment, MRCP detected 4 cases compared to only 1 case detected by USG. This suggests that MRCP is more accurate, particularly in identifying distally located stones that may be missed on USG.

Table 3: Causes of jaundice among the study participants on the basis of USG

Disease	**Frequency**	**Percentage (%)**
Choledocholithiasis	14	31.1
Periampullary mass	4	8.88
Choledochal cyst	2	4.44
Benign CBD stricture	3	6.6
Cholangiocarcinoma	2	4.4
Gallbladder mass	3	6.6
Post-operative stricture	2	4.44
Nodal mass	1	2.22

Table 4 outlines the various causes of jaundice among the study participants as identified through ultrasonography (USG). The most common cause was choledocholithiasis, accounting for 14 cases (31.1%), indicating that bile duct stones were the leading etiology in this group. Periampullary masses were found in 4 cases (8.88%), followed by benign common bile duct (CBD) strictures and gallbladder masses, each observed in 3 cases (6.6%). Choledochal cysts, cholangiocarcinoma, and post-operative strictures were each noted in 2 cases (4.44%), while a nodal mass was identified as the cause of jaundice in 1 case (2.22%)

Table 4: Causes of jaundice among the study participants on the basis of MRCP

Disease	Frequency	Percentage (%)
Choledocholithiasis	17	37.8
Periampullary mass	5	11.1
Choledochal cyst	3	6.66
Nodal mass	1	2.22
Gallbladder mass	3	6.6
Cholangiocarcinoma	3	6.6
Benign stricture	3	6.6
Post-operative stricture	2	4.4
No cause	4	8.9

Table 5 summarizes the causes of jaundice among the study participants as diagnosed by MRCP. The most common cause identified was choledocholithiasis, observed in 17 cases (37.8%), reaffirming its role as a leading cause of obstructive jaundice. Periampullary masses accounted for 5 cases (11.1%), while choledochal cysts, gallbladder masses, cholangiocarcinoma, and benign strictures were each noted in 3 cases (6.6%), indicating a diverse spectrum of both benign and malignant conditions. Post-operative strictures were found in 2 cases (4.4%), and nodal mass was the cause in 1 case (2.22%). Interestingly, in 4 cases (8.9%), MRCP did not reveal any specific cause of jaundice. These findings demonstrate the broad diagnostic capability of MRCP in evaluating the underlying etiologies of jaundice, with choledocholithiasis being the most frequently encountered pathology.

Table 5: Causes of jaundice among the study participants on the basis of ERCP

Disease	Frequency	Percentage (%)
Choledocholithiasis	17	37.8
Periampullary Carcinoma	5	11
Choledochal cyst	3	6.6
Metastatic Nodal mass	1	2.22
Gallbladder Carcinoma	4	8.89
Cholangiocarcinoma	3	6.6
Benign stricture	4	8.89
Post-operative stricture	3	6.6
No cause	5	11

Table 6 presents the various causes of jaundice among the study participants as diagnosed through ERCP. The most frequently identified cause was choledocholithiasis, found in 17 cases (37.8%), indicating that bile duct stones were the leading etiology. Periampullary carcinoma accounted for 5 cases (11%), while gallbladder carcinoma and benign strictures were each seen in 4 cases (8.89%). Other notable causes included cholangiocarcinoma, choledochal cysts, and post-operative strictures, each diagnosed in 3 cases (6.6%), and a metastatic nodal mass in 1 case (2.22%). Interestingly, in 5 cases (11%), ERCP did not reveal any identifiable cause of jaundice. These findings suggest that ERCP is effective in diagnosing a wide range of both benign and malignant causes of jaundice, with choledocholithiasis being the most prevalent.

Table 6: Overall Sensitivity, Specificity, PPV and Accuracy. of USG and MRCP with respect to final diagnosis

	USG	**MRCP**
Sensitivity	77.5%	92.5%
Specificity	60%	80%
Accuracy	75.6%	91.1%
Positive predictive value	93.9%	97.4%

Table 10 presents a comparative analysis of the diagnostic performance of USG and MRCP in identifying the etiologies of jaundice, using the final clinical diagnosis as the reference standard. MRCP demonstrated superior diagnostic performance across all evaluated parameters. The sensitivity of MRCP was 92.5%, markedly higher than that of USG (77.5%), indicating a greater ability to correctly identify true positive cases. Similarly, MRCP exhibited higher specificity (80%) compared to USG (60%), reflecting improved accuracy in correctly identifying true negative cases. The overall diagnostic accuracy of MRCP was 91.1%, significantly exceeding that of USG, which was 75.6%. Furthermore, the PPV of MRCP was 97.4%, compared to 93.9% for USG, underscoring MRCP's enhanced reliability in confirming disease presence. Collectively, these findings establish MRCP as a more accurate and dependable imaging modality than USG in the evaluation of patients with jaundice.

4. DISCUSSION

Obstructive jaundice, frequently resulting from periampullary and biliary system pathologies such as choledocholithiasis, strictures, and malignancies, necessitates timely and accurate imaging for effective diagnosis and management. Among the available diagnostic tools, transabdominal ultrasonography (USG) is widely utilized due to its affordability and accessibility, while MRCP offers superior anatomical visualization and non-invasive evaluation of the biliary tract. [1] This study aimed to assess and compare the diagnostic efficacy of USG and MRCP in patients presenting with clinical features suggestive of biliary obstruction.

In our study involving 45 patients, a slight female predominance was observed (female-to-male ratio: 1.37:1), consistent with the findings of Swaraj S et al. [1], who reported a similar ratio of 1.1:1. The most commonly affected age group was 41–50 years, followed by 31–40 years—corroborating the trends reported by Upadhyaya V et al. [13] and Singh A et al. [14], who also noted a higher prevalence in middle-aged individuals, particularly among females.

USG identified choledocholithiasis as the most common etiology, observed in 14 out of 45 patients (31.1%), aligning with the results of Singh A et al. [14] and Prasad AS et al. [15]. However, USG failed to detect 3 of the 17 confirmed cases, indicating reduced sensitivity—especially for distal common bile duct (CBD) stones. In contrast, MRCP detected 4 such distal CBD stones compared to only 1 by USG. Alsaigh S et al. [16] similarly reported USG's low sensitivity (26.6%) but high specificity (100%) for CBD stone detection.

Kaur A et al. [17] also recognized the CBD as the most common site of choledocholithiasis. In our study, this remained the leading cause of obstructive jaundice across both imaging modalities. Other benign conditions such as strictures, choledochal cysts, and postoperative changes were poorly visualized on USG. Kaur A et al. [17] reported comparable findings, with USG showing a sensitivity of just 20% and specificity of 100% for benign CBD strictures. These limitations are likely due to challenges in visualizing the distal CBD and periampullary region, particularly when obscured by bowel gas or suboptimal patient anatomy.

MRCP demonstrated superior diagnostic capability across all major categories: detecting 17 cases of choledocholithiasis

(versus 14 by USG), 5 periampullary masses (versus 4), and 3 choledochal cysts (versus 2). Overall, MRCP established a diagnosis in 91.1% of cases, compared to 75.6% by USG. These results are consistent with those of Khopde PA et al. [18], who reported 100% diagnostic accuracy of MRCP for choledochal cysts versus 66.6% for USG. Similar outcomes were noted by Bhatt et al. [19] and Kushwah AP et al. [20]. Furthermore, MRCP detected 3 out of 4 periampullary masses later confirmed histologically, as also observed by Khopde PA et al. [18].

ERCP, used as the reference standard in this study, confirmed choledocholithiasis in 17 patients (37.8%) and periampullary carcinoma in 5 patients (11%). ERCP failed to detect pathology in 5 cases (11%), slightly higher than the 4 missed by MRCP (8.9%). These differences may be attributable to technical challenges or sampling limitations. Similar observations were reported by Khopde PA et al. [18]. Adamek, HE emphasized the role of MRCP in patients for whom ERCP is contraindicated—such as those with biliary-enteric anastomosis or prior gastric surgeries.

Diagnostic performance analysis showed MRCP to have superior sensitivity (92.5%), specificity (80%), and accuracy (91.1%) compared to USG (77.5%, 60%, and 75.6%, respectively). MRCP also yielded a higher positive predictive value (PPV) of 97.4% versus 93.9% for USG. These findings further highlight MRCP's superiority in the detailed evaluation of biliary and periampullary pathologies.

These outcomes are in line with existing literature. Calvo et al. [21], Huassein et al. [22], and Varghese et al. [23] have reported MRCP sensitivity and specificity ranging from 81–100% and 84–100%, respectively. Verma et al. [24] documented MRCP sensitivity and specificity of 92.3% and 86%, compared to 85.3% and 88.4% for USG. Ferrari FS et al. [12] reported an overall diagnostic accuracy of 93.13% for MRCP, with sensitivity and specificity of 90% and 94%, respectively.

MRCP's enhanced diagnostic capability stems from its ability to produce high-resolution, multiplanar images unaffected by bowel gas or body habitus—two common limitations of USG. In addition, MRCP can simultaneously detect multiple abnormalities, including intrahepatic biliary dilatation, strictures, cysts, or masses, which may go unrecognized or under-characterized on USG.

In conclusion, while USG remains a valuable first-line investigation due to its accessibility and cost-effectiveness, it demonstrates limited sensitivity in detecting distal CBD stones and periampullary lesions. When USG findings are inconclusive or when malignancy is suspected, MRCP should be the imaging modality of choice for comprehensive biliary evaluation. This study underscores the complementary roles of USG and MRCP in a stepwise diagnostic algorithm for patients with obstructive jaundice.

5. CONCLUSION

The present study highlights that periampullary and biliary system pathologies were more commonly observed in females (57.78%), with the highest prevalence in the 41–50 years age group (26.67%), indicating a predominance in middle-aged individuals. Choledocholithiasis emerged as the most frequent cause of obstructive jaundice across all diagnostic modalities—accounting for 31.1% on USG and 37.8% on both MRCP and ERCP—underscoring its clinical significance. MRCP outperformed USG in detecting biliary calculi, particularly in the distal common bile duct, where it identified four cases compared to only one by USG, reflecting its superior sensitivity in anatomically challenging areas.

Furthermore, MRCP demonstrated a broader diagnostic capacity, successfully identifying a wider spectrum of both benign and malignant pathologies, including periampullary masses, gallbladder carcinoma, cholangiocarcinoma, and post-operative strictures. When benchmarked against final diagnoses, MRCP showed markedly higher sensitivity (92.5% vs. 77.5%), specificity (80% vs. 60%), diagnostic accuracy (91.1% vs. 75.6%), and positive predictive value (97.4% vs. 93.9%) than USG. These findings establish MRCP as a highly reliable, non-invasive imaging modality for comprehensive evaluation of obstructive jaundice and reinforce its role as the preferred investigation, especially when USG yields inconclusive results or when malignancy is suspected.

6. STRENGTHS AND LIMITATIONS

This study has a few limitations. The operator dependency of ultrasonography reduced its accuracy, particularly in obese patients and those with bowel gas, limiting visualization of distal CBD and periampullary regions. The small sample size and lack of consistent histopathological confirmation in malignant cases may affect generalizability. Some MRCP images were compromised by poor breath-holding, and delays between MRCP and ERCP could have led to discrepancies due to stone migration.

Nonetheless, the study's strengths include a direct comparison of USG and MRCP within the same cohort, validated against ERCP. The inclusion of varied benign and malignant pathologies adds clinical relevance. MRCP's superior performance and non-invasiveness support its utility as a preferred modality in evaluating obstructive jaundice.

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