

DIAGNOSTIC ACCURACY OF MAGNETIC RESONANCE CHOLANGIOPANCREATOGRAPHY (MRCP) IN DETECTING CHOLEDOCHOLITHIASIS TAKING ENDOSCOPIC RETROGRADE CHOLANGIOPANCREATOGRAPHY (ERCP) AS GOLD STANDARD

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Abstract

Background: Choledocholithiasis is a common condition of biliary system that may result in serious complications if not diagnosed and treated promptly. Magnetic resonance cholangiopancreatography (MRCP) is a noninvasive imaging modality used for the detection of common bile duct (CBD) stones. However, its diagnostic performance may vary, particularly in the detection of small stones. Endoscopic retrograde cholangiopancreatography (ERCP) remains the reference standard but is invasive and associated with potentially serious complications. This study aimed to determine the diagnostic accuracy of MRCP in detecting choledocholithiasis using ERCP as the reference standard.

Methods: This cross-sectional validation study was conducted at the Department of Radiology, Ayub Teaching Hospital, Abbottabad, from January 2025 to December 2025. A total of 112 patients aged 15-90 years with clinical, biochemical and ultrasonographic suspicion of choledocholithiasis were included through consecutive sampling. All patients underwent MRCP followed by ERCP. MRCP findings were compared with ERCP findings, and sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall diagnostic accuracy were calculated. Diagnostic performance was also assessed according to age, gender, BMI and other socio-demographic characteristics.

Results: Among 112 patients, ERCP confirmed choledocholithiasis in 98 (87.5%) patients. MRCP correctly identified 95 true-positive and 10 true-negative cases, while 4 false-positive and 3 false-negative cases were observed. The sensitivity of MRCP was 96.9%, specificity 71.4%, PPV 96%, NPV 76.9%, and overall diagnostic accuracy 93.8%. There was substantial agreement between MRCP and ERCP ($\kappa = 0.64$, $p < 0.001$). Stratified analysis showed that MRCP maintained good diagnostic performance across different socio-demographic variables including age, gender and BMI.

Conclusion: MRCP demonstrated high diagnostic performance for detecting choledocholithiasis when ERCP was used as the reference standard. Its high sensitivity and overall diagnostic accuracy support its role as a reliable

noninvasive imaging modality, particularly in patients who do not require immediate therapeutic ERCP. However, the possibility of missed small CBD stones should be considered, and further evaluation with EUS or ERCP may be warranted when clinical or biochemical suspicion persists despite a negative MRCP.

INTRODUCTION:

Choledocholithiasis, defined as the presence of stones in common bile duct (CBD), is a common complication of cholelithiasis occurring in 10-15% of affected individuals as these stones may migrate from gall bladder into the CBD. Primary bile duct stones can also occur but are rare (1, 2).

These stones can cause partial or complete obstruction of bile flow which causes symptoms like abdominal pain, vomiting, jaundice, fever and evidence of cholestasis on biochemical workup. If untreated, choledocholithiasis can lead to complications like acute cholangitis, pancreatitis, hepatic dysfunction and sepsis which increases hospitalization rate and duration leading to increased burden on healthcare. Therefore, timely and accurate diagnosis is essential for appropriate management (3, 4).

Choledocholithiasis is generally diagnosed through clinical assessment, biochemical investigations and imaging. Once CBD stones are suspected on clinical and biochemical evaluation, the first line imaging modality is trans-abdominal ultrasonography because it is noninvasive, widely available and relatively inexpensive. It shows dilated CBD with high accuracy of 90% but it cannot specifically rule out the cause in majority of cases detecting stone within the CBD with sensitivity of 15-20%. It has its own limitations like gas in duodenum can impede the clear visualization of distal part of CBD and thus detection of any calculus in it (4). Magnetic resonance cholangiopancreatography (MRCP) is a noninvasive magnetic resonance imaging technique that provides detailed visualization of biliary and pancreatic ductal system. Several studies showed high sensitivity and specificity of MRCP in diagnosing choledocholithiasis. However, its diagnostic sensitivity may be affected by smaller size of stones particularly those measuring less than or equal to 5mm. (5).

Endoscopic ultrasound is another useful modality for detecting CBD stones but it also has limitations including its availability, cost effectiveness, operator dependence and need for specialized expertise (6,7) Endoscopic retrograde cholangiopancreatography (ERCP) is reference standard tool for detecting choledocholithiasis having an added benefit of intervention when needed (8). However, it is an invasive procedure with risk of potentially serious complications like post ERCP pancreatitis, bleeding, infection and perforation. Overall ERCP-related adverse events have been reported in approximately 9.8% of procedures. (9, 10).

Several studies have reported favorable diagnostic performance of MRCP for detection of choledocholithiasis. A meta-analysis by Chen et al. showed that MRCP has sensitivity and specificity of 90% and 95% respectively for detecting choledocholithiasis (11). Sherpa et al. demonstrated an overall accuracy of 92.4% and the study identified CBD stones as the most common benign cause of cholestasis (12). Similarly, a prospective study conducted in Bahawalpur Victoria Hospital involving 138 patients demonstrated good accuracy of MRCP in diagnosing choledocholithiasis with sensitivity of 90%, specificity of 83.3%, positive predictive value (PPV) of 85.5%, negative predictive value (NPV) of 88.7% and diagnostic accuracy of 86.9% (13). Despite the high diagnostic accuracy of MRCP in detecting choledocholithiasis, limitations remain, particularly in the detection of small stones. Reported diagnostic performance varies among studies and differences in patient population, disease prevalence, stone characteristics and institutional expertise may contribute to this variation. Although studies from different centers have reported favorable results, some studies also suggest that it should not be used as diagnostic tool for workup of biliary duct pathology due to its

questionable negative predictive value. (6, 8). Therefore, further evaluation of MRCP against a reference standard like ERCP is valuable, particularly in local clinical settings where access to alternative modalities such as EUS may be limited.

Therefore, the present study aims to determine the diagnostic accuracy of MRCP in detecting choledocholithiasis using ERCP as the reference standard. The study assesses the sensitivity, specificity, positive predictive value, negative predictive value and overall diagnostic accuracy of MRCP for detection of CBD stones. It provides locally relevant evidence regarding the diagnostic utility of MRCP and assists clinicians in selecting an appropriate noninvasive imaging modality, reducing the unnecessary exposure to invasive procedures.

MATERIALS AND METHODS:

This cross-sectional validation study was conducted in the Department of Radiology, Ayub Teaching Hospital, Abbottabad after the approval from the Institutional Ethical Review Board (Approval No. RC-EA-2024/198) and College of Physicians and Surgeons Pakistan (CPSP). It spanned from January 2025 to December 2025. The research aimed to determine the diagnostic accuracy of MRCP in detecting choledocholithiasis using ERCP as the reference standard.

This study included 112 patients using consecutive sampling. The sample size was calculated using the WHO sample size calculator for diagnostic accuracy studies based on the expected prevalence of choledocholithiasis to be 52.17%, sensitivity and specificity of MRCP for the diagnosis of choledocholithiasis to be 90% and 83.3% respectively (13). The absolute precision was taken at 10% and the confidence interval at 95%.

Patients of either gender aged between 15 and 90 years with severe pain in right hypochondrium, jaundice, biochemical evidence of cholestasis and suspicion of choledocholithiasis on abdominal ultrasound were included. Patients with contraindications of MRI and ERCP and

pregnant female patients were excluded from this study. Patients were included after an informed consent with the right to withdraw from the study anytime without affecting their treatment and their confidentiality was strictly maintained. Detailed study information was provided to the patients before enrolling them in the study. All the patients then underwent MRCP in the Department of Radiology on 1.5 Tesla MRI scanner using torso phased array coils. Imaging parameters were Field of view (FOV) of 32-36cm, slice thickness of 5mm, spacing of 1mm and frequency matrix of 256 MHZ. It was performed utilizing fast advanced spin-echo (FASE) pulse sequence and three-dimensional images were taken when necessary. The MRCP was reviewed by single consultant radiologist having at least five years of experience. Patients were then followed until ERCP was performed. ERCP was performed by the gastroenterologist having at least five years of post-fellowship experience. The extracted data from MRCP and ERCP along with demographic data including age, gender, education, socio-economic status, height, weight, BMI, clinical presentation and ultrasound findings were then recorded into pre-designed structural proforma for further evaluation.

Statistical analysis of data was performed using SPSS version 27.0. Mean $\pm$ Standard deviation (SD) and Median (IQR) were calculated for quantitative variables like age, height, weight and BMI after checking normality by Shapiro-Wilk Test. Frequency and percentage was calculated for categorical variables like gender, education and socioeconomic status. The 2x2 contingency table was formulated to compare ERCP findings and MRCP diagnosis. The diagnostic accuracy, sensitivity, specificity, PPV, and NPV of MRCP for the detection of choledocholithiasis was calculated using standard statistical methods and the 2x2 table. Diagnostic accuracy was stratified against potential effect modifiers, such as age, gender, height and weight. Post stratification Chi-Square Test or Fisher's Exact Test was applied taking p-value of <0.05 significant.

RESULTS:

A total of 112 patients with clinical, biochemical and ultrasonographic suspicion of choledocholithiasis were enrolled during the study period.

Table 1 shows the anthropometric characteristics of the study participants. The mean age of the

participants was 53.43 ± 16.81 years, and the mean height was 1.66 ± 0.07 m. Weight and BMI were summarised using the median and interquartile range because these variables were not normally distributed.

Table 1: Anthropometric and Physical Characteristics of the study participants (N = 112)

Characteristics	Mean $\pm$ SD	Median (IQR)
Age (years)	53.43 ± 16.81	-
Height (m)	1.66 ± 0.07	-
Weight (kg)	-	79.45 (69.45 - 87.22)
BMI (kg/m ²)	-	29.56 (25.19 - 31.62)

Table 2 shows the Socio-demographic characteristics of the study participants. The females constituted 69.6% of the sample, while 67.0% of participants resided in urban areas. Most

participants belonged to the middle or lower socioeconomic classes and had high school education or below.

Table 2: Socio-demographic Characteristics

Characteristics	Frequency (%)
Gender	
1. Male	34(30.4%)
2. Female	78(69.6%)
Education	
1. No formal education - middle school	39(34.8%)
2. High school	43(38.4%)
3. Bachelors	22(19.6%)
4. Masters	8(7.1%)
Residence	
1. Rural	37(33%)
2. Urban	75(67%)
Marital status	
1. Unmarried/ Divorced/ Widowed	28(25%)
2. Married	84(75%)
Occupation	
1. Employed/ Businessman/ Laborer	29(25.9%)
2. Unemployed/ Retired	27(24.1%)
3. Housewife	47(42%)
4. Student	9(8%)
Socio-economic status	
1. Upper class	3(2.7%)
2. Middle class	50(44.6%)

3.	Lower class	59(52.7%)
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The table 3 shows the comparison of MRCP with ERCP findings. Comparison of MRCP with ERCP demonstrated 95 true-positive, 10 true-

negative, 4 false-positive and 3 false-negative results. These findings formed the basis for calculating the diagnostic performance of MRCP.

Table 3: Comparison of MRCP Findings with ERCP Findings (2x2 Table)

MRCP Findings	ERCP Positive	ERCP Negative	Total
MRCP Positive	95 (True Positive)	4(False Positive)	99
MRCP Negative	3(False Negative)	10(True Negative)	13
Total	98	14	112

The table 4 shows the diagnostic validity parameters of MRCP. Using ERCP as the reference standard, MRCP demonstrated a sensitivity of 96.9%, specificity of 71.4%, positive

predictive value of 96.0%, negative predictive value of 76.9%, and overall diagnostic accuracy of 93.8%.

Table 4: Diagnostic Performance Parameters of MRCP

Diagnostic Parameter	Formula	Value (%)
Sensitivity	$TP / (TP + FN) * 100$	96.9%
Specificity	$TN / (TN + FP) * 100$	71.4%
Positive Predictive Value (PPV)	$TP / (TP + FP) * 100$	96%
Negative Predictive Value (NPV)	$TN / (TN + FN) * 100$	76.9%
Diagnostic Accuracy	$(TP + TN) / Total * 100$	93.8%

Subgroup analysis as shown in table 5 demonstrated significant MRCP-ERCP agreement across most demographic and clinical subgroups. Fisher's exact tests were statistically significant across all age groups, both sexes, all BMI categories, urban and rural residence, most educational categories, middle and lower

socioeconomic groups, married participants, and all professional groups except students. The no formal education/middle-school subgroup ($p=0.068$) and student subgroup ($p=0.111$) did not demonstrate statistically significant association. Overall, the observed concordance was high across subgroups, ranging from 85.7% to 100%.

Table 5. Subgroup analysis of agreement between MRCP and ERCP for detection of choledocholithiasis

Subgroup	Category	n	Concordant, n (%)	Discordant, n (%)	Fisher's exact p-value
Age group	15-39 years	22	20 (90.9)	2 (9.1)	0.038
	40-59 years	45	42 (93.3)	3 (6.7)	<0.001
	60-90 years	45	41 (91.1)	4 (8.9)	0.007
Gender	Male	34	30 (88.2)	4 (11.8)	0.004
	Female	78	73 (93.6)	5 (6.4)	<0.001
BMI (kg/m ²)	Normal (18.5/18.6-24.9)	26	24 (92.3)	2 (7.7)	0.009

	Overweight (25–29.9)	39	35 (89.7)	4 (10.3)	<0.001
	Obese (≥30)	47	43 (91.5)	4 (8.5)	0.005
Residence	Urban	70	64 (91.4)	6 (8.6)	<0.001
	Rural	42	39 (92.9)	3 (7.1)	0.020
Education	No formal education-Middle school	44	42 (95.5)	2 (4.5)	0.068
	High school	28	24 (85.7)	4 (14.3)	0.027
	Bachelors	25	23 (92.0)	2 (8.0)	0.007
	Masters	15	14 (93.3)	1 (6.7)	0.009
Socioeconomic status	Upper	3	3 (100.0)	0 (0.0)	—
	Middle	50	45 (90.0)	5 (10.0)	<0.001
	Lower	59	55 (93.2)	4 (6.8)	0.003
Marital status	Unmarried/Widowed/Divorced	28	28 (100.0)	0 (0.0)	—
	Married	84	79 (94.0)	5 (6.0)	<0.001
Profession	Employed/Business/Labourer	29	25 (86.2)	4 (13.8)	0.020
	Unemployed/Retired	27	25 (92.6)	2 (7.4)	0.017
	Housewife	47	44 (93.6)	3 (6.4)	<0.001
	Student	9	9 (100.0)	0 (0.0)	0.111

Stratified analysis demonstrated consistently high sensitivity and diagnostic accuracy of MRCP across demographic, clinical, and socioeconomic subgroups. Sensitivity ranged from 91.3% to 100%, while diagnostic accuracy ranged from 86.21% to 100%, with some variation in specificity and predictive values across subgroups.

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Table 6. Stratified diagnostic performance of MRCP across demographic and socioeconomic subgroups

Stratification variable	Subgroup	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Diagnostic accuracy (%)
Gender	Male	92.85	66.6	92.85	66.6	88.23
	Female	95.71	75.0	97.1	66.6	93.58
Age (years)	15–39	94.7	66.7	94.7	66.7	90.9
	40–59	94.9	83.3	97.1	71.4	93.3
	60–90	96.0	60.0	95.0	60.0	91.1
BMI (kg/m ²)	Normal (18.5–24.9)	95.65	100.0	100.0	66.6	96.0
	Overweight (25–29.9)	95.65	62.5	100.0	83.3	89.74
	Obese (≥30)	93.2	76.0	97.5	80.0	91.49
Socioeconomic status	Upper class	100.0	—	100.0	—	100.0
	Middle class	92.68	72.7	95.0	70.0	90.0
	Lower class	96.3	60.0	96.3	60.0	93.2

Residence	Urban	94.9	72.7	94.9	72.7	94.4
	Rural	97.4	50.0	94.9	66.7	92.9
Marital status	Unmarried/divorced/widowed	100.0	—	96.4	—	96.4
	Married	93.0	76.9	85.7	66.7	90.5
Profession	Employed/businessman/labourer	95.65	60.0	88.0	75.0	86.21
	Unemployed/retired	92.0	100.0	100.0	50.0	92.89
	Housewife	95.24	80.0	97.5	66.6	93.22
	Student	100.0	100.0	100.0	100.0	100.0
Education	No formal education - middle school	96.35	100.0	100.0	33.3	95.45
	High school	91.3	60.0	91.3	60.0	86.71
	Bachelor's	95.24	75.0	95.2	75.0	92.0
	Master's	100.0	75.0	91.6	100.0	93.33

DISCUSSION:

In this study using ERCP as reference standard, MRCP achieved a sensitivity of 96.93%, specificity of 71.42%, PPV of 95.95%, NPV of 76.92% and an overall diagnostic accuracy of 93.75% for the detection of choledocholithiasis. There was substantial agreement between MRCP and ERCP ($k=0.64$, $p<0.001$). The high sensitivity observed in our study shows that MRCP was able to identify majority of patients with choledocholithiasis while its high specificity demonstrates its good result in correctly identifying patients without choledocholithiasis. These findings support the diagnostic utility of MRCP in evaluation of suspected CBD stones and are consistent with the findings reported by Naz et al. and Kimura et al (14,15).

The results of our study are clinically relevant because MRCP provides a noninvasive method of evaluating the biliary tree. However, ERCP is an invasive procedure with risk of potential complications. Therefore, a diagnostic modality with high sensitivity and specificity can help select patients who are likely to benefit from therapeutic ERCP while avoiding unnecessary invasive procedures.

Age was stratified into three groups (18-39, 40-59 and ≥ 60 years) to evaluate its influence on the

diagnostic performance of MRCP in detecting choledocholithiasis, with ERCP as the reference standard. The middle-aged group (40-59 years) had the highest prevalence of choledocholithiasis confirmed on ERCP, as well as the highest diagnostic accuracy for MRCP, at 93.3%. These findings are in line with previous literature, which has reported that choledocholithiasis is most commonly seen and diagnosed with high accuracy in middle-aged individuals, with a mean age of approximately 48 years.(16) The results of our study, therefore, support the notion that MRCP has the greatest diagnostic yield in the 40-59 years age group. Age did not show a significant effect on the overall diagnostic performance of MRCP, with similar sensitivity, specificity, PPV and NPV observed across the age groups. This suggests that MRCP is a reliable imaging modality for detecting choledocholithiasis irrespective of age, although the highest accuracy was noted in the middle-aged population.

Regarding the gender distribution, our study showed female predominance with females accounting for 69.6% of study population compared to 30.4% males, with a female-to-male ratio of 2.29:1. MRCP showed high sensitivity and PPV in both genders but performed slightly better in females regarding overall diagnostic accuracy

and specificity. It correlates with the study conducted by Kumar et al. (17). The higher prevalence of gallstones related disease among females may have contributed to the observed female predominance in patients with choledocholithiasis and slightly higher sensitivity and PPV.

Regarding BMI, previous studies suggest that increased BMI may adversely affect the diagnostic performance of MRCP in detecting CBD stones, probably due to technical limitations associated with higher body habitus. Çoban et al. reported a decline in diagnostic performance of MRCP in overweight and obese patients (18). However, in our study, MRCP maintained high sensitivity across all BMI subgroups. Although some variation in specificity and diagnostic accuracy was observed, the high sensitivity was maintained across all BMI categories.

The diagnostic performance of MRCP was also assessed across different socio-demographic characteristics, including residence, education, marital status, occupation and socioeconomic status. MRCP demonstrated consistently good diagnostic performance across these subgroups. There were slight variations in diagnostic parameters in these subgroups that may reflect the subgroups size and the distribution of ERCP confirmed cases rather than differences in the diagnostic ability of MRCP. Overall, these findings show that MRCP maintained good diagnostic performance across different socio-demographic characteristics in the study population.

Despite the overall high diagnostic performance of MRCP, discordant findings between MRCP and ERCP were observed. False positive findings were seen in 4 out of 112 patients which may be due to air bubbles, blood clots or spontaneous migration of calculi during the interval between MRCP and ERCP. Lee et al. reported mean delay of 1.8 days between MRCP and ERCP that resulted in high false positive cases (19).

Diagnostic performance of MRCP may decrease for smaller stones as evident by the study conducted by Polistina et al. (20). In our study, 3 cases were missed on MRCP which were

subsequently diagnosed on ERCP which could be due to smaller stone size leading to under-diagnosis on MRCP.

The ability to exclude CBD stones is important because non-visualization of stone on MRCP can result in avoidance of ERCP and prevent potential complications related to it. Although our overall NPV of 76.92% is slightly lower than the 90% reported by Mandelia et al. and 90.4%-93.5% range given by Mattila et al., it still shows that a negative MRCP is genuinely useful for ruling out choledocholithiasis and sparing patients unnecessary invasive procedures (21,22). The reason for slightly lower NPV can be higher pre-test probability as only those patients were included in the study who were scheduled for ERCP or a greater overall prevalence of CBD stones compared to reference studies.

The findings of our study have important clinical implications in context of 2019 American Society for Gastrointestinal Endoscopy (ASGE) guidelines according to which patients with intermediate probability of choledocholithiasis should undergo further evaluation with MRCP or EUS rather than proceeding directly to ERCP. ERCP is recommended for patients at high risk of CBD stones or when therapeutic intervention is anticipated. This risk stratified approach aims to minimize unnecessary diagnostic ERCP and thereby reduce exposure to its potential adverse events. The results of our study support this risk-stratified approach.

In the present study, MRCP demonstrated high sensitivity and specificity for detection of CBD stones with ERCP as reference standard. These findings support the role of MRCP as reliable noninvasive diagnostic modality in patients with choledocholithiasis, particularly those who do not meet ASGE high risk criteria for immediate therapeutic ERCP. The high diagnostic performance observed in our study suggests that MRCP can help accurately identify patients who are likely to require therapeutic ERCP while potentially reducing the number of unnecessary invasive ERCP procedures.

Limitations:

This was a single-centre study using consecutive sampling, which may limit generalisability. The high prevalence of choledocholithiasis in the study population affects predictive values, particularly the negative predictive value. Stone size and location were not analysed.

CONCLUSIONS:

MRCP demonstrated high diagnostic performance for the detection of choledocholithiasis when ERCP was used as the reference standard. Its noninvasive nature, combined with high sensitivity, specificity and diagnostic accuracy supports its role in the evaluation of patients with suspected CBD stones, particularly those with an intermediate probability of choledocholithiasis. MRCP may therefore facilitate appropriate selection of patients for therapeutic ERCP and reduce unnecessary invasive procedures.

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