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Prevalenceand Risk Factors Assessment of Biliary Stones using Magnetic Resonance Cholangiopancreatography

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Abstract

Biliary stone disease is a common cause of hospitalization and can lead to serious complications. Understanding the demographic, clinical, and lifestyle factors contributing to its formation is essential for prevention and management. This study aimed to assess the prevalence, anatomical distribution, and risk factor associations of biliary stones in patients undergoing Magnetic Resonance Cholangiopancreatography (MRCP), as well as to evaluate the diagnostic utility of MRCP in detecting stone size and number. A cross-sectional study was conducted from March to July 2025, including 139 patients selected through non-probability convenience sampling. Patients clinically suspected of biliary stones underwent MRCP. Demographic, clinical, and biochemical data was collected, and risk factors such asbody mass index (BMI), diabetes mellitus, liver disorders, blood disorders, nicotine use, family history, lifestyle, and dietary habits were analyzed using SPSS. The Chi-square test was applied to assess associations. Biliary stones were detected in 85.6% of participants. The gallbladder was the most affected site (41.7%), followed by the common bile duct (20.1%), combined GB & CBD (17.3%), and hepatic duct (6.5%). Significant associations were observed with female gender ($p = 0.021$), age group 34–49 years ($p = 0.042$), obesity ($p = 0.040$), diabetes mellitus ($p = 0.008$), nicotine use ($p = 0.006$), and family history ($p = 0.047$). No significant associations were found with liver disorders, blood disorders, or rapid weight loss. MRCP proved effective in detecting and mapping both solitary and multiple stones across the biliary system. These findings highlight its clinical value as a non-invasive diagnostic tool and support targeted screening strategies for high-risk groups.

Keywords: Biliary stones, Magnetic resonance cholangiopancreatography, cholelithiasis, choledocholithiasis, stone mapping, risk factors, body mass index.

Introduction

The biliary system, also known as the biliary tract or biliary tree, is a series of ducts within the liver, gallbladder, and pancreas that empty into the small intestine. It has two main components: intrahepatic (within the liver) and extrahepatic (outside the liver). The extrahepatic biliary system includes the gallbladder, where bile is stored and concentrated. Bile formed in the liver is essential for fat digestion, cholesterol excretion, and possesses antimicrobial activity (Klaassen, 2019). The gallbladder lies in the right upper quadrant, on the undersurface of the liver, at the gallbladder fossa. Via the cystic duct, it is attached to the rest of the extrahepatic biliary system. The cystic duct then merges with the common hepatic duct to form the common bile duct. The common bile duct travels through the lesser omentum, passes behind the duodenum and pancreas, and joins the main pancreatic duct to form the ampulla of Vater. This ampulla drains into the duodenum at the major duodenal papilla, which is located on the medial wall of the second part of the duodenum (D2 segment) (Bashir *et al.*, 2025; Standring, 2021).

Biliary stone disease stands as one of the leading causes of hospitalization. The asymptomatic nature of biliary stone disease, however, makes it difficult to determine the prevalence of gallstones in the general population (Shaffer, 2018). Cholelithiasis is a prevalent global health issue, affecting approximately 5–25% of adults worldwide.

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Notably, about 30% of these patients may experience biliary colic within a 10-year period (Portincasa*et al*., 2016). Furthermore, studies suggest that 8–20% of patients with cholelithiasis presenting with symptoms may have common bile duct (CBD) stones (Williams *et al*., 2017). Only around one-third of gallstones cause symptoms or complications such as choledocholithiasis. Choledocholithiasis is a medical condition in which one or more stones form in the common bile duct. Primary choledocholithiasis is characterized by the formation of stones directly within the biliary tree, while secondary choledocholithiasis occurs when stones migrate from the gallbladder to the bile ducts. Primary stones are typically brown in color and mainly composed of calcium bilirubinate, with a higher prevalence in Asian populations compared to Western populations, where they are relatively rare (Kim & Kim, 2020). In contrast, secondary choledocholithiasis stones have a similar composition to gallstones, with cholesterol being the most common type. The position of the stones determines the clinical impact and associated laboratory findings. Liver enzymes including bilirubin, alanine aminotransferase (ALT), aspartate aminotransferase (AST), gamma-glutamyl transferase (GGT), and alkaline phosphatase (ALP) are likely to be elevated if the stone causes biliary obstruction. Amylase and lipase levels rise as a result of pancreatitis if the stone obstructs the pancreatic duct (Everhart & Ruhl, 2009). Choledocholithiasis affects approximately 3–22% of individuals, and in 95% of cases, these stones are associated with pre-existing cholelithiasis, while 5% occur independently (Park et al., 2014). Cholesterol stones originate solely in the gallbladder, whereas brown pigment stones can form de novo due to bacterial interactions with phospholipids and bilirubin in bile (Tazuma, 2006). Black pigment stones, which are less common, develop in the gallbladder and are typically associated with aging, hemolysis, alcoholism, and cirrhosis. These stones are generally located in the distal third of the CBD, often leading to bile duct obstruction, which increases proximal bile pressure and results in duct dilation (Murphy *et al*., 2016).

Symptoms of bile duct stones mainly include right upper abdominal pain and may present with yellowing of the eyes or skin (jaundice). Patients may experience dark urine and clay-colored stools. If the stone blocks pancreatic enzyme flow by lodging in the common bile duct, it can cause gallstone pancreatitis, leading to severe upper abdominal pain, vomiting, and nausea. If the gallbladder becomes inflamed, it may lead to acute cholecystitis, while infection of the bile ducts results in cholangitis. Both conditions cause right-sided abdominal pain, fever, nausea, and vomiting (Sung *et al*., 2017). Approximately 45% of choledocholithiasis patients remain asymptomatic for years, as stones often pass silently into the duodenum (Williams *et al*., 2017). When symptoms develop, they usually present as life-threatening complications such as cholangitis (characterized by abdominal pain, jaundice, and fever) and acute pancreatitis (manifesting as abdominal pain, fever, and vomiting) (Portincasa*et al*., 2016). Acute obstruction typically manifests with pain, jaundice, and cholangitis, whereas chronic obstruction often results in pruritus and persistent jaundice. Long-standing obstruction may progress to secondary biliary cirrhosis (Livero*et al*., 2020).

Multiple risk factors are associated with gallstone disease, which includes obesity, rapid weight loss, sedentary lifestyle, liver disorders, blood disorders, diabetes mellitus and Family history. (Méndez-Sánchez *et al*., 2020).

The obesity epidemic is now a global health issue, affecting both the developed and developing countries like China. Obesity, particularly abdominal or centripetal obesity is a significant risk factor for gallstone disease. Only 25% of morbidly obese individuals showing evidence of gallstones disease. Obesity in the late teenage years carries the greatest risk, while being underweight appears to be protected. Women with severe obesity (body mass index [BMI] >32kg/m^2) are at greater risk, poses six-fold increased risk of developing gallstones. This increased risk is mainly because of the activity of enzyme HMG-CoA reductase, leading to increased cholesterol synthesis in liver and heightened secretion into bile (Parra-Landazury*et al*., 2021).

METHODOLOGY

3.1 Study Design

The current research study was a cross-sectional studyconducted in the department of Radiology at Rehman Medical Institute (RMI), Peshawar.

3.2 Study Duration

The study was conducted between May to August 2025.

3.3 Sampling Technique

The sampling technique used was non-probability convenience sampling technique for the collection of samples.

3.4 Sample Size

The Sample size for the current cross-sectional study was calculated by WHO calculator,

N =Sample size (to be calculated)

Z= Confidence level (1.96 for 95% C-I)

P= Prevalence (10% prevalence of biliary stones)

E= Margins of Error (0.05% or 5%)

Total sample size is = **139.**

3.5 Selection criteria for biliary stones

3.5.1 Inclusion Criteria

- All Individualshaving MRCP for evaluating biliary stones was included.
- Individuals (⩾ 18 years old) to ensure proper clinical assessment.
- Patient with relevant clinical symptoms such as Jaundice, Right Upper Quadrant (RUQ) painand abnormal liver function tests.

3.5.2 Exclusion criteria

- Individual with Contraindication of Being claustrophobic or having Metallic implants are excluded.
- Cases with poor quality MRCP images due to motion artifacts or technical issues are excluded.
- Individuals unable to provide a reliable medical history are excluded.

3.6 Data Collection Procedure

Ethical approval had been obtained from the Ethical Research Committee of our University (Sarhad University). Approval was taken from the Research Study Committee of Rehman Medical Institute (RMI) prior data collection. Firstly we had taken written informed consent from each research participant and then collected our data through a standard semistructured questionnaire. Our questionnaire consisted of five parts including demographic profile, whilethe second and third part included questions related to medical history and Dietary Habits of the patient. The Fourth portion of the questionnaire was related to Family history and the last portion was related to MRCP scan findings,which clarified presence of any biliary stone(s) in the system. The data was collected in a very respectful manner by not bothering anyone along with the permission of the concerned Head of Department (HOD). The study data was only

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collected from the volunteers who were conscious and willing to provide accurate information.

3.7 Data Analysis Procedure:

SPSS version 24 had been used to analyze the data.

RESULTS

1.1 Age of Participants:

Table 4.1: Age-wise distribution of research participants

Age	Frequency (f)	Percentage (%)
18-33	30	21.6
34-49	46	33.1
50-65	39	28.1
66-above	24	17.3
Total	139	100.0

Figure 4.1 Gender wise Distribution of the Research Participants.

Table 4.2: Frequency distribution of BMI status of the participants.

BMI	Frequency (f)	Percentage (%)
Underweight	19	13.7
Normal	30	21.6
Overweight	25	18.0
Obese	65	46.8
Total	139	100.0

Table 4.3: Frequency Distribution of the Participants based on Medical Background.

S No.	Variables	Frequency (f)		Percentage (%)
1.	Jaundice symptoms	Yes	54	38.8
		No	85	61.2
2.	Right Upper Quadrant Pain	Yes	100	71.9
		No	39	28.1
3.	Rapid Weight Loss	Yes	2	1.9
		No	137	98.6
4.	Diabetes Mellitus	Yes	103	74.1
		No	36	25.9
5.	Liver Disease	Yes	55	39.6
		No	84	60.4
6.	Blood Disorders	Yes	9	6.5
		No	113	93.5

This table presents the medical background of the participants where 54 (38.8%) had jaundice symptoms, while large group of participants i.e. 100 (71.9%) experienced Right Upper Quadrant Pain, only 2 (1.4%) of participants reported undergoing rapid weight loss in the past years. A majority, 103 (74.1%) have been diagnosed with diabetes, 55

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(39.6%) of participants had liver diseases and only 9 (6.5%) of participants had blood disorder.

4.5 Frequency Distribution ofthe Participants based on Life Style and Dietary Habits:

Table 4.4: Frequency distribution based on life style and dietary habits.

S.NO	Variable	Frequency (f)		Percentage (%)
1.	Nicotine Consumer	Yes	25	18.0
		No	114	82.0
2.	Typical Diet	High in fat	34	24.5
		High in cholesterol	52	37.4
		Low in fiber	27	19.4
		Balanced diet	26	18.7

Table 4.5: Frequency Distribution of Family History of Biliary Stones

Family history	Frequency (f)	Percent (%)
Yes	77	55.4
No	62	44.6
Total	139	100.0

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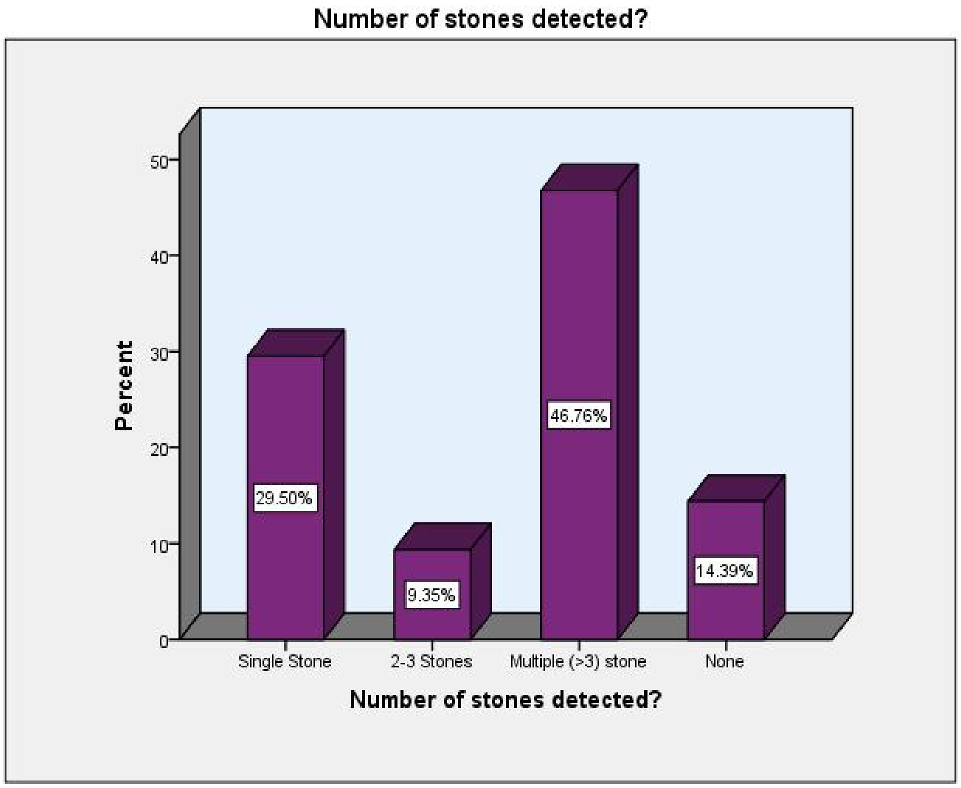

Figure 4.6 Frequency distribution of detected biliary stones.

Table 4.7: Frequency distribution of biliary stones size.

Biliary stones size	Frequency (f)	Percent (%)
Less than 5mm	30	21.6
5-10mm	15	10.8
10-15mm	5	3.6
Greater than 15mm	3	2.2
Multiple stones of different sizes.	66	47.5
None	20	14.4
Total	139	100.0

Table 4.8: Regions Base distribution of GB stones.

GB stone regions	Frequency (f)	Percentage (%)
Fundus	39	28.1

Body	11	7.9
Neck	12	8.6
Multiple region	8	5.8
None	49	35.3
Total	119	85.6

Table 4.9: Regions Base distribution of CBD stones.

CBD stone regions	Frequency (f)	Percentage (%)
Proximal CBD	6	4.3
Mid CBD	8	5.8
Distal CBD	25	18.0
Multiple regions	1	.7
None	79	56.8
Total	119	85.6

Table 4.10: Regions Base distribution of HD stones.

Hepatic Duct Stones	Frequency (f)	Percentage (%)
Intrahepatic Duct	2	1.4
Common Hepatic Duct	4	2.9
Multiple Regions	3	2.2
None	110	79.1
Total	119	85.6

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Table 4.11: Association of specific risk factors with biliary stones.

S No.	Variables		Frequency of the Biliary stones N = 139	X^2 (Chi-square value)	P (Probability value)
1.	BMI of the participants	Underweight Normal Overweight Obese	19 (13.7%) 30 (21.6%) 25 (18.0%) 65 (46.8%)	8.310	0.040
2.	Rapid weight Loss in the past years	Yes	2 (1.9%)	0.341	0.559
		No	137 (98.6%)		
3.	Diabetes Mellitus	Yes	103 (74.1%)	7.070	0.008
		No	36 (25.9%)		
4.	Liver Disease	Yes	55 (39.6%)	0.204	0.652
		No	84 (60.4%)		
5.	Blood Disorders	Yes	9 (6.5%)	0.479	0.489
		No	113 (93.5%)		
6.	Nicotine consumer	Yes	25 (18.0%)	7.675	0.006
		No	114 (82.0%)		
7.	Family History	Yes	77 (55.4%)	3.933	0.047
		No	62 (44.6%)		

DISCUSSION

Biliary stone disease is a common cause of hospitalization and can result in serious, potentially life-threatening complications. In the present study, we evaluated the prevalence of biliary stones, their distribution and the correlation with specific risk factors contributing to their formation using the 1.5 Tesla MRCP techniquein a sample of 139 participants. Furthermore, the size and number of stones within the biliary system were identified to provide a comprehensive understanding of disease patterns in our study population.The prevalence of biliary stones was notably high at 85.6%, with the majority of stones located in the gallbladder (41.7%), followed by the common bile duct (20.1%), combined GB and CBD involvement (17.3%) and only few stones located in hepatic duct (6.5%). Most participants had multiple stones of varying sizes (47.5%), and the most common region for gallbladder stones was the fundus (28.1%), while distal CBD (18.0%) was the most affected segment in the bile duct. Statistical analysis showed significant associations between biliary stones and several risk factors includingBMI (p = 0.040) with obesity prevalent in 46.8% of participants, diabetes mellitus (p = 0.008) present in 74.1%, nicotine use (p = 0.006) in 18.0%, family history (p = 0.047) in 55.4%.

Our results show that out of N = 139 participants, 65 (46.8%) were obese, indicating that nearly half of the sample population falls into the obesity category. As compared to our study (Zhang et al. 2023) conducted a cross-sectional study at the Health Promotion Center of Run Shaw Hospital, Zhejiang University School of Medicine, including125,668 adults in China to examine the association between metabolically healthy overweight/obesity (MHOW/MHO) and gallstones.Gallstones were detected in 4.4% of participants, with MHOW (OR 1.40) and MHO (OR 1.80) individuals at significantly higher risk than metabolically healthy normal-weight individuals. The study bears a close resemblance to our study with the same reason being the similarity of the nature of the studies.

In our study, gallbladder stones were found in 41.7% of participants. In contrast, Faheem et al. (2024) conducted a case-control study at MMC Mardan, Pakistan, including 200 participants (100 cases and 100 controls), and found gallbladder stones in 39% of cases. Their results closely resemble ours, supporting gallbladder stones as the most frequent type of biliary calculi in both hospital- and community-based populations.

In our analysis, 65% of participants had multiple stones. Similarly, Junhai et al. (2024) conducted a cross-sectional study at Dhaka Medical College and Sir Salimullah Medical College, Bangladesh, including 170 young adults with gallstone disease, and reported that 49% of cases had multiple stones. Their findings resemble ours, although the proportion was lower, which may be attributed to differences in age group and population characteristics.

CONCLUSION

This research assessed the prevalence and mapping of biliary stones using Magnetic Resonance Cholangiopancreatography (MRCP), while also examining their association with various risk factors. The study revealed a high prevalence (85.6%) of biliary stones among participants, particularly in females and obese individuals.Multiple stones (46.76%) were more common than solitary stones, and stones of varying sizes (47.48%) were more prevalent than uniform-sized stones. Significant associations were found between biliary stone formation and factors such as Obesity, diabetes mellitus, nicotine consumption and family history. MRCP proved to be an effective non-invasive imaging modality, capable of accurately identifying stone location and size, especially in complex cases involving multiple regions. These findings align with the global trends and highlight the need for targeted interventions.

RECOMMENDATIONS

Implement preventive public health strategies focusing on healthy diet and physical activity to reduce obesity and diabetes—two major risk factors for biliary stones.

Encourage early, non-invasive screening using MRCP for high-risk groups, such as obese individuals, diabetics and those with a family history of gallstones.

Promote MRCP as a first-line diagnostic tool in clinical practice due to its safety, accuracy and comprehensive visualization capabilities.

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