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An Observational Study on Evaluation of Intrahepatic Biliary Tree Anatomy and Its Variation by Magnetic Resonance Cholangiopancreatography

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Abstract

Introduction: The biliary tree's complex anatomy with its intrahepatic and extrahepatic components presents numerous variations, necessitating a thorough understanding for successful hepatobiliary surgeries. Magnetic Resonance Cholangiopancreatography (MRCP) has emerged as a crucial non-invasive imaging technique for assessing pancreaticobiliary disorders, offering detailed anatomical visualization.

Objectives: This study aimed to estimate the prevalence of various biliary tree variations and classify intrahepatic biliary tree variations according to Huang and Cho classifications based on MRCP.

Methodology: An observational, hospital-based cross-sectional study was conducted in the Department of Radiodiagnosis, SMS Medical College and Hospital, Jaipur, Rajasthan. Seventy patients undergoing MRCP were included in the study, and data were collected using a pre-designed, pre-validated, and pre-tested proforma. MRCP was performed using a 3T Philips Ingenia MRI Machine, and images were acquired with thin sections or with multiple thick slabs to visualize the biliary tree.

Results: The study population consisted of 35 males and 35 females, with a mean age of 50.5 ± 13.2 years. Cholelithiasis was the most common lesion identified, followed by GB Malignancy, Choledocholithiasis, and Chronic pancreatitis. Gender distribution showed a male predominance in certain conditions. The majority of patients had Huang Classification type A1 variations. Cho Classification showed a higher prevalence of type 1 variations. No significant association was found between gender and biliary tree anatomy diagnoses.

Conclusion: MRCP, particularly with the use of advanced techniques such as the Thick Slab Single Shot

Spin Echo Turbo Echo Sequence and Three-Dimensional Turbo Spin Echo sequence, plays a crucial role in evaluating biliary anatomy and variations. This information is essential for preoperative planning in hepatobiliary surgeries, aiding in the prevention of complications.

Keywords: Magnetic Resonance Cholangiopancreatography, biliary tree variations, hepatobiliary surgeries, Huang Classification, Cho Classification.

Introduction

The biliary tree, comprising both intrahepatic and extrahepatic components, exhibits a complex anatomy with numerous variations. A thorough understanding of this anatomy and the ability to identify these variations are vital for effective presurgical planning in hepatobiliary surgeries, such as liver resections and transplants, to minimize the risk of perioperative and postoperative complications, including biliary leaks.[1]. Preoperative knowledge of biliary anatomy is crucial for surgical success, emphasizing the significance of precise imaging techniques like Magnetic Resonance Cholangiopancreatography (MRCP) [2].

MRCP has become an essential non-invasive tool for evaluating pancreaticobiliary disorders. One key technique used in MRCP is the Thick Slab Single Shot Spin Echo Turbo Echo Sequence, which produces T2-weighted images resembling those from projection radiography or Endoscopic Retrograde Cholangiopancreatography (ERCP). This method offers rapid image acquisition (around 1 second) with a high slice thickness (30-80 mm), enabling visualization of the entire pancreaticobiliary system in a single planar projection[3-5].

Another MRCP technique, the Three-Dimensional Turbo Spin Echo (3D-TSE) sequence, provides higher spatial resolution along the z-plane, offering more detailed imaging of the biliary tree[6]. This sequence is often used alongside conventional MRCP to clarify diagnostic uncertainties and define pathologies or variations in the biliary anatomy. Despite the benefits of the Thick Slab Single Shot Spin Echo Turbo Echo Sequence, it has limitations such as reduced image quality due to thicker slices and interference from overlying structures with high T2-weighted signals [7-9]. These issues, however, can be mitigated by adjusting the section thickness and positioning to align with the patient's duct anatomy during image acquisition.

In summary, MRCP, particularly through the use of the Thick Slab Single Shot Spin Echo Turbo Echo Sequence and the Three-Dimensional Turbo Spin Echo sequence, plays an indispensable role in assessing biliary anatomy and variations, facilitating preoperative planning for hepatobiliary surgeries.

Objectives

1. To estimate the prevalence of various biliary tree variations in our study population.
2. To classify intrahepatic biliary tree variations according to Huang and Cho classifications based on Magnetic Resonance Cholangiopancreatography.

Materials and Methods

This study was structured as an observational, hospital-based cross-sectional investigation carried out in the Department of Radiodiagnosis, SMS Medical College and Hospital, Jaipur, Rajasthan. Data collection began subsequent to institutional research and review board approval and continued until reaching the sample size or September 2023, whichever arrived earlier. An additional two months were allocated for data processing and thesis composition. The study enrolled patients referred to the Department of Radiodiagnosis, SMS Medical College & Hospital, Jaipur, for Magnetic Resonance

Cholangiopancreatography (MRCP) who fulfilled the inclusion and exclusion criteria. Inclusion criteria involved patients aged 18 and above, exhibiting dilated intrahepatic biliary radicles on ultrasound, with or without obstructive jaundice, and willing to provide written and verbal informed consent. Exclusion criteria encompassed patients deemed unfit for MRI due to absolute contraindications (such as metallic aneurysm clips, pacemakers, metallic vascular clamp placement), claustrophobia, and uncooperative behaviour.

The sample size was determined with a study power of 80% and an alpha error of 0.05, assuming a proportion of type 1 anatomical variants of the biliary tree on MRCP to be 65.8%. With an allowable error of 12%, the requisite sample size for this study was calculated to be 70.

All eligible cases adhering to the inclusion and exclusion criteria were incorporated. Seventy patients meeting the inclusion criteria in the Department of Radiodiagnosis, SMS Medical College & Hospital, Jaipur, for MRCP, were chosen for the study in each group. Patients selected for MRCP but falling into exclusion criteria were excluded from the study. Data collection employed a pre-designed, pre-validated, and pre-tested proforma. The study employed a 3T Philips Ingenia MRI Machine. Baseline data, comprising demographic profile, vital symptoms/signs, physical findings, MRCP findings, and type of variant according to the Huang Classification and Cho classification, were documented by the in a structured Performa. The methodology and technique involved MRCP as a non-invasive method for biliary tree representation based on heavily T2-weighted images. The protocol included two-dimensional single-shot fast spin-echo images, acquired with thin sections or with multiple thick slabs. Recent advances encompassed three-dimensional T2-weighted fast-recovery fast spin-echo images, enhancing biliary anatomy demonstration. An observational study was conducted at the Radiodiagnosis Department of SMS Medical College, Jaipur, post approval from the Institutional Ethical Committee. Patients were chosen following application of inclusion and exclusion criteria. Written and verbal informed consent was obtained from each patient. Subsequently, 3T MRCP was performed utilizing appropriate techniques. Fasting for 4 hours prior to the examination was mandatory. MRI examinations were conducted on a 3 Tesla Philips Ingenia MR system situated at the Superspecialisty block of SMS Hospital. A slice thickness of 3 mm with no inter-slice gap utilizing phased-array body coil was applied. Patients were positioned supine with arms positioned above the head. The technique capitalized on the fluid within the biliary and pancreatic ducts as an intrinsic contrast medium by acquiring images using heavily T2-weighted sequences.

Observations and Results

A total of 70 patients undergoing MRCP were included in the study after excluding poor-quality images or motion artifacts. The study population consisted of 35 males (50%) and 35 females (50%), with a mean age of 50.5 ± 13.2 years. The maximum number of patients were in the age group of 40-50 years, accounting for 26 patients (37%) of the study population.

Cholelithiasis was the most common lesion identified (table 1), found in 15 patients (21%), followed by GB Malignancy in 11 cases (16%), Choledocholithiasis in 9 patients (13%), and Chronic pancreatitis in 8 patients (11%). Acute intestinal pancreatitis, Acute necrotizing pancreatitis, and hepatolithiasis were present in 6 patients (9%) each. Cholangiocarcinoma was identified in 4 patients (7%), and no abnormalities were detected in 5 patients (7%). In terms of gender distribution (Figure 1), there was a male predominance in cases of GB malignancy (7 cases, 10%), Acute Necrotizing

Pancreatitis (5 cases, 7.14%), and Cholangiocarcinoma (3 cases, 4.29%) compared to females. Acute Interstitial Pancreatitis (5 cases, 7.14%), Choledocholithiasis (6 cases, 8.57%), and Cholelithiasis (9 cases, 12.9%) were more common in females compared to males. Hepatolithiasis (3 cases, 4.29%) and Chronic pancreatitis (4 cases, 5.7%) were equally distributed among males and females. The Chi-square test showed that none of the values were statistically significant (p-value < 0.05).

The prevalence of Huang Classification (Figure 2) type A1 was 53 patients (76%), while 10 patients (14%) were in A2, 4 patients (6%) in A3, and 1-2 patients each in A4 and A5. Among males (table 2), 27 (39%) were classified as A1, 4 (6%) as A2, and 2 (3%) as A3. Among females, 26 (37%) were classified as A1, 6 (9%) as A2, and 2 (3%) as A3. There was no significant association found between male and female patients in Huang Classification types (p-value calculated by Chi-square test). The prevalence of Acute Interstitial Pancreatitis and Acute Necrotizing Pancreatitis was 6 patients (8.6%) (table 3), all of whom were classified as Huang Classification type A1. Among patients diagnosed with Cholelithiasis (15 patients, 21.4%), 11 were classified as A1 and 4 as A2. Only 1 patient was classified as A4 with a diagnosis of Cholangiocarcinoma, while 4 patients (5.7%) with the same diagnosis were classified as A1 (2 patients) and A2 (1 patient). Type A5 was observed in only 2 patients, both diagnosed with Choledocholithiasis and GB Malignancy.

The majority of cases were classified as Huang Classification type A1 (53 patients, Mean ± SD: 5.9 ± 2.6), followed by A2 with 10 patients (Mean ± SD: 1.1 ± 1.4), A3 with 4 patients (Mean ± SD: 0.4 ± 0.96), A4 with 1 patient (Mean ± SD: 0.1 ± 0.3), and A5 with 2 patients (Mean ± SD: 0.2 ± 0.41). The total mean and standard deviation associated with Huang Classification types was 7.8 ± 3.3. The distribution of males and females was fairly even across the types, with no statistically significant differences (p-value < 0.05).

When the diagnoses were arranged according to Cho classification (table 4) (figure 3), 44 patients (62.9%) fell into type 1, 21 patients (30%) into type 2, and 5 patients (7.1%) into type 3. The majority of type 1 patients were diagnosed with Cholelithiasis, while the least common diagnosis was Cholangiocarcinoma. Type 2 patients were predominantly diagnosed with Choledocholithiasis, Cholelithiasis, and GB Malignancy, while type 3 patients had diagnoses of Cholelithiasis and GB Malignancy. The majority of cases belong to Cho Classification type 1, comprising 44 patients (62.9%) (table 5) with a mean and standard deviation of 4.88 ± 1.8. Type 2 accounts for 21 patients (30%) with values of 2.33 ± 1.4, and type 3 includes 5 patients (7.1%) with values of 0.56 ± 1.1. The total mean and standard deviation associated with Cho Classification types is 7.8 ± 3.3.

In the diagnostic categorization based on Cho classification (table 6) within the total population of 70 patients, the majority, comprising 44 patients (62.9%), are classified under type 1. Approximately 21 patients (30%) are categorized as type 2, while 5 patients (7.1%) fall into type 3. Among patients classified as type 1, the predominant diagnosis is Cholelithiasis, with Cholangiocarcinoma being less common. For patients in type 2, the majority present with diagnoses of Choledocholithiasis, Cholelithiasis, and GB malignancy, while fewer cases are associated with Acute Interstitial Pancreatitis or no detected abnormalities. Type 3 patients predominantly exhibit diagnoses of Cholelithiasis (3 patients) and GB malignancy (2 patients).

Discussion

Our findings corroborate previous studies highlighting the complexity of biliary anatomy and the necessity for accurate imaging modalities such as MRCP. Gender-specific analyses revealed certain pathological conditions exhibiting a male predominance, while others were more prevalent in females. However, statistical analysis did not reveal any significant associations. Classification systems like Huang and Cho provided valuable insights into intrahepatic biliary variations. Most cases exhibited Type A1 variations according to Huang Classification, whereas Cho Classification revealed a predominance of Type 1 variations. Despite differences in prevalence, statistical analysis did not yield significant results.

A 2001 study by Koenraad J. Mortelé et al. [10] emphasized the complex nature of biliary anatomy. Gender differences in diagnoses were noted, with males showing predominance in certain conditions. A 2005 study by Guarise A et al. [11] confirmed MRCP's accuracy in diagnosing choledocholithiasis and biliary strictures. Huang Classification revealed most patients had type A1 variation (76%). Cho Classification indicated 63% had type 1 variation. No significant gender association was found in classification types. In conclusion, our study emphasizes MRCP's importance in diagnosing intrahepatic biliary anatomical variations, aiding clinical management and surgical planning. In a 2023 study by Mazroua J. A. et al. [2], 35 subjects underwent imaging with intraoperative cholangiography (IOC) and 3D magnetic resonance cholangiopancreatography (MRCP). IOC detected Type I variation in 23 subjects, MRCP in 22; Type II: 4 with IOC, 6 with MRCP; Type III: 4 with both; Type IV: 3 with both. Unclassified type: 1 with IOC, missed with MRCP. MRCP accurately detected biliary anatomy in 33 subjects (94.3% accuracy, 100% sensitivity). However, it yielded a false-positive trifurcation pattern in 2 subjects. Overall, MRCP effectively mapped biliary anatomy and its variations. Other studies have similarly emphasized the importance of understanding biliary anatomy variations to enhance surgical outcomes and reduce complications. MRCP has proven its efficacy in accurately delineating biliary anatomy and detecting anatomical variants, making it a valuable diagnostic tool in clinical practice. Further research and widespread adoption of MRCP are warranted to optimize patient care in biliary diseases.

References

1. Swain B, Sahoo RK, Sen KK, G MK, Parihar SS, Dubey R. Evaluation of intrahepatic and extrahepatic biliary tree anatomy and its variation by magnetic resonance cholangiopancreatography in Odisha population: a retrospective study. Anat Cell Biol. 2020 Mar;53(1):8-14. doi: 10.5115/acb.19.177. Epub 2019 Mar 31. PMID: 32274243; PMCID: PMC7118263.
2. Mazroua JA, Almalki YE, Alaa M, Alduraibi SK, Aboualkheir M, Aldhilan AS, Almushayti ZA, Aly SA, Basha MAA. Precision Mapping of Intrahepatic Biliary Anatomy and Its Anatomical Variants Having a Normal Liver Using 2D and 3D MRCP. Diagnostics (Basel). 2023 Feb 14;13(4):726. doi: 10.3390/diagnostics13040726. PMID: 36832212; PMCID: PMC9955884.
3. Aljiffry M, Abbas M, Wazzan MAM, Abduljabbar AH, Aloufi S, Aljahdli E. Biliary anatomy and pancreatic duct variations: A cross-sectional study. Saudi J Gastroenterol. 2020 May 26;26(4):188–93. doi: 10.4103/sjg.SJG_573_19. Epub ahead of print. PMID: 32461381; PMCID: PMC7580731.
4. Gupta, A., Rai, P., Singh, V. et al. Intrahepatic biliary duct branching patterns, cystic duct anomalies, and pancreas divisum in a tertiary referral center: A

magnetic resonance cholangiopancreaticographic study. Indian J Gastroenterol 35, 379–384 (2016).

5. Naeem MQ, Ahmed MS, Hamid K, Shazlee MK, Qureshi F, Asad Ullah M. Prevalence of Different Hepatobiliary Tree Variants on Magnetic Resonance Cholangiopancreatography in Patients Visiting a Tertiary Care Teaching Hospital in Karachi. Cureus. 2020 Dec 27;12(12):e12329. doi: 10.7759/cureus.12329. PMID: 33520527; PMCID: PMC7837639.
6. El Hariri, M., Riad, M.M. Intrahepatic bile duct variation: MR cholangiography and implication in hepatobiliary surgery. *Egypt J Radiol Nucl Med* **50**, 78 (2019).
7. Shizuku M, Kurata N, Jobara K, Yoshizawa A, Ogura Y. A novel anatomic variation of the intrahepatic biliary tree in live liver donor surgery: A case report. Int J Surg Case Rep. 2021 Feb;79:231-233. doi: 10.1016/j.ijscr.2021.01.042. Epub 2021 Jan 15. PMID: 33485172; PMCID: PMC7820795.
8. Sharma R, Acharya S, Sharma A. Magnetic Resonance Cholangiopancreatography Evaluation of Intrahepatic Biliary Tree Variants in Nepalese Population based on Yoshida classification. Medphoenix. 2021;6(2):30-34 DOI: 10.3126/medphoenix.v6i2.42694
9. Hyodo T, Kumano S, Kushihata F, Okada M, Hirata M, Tsuda T, Takada Y, Mochizuki T, Murakami T. CT and MR cholangiography: advantages and pitfalls in perioperative evaluation of biliary tree. Br J Radiol. 2012 Jul;85(1015):887-96. doi: 10.1259/bjr/21209407. Epub 2012 Mar 14. PMID: 22422383; PMCID: PMC3474084.
10. Mortelé KJ, Ros PR. Anatomic variants of the biliary tree: MR cholangiographic findings and clinical applications. AJR Am J Roentgenol. 2001 Aug;177(2):389-94. doi: 10.2214/ajr.177.2.1770389. PMID: 11461869.
11. Guarise A, Baltieri S, Mainardi P, Faccioli N. Diagnostic accuracy of MRCP in choledocholithiasis. Radiol Med. 2005 Mar;109(3):239-51. English, Italian. PMID: 15775893.

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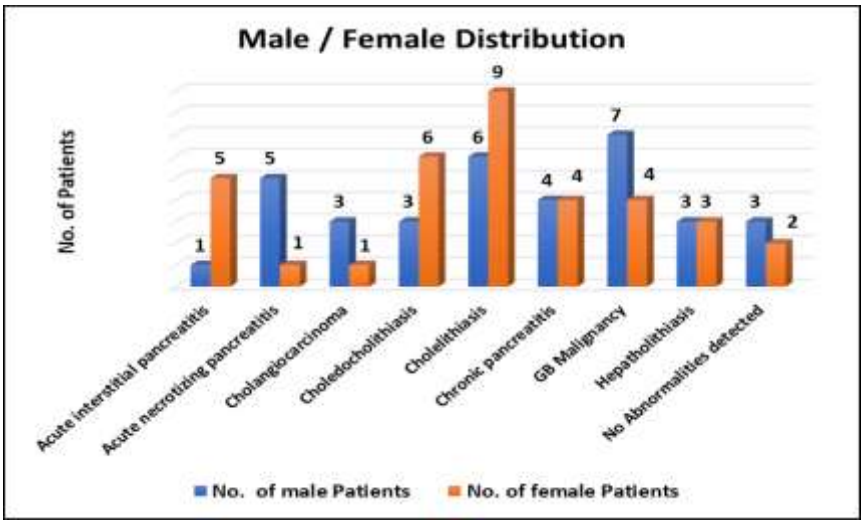
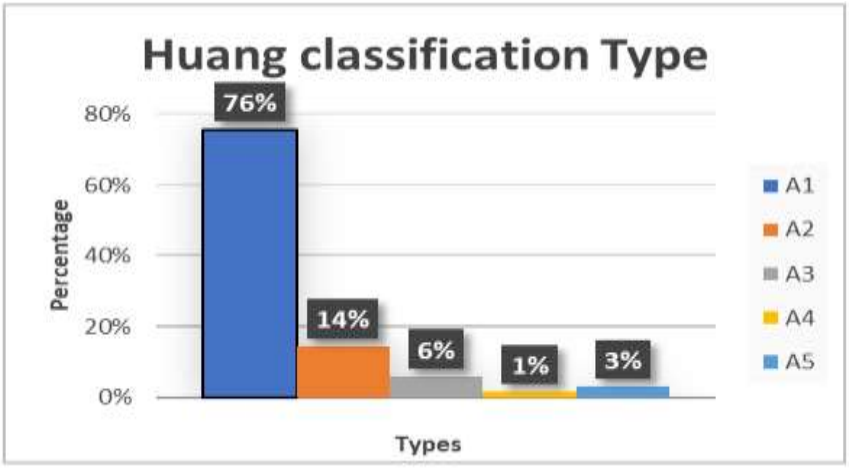
Legend of Graphs, Tables & Figures



Graph 1: Bar diagram showing Male / Female Distribution of Diagnosis

Sr. No.	Diagnosis	No. of Patients(n)	Percentage (%)
1	Acute interstitial pancreatitis	6	9%
2	Acute necrotizing pancreatitis	6	9%
3	Cholangiocarcinoma	4	6%
4	choledocholithiasis	9	13%
5	Cholelithiasis	15	21%
6	Chronic pancreatitis	8	11%
7	GB Malignancy	11	16%
8	Hepatolithiasis	6	9%
9	No Abnormalities detected	5	7%
Grand Total	70		

Table 1: Distribution of Diagnosis among patients



Graph 2: showing distribution of Huang Classification Types among study population

Huang classification Type	n	%	Male (n)	Male (%)	Female (n)	Female (%)	p-value
A1	53	76%	27	39%	26	37%	1.000
A2	10	14%	4	6%	6	9%	0.743
A3	4	6%	2	3%	2	3%	0.612
A4	1	1%	1	1%	0	0%	1.000
A5	2	3%	1	1%	1	1%	0.476
Total	70	100%	35	50%	35	50%	

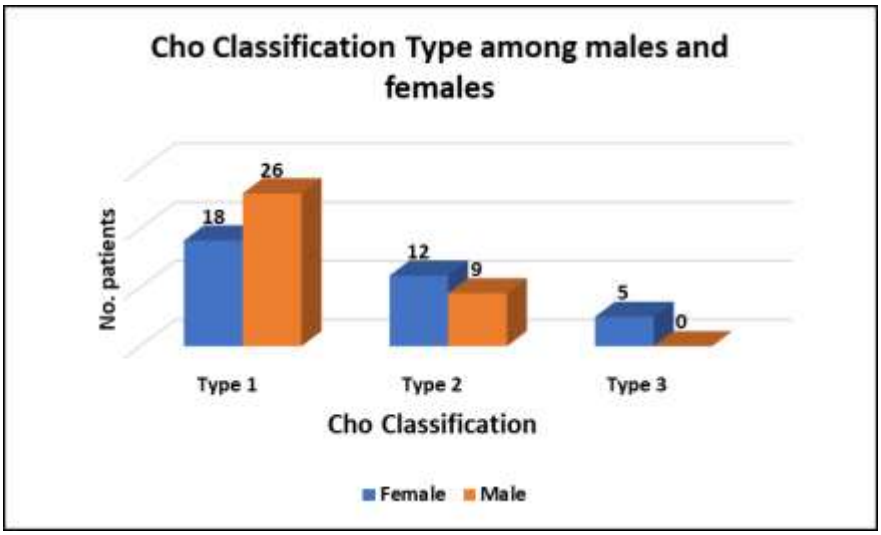
Table 2: Huang Classification Type among males and females

Diagnosis	A1	A2	A3	A4	A5	Grand Total
Acute interstitial pancreatitis	6	0	0	0	0	6 (8.6%)
Acute necrotizing pancreatitis	6	0	0	0	0	6 (8.6%)
Cholangiocarcinoma	2	1	0	1	0	4 (5.7%)
Choledocholithiasis	4	3	1	0	1	9 (12.9%)
Cholelithiasis	11	4	0	0	0	15 (21.4%)
Chronic pancreatitis	7	1	0	0	0	8 (11.4%)
GB Malignancy	9	1	0	0	1	11 (15.7%)
Hepatolithiasis	3	0	3	0	0	6 (8.6%)
No Abnormalities detected	5	0	0	0	0	5 (7.1%)
Grand Total	53	10	4	1	2	70

Table 3: Distribution of Huang Classification Type among different diagnosis

Cho Classification Type	Males	Females	Total patients	p-value
Type 1	26(37.1)%)	18 (25.7%)	44	0.203
Type 2	9 (12.9%)	12 (17.1%)	21	0.636
Type 3	0	5 (7.1%)	5	0.069
Total	35	35	70	

Table 4: Cho Classification Type among males and females



Graph 3: Cho Classification Type among males and females

Cho Classification Types	No. of patients	Mean ± SD
Type 1	44 (62.9%)	4.88 ± 1.8
Type 2	21 (0.3%)	2.33 ± 1.4
Type 3	5 (7.1%)	0.56 ± 1.1
Total	70	7.78 ± 3.3

Table 5: Distribution of Cho Classification Type with Mean and SD

Diagnosis	Type 1	Type 2	Type 3	Grand Total
Acute interstitial pancreatitis	5	1	0	6
Acute necrotizing pancreatitis	6	0	0	6
Cholangiocarcinoma	1	3	0	4
Choledocholithiasis	5	4	0	9
Cholelithiasis	8	4	3	15
Chronic pancreatitis	6	2	0	8
GB Malignancy	5	4	2	11
Hepatolithiasis	4	2	0	6
No Abnormalities detected	4	1	0	5
Grand Total	44 (62.9%)	21 (0.3%)	5 (7.1%)	70

Table 6: Distribution of Cho Classification Type among different diagnosis

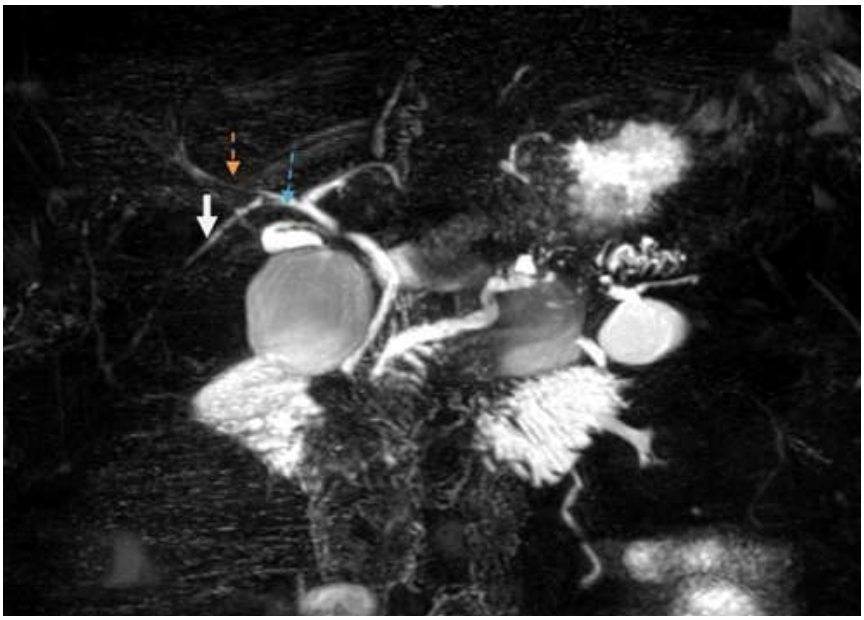


Figure 1: MRCP image shows Huang Type A1 Variant: Right Posterior Sectoral Duct (white arrow) draining into Right Anterior Sectoral Duct (orange arrow)

Figure 2: MRCP image shows Huang type A2 variant: trifurcation pattern of insertion (grey arrow)of Right Anterior Sectoral Duct ,Right Posterior Sectoral Duct and Left Hepatic Duct

Figure 3: MRCP image shows Huang type A3 variant: Right Posterior Sectoral Duct (orange arrow) draining into Left Hepatic Duct(blue arrow)

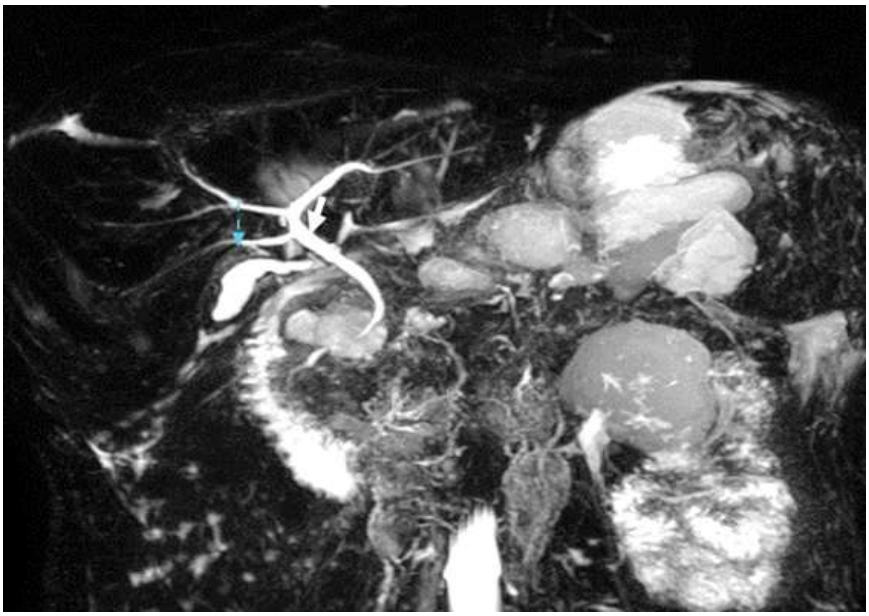


Figure 4: MRCP image shows Huang type A4 variant- Right Posterior Sectoral(blue arrow) Duct draining into Common hepatic duct (white arrow)

Figure 5: MRCP image shows Huang type A5 variant-Right Posterior Sectoral Duct (thin white arrow) draining into cystic duct(broad white arrow)