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Magnetic Resonance Cholangiopancreatography Evaluation Of Biliary Tree Anatomy And Its Variation- A Retrospective Study

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ABSTRACT

Background

The hierarchical structure of the biliary tree is vital for proper liver function. Anatomical variations in the biliary tree are prevalent, reported in 20% to 55% of populations globally and 16% to 48% of the Indian population. The biliary tree's complex anatomy, with numerous intrahepatic and extrahepatic variations, necessitates detailed preoperative mapping to guide surgical and interventional procedures. This study aims to identify common biliary tree variations in the population of Madhya Pradesh, India, using MRCP, and to evaluate the applicability of Huang's classification system.

Methods

A retrospective observational study was conducted in the Department of Radiodiagnosis at M.G.M. Medical College & M.Y. Hospital, Indore, Madhya Pradesh, India, from July 2023 to June 2024. The study included 402 patients referred for MRCP between January 2020 and October 2023. MRCP was performed using a 3T MRI machine, with images analyzed using Huang's classification for RHD variations and Cho's classification for LHD and cystic duct variations.

Results

Among the 402 patients, 36% were over 60 years old, with a female predominance (50.5%). Right upper quadrant pain was the most common clinical finding. The most common RHD variation was Type A1 (62.2%), followed by Type A2 (23.6%), and Type A3 (11.4%). The most common LHD variation was Type A (71%), followed by Type C (17%) and Type B (8%). The most common cystic duct variation was lateral insertion (64.2%). The overall prevalence of hepatobiliary variations was 34.2%.

Conclusion

This study reveals that a significant portion of the Central Indian population exhibits biliary tree anatomical variations. MRCP is a valuable non-invasive tool for identifying these variations, which is crucial for surgical planning and reducing intraoperative complications. Understanding these variations can improve surgical outcomes and patient care.

Keywords- ***MRCP; Hepatobiliary surgery; Preoperative mapping; Huang's classification; Cho's classification***

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BACKGROUND

The precise and organized hierarchical structure of a biliary tree play a crucial role in maintaining proper liver function. The anatomic variations of the biliary tree are common with studies reporting variations in 20% to 55% of the population in different parts of the world and 16% to 48% of Indian population.
The structure of the biliary tree is complicated, with numerous intrahepatic and extrahepatic anatomical variants.The intrahepatic bile ducts normally align with the portal veins at their anterior side. The right anterior sectoral duct (RASD) is vertical, whereas the right posterior sectoral duct (RPSD) is horizontally orientated.RPSD typically joins RASD from the medial aspect.
This typical branching pattern is seen in 50–60% of the population with a significant number of subjects showing variation in the branching pattern.

Assessment of biliary tree anatomy before any hepatobiliary surgery or interventional procedures is very helpful for surgeons to deciding the best surgical approach and to avoid intraoperative and post operative complications.

However, information regarding the role of ethnicity, sex, and age on variations in biliary tree anatomy is lacking in central India population and therefore further investigation is needed to identify the most common types and assess the standard anatomical structures of the biliary tree in population of Madhya Pradesh.

Magnetic resonance cholangiopancreatography (MRCP) is an advanced and modern body magnetic resonance imaging technique based on T2-weighted sequences that facilitates the non-invasive visualization of the intra- and extrahepatic biliary tree, does not require contrast agent administration.The purpose of this study is to review our data with respect to biliary anatomy and highlight the most common types of anatomical variations in group of patients undergoing MRCP and to assess the applicability of HUANG'S classification system.

METHODS

A time-bound, Retrospective observational study, was conducted in the Department of Radiodiagnosis, M.G.M. Medical College & M.Y. Hospital, Indore, Madhya Pradesh, India after receiving approval from the Institutional Scientific and Ethics Committee. The duration of the study was from July 2023 to June 2024. A total of 402 patients who were referred to the Department of Radiodiagnosis for magnetic resonance cholangiopancreatography from January 2020 to October 2023 were Studied retrospectively in our study. The MRCP procedure was done in a supine position with the patient's head reclined and the neck flexed using MRI 3T machine.It takes about 15 – 30 min to finish an examination for one patient and images were acquired by magnetic resonance imaging (MRI) machine (3T system) using a body coil for the acquisition of images.The 3D MRCP, coronal, and axial MR images extracted from the Picture Archiving and Communication System were analyzed.Classification used for biliary tree anatomical variations was based on Haung's classification for Right hepatic duct variations and Cho et al. classification for Left hepatic duct variation and Cystic duct variations.

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Figure 1

(A)

(B)

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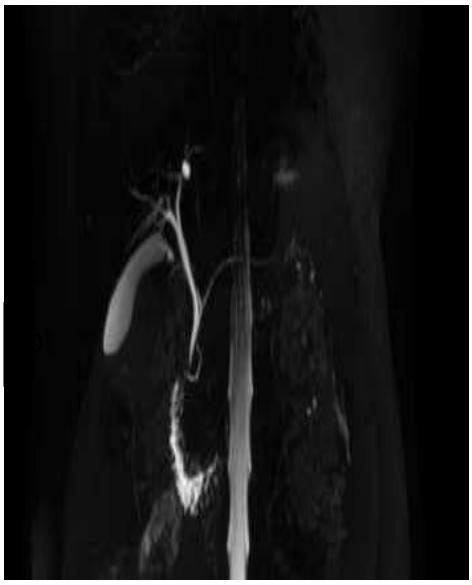
(C)

(D)



Figures **(A), (B),(C), and (D)**Projective coronal MRCP 3D images showing fusion of the right anterior and right posterior ducts to form the right hepatic duct (Type A1). Primary confluence is formed by the fusion of the right and left hepatic ducts. And hepatic ducts of segment 2, 3 and segment 4 join together forming LHD (Type C). Cystic duct joins CHD in its medial part and forms CBD, Cystic duct Type D.

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Figure 2

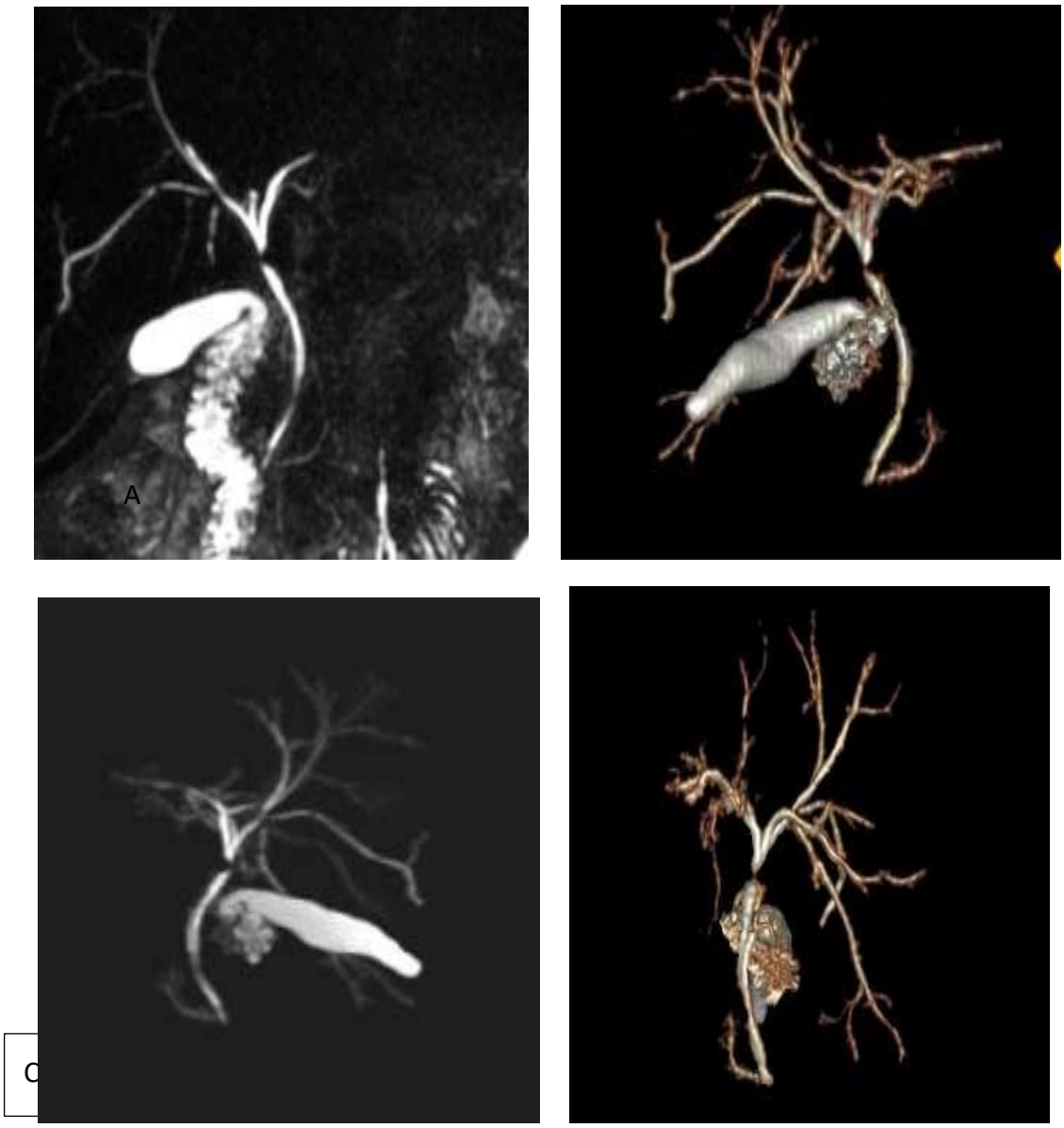

Figure- **(A), (B),(C), and (D)**Case Short segment narrowing within CHD,Projective coronal 3D MRCP images showingtrifurcation anomaly of the biliary tree in the form of right anterior, right posterior, and left hepatic duct, forming the primary confluence (RHD Type A2). tri confluence formed by the hepatic duct of segments 2,3 and 4 joins together to form LHD (Type C).The cystic duct joins thecommon hepatic duct laterally to form the common bile duct (Cystic duct Type A)

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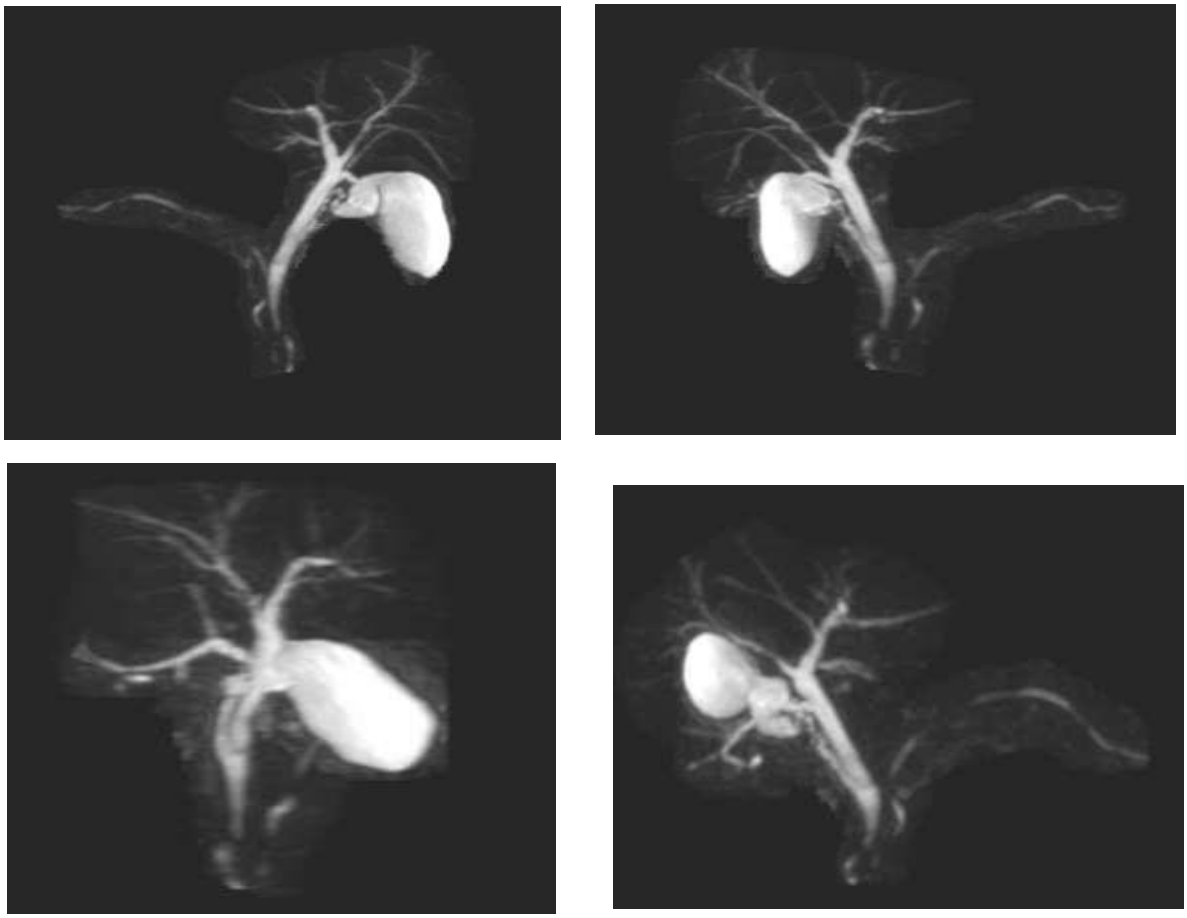
Figure 3



Figures **(A), (B),(C), and (D),** Projective coronal MRCP image showing fusion of the right posterior ducts to CHD, RHD Type A4. Primary confluence is formed by the fusion of the right and left hepatic ducts.And hepatic duct of segment 2 drains into the common trunk of segments 3 and 4 and forms LHD (Type C) with the parallel course of the cystic duct(TypeE)

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RESULTS

More than one third of patients(36%) patients enrolled in our study were of age group between >60 year of age with group 40-60 year of age being second most populated group.
There were 203 (50.5%) females and 199 (49.5%.) males and in this study,showing a female predominance.
In our study,Right upper quadrant pain was the most common finding in 50 % of patients followed by vomiting, jaundice and fever.

In our study, The most common right hepatic duct variation observed according to Huang's classification was type 1 (62.2%) followed by type 2 (23.6%) and the third most common variation observed was type 3 (11.4%) in 43 Patients.
The most common left hepatic duct variation observed according to Choi et classification was type A (71%) followed by type C (17%) and the third most common variation observed was type B (8%) in 32 Patients. And most common cystic duct Lateral insertion observed in 258 patients (64.2%) it was followed by medial insertion in 121 patients (30.2%). Other three variations were rare.
Most prevalent primary confluence is RHD type A1 (62.2%) and LHD type A (71%).
Most prevalent secondary confluence is cystic duct type A (64.2%) and cystic duct type D (30.2%).
In our study, Prevalence of RHD Variations is 37.8%, LHD Variation is 29% and Cystic Duct Variation is 35.8% in our study population. Overall prevalence of hepatobiliary variation in our study population is 34.2%.

Table 1 : Distribution of patients according to right hepatic duct variation on MRCP
Table no.-1

Types	Frequency (N)	Percentage (%)
Type A1	250	62.2
Type A2	95	23.6
Type A3	46	11.4
Type A4	8	2
Type A5	3	0.9
Total	402	100

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Table 2: Distribution of patients according to left hepatic duct variation on MRCP
Table no.-2

LHD variation types	Frequency (N)	Percentage (%)
Type A	285	71
Type B	32	8
Type C	68	17
Type D	17	4
Total	402	100

Table 3: Distribution of patients according to Cystic duct variation on MRCP
Table no.-3

Cystic duct variation types	Frequency (N)	Percentage (%)
TYPE A Lateral insertion	258	64.2
TYPE B High insertion	8	2
TYPE C Low medial insertion	5	1.2
TYPE D Medial insertion	121	30.2
TYPE E Parallel course of cystic duct	5	1.2
TYPE F Posterior insertion	5	1.2
Total	402	100

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Table no.- 4 Prevalence of different types of Primary Confluences in all subjects included in the study.

Table no.- 4

TYPES	FREQUENCY (N)	PERCENTAGE (%)
RHD Type A1	250	62.2
RHD Type A2	95	23.6
RHD Type A3	46	11.4
LHD Type A	285	71
LHD Type B	32	8
LHD Type C	68	17
LHD Type D	17	4

Table no. –5 Prevalence of different types of Secondary Confluences in all subjectsincluded in the study.

Table no.- 5

TYPES	FREQUENCY (N)	PERCENTAGE (%)
RHD Type A4	8	2
RHD Type A5	3	0.9
Cystic duct Type A	258	64.2
Cystic duct Type B	8	2
Cystic duct Type C	5	1.2
Cystic duct Type D	121	30.2
Cystic duct Type E	5	1.2
Cystic duct Type F	5	1.2

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Table no. – 6 Prevalence of hepatobiliary variation in in study population

Table no. – 6

Types	Frequency (N)	Percentage (%)
RHD Variation	152	37.8%
LHD Variation	117	29%
Cystic Duct Variation	144	35.8%
Total	413	34.2%

DISCUSSION

The biliary tree anatomy is complex, with the existence of multiple intrahepatic and extrahepatic anatomical variations seen in around 16 to 48% of the Indian population, and mapping of biliary tree anatomy before any hepatobiliary surgery or interventional procedures is very helpful for surgeons to decide the best surgical approach and to avoid intraoperative and post-operative complications.

Huang's classification is widely used for the classification of biliary variation based on the variable insertion of the Right posterior hepatic duct. In our study evaluation of hepatobiliary tree anatomical variations done based on Huang's classification is done using MagneticResonanceCholangiopancreatography(MRCP)anon-invasive, non-ionizing, and safe imaging technique.

Inourstudy,The most common Right hepatic duct pattern observed accordingto Huang's classification was Type A1, a typical branching pattern in(62.2%) followed by Type A2 (23.6%) which is most common anatomical variation of RHD and the second most common variation observed was Type A3 (11.4%).

In our study, the most common Left hepatic duct pattern observed according to Choietal classification was TypeA(71%) which is classic anatomic pattern. However, the most common variation observed was TypeC(17%) and the second most common variation observed was Type B (8%).

In our study, the most common cystic duct variation observed was Type A Lateral insertion (64.2%) followed by Type D Medial insertion observed (30.2%) and rest were rare variations of our study.

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In our study, the most prevalent primary confluence was LHD Type A (71%) followed by RHD Type A1 62.2% in our study population, Most prevalent Secondary confluence in our study population was Type A Cystic duct (64%) followed by Type D Cystic duct secondary confluence(30.2%).
In our study, the prevalence of different hepatobiliary variations was (37.8%) in the right hepatic duct(29%) in the left hepatic duct and(35.8%) in the cystic duct, while the overall prevalence was 34.2% in our study population.

CONCLUSION

In conclusion, our study demonstrated that hepatobiliary anatomy comprises a variety of common and uncommon variants, including those in the right hepatic duct (RHD), left hepatic duct (LHD), and cystic duct. Our findings showed that the normal branching pattern of hepatobiliary anatomy was present in 65.8% of patients who underwent the MRCP procedure for various indications, while anatomical variations were found in 34.2% of cases. Magnetic resonance cholangiopancreatography (MRCP) is an excellent non-invasive imaging technique for visualization of detailed biliary anatomy.

In sum, the knowledge of the pattern of hepatobiliary anatomy and variations is essential and should be mandatorily mentioned in the MRCP report, as it helps surgeons anticipate and minimize potential intraoperative challenges, increases the efficiency of radiological biliary interventions, and reduces the risk of complications.

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