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Evaluation of Intrahepatic Bile Duct Variations in Magnetic Resonance Cholangiopancreatography

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ABSTRACT

Introduction: A detailed knowledge of normal branching pattern of intrahepatic bile duct and their variations is of utmost importance for any liver or biliary tract surgery to avoid severe post-surgery complications and morbidity. The objective of this study was to evaluate variations of intrahepatic bile ducts in Magnetic Resonance Cholangiopancreatography (MRCP) examinations in Nepalese population.

Methods: This quantitative, cross sectional study was performed in patients referred for MRCP examinations for various clinical indications to Tribhuvan University Teaching Hospital, Maharajgunj, Nepal. Data were collected for a period of four months from August to November 2019 after IRB approval. Convenience sampling was employed and a total of 90 examinations were included. Data were obtained from the 1.5T Magnetom Amira Siemens MRI scanner. The 3D MRCP images were visually analyzed and classified into 7 Types according to the classification given by Choi et al.

Results: In our study 47.8% patients had Type 1/normal IHBD (n=43). 20% had Type 2 (n=18), 3.3% had Type 3A (n=3), 5.6% had Type 3B. Type 5A (n=5), 7.8% had 5B (n=7), 3.3% had Type 6 (n=3) and 6.7% had Type 7 (n=6). No patients were found to have Type 3C and Type 4 IHBD variation. Among the total number of Type 1 cases, 67.44% (n=29) were female and rest were male.

Conclusions: Typical IHBD was only found in a 47.8% patients and common other variations were also noted in our population. Type 2 and Type 5B were found in 20% and 7.8% patients respectively.

Keywords**:** *Common Bile Duct, Cystic duct, Intra Hepatic Bile Duct, Magnetic Resonance Cholangiopancreatography, Variation*

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INTRODUCTION

Normal biliary anatomy is seen in only 58% of the population.[1] Magnetic resonance cholangiopancreatography (MRCP) is an excellent non-invasive imaging technique

for visualization of detailed biliary anatomy. An accurate knowledge of normal branching pattern of intrahepatic bile duct and their variations is of crucial importance for liver and biliary tract surgery including liver transplantation, tumor resection and laparoscopic hepatobiliary surgeries.[2] Drainage of the right posterior duct into the left hepatic duct or at its confluence with the right anterior duct is the most common anatomic variant of the biliary system and is reported in about 30% of cases.[3] Most of the complications in these surgeries are caused by the presence of anatomical variation of bile ducts which lead to difficult anastomosis thus increased morbidity.[4] While the epidemiology of extrahepatic biliary abnormalities is well described in the literature, especially as regards pancreaticobiliary duct maljunction few data is available regarding the epidemiology of intrahepatic biliary abnormalities.[5] In fact, in opposition to what has been observed for extrahepatic biliary anatomy, very few data is reported about regional or ethnical disparities, or correlation with other demographical characteristics. Different IHBD classifications have been proposed by various authors. In our study we have used the classification given by Choi et al.[6] There is increasing number of case post cholecystectomy strictures, which is due to lack of prior knowledge of biliary duct anatomy. The objective of the study is to determine the percentage of population with the typical (Type 1) IHBD and atypical (Type 2 to 7) IHBD.

METHODS

This quantitative, cross sectional study was performed in patients referred for MRCP examinations for various clinical indications to the Department of Radiology and Imaging, Tribhuvan University Teaching Hospital, Maharajgunj, Nepal. Data were collected for a period of four months from August to November 2019 after IRB approval.

Convenience sampling was employed and a total of 90 examinations were included. Patients with history of hepatic or biliary surgery were excluded from the study. Data were obtained from the 1.5T Magnetom Amira Siemens MRI scanner. Informed consent forms were taken from the patients meeting the inclusion criteria. The routine department protocol was followed for the MRCP examinations. The patients were thoroughly screened as per department guidelines for any ferromagnetic material.. Freshly crushed pineapple juice was given to the patients prior to the examination to reduce fluid signal from the stomach. The routinely obtained sequences in TUTH are as follows:

- T2 HASTE coronal respiratory triggering: FOV 350mm, slice thickness 4.5mm, TR 2000ms, TE 93ms, slices 25, distance factor 50%, PAT 2, voxel size 1.1x1.1x4.5mm.
- T2 HASTE transverse respiratory triggering: FOV 370mm, slice thickness 5mm, TR 2000ms, TE 99ms, slices 30, distance factor 40%, PAT 2, voxel size 1.4x1.4x5mm.
- T2 FBLADE FATSAT respiratory triggering: FOV 380mm, slice thickness 6mm, TR 3000ms, TE 90ms, slices 30, distance factor 30%, PAT 2, voxel size 1.2x1.2x6 mm.
- T2 HASTE FATSAT coronal thick slab breath hold: FOV 350mm, slice thickness 4.5mm, TR 2000ms, TE 93ms, slices 25, distance factor 50%, PAT 2, voxel size 1.1x1.1x4.5mm.
- T2 SPACE coronal respiratory triggering: FOV 380mm, slice thickness 1mm, TR 2500ms, TE 520ms, slabs 1, slices per slab 72, no slice oversampling, PAT 2, voxel size 0.5x0.5x1mm.

The 3D SPACE images were reformatted with Maximum Intensity Projection. These images were then visually analyzed to determine the IHBD variations.

The percentage of IHBD variations according to gender were cross tabulated. The percentage of cases having normal (Type 1) and abnormal (Type 2/3A/3B/3C/4/5A/5B/6/7) were determined. Chi-square test was applied for statistical significance of IHBD variations in male and female.

RESULTS

A total of 90 patients were selected. Among them there were 32 males and 58 females i.e. 64.4% females and 35.6% males. The mean age was found to be 46.33±17 years. The minimum and maximum ages were 3 and 87 years respectively. (Figure 1)

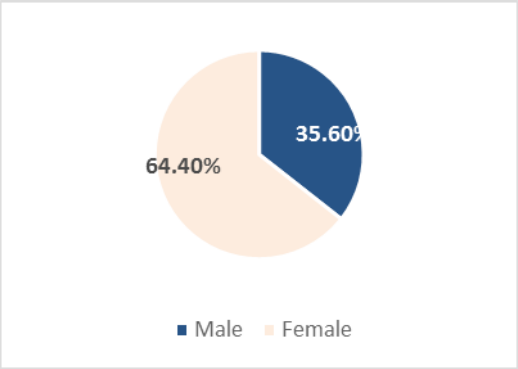

Figure 1. *Pie Chart showing percentage of Males and Females.*

The variations were divided into Type 1, 2, 3A, 3B, 4, 5A, 5B, 6 and 7. (Figures 3 to 9) Type 1 was considered as normal. Others were categorized as abnormal IHBD variations. Forty three patients among 90 selected for the study had Type 1 IHBD. This constituted 47.8% who had normal type of IHBD i.e. common hepatic duct is formed by fusion of the RHD and LHD. The RHD arises through fusion of the RASD, which drains anterior segments V and VIII, and the RPSD, which drains posterior segments VI and VII. (Figure 2)

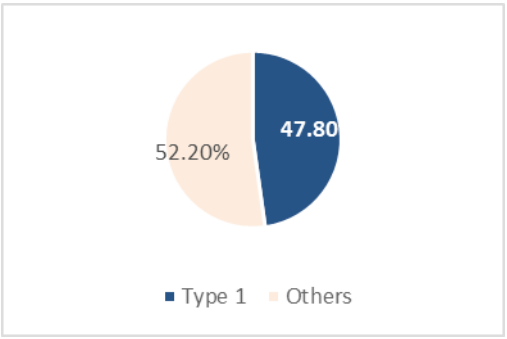

Figure 2. *Pie chart showing percentage of normal and abnormal IHBD.*

Among the remaining 47 patients, 18 patients had Type 2 IHBD variation, 3 patients had Type 3A, 5 patients had Type 3B, 5 patients had Type 5A, 7 patients had Type 5B, 3 patients had Type 6 and 6 patients had Type 7 IHBD variations. No patients were found having Type 3C and Type 4 IHBD variations. (Table 1)

Table 1. Percentage of IHBDs.

Type	Frequency	Percentage (%)
Type 1	43	47.8
Type 2	18	20
Type 3A	3	3.3
Type 3B	5	5.6
Type 3C	0	0
Type 4	0	0
Type 5A	5	5.6
Type 5B	7	7.8
Type 6	3	3.3
Type 7	6	6.7

Figure 3. *Type 1. The CHD is formed by fusion of the RHD and LHD. The RHD is formed by fusion of the RASD, and the RPSD.*

Figure 4. *Type 2. It demonstrates simultaneous emptying of the RASD, RPSD and LHD into the CHD.*

Figure 5. *Type 3A. It demonstrates anomalous drainage of RPSD into LHD.*

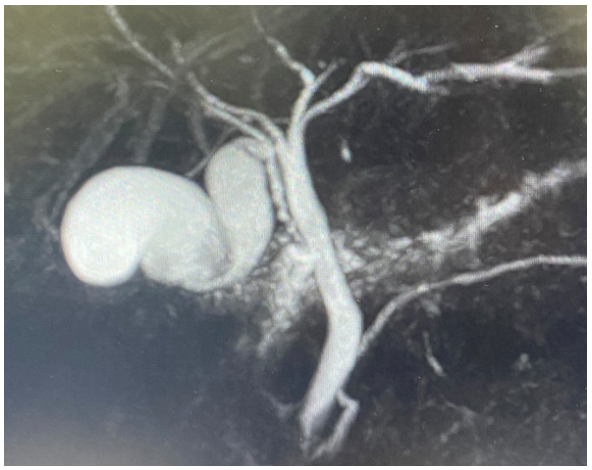

Figure 6. *Type 3B. It demonstrates anomalous drainage of RPSD into the CHD.*

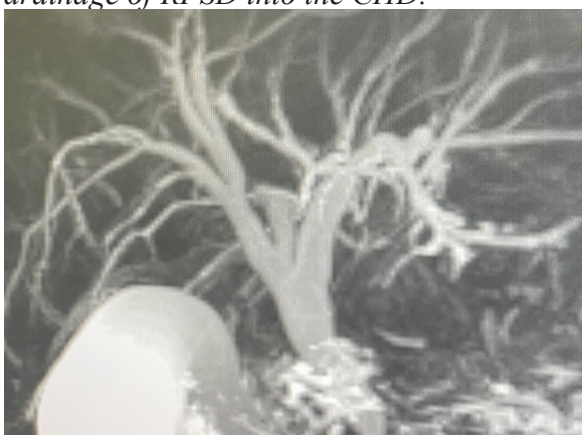

Figure 7. *Type 5B. It demonstrates an accessory duct draining into the Right Hepatic Duct.*

Figure 8. *Type 6. It demonstrates Segments II and III of the segmental duct drain individually into the RHD or CHD.*

Figure 9. *Type 7. Multiple accessory ducts.*

Sex and IHBD Types

Cross tabulation of sex and IHBD types

Among 43 patients who had Type 1, 29 were female and 14 were male.

Among 18 patients who had type 2 IHBD, 11 were female and 7 were male.

Among 3 patients who had type 3A IHBD, 2 were female and 1 was male.

Among 5 patients who had Type 3B IHBD, all were female.

Among 5 patients who had Type 5A IHBD, 3 were female and 2 were male.

Among 7 patients who had Type 5B IHBD, 3 were female and 4 were male.

Among 3 patients who had type 6 IHBD, 2 were female and 1 was male.

Among 6 patients who had Type 7 IHBD, there were 3 males and 3 female. (Table 2)

Table 2. Cross Tabulation of Sex and Type.

	Sex		
Type	Female	Male	Total
1	29 (67.4%)	14 (32.6%)	43
2	11 (61.1%)	7 (38.9%)	18
3A	2 (66.7%)	1 (33.3%)	3
3B	5 (100%)	0 (0%)	5
5A	3 (60%)	2 (40%)	5
5B	3 (42.9%)	4 (57.1%)	7
6	2 (66.7%)	1 (33.3%)	3
7	3 (50%)	3 (50%)	6
Total	58 (64.4%)	32 (35.6%)	90

The Chi-square statistic value obtained by the chi-square test in SPSS was 0.32. The p-value was 0.57 i.e. the difference in IHBD variation between male and female was not significant ($p>0.05$).

DISCUSSION

Currently MRI is considered the method of choice for the study of the biliary system owing to its high sensitivity, non-invasive nature as well as absence of ionizing radiation. Due to several technical improvements introduced in its protocol over recent years, MRCP allows us to investigate the morphology of intra-hepatic bile ducts and cystic duct.

The need for precise intrahepatic biliary anatomy is essential especially for the biliary interventional procedures as well as liver surgery like liver resection and transplantation and to reduce biliary complications. [7,8] While biliary anatomical variants are not a contraindication for liver donation, however, detailed accurate pre-operative identification is essential to avoid severe post-surgical morbidity and complications.

There is a high prevalence of biliary variants which was shown in many previous studies.[6] Normal or Type 1 IHBD was found in only 43 patients consisting of 47.8% among the 90 patients included in the study. In the current study, we used the classification given by Choi et al.[6] In their study anatomical variation in IHBDs was classified according to the branching pattern of the right anterior and right posterior segmental duct (RASD and RPSD, respectively) and the presence or absence of the first-order branch of the left hepatic duct (LHD) and of an accessory hepatic duct. They found the normal/Type 1 IHBD in 63% subjects (n=188). Our study found a lower percentage of normal IHBD i.e. 47.8% subjects. This difference may be in part due to the smaller sample size used in our study (90 v/s 300 in previous study). The study by Choi et al.[6] was obtained from carefully selected liver donors who underwent an intraoperative cholangiogram. Thus our study may be more representative of the general population. Similarly, normal or Type 1 IHBD was found in 55% cases by

Cocuzza G et al.[7] They studied the MRCP examinations of 534 patients. Nayman et al.[9] found normal IHBD in 62% cases. They studied MRCP examinations of 2624 patients and also provided classification for 10 novel variations encountered by them.

In our study, the triple confluence/ Type 2 IHBD was encountered in 20% subjects (n=18). Previous studies by Choi and Coccuza G both found similar type of biliary anatomy in 10% cases.[6,7] Type 2 IHBD was encountered in 9% of the cases in a study by Nayman et al.[9] Type 3 representing anomalous drainage of the right posterior sectoral duct was subdivided into 3A, 3B and 3C by Choi et al.[6] In our study 3A i.e. RPSD drains into LHD in 3.3% subjects (n=3). In the study by Choi et al.[6], 3A constituted 11% of the total cases. Cocuzza et al.[7] found it to be the second most frequent IHBD variation with 19.8%. Type 3B i.e. RPSD draining into the common hepatic duct was found in 5.6% cases (n=5). The study by Choi found Type 3B IHBD in 6% cases.[6] Cocuzza found this type of variation in 6.74% cases.[7] Type 3C i.e. RPSD draining into the cystic duct was not encountered in our study. However Choi found such type of variation in 2% cases.[6] Nayman et al.[9] found Type 3 IHBD in 11% cases. We found Type 3 IHBD in 8.9% cases.

No cases having Type 4 IHBD was observed in our study. The study by Choi found only 1 Type 4 IHBD case.[6]

Type 5 in which an accessory duct is present was further sub divided into 5A and 5B. In 5A, the accessory duct drains into the common hepatic duct. This was found in 5.6% cases (n=5) in our study. While Choi found this type in 3% cases.[6] In 5B, accessory duct drains into the Right Hepatic Duct. This type of variation was found in 7.8% cases (n=7). The study by Choi et al.[6] reported this type in 3% cases.

Type 6 is one in which segments II and III of the segmental duct drain individually into the RHD or CHD. This type of variation was only found in 1% cases in Choi's study.[6] However we found 3 cases with Type 6 IHBD that constituted 3.3%.

Type 7 includes the variations that don't fall into any of the above Types and hence includes the unclassified/ complex variations. The study by Choi found 3 cases belonging to Type 7, whereas we found 6 cases constituting 6.7% of the total cases.[6] Among the 6 patients, in 2 patients the cystic duct drained into right hepatic duct, in 4 patients there were numerous accessory ducts draining into CHD and RHD. No significant difference was found in the IHBD variations in between male and female ($p>0.05$) as given by Chi-square test.

CONCLUSIONS:

MRCP is the modality of choice for evaluation of hepatobiliary anatomy. Typical IHBD was only found in 47.8% patients and common other variations were also noted in our population. Type 2 was found in 20% and Type 5B was found in 7.8% patients. Type 3C and Type 4 variations were not found in our study. Detailed, accurate pre-operative identification of biliary anatomical variants is essential to avoid severe post-surgical morbidity and complications.

CONFLICT OF INTEREST

None

SOURCES OF FUNDING

None

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