ORIGINAL ARTICLE

Variations in Hepatobiliary Confluence on MRCP in 3-T MRI Machine - A Cross Sectional Descriptive Study

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ABSTRACT

Background: With the growing prevalence and complexity of hepatobiliary surgery and interventions a detailed preoperative assessment of vascular and biliary anatomy is a must to avoid iatrogenic injuries. Among various modalities of mapping biliary anatomy MRCP is an excellent non-invasive diagnostic tool ideally suited for this purpose. Nepalese data on variation in hepatobiliary confluence is lacking, hence this study aims to fulfill the gap. **Method:** This was a cross-sectional observational (descriptive) study carried out in 128 patients undergoing Magnetic Resonance Cholangiopancreatography (MRCP) at a high flow imaging centre between December 2015 to 2017. MRCP was performed on 3.0 T MR scanner following standard protocol. The images obtained were retrospectively analysed, classified into seven types according to Choi et al and data was entered in proforma. Statistical analysis was performed using IBM SPSS v 16. **Results:** Among 128 patients 56 were males (43.8 %) and 72 were females (56.2 %). The mean age of patient was 48.72 ± 18.051 with median age of 48 (range 3 - 84 years). The common indications for undergoing MRCP were pain abdomen (82.8%), vomiting (43%) and jaundice (28.9%). Three patients were excluded due to distorted anatomy. Among the remaining 125 patients, the most common type was the normal pattern was found in 61.7 % patients. Remaining 36 % patients were found to have variant anatomy among which the most common variant was trifurcation pattern observed in 12.5 % patients followed by type III b in 10.9 % patients. None of the patients had type IV and VI variant. No statistical correlation was observed between gender and type of variant. **Conclusion:** MRCP is a promising diagnostic tool for mapping biliary anatomy, the knowledge of which is critical to prevent intra and post-operative biliary complications following surgical, endoscopic or interventional procedures.

Key words: Biliary anatomy, MRCP, confluence, variant, trifurcation.

INTRODUCTION

The biliary tract is anatomically divided into intrahepatic and extrahepatic ducts. The intrahepatic duct is distributed in accordance with Couinaud's segmental anatomy of the liver, which divides the liver into eight segments, each with its own vascularisation and biliary and venous drainage systems. (1) The segmental bile ducts drain the various liver segments, with the right anterior sectoral duct draining segments V and VIII and the right posterior sectoral duct draining segments VI and VII having a more vertical course. The right posterior duct usually runs posterior to the right anterior duct and joins it from the left (medial) side to form the right hepatic duct. The left hepatic duct is formed by the union of the segmental ducts II, III, and IV. (2) The segment I duct is very small and drains

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into the left or right hepatic duct's origin. The right hepatic duct is typically shorter than the left, and they both connect to form the common hepatic duct, which continues as the extrahepatic biliary system. (3) This is the most common and typical type of confluence seen in approximately 58 percent of the population.(1)

With the growing prevalence and complexity of hepatobiliary surgery and interventions such as, laparoscopic cholecystectomy, living donor liver transplantation, hepatic tumor resection and therapeutic biliary drainage, a detailed preoperative assessment of vascular and biliary anatomy is a must. The proper assessment ensures patient safety as well as the best therapeutic approach to prevent iatrogenic biliary complications.

Biliary anatomy can be mapped pre-operatively by various modalities which may be direct methods like endoscopic retrograde cholangiopancreatography (ERCP), percutaneous transhepatic cholangiography (PTC), intravenous cholangiography and T-tube cholangiography, as well as indirect methods like magnetic resonance cholangiopancreatography (MRCP) or cholescintigraphy. (6) Although ERCP is still considered the gold standard and MRCP a secondary tool if ERCP is contraindicated or unsuccessful (7), due to the non-invasiveness, ease and reliability MRCP is gaining popularity as a promising diagnostic tool for pre-surgical planning.

Data regarding the variation in hepatobiliary confluence is largely lacking in our part of the world. Hence, the main aim of this study is to document and assess frequencies of various types of hepatobiliary confluence in the Nepalese population on MRCP using a 3-T machine.

MATERIALS AND METHODS

Subjects

This study is a retrospective analysis of patients who had undergone MRCP for various indications at a high flow Imaging Centre between December 2015 and December 2017. A total of 128 patients were included in the study ranging from the age of 3 to 84. The sampling method was non-probability convenient sampling based on whether the biliary ductal system could be viewed and evaluated. No age limits were applied during the selection phase. However, patients with previous hepatobiliary surgery which can distort the confluence (not including cholecystectomy), ascites or cases where hepato-biliary confluence could not be adequately seen were excluded from the study.

Ethical approval was obtained from our Institutional Review Board (IRB), Tribhuvan University before the initiation of the study with waiver of patient consent.

Imaging Technique

MRCP was performed on a 3.0 T MR scanner (Ingenia, Philips Medical System) using a sixteen element quadrature phased array body coil over the liver. The standard MRCP protocol consisted of the following imaging sequences and parameters:

1. Respiratory triggered T2 SPAIR axial and T2 coronal sequence with slice thickness 5mm (TR 800ms, TE 70ms) in the region of the liver to pancreatic parenchyma.

2. 2D MRCP images were obtained using breath-hold thick-slab heavily T2-weighted fat saturated singleshot fast spin-echo images (TE 740ms and TR 5100ms) with a slab thickness of 30-50 mm (centering at CBD) in 12 para coronal planes constituting an angle of 180 degrees or the acquisition of each plane, patients held their breath for about 5 seconds.

3. Respiratory triggered 3D MRCP with TE of 650ms (heavily T2 weighted) and shortest possible TR in the coronal oblique plane centering at the level of CBD covering whole intrahepatic bile ducts and gall bladder.

Volume data was obtained from which, a MIP reformat was generated. We conventionally created 16 MIP reformats at about 12-degree intervals to each other over a radial array of 180 degrees for analysis.

Evaluation of Images

During the evaluation of the findings, the thick cross-sections, MIP images and thin collimation axial and coronal source images were evaluated in combination. The retrospective evaluation was carried out by two radiologists with more than 7 years of experience. Variations in hepatobiliary confluence were documented and classified into seven types as described by Choi et al and Mc Sweeney et al. (5)

According to Choi et al and Mc Sweeney et al, hepatobiliary confluence at hepatic hilum have been classified into the following types: (4,5)

Type	Interpretation
Type I	Typical: RPSD joining RASD medially to form RHD
Type II	Trifurcation: Simultaneous emptying of the RASD, RPSD and LHD into the CHD
Type III	Anomalous drainage of RPSD RPSD joining LHD (crossover anomaly) RPSD joining CHD RPSD joining cystic duct

Type IV	Aberrant drainage of RHD into the cystic duct
Type V	Accessory right segmental intrahepatic duct directly drains to the CHD.
Type VI	Segments II and III draining individually into the RHD or CHD
Type VII	Others or unclassified variations

RPSD: Right posterior sectoral duct, RASD- Right anterior sectoral duct, RHD- Right hepatic duct, LHD- Left hepatic duct, CHD- Common hepatic duct.

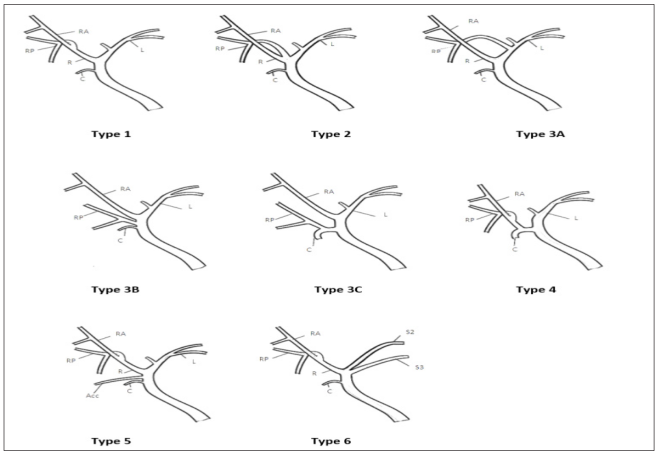


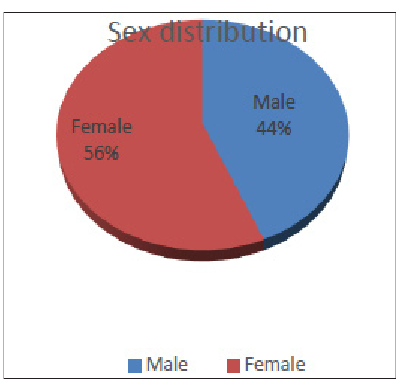
Figure: Biliary branching pattern at hepatic hilum.

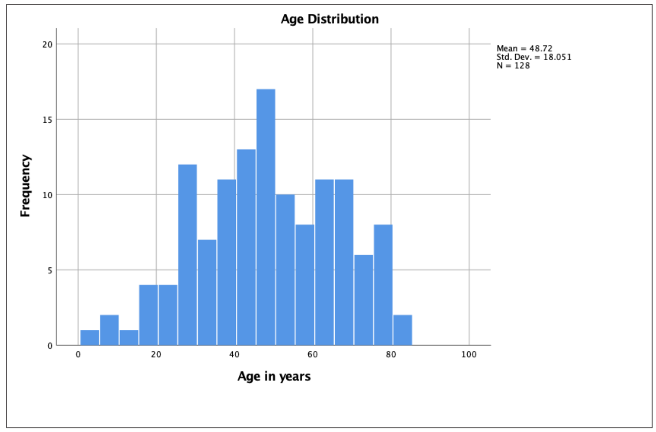
Statistical Analysis

All data were coded, tabulated, and represented as frequencies with percentages. Numerical data were presented as means and standard deviations. Statistical analysis was performed using IBM SPSS v25.0. A P value < 0.05 was considered statistically significant.

RESULTS

MRCPs of total 128 patients were included in the study, among which 56 were males (43.8 %) and 72 were females (56.2 %). The mean age of the patient was 48.72 ± 18.051 with a median age of 48 (range 3 - 84 years).





Patients had presented for MRCP with various clinical symptoms, the common ones being pain abdomen (82.8%), vomiting (43%) and jaundice (28.9%). Other symptoms included loss of appetite (20.3%), itching (13.3%), fever (10.2%) and weight loss (1,6%). Twenty-three patients (18%) had a history of prior cholecystectomy, among which 15 were females and the rest 8 were males.

Prior ultrasound was available in only 43 patients (33.6 %) and the most common findings were choledocholithiasis in 12 (9.4%) and cholelithiasis in 11 (8.6%) patients followed by both cholelithiasis and choledocholithiasis in 6 patients (4.7%).

Previous CT was available in only 17 (13.3%) patients among which pancreatitis was the most common finding.

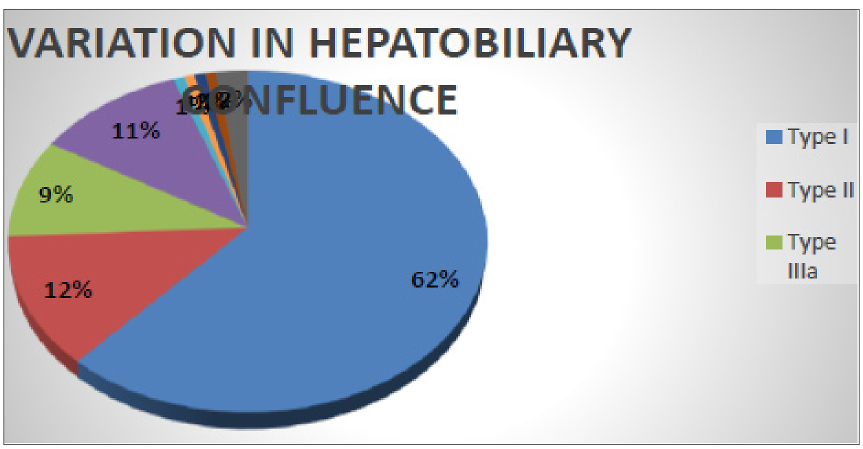
MRCP findings in these patients were as listed in the table below:

MRCP findings	Frequency	Percent
Normal	30	23.4
CBD dilatation	3	2.3
Choledochal cyst	1	.8
Pancreatic divisum	1	.8
Acute pancreatitis	11	8.6
Chronic pancreatitis	6	4.7
Carcinoma GB	4	3.1
Cholelithiasis and choledocholithiasis	13	10.2
Cholecystitis	7	5.5
CHD injury	1	.8
Primary sclerosing cholangitis	1	.8
Hepaticolithiasis	1	.8
Cholelithiasis	25	19.5
Choledocholithiasis	13	10.2
Hilar cholangiocarcinoma	3	2.3

Distal cholangiocarcinoma	1	.8
Other masses/carcinoma	5	3.9
IHBD dilatation	2	1.6
Total	128	100.0

Among 128 patients, 3 patients had infiltrative hilar mass distorting the biliary anatomy due to which the hepatobiliary confluence could not be adequately assessed and thus were excluded from the study. Of the remaining 125 patients, the most common type was the normal pattern in which the right posterior duct (draining segments VI and VII) joins the right anterior duct (draining segments V and VIII) to form the right hepatic duct, which then joins the left hepatic duct (draining segments II, III, and IV) to form the common hepatic duct which was found in 61.7 % patients (n= 79). The remaining 6 % of the patients were found to have variant anatomy among which the most common variant was trifurcation pattern observed in 12.5 % of the patients (n=16) followed by type III b in 10.9 % of the patients (n=14). None of the patients in the study population were observed to have type IV and VI variants. The distribution of hepatobiliary confluence is summarized in the table below:

Hepatobiliary confluence	Frequency	Percent
Normal type I IHBD pattern	79	61.7
Type II trifurcation pattern	16	12.5
Type IIIa (RPD to LHD)	12	9.4
Type IIIb (RPD to CHD)	14	10.9
Type IIIc (RPD to CD)	1	.8
Type IV	0	0
Type Va (Accessory duct to CHD)	1	.8
Type Vb (Accessory duct to RHD)	1	.8
Type VI	0	0
Type VII (unclassified or other than these)	1	.8
NA	3	2.3
Total	128	100.0



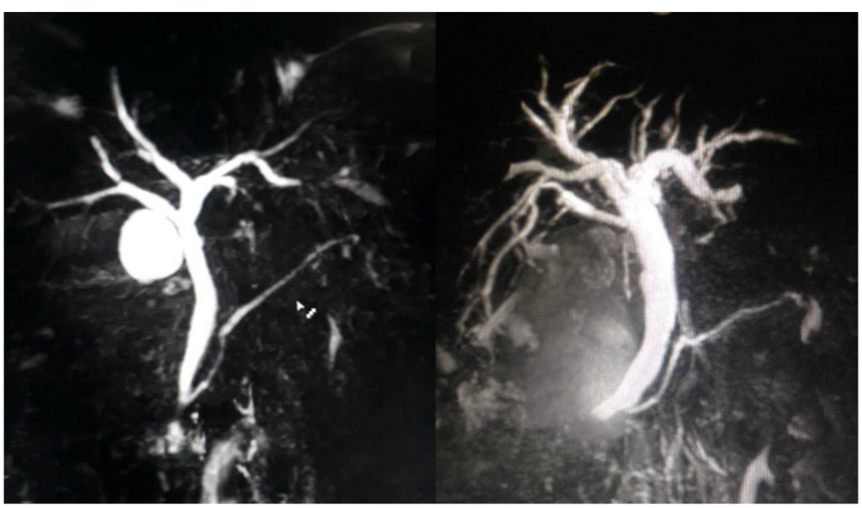


Figure: Type III b and VII pattern of hepatobiliary confluence.

The type of hepatobiliary confluence was cross-tabulated with sex and observed that the most common variant in females was trifurcation pattern (type II) whereas the most common variant in males was RPD draining into the CHD (type IIIb).

Sex/Type	Type I	Type II	Type IIIa	Type IIIb	Type IIIc	Type Va	Type Vb	Type VII
Male	35	3	4	8	1	0	1	1
Female	44	13	8	6	0	1	0	0

On statistical analysis using Pearson chi-square test for correlation between sex and type of hepatobiliary confluence, the p-value was calculated to be 0.079 which is >0.05, hence not statistically significant.

DISCUSSION

Accurate knowledge of biliary anatomy is crucial for pre-surgical planning of hepatobiliary surgeries to minimize the risk of intra- and postoperative complications, such as bile leakage, bile peritonitis, biliary stricture, obstructive jaundice, cholangitis, and liver abscess. (8) Among various methods of imaging the biliary tract MRCP is evolving as an excellent non-invasive diagnostic tool for pre-operative assessment with the added advantage of lack of ionizing radiation, non-requirement of contrast agents and anesthesia during the procedure.

At least six different classification systems for intrahepatic biliary anatomical variants have been described by Deka et al. (9)These include Couinaud (10), Champetier (8), Huang et al. (11), Choi et al. (4), Ohkubo et al. (12), and Karakas et al. (13). Our study was based on Choi classification which classified the branching pattern of intrahepatic ducts into seven different types with subtypes in type III and V.

According to Choi et al, the majority of the subjects (63%) had type I, or typical anatomy. Among the variants, type III a (drainage of the RPSD into the LHD) was the most common, followed by type 2 (trifurcation) present in 11% and 10% of donors, respectively. (4) The typical hepatobiliary confluence pattern has been reported to occur in 55% to 67% in larger population studies. (8,14). In our study, the typical pattern (type I) has been observed in 61.7 % of the study population which is largely in concordance with the previous studies. Among the variant anatomy, the most common variant observed in our study was the trifurcation pattern seen in 12.5% followed by the type III b pattern in 10.9 % of the patients. Whereas Type III a pattern which was the most common variant as per Choi et al, was the third most common variant in our study which was observed in only 9.4 % of the patients.

In a study by Surekha et al, type I anatomy was found in 64 % of the patients, combined type III pattern in 17 % followed by trifurcation pattern in 5 % of the patients.(2) The combined type III pattern in our study is reported to be 21.1 % which is higher than the prevalence reported in previous studies.

Various other similar studies have also been performed in various parts of the world. Most of these studies have used Huang classification for classifying the right hepatic duct variation. According to Huang classification, the RHD is classified into five types according to RASD and RPSD insertions: type A1 RPSD drains in the RASD, type A2 is a tri-confluence pattern of RASD, RPSD, and LHD insertion, type A3 RPSD drains in LHD, type A4 RPSD drains in CHD, and type A5 RPSD drains in the cystic duct (15). In a study by Huang et al, (11) 959 patients were evaluated using both ERCP and MRCP for right hepatic duct variation, the typical pattern A1 was observed in 62.6 %, the most common variant was observed A2 which was found in 19 % of the patients followed by A3 pattern seen in 11% patients. These findings are correlating well with our study in which the most common variant is the trifurcation pattern.

Reviewing previous literature, the variation in hepatobiliary confluence observed based on Huang classification are as listed below:

Previous studies	Type A1	Type A2	Type A3	Type A4	Type A5
Puente et al(16)	57.6	11.1	12.9	4.6	-
Huang et al(11)	63	19	11	6	2
Couinaud et al(10)	57	12	16	4	2
Yoshida et al(14)	67.7	17.7	8	6	0.1
Choi et al(4)	63	10	11	6	2
Ohkubo et al(12)	65	5	12	5	-
Song et al(17)	60.4	8.1	19.8	7.2	1.8
Karakas et al(13)	55	16	21	10	-
Sarawagi et al(15)	55.3	9.3	27.6	4	0.8

Surekha et al(2)	64	5	17 (type A3, A4 and A5)		
Swain et al(3)	72.7	11.3	9.7	5.6	0.4
Cawich et al (18)	71.7	29	7	6	0
Present study	61.7	16	12	14	1

In a similar study performed in the Taiwanese population by Lee et al, the MRCP imaging findings showed that the most common biliary tree variants were triple confluence and typical pattern which together comprised 70% of all variants.(19) In our study, the two types together comprise about 74.2 % of all variants.

Slight variations in the type of confluence pattern may be attributed to the modalities that were used in these studies such as intra-operative cholangiogram, ERCP, MRCP or a combination of these.

According to Cawich et al, there was no statistical relationship between the presence of anatomic variants and gender (26.7% vs 30.3%; P = 0.717) which is similar to that of our study.

The major limitation of our study was that no comparison of the MRCP finding with intraoperative cholangiogram or ERCP was made. Secretin enhanced or hepatobiliary agents were not injected hence thin collapsed segmental biliary duct without bile may not be seen in plain MRCP and identification of small aberrant or accessory ducts may not be possible. In a study by Ragab et al correlating 3D MRCP and intraoperative cholangiography in the right liver donor, MRCP accurately predicted the biliary anatomy in 18 of 20 cases, specificity and positive predictive value of 3D MRCP in defining normal biliary anatomy was 100% and in 2 patients, it failed to identify abnormal anatomy. The study concluded that 3D MRCP reliably represents normal biliary anatomy but the presence of anatomical variations decreases MRCP sensitivity and makes intra-operative cholangiography or duct probing a necessary tool for accurately performing the transection of the right hepatic duct.(20)

CONCLUSION

In conclusion, 61.7 % of patients having MRCP for various indications had normal architecture of the hepatobiliary confluence. Atypical branching patterns were detected in 36% of the patients, with trifurcation pattern being the most common variation, followed by type III b pattern. MRCP is a potential diagnostic method for mapping biliary anatomy, which is essential for avoiding biliary problems before and after surgical, endoscopic, or interventional treatments.

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