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Anatomy

ANATOMIC VARIANTS OF INTRAHEPATIC BILE DUCTS AND CYSTIC DUCTS IN SAUDI ARABIA: MAGNETIC RESONANCE CHOLANGIOPANCREATOGRAPHY ANALYSIS IN LIVER DONORS

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ABSTRACT **Background:** Data regarding the pattern of the anatomical variations of biliary tree from the Middle East is considerably deficient when compared with the literature available elsewhere. **Objective:** To determine anatomic variation in branching pattern of intra hepatic bile duct and cystic duct on Magnetic resonance Cholangiopancreatography in liver donors from Saudi Arabia. **Methods:** This descriptive study was done at Radiology Department Prince Sultan Military Medical City Riyadh, KSA between 2019-2020 after taking IRB approval (IRB No:1404) and collecting data of liver donors (n=92) using Magnetic resonance cholangiopancreatography. **Result:** Regarding the right hepatic duct, in our study Type A1(69.6%) was predominant followed by Type A2(16.3%). As for the left hepatic duct, typical pattern Type A was observed in 94.6% cases. Drainage of right posterior hepatic duct into left hepatic duct, A3(7.6%) and A4(5.4%) drainage of right posterior hepatic duct into the common hepatic duct were the most common variants in our study. Accessory bile duct with segment 5 draining into CHD with segment 5and 8 draining into CHD was found in 2.2% of cases, and an aberrant bile duct in 1.1% In our study, majority (97.8%)had lateral insertion of cystic duct and in 1.4% accessory cystic duct was noted. **Conclusion:** Because of growing trend found in number of liver transplant surgeries being performed, magnetic resonance cholangiopancreatography (MRCP) has become optimal for noninvasive evaluation of abnormalities of the biliary tract.

KEYWORDS : Hepatic duct, Cystic duct, Liver donors, Magnetic resonance cholangiopancreatography

Introduction

The bile duct is formed on the free edge of the lesser omentum by the union of the cystic duct and the common hepatic duct. The right and left hepatic ducts unite to form the common hepatic duct. The length of the bile duct is usually 5 to 15 cm, depending on where the cystic duct joins the common hepatic duct. The cystic duct is usually 4 cm long, connects the neck of the gall bladder to the common hepatic duct and usually runs parallel to the common hepatic duct. The anatomy of the biliary tree is intricate, with many intrahepatic and extrahepatic variations. It has been reported that 58% of the population has a typical biliary structure.[1]

It is essential to understand in detail the normal branching patterns of the intrahepatic bile duct and cystic duct along with their variations to perform living liver donor transplantation, tumour resection and laparoscopic hepatobiliary surgeries.[2]

Endoscopic retrograde cholangiopancreatography (ERCP) and intraoperative cholangiography are invasive techniques used for imaging the biliary tree.

Magnetic resonance cholangiopancreatography (MRCP) is an excellent non-invasive imaging technique that provides two-dimensional (2D) and three-dimensional (3D) projection images for visualization of the biliary anatomy in detail.[3] Earlier reports have assessed anatomic variations in intrahepatic bile ducts (IHBDs) observed directly or with MR cholangiography in patients with suspected pancreatobiliary disease.[4]

Huang et al. described the following biliary classifications: A1 corresponded to right and left hepatic ducts forming a common hepatic duct, A2 corresponded to trifurcation formed by the right anterior hepatic duct, A3 corresponded to drainage of the right posterior hepatic duct into the left hepatic duct, A4 corresponded to drainage of the right posterior hepatic duct into the common hepatic duct, A5 corresponded to drainage of the right posterior hepatic duct into the cystic duct, and A6 corresponded to all other cases and unclassified cases.[5]

Confluence patterns of B2, B3 and B4 in the left lobe of the liver for the left hepatic duct can be classified into three main types: Type A, in which the common trunk of B2 and B3 joins B4; Type B, which shows a triple confluence of B2, B3 and B4; and Type C, in which B2 joins the common trunk of B3 and B4.[3]

Variations in cystic duct insertion are also frequently seen. Type A is a long cystic duct with low insertion into the distal third of the CBD, Type B is a duct with medial insertion of the cystic duct, Type C is a cystic duct running parallel to the common hepatic duct for at least a 2 cm segment, Type D is a cystic duct with abnormally high fusion with the CBD, Type E is a cystic duct entering the right hepatic duct, Type F is a cholecystohepatic duct, Type G is a cystic duct with a cystic malformation, and Type H is a cystic duct with lateral insertion.[3,6]

In this study, we intended to determine the anatomic variations in the branching patterns of the IHBD and cystic duct by performing magnetic resonance cholangiopancreatography (MRCP) in liver donors from Saudi Arabia and to explain the clinical significance of the findings.

Additional aberrant and accessory bile ducts and complex uncategorized configurations of biliary tree variants are described.

Methods

This descriptive study was performed at the Radiology Department of Prince Sultan Military Medical City in Riyadh, KSA between 2019 and 2020 after IRB approval was received (IRB no: 1404) and data were collected from liver donors (n=92). The study was carried out according to the principles of the Helsinki Declaration.

Liver donors who underwent MRCP scans with adequate and clear images of the intrahepatic bile duct and cystic duct were included. Donors whose biliary tree images were inadequate or had poor quality were excluded from the study.

Demographic details, such as age, sex, and the clinical diagnosis, were obtained in addition to the branching patterns of the intrahepatic bile duct, cystic duct and their variations after experienced radiologists evaluated the magnetic resonance images.

The data obtained were tabulated in an Excel sheet and analysed by Statistical Package for Social Sciences for Windows, version 22 (Armonk, NY: IBM Corp.). Descriptive statistics for the variations observed were calculated and the chi-square test was used to assess the differences in pattern distributions between males and females.

Results

This study included 92 liver donors (22=females, 70=males) who underwent MRCP scans.

The following tables depict the biliary patterns in all the cases and within the females and males. The differences in these values between the males and females were statistically non-significant.

Table 1: Prevalence of patterns in the right hepatic duct

Subjects	A1	A2	A3	A4	A5	A6
All (n=92)	64 (69.6%)	15 (16.3%)	7 (7.6%)	5 (5.4%)	0	1 (1.1%)
Females (22)	19 (86.4%)	2 (9.1%)	1 (4.5%)	0	0	0
Males (70)	45 (64.3%)	13 (18.6%)	6 (8.6%)	5 (7.1%)	0	1 (1.4%)

Table 2: Prevalence of patterns in the left hepatic duct

Subjects	A	B	C
All (n=92)	87 (94.6%)	2 (2.2%)	3 (3.3%)
Females (22)	21 (95.5%)	1 (4.5%)	0
Males (70)	66 (94.3%)	1 (1.4%)	3 (4.3%)

Table 3: Prevalence of patterns in the cystic duct

Subjects	A	B	H
All (n=92)	1 (1.1%)	1 (1.1%)	90 (97.8%)
Females (22)	0	0	22 (100%)
Males (70)	1 (1.4%)	1 (1.4%)	68 (97.1%)

Table 4: Prevalence of accessory and aberrant patterns in the bile duct and cystic duct

Subjects	Accessory Bile Duct			Accessory Cystic Duct	
	No	Yes-SEG 5 in CHD	Yes-SEG 5,8 to CHD	No	No
Females (22)	21 (95.5%)	0	1 (4.5%)	22 (100%)	0
Males (70)	69 (98.6%)	1 (1.4%)	0	69 (98.6%)	0
	Aberrant Bile Duct		Aberrant Cystic Duct		
	No	Yes-SEG 5 in CHD	No	Yes	
Females (22)	22 (100%)	0	22 (100%)	0	
Males (70)	69 (98.6%)	1 (4.5%)	70 (100%)	0	

Fig 1: Standard biliary anatomy (Type A1): Coronal thick slap MRCP image showing a primary confluence (arrow) formed by the fusion of the left main hepatic duct with the right main hepatic duct to form the common bile duct.

Fig 2: Trifurcation biliary anatomy (Type A2): Coronal thick slap MRCP image showing a primary confluence (arrow) formed by the fusion of the left main hepatic duct, right anterior hepatic duct and right posterior hepatic duct.

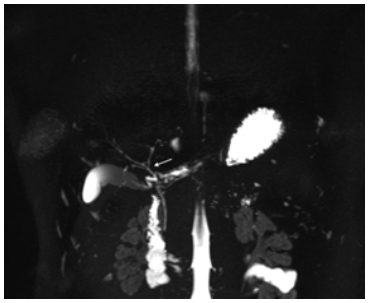


Fig 3. Right posterior hepatic duct draining into the left main hepatic duct: Coronal thick slap MRCP image showing the right posterior sectoral duct (arrow) draining into the left main hepatic duct.

Fig 4: Accessory segment V duct draining into the common hepatic duct: Coronal thick slap MRCP image showing an accessory duct draining segment V (arrow) into the common hepatic duct below the level of the primary confluence.

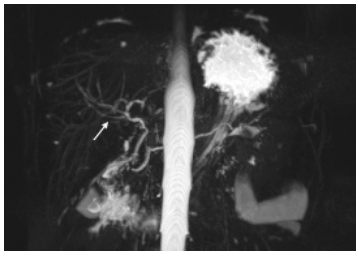


Fig 5: Aberrant segment V sectoral duct draining directly into the common hepatic duct: Coronal thick slap MRCP image showing an aberrant segment V sectoral duct (arrow) draining separately into the common hepatic duct below the level of the primary confluence forming the common bile duct (asterisk).

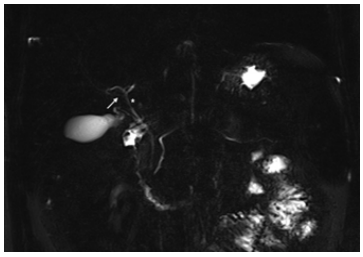
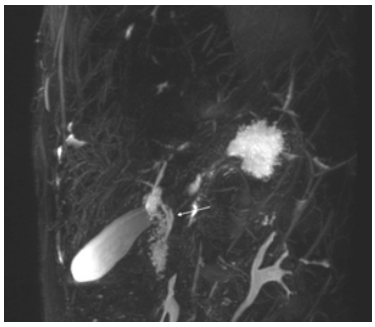


Fig 6. Medial low insertion of the cystic duct: Coronal thick slap MRCP image showing the cystic duct (arrow) inserting into the lower third of the common hepatic duct at its medial aspect.



Discussion

Regarding the right hepatic duct, in our study, the typical pattern, which is Type A1 (69.6%) (Fig 1), was predominant, followed by Type A2 (16.3%) (Fig 2). For the left hepatic duct, the typical pattern, Type A, was observed in 94.6% of cases. In 2016, Neha K et al reported that the anatomy of the intrahepatic bile duct was typical in 63% of 100 cases. Thirty-seven percent of the patients had atypical configurations, where 18% of patients had type A2, 9% had type A3, 8% of had type A4 and 0% had type A5, and 2% of the patients had other types of biliary configurations. By comparing the values of the females and males, we found that the incidence of atypical patterns was significantly higher in the males and that of typical patterns was significantly higher in the females.[4]

In 2019, Al Muhanna et al. reported that the typical right hepatic duct (RHD) configuration was observed in 56% of patients, the typical left hepatic duct (LHD) configuration was observed in 81.4% of patients and the typical cystic duct configuration was observed in 72% of patients, suggesting that the normal biliary tree anatomy is similar among the Saudi population and in other ethnic groups.[7]

The potential risk of developing biliary complications is 5.9 times higher in patients with a biliary anatomical pattern other than A1. Choi et al conducted a study on 300 liver donors and reported that the branching pattern of IHDs was atypical in 37% of cases. The two most common variations were drainage of the RPSD into the LHD (11%) and triple confluence of the RASD, RPSD and LHD (10%).

The authors also observed accessory hepatic ducts, which included type 5A, type 5B and two type 7 cases, in 18 patients (6%). Although accessory ducts are insignificant, they should not be overlooked when liver transplantation or hepatic resection is performed for other disorders.[8]

Drainage of the right posterior hepatic duct into the left hepatic duct in A3 cases (7.6%) (Fig 3) and drainage of the right posterior hepatic duct into the common hepatic duct in A4 cases (5.4%) were the most common variants in our study. An accessory bile duct is a supplementary bile duct that drains a certain area of the liver. Accessory bile ducts with segment 5 draining into the CHD were observed in 1.4% of patients (Fig 4), and ducts with segments 5 and 8 draining into the CHD were found in 4.5% of patients.

An aberrant bile duct is the solitary bile duct that drains a specific segment of the liver. In our study, in 4.5% of cases (Fig 5), the aberrant segment V sectoral duct drained directly into the common hepatic duct. Preoperative assessments of the hepatic vascular and biliary anatomy is necessary in liver donors, as ligation of these ducts may cause biliary cirrhosis.

In 2015, Al Jiffry et al found normal direct cystic ducts in 74.6% of patients, type B in 14.1% of patients, and type C in 11.3% of patients.[9] In our study, 97.8% of patients had lateral insertion of the cystic duct, 1.1% had low medial cystic insertion (Fig 6) and 1.4% had accessory cystic ducts. Aberrant or accessory ducts during biliary surgeries may be inadvertently ligated, leading to biliary leaks; hence, surgeries need to be performed carefully to prevent hidden cystic duct syndrome.

In 2016, Sarawagi et al reported that the branching pattern of the right hepatic duct (RHD) was typical in 55.3% of subjects. The most common variant was the right posterior sectoral duct (RPSD) draining into the left hepatic duct (LHD), which occurred in 27.6% of subjects. A trifurcation pattern was noted in 9.3% of subjects. In 4% of subjects, the RPSD drained into the common hepatic duct (CHD), and in 0.8% of subjects, the RPSD drained into the cystic duct. Other variants were noted in 2.6% of subjects. In 4.9% of the subjects, there was an accessory duct. The most common LHD branching pattern was a common trunk of segment 2 and 3 ducts joining the segment 4 duct, which occurred in 67.8% of subjects.

There is a high incidence of biliary variants, as reported in many studies,11-13 but radiologists should assess patients' biliary anatomy carefully and report the findings to promote successful liver surgeries and transplantation. A lack of awareness of the variations will result in the diagnosis being missed completely or confused with other types of conditions, leading to inappropriate treatment.

Limitation: This study was performed in liver donors without complicated vascular variations.

Implications for future research: We intend to assess the hepatic vascular anatomy in patients who undergo MRCP scans before liver transplantation and observe any variations and associations of vascular and biliary variation.

Conclusion: Because the number of liver transplant surgeries being performed is increasing, magnetic resonance cholangiopancreatography (MRCP) is considered the optimal method for the noninvasive evaluation of abnormalities of the biliary tract.

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