Study of anatomic variations of intrahepatic bile ducts using magnetic resonance cholangiopancreatography

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Article Info

ISSN (online): 2582-8940
Volume: 03
Issue: 04
October-December 2022
Received: 18-11-2022;
Accepted: 08-12-2022
Page No: 71-94

Abstract
Background and Aim: The aim of this study was to describe the anatomical variations occurring in the branching patterns of intrahepatic bile ducts(IHDs) and their frequencies in general north Indian population using MR cholangiography.
Methods: The study was conducted on 110 patients undergoing MR cholangiography for different indications. Anatomical variations in IHDs were classified based on the variable insertion of right posterior hepatic bile duct (RPHD) using Huang classification.
Results: Anatomy of the IHD was typical (Huang A1) in 58.2% of cases (*n* = 64) and atypical in 41.8% (n=46), showing Huang A2, 13.6% (n = 15); Huang A3, 15.4% (n = 17); Huang A4, 9.1% (n = 10); and Huang A5, 3.63% (n = 4).
The Huang A1 cases were then subtyped according to distance (L) between RPHD insertion and the junction of right and left hepatic ducts into S1 subtype (L > 1 cm) and S2 subtype (L ≤ 1 cm). We had 43 subjects with subtype S1 (39.1%) and 21 subjects with subtype S2 (19.1%).
Conclusion: MRC is an important tool for biliary tract mapping and it provides excellent identification of biliary variants which can reduce the incidence of biliary complications in hepatobiliary surgeries.

Keywords: intrahepatic, magnetic, anatomic, variations

Introduction

The growing prevalence and complexity of hepatobiliary surgery necessitate a detailed preoperative assessment of vascular and biliary anatomies in order to insure the safety of patient as well as the best selection of therapeutic approach [1-3]. 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] This can be lowered by providing the surgeons with clear biliary anatomy map that helps to plan their approach before beginning the procedure [1] Although the diagnostic endoscopic retrograde cholangiography is the standard examination for defining biliary anatomy, it carries a major complication rate of 1.4–3.2% [5], so the development of a safer method of evaluating biliary anatomy would be beneficial. Magnetic resonance cholangiopancreatography (MRCP) is an excellent non-invasive, simpler imaging technique for visualization of detailed biliary anatomy and does not expose the patient to ionizing radiation and requires no intravenous contrast agent.
There are many classifications of biliary anatomical variations, of which Huang classification method [6] is a widely used based on the variable insertion of right posterior hepatic bile duct (RPHD) and is used in this study. It has five variants classification (Table 1 and figure 1).
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 [7].

In this study, we present MR cholangiograms to illustrate normal and aberrant hepatic biliary segmental anatomy. Additionally, we discuss the significance of familiarity with the MR cholangiographic biliary segmental anatomy to clinical practice.

Table 1: Huang Classification

Variant type	Site of opening of tight posterior hepatic duct (RPHD)
Huang A1	The right anterior hepatic duct (RAHD)
Huang A2	The hepatic confluence (trifurcation)
Huang A3	The left hepatic duct (LHD)
Huang A4	The main hepatic duct (MHD)
Huang A5	The cystic duct

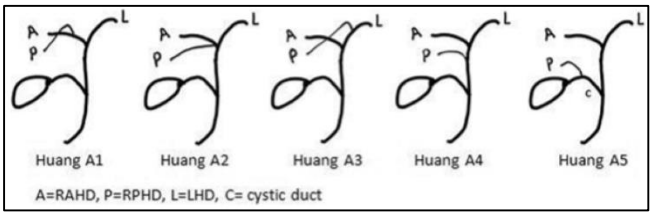

Fig 1

Methods

This is cross sectional type of study and was conducted on patients referred for MRCP examinations for various clinical indications to the Department of Radiology and Imaging at Saraswathi Institute of Medical Sciences**,** Anwarpur, Hapur (U.P). Data were collected for a period of one year from January 2021 to December 2021.

The current study included 110 patients after convenience sampling. Informed consent forms were taken from the patients meeting the inclusion criteria. Patients with history of previous hepatic or biliary surgery were excluded from the study.

MRCP Protocol

The routine department protocol was followed for the MRCP examinations. MRI was done for all subjects using 1.5-T magnetic resonance system.

The subjects were instructed to fast 6 h prior to MRI to distend the gallbladder and to have an empty stomach as well as to suppress the movement of intestines; however, no anti-peristaltic medicine or oral contrast media were applied.

Image data analysis was done using dedicated workstation depending on the raw images.

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

Image interpretation

The insertion of right posterior hepatic duct was traced in each case and the classification of subjects was done based on Huang classification [6]. The distance of RPHD insertion to the right and left hepatic duct junction was measured.

Statistical methods

The data collected was entered into the IBMSPSS version 25.0. Statistical analysis was performed by using statistical tools, techniques and test such as chi square test/fisher exact test.

All other appropriate/required statistical method were used. P-value less than 0.05 considered as significant at 95% confidence level.

Results

A total of 110 patients were selected with minimum and maximum ages were 15 and 70 years respectively Among them there were 58 males and 52 females i.e. 52.7% females and 57.2% males.

According to Huang classification [7], the frequencies of each type were as follows (*Table 2 and Table 3*): Anatomy of the IHD was Huang A1 (typical) in 58.2% of cases (n = 64) among which 35 were male and 29 were female *(figure 2).*

Huang A2 seen in 13.6% (n=15) among which 7 were male and 8 were female (*figure 3).*

Huang A3, 15.4% (n = 17) among which 8 were male and 9 were female *(figure 4)*

Huang A4, 9.1% (n = 10) among which 6 were male and 4 were female (*figure 5).*

Huang A5, 3.63% (n = 4) among which 2 were male and 2 were female.

From the surgical point of view, RPHD insertion within 1 cm to right and left hepatic duct junction is more amenable to intra-operative technical modification. So standard surgical techniques mandate to classify the type Huang A1 subjects, in which the distance between RPHD and the right and left hepatic duct junction (d) is 1 cm or less, as a common junction of RAHD, RPHD and LHD[8]. As we had 64 subjects with this character (A1), we had to Re-classify Huang A1 from this view into S1 (d > 1 cm) and S2 ($d \leqslant 1$ cm). In this manner, we had 43 subjects with subtype S1 (39.1%) and 21 subjects with subtype S2 (19.1%).

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

Table 2: Percentage of IHBDs

	Number	Frequency (%)
Typical		
Huang A1		
• Type S1	43	39.1
• Type S2	21	19.1
Atypical		
HuangA2	15	13.6
HuangA3	17	15.4
Huang A4	10	9.1
Huang A5	4	3.6
Total	110	100

Table 3: Cross Tabulation of Sex and Type

Type	male	female	Total
Typical			
Huang A1	35	29	64
• Type S1	23	18	43
• Type S2	12	11	21
Atypical			
HuangA2	7	8	15
HuangA3	8	9	17
Huang A4	6	4	10
Huang A5	2	2	4
Total	58	52	100

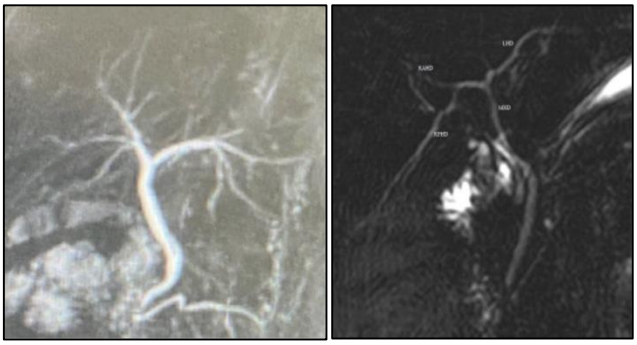

Fig 2: Huang type A1: right posterior hepatic duct (RPHD) opens into the right anterior hepatic duct The MHD = main hepatic duct is formed by fusion of the RHD and LHD.

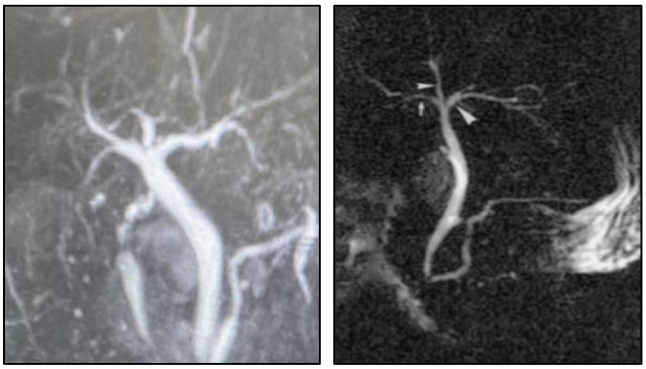

Fig 3: Huang type A2 (trifurcation) It demonstrates simultaneous emptying of the RASD, RPSD and LHD into the CHD

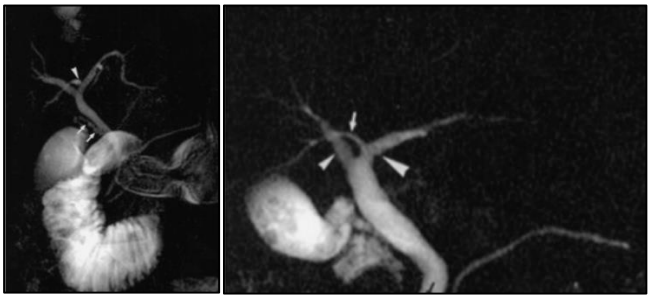

Fig 4: Huang type A3: right posterior hepatic duct (RPHD) opens into left hepatic duct (LHD)

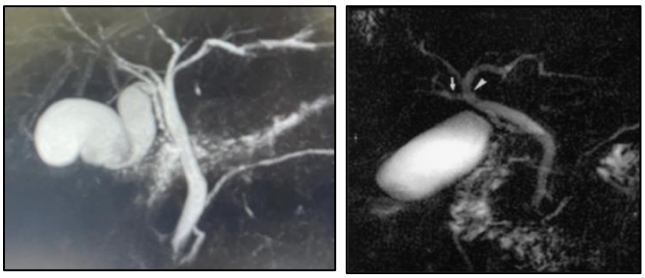

Fig 5: Huang type A4: right posterior hepatic duct (RPHD) opens into main hepatic duct (MHD)

Discussion

The individual biliary drainage system is parallel to the portal venous supply [9]. The right hepatic duct drains the segments of the right liver lobe (V–VIII) and has two major branches: the right posterior duct draining the posterior segments, VI and VII, and he right anterior duct draining the anterior segments, V and VIII. The left hepatic duct is formed by segmental tributaries draining segments II–IV. The common hepatic duct is formed by fusion of the right hepatic duct, which is usually short, and the left hepatic duct. The bile duct draining the caudate lobe usually joins the origin of the left or right hepatic duct [10]. The cystic duct classically joins the common hepatic duct below the confluence of the right and left hepatic ducts. This normal biliary anatomy is thought to be present in 58% of the population [10].

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 [11, 12]. While biliary anatomical variants are not a contraindication for liver donation, however, detailed accurate pre-operative identification is essential to avoid iatrogenic ligation of the donor or recipient's major biliary tract, for example, ligation of aberrant RAHD or RPHD drainage into the left hepatic duct can cause cirrhosis [13, 14]. On the other hand, during right lobe transplantation, multiple biliary anastomoses in the recipient may be needed to prevent biliary obstruction [15].

In the current study, we used Huang classification to categorize intrahepatic ducts according to the RPHD insertion.

The current study showed that vast subject number had intrahepatic duct typical (Huang A1) in 58.2% of cases (n = 64) and atypical in 41.8% (n=46), showing Huang A2, 13.6% (n = 15); Huang A3, 15.4% (n = 17); Huang A4, 9.1% (n = 10); and Huang A5, 3.63% (n = 4).

This coincides with many previous studies [16, 17, 18]. The difference in frequencies in comparison to other studies was might be because of sample size and was not significant.

Huang type A1 is considered the simplest, and ideal for living donor liver transplantation (LDLT) as in right lobe transplantation, a single biliary-enteric anastomosis can be made with a relative ease. HOWEVER, the right hepatic duct (RHD) length has a crucial impact as with sufficient length, one biliary-enteric anastomosis may be done easily, while in the case of short RHD, it may need modification as double anastomoses to avoid injury risk of the bile duct in hepatic resection. This raises the requirement of surgical techniques to classify the subjects in which the distance between RPHD and the right and left hepatic duct junction is 1 cm or less [8, 15].

In the current study, Huang A1 was the dominant type representing 58.2% (n = 64) of the subjects included in our study. Due to the surgical importance of the distance between RPHD insertion and the right and left hepatic duct junction which assume a trifurcation pattern (common RAHD, RHPD, and LHD junction) for distance of 1 cm or less [4, 8, 16, 19], we had to subtype our subjects of Huang A1 based on the distance (D) between the insertion of RPHD and the right and left hepatic duct junction into S1 (D > 1 cm) and S2 (D = 1 cm or less). Accordingly, we had Huang A1 subtypes: subtype S1 (n = 43, 39.1%) and subtype S2 (n = 21, 19.1%).

Huang type A3 variant in which the RPHD drains into the left hepatic duct, occupied the second order and showed a frequency of 15.4% (n= 17). This variant can lead to inadvertent biliary tract injury in the donor and it may need double anastomoses to avoid postoperative biliary leakage or

segmental atrophy [8, 15].

The third frequency was in the current study was for Huang A2 in which the RPHD open to the hepatic confluence (trifurcation) and represented 13.6% (n = 15) of our subjects Some centres may avoid graft harvesting in biliary trifurcation to prevent a higher rate of postoperative complications [8, 15].

The presence of an aberrant right posterior duct draining into the common hepatic duct (Huang type A4) or into the cystic duct (Huang type A5) may disorient the surgeon, causing him to inadvertently ligate or section the aberrant ducts. In our series, Huang type A4 was encountered in 10 (9.1%) of our subjects. This type also may need double anastomoses to avoid post-transplantation biliary complications [8, 15].

We encountered Huang A5 in four subjects (3.6%). Huang type 5 with RPHD draining into the cystic duct is of biliary surgical importance especially during laparoscopy as its damage may lead to biliary leakage and biloma [8, 16].

References

1. Ragozzino A, De Ritis R, Mosca A, Iaccarino V, Imbriaco M. Value of MR cholangiography in patients with iatrogenic bile duct injury after cholecystectomy. American Journal of Roentgenology. 2004; 183(6):1567-72.
2. Guiney MJ, Kruskal JB, Sosna J, Hanto DW, Goldberg SN, Raptopoulos V. Multi-detector row CT of relevant vascular anatomy of the surgical plane in split-liver transplantation. Radiology. 2003; 229(2):401-7.
3. Kapoor V, Peterson MS, Baron RL, Patel S, Eghtesad B, Fung JJ. Intrahepatic Biliary Anatomy of Living Adult Liver Donors: Correlation of Mangafodipir Trisodium-Enhanced MR Cholangiography and Intraoperative Cholangiography. American Journal of Roentgenology. 2002; 179(5):1281-6.
4. Karakas HM, Celik T, Alicioglu B. Bile duct anatomy of the Anatolian Caucasian population: Huang classification revisited. Surg Radiol Anat. 2008; 30(7):539-45.
5. Yeh BM, Breiman RS, Taouli B, Qayyum A, Roberts JP, Coakley FV. Biliary tract depiction in living potential liver donors: comparison of conventional MR, mangafodipir trisodium-enhanced excretory MR, and multi-detector row CT cholangiography-initial experience. Radiology. 2004; 230(3):645-51.
6. Huang TL, Cheng YF, Chen CL, Chen TY, Lee TY. Variants of the bile ducts: clinical application in the potential donor of living-related hepatic transplantation. In Transplantation proceedings 1996 28(3):1669-1670).
7. Kamisawa T, Takuma K, Anjiki H, *et al*. Pancreatico biliary maljunction. *Clin Gastroenterol Hepatol* 2009; 7(11):S84-8.
8. Limanond P, Raman SS, Ghobrial RM, Busuttil RW, Lu DS. The utility of MRCP in preoperative mapping of biliary anatomy in adult-to-adult living related liver transplant donors. Journal of Magnetic Resonance Imaging: An Official Journal of the International Society for Magnetic Resonance in Medicine. 2004; 19(2):209-15.
9. Gazelle GS, Lee MJ, Mueller PR. Cholangiographic segmental anatomy of the liver. *Radio Graphics*. 1994; 14:1005-1013.
10. Puente SG, Bannura GC. Radiological anatomy of the biliary tract: variations and congenital abnormalities. World J Surg. 1983; 7:271-276.
11. Piana S, Piccoli M, Roccasalva F, *et al*. Anatomic variants of the biliary tree: a retrospective Magnetic Resonance Cholangiopancreatography (MRCP) evaluation. European Congress of Radiology, 2017. https://dx.doi. org/10.1594/ecr2017/C-2417.
12. Mortelé KJ, Ros PR. Anatomic variants of the biliary tree: MR cholangiographic findings and clinical applications. AJR Am J
13. Goldman J, Florman S, Varotti G, Gondolesi GE, Gerning A, Fishbein T, *et al*. Noninvasive preoperative evaluation of biliary anatomy in right-lobe living donors with mangafodipir trisodium enhanced.
14. Caruso S, Miraglia R, Maruzzelli L, Gruttadauria S, Luca A, Gridelli B. Imaging in liver transplantation. World J Gastroenterol. 2009; 15(6):675-683.
15. Ohkubo M, Nagino M, Kamiya J, Yuasa N, Oda K, Arai T, *et al*. Surgical anatomy of the bile ducts at the hepatic hilum as applied to living donor liver transplantation. Ann Surg. 2004; 239:82-86.
16. Kim RD, Sakamoto S, Haider MA, Molinari M, Gallinger S, McGilvray ID, *et al*. Role of magnetic resonance cholangiography in assessing biliary anatomy in right lobe living donors. Transplantation 200; 79:1417-1421.
17. Dusunceli E, Erden A, Erden I. Anatomic variations of the bile ducts: MRCP findings. Tani Girisim Radyol. 2004; 10:296-303.
18. Choi JW, Kim TK, Kim KW, Kim AY, Kim PN, Ha HK, *et al*. Anatomic variation in intrahepatic bile ducts: an analysis of intraoperative cholangiograms in 300 consecutive donors for living donor liver transplantation. Korean J Radiol. 2003; 4(2):85-90.