The Egyptian Journal of Radiology and Nuclear Medicine (2012) **43**, 111–117

Egyptian Society of Radiology and Nuclear Medicine

The Egyptian Journal of Radiology and Nuclear Medicine

www.elsevier.com/locate/ejrnm
www.sciencedirect.com

ORIGINAL ARTICLE

Anatomic variations of intrahepatic bile ducts in the general adult Egyptian population: 3.0-T MR cholangiography and clinical importance

Mohamed A. Tawab [a], Tamer F. Taha Ali [b,*]

[a] *Department of Radiodiagnosis, Faculty of Medicine, Al-Azhar University, Egypt*
[b] *Department of Radiodiagnosis, Faculty of Medicine, Zagazig University, Egypt*

Received 20 January 2012; accepted 15 February 2012
Available online 9 March 2012

KEYWORDS

Magnetic resonance;
cholangiography (MRC);
Biliary variants;
Huang's classification;
Liver transplantation;
Biliary surgery

Abstract *Objective:* To describe the anatomical variations occurring in intrahepatic bile ducts (IHDs) and their frequencies in general adult Egyptian population using 3.0-T MR cholangiography (MRC) as well as its clinical importance to reduce the biliary complications of hepatobiliary surgery.
Materials and methods: MRC was applied to a study group of 106 subjects (26 potential liver donors and 80 volunteers). Anatomical variations in IHDs were classified based on the variable insertion of right posterior hepatic bile duct (RPHD) using Huang classification.
Results: According to this classification, the frequencies of each type were as follows: Huang A1 (typical pattern): 63.2% (n = 67), Huang A2: 10.4% (n = 11), Huang A3: 17% (n = 18), Huang A4, 7.5% (n = 8), and Huang A5: 1.9% (n = 2). Total frequency for atypical types (i.e. A2, A3, A4 and A5) was 36.8%. No significant difference was detected in the distance between RPHD insertion to the junction of right and left hepatic duct in-between these Huang types. This distance was short (< 1 cm) in 21 of subjects under Huang A classification. Twenty-one donors underwent

* Corresponding author.
E-mail address: tamerfathi2008@yahoo.com (T.F. Taha Ali).

Peer review under responsibility of Egyptian Society of Radiology and Nuclear Medicine.
doi:10.1016/j.ejrnm.2012.02.004

ELSEVIER Production and hosting by Elsevier

intraoperative cholangiograms, of which twenty (95.2%) had similar classification in both intraoperative and MRC findings.

Conclusion: The incidence of variant biliary anatomy in general Egyptian population (36.8%) as well as the presence of Huang type A with short distance (< 1 cm) between RPHD insertion and junction of right and left hepatic duct (19.8%) enhance the importance of MRC as a pre-operative tool before hepato-biliary surgical procedures to reduce post-operative biliary complications.

1. 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 (1–4). Iatrogenic biliary pathology is relatively a frequent problem following hepatic surgery that negatively influences the postoperative course, leading to increased complication rates and mortality, in addition to reducing the quality of life (5–7). Despite improved survival rates and advances in surgical technique, biliary complications which occurring in 7–10% of donors, represent the most common cause of morbidity in living donor liver transplantation (8–10). Biliary complications after hepatic tumor resection are also an important cause of major morbidity with a prevalence of 3.6–8.1% (11). Even in the laparoscopic cholecystectomy which has low complication rate (< 1%), some anatomic variants can increase the risk of biliary injuries if unrecognized by the surgeon (12). This can be lowered by providing the surgeons with clear biliary anatomy map that helps to plan their approach before beginning the procedure (1,13).

Biliary anatomy mapping can be defined using endoscopic retrograde cholangiopancreaticography (ERCP), intraoperative cholangiography, computed tomography (CT) cholangiography and/or magnetic resonance cholangiopancreaticography (MRCP) (1,2,14).

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% (15,16), so the development of a safer method of evaluating biliary anatomy would be beneficial. On the other hand, CT imaging of biliary system has some disadvantages, mainly related to the biliary contrast agent and high radiation dose (17). The introduction of Magnetic resonance cholangiopancreatography (MRCP) in the early 1990s served as a non-invasive safe examination that does not expose the patient to ionizing radiation and requires no intravenous contrast agent (12,15,18). Since the early 2000s, 3 Tesla clinical MRI has been one of the fastest growing segments of the MRI market; MRCP at 3 Tesla is very promising as a diagnostic tool for diseases of the biliary tree showing high resolution and short scan time as well as nearly free of motion artifacts image (19).

Huang classification method (20) is a widely used classification of biliary anatomical variations based on the variable insertion of right posterior hepatic bile duct (RPHD). It is composed of five distinct anatomic types: Right posterior hepatic duct (RPHD) opens to the right anterior hepatic duct (RAHD) in Huang type A1, to the hepatic confluence in type A2 (trifurcation), to the left hepatic duct (LHD) in type A3, to the main hepatic duct (MHD) in type A4, and to the cystic duct in type A5.

Ohkubo (21) divides the bile ducts according to the position of RPHD insertion relative to portal vein level, so (types A–C) are supraportal, and types D and E are infraportal patterns. Ohkubo types F and G are applied when accessory branches of RPHD exist, in this situation; RPHD opens to main hepatic duct from superior (above), and inferior (infraportal) in type F. In type G, RPHD opens to the hepatic duct, and the accessory branch to left hepatic duct.

Champetier classification (22), in comparison to Huang classification, deals only with the variations and not with the dominant Huang type A. It has an additional type (E) in which both RPHD and RAHD open to cystic duct.

With this work, we aimed to study the frequencies of biliary anatomic variations in general adult Egyptian population using 3-T MR cholangiography (MRC) in order to reduce the morbidity and mortality of hepatobiliary surgery.

2. Material and methods

2.1. Study subjects

Our study population consisted of 106 subjects 26 potential liver donors and 80 volunteers referred for lumbar MRI with no significant past or present medical problems. They included 59 males and 47 females with mean age of 37 ± 15.2 years (range 17–62 years).

This study was approved by our institutional review board and informed subject consent was obtained.

2.2. MRC protocol

All subjects underwent MR imaging (MRI) at 3.0-T MR system (Intera Achieva; Philips Medical Systems, Netherlands) with a phased array coil using 6 elements. The subjects were instructed to fast for 6 h before the MRI examination in order to fill their gallbladder, obtain an empty stomach, and to suppress intestinal movements. Initially, the routine breath-hold transverse T1- weighted in- and opposed-phase gradient-echo MRI and T2- weighted TSE MRI with fat saturation for localization of the biliary ducts was done. Subsequently MRC was conducted. First, breath-hold single-slice rapid acquisition with relaxation enhancement (RARE) was done with coronal and ±15 degree oblique coronal orientation resulting in nine slices. Second, respiratory-triggered 3-dimensional turbo spin-echo (3D TSE) was done using a respiratory belt placed on a subject's abdomen. Maximum intensity projections (MIPs) in an analogous orientation of RARE sequences (coronal and ±15 degree oblique coronal orientation) were generated from the MR console using a dedicated workstation (Table 1).

Table 1 MRC protocol.

	RARE	3D TSE
Repetition time (TR) in milliseconds	9800	2600
Echo time (TE) in milliseconds	920	740
Matrix	256 × 256	217 × 256
Number of signal averages	1	1
Flip angle (degree)	90	90
Echo train length	256	87
Slice thickness	50 mm	1 mm
Field of view	30 × 30 cm^2	30 × 30 cm^2
Acquisition time	9.8 s for each slice	2–5 min depending on respiratory frequency

2.3. 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 (20). The distance of RPHD insertion to the right and left hepatic duct junction was measured and its mean was calculated in each type separately.

Intra-operative cholangiograms and bile duct explorations of 21 donor candidates were retrospectively compared with the classification that was made after MRCP.

2.4. Statistical analysis

Statistical analysis was done using statistical package SPSS version 10. McNemar and T test were used for statistical analyses (P value < 0.05 was set to be statistically significant).

3. Results

This study included 106 candidates, (59 males and 47 females) with mean age of 37 ± 15.2 years (range 17–62 years). Anatomic biliary variations were divided into five types, based on RPHD insertion (Fig. 1), according to Huang classification (20). According to this classification, the frequencies of each type were as follows (Fig. 2 and Table 2): Huang A1: 63.2% (n = 67) (Fig. 3), Huang A2: 10.4% (n = 11) (Fig. 4), Huang A3: 17% (n = 18) (Fig. 5), Huang A4: 7.5% (n = 8) (Fig. 6) and Huang A5: 1.9% (n = 2) (Fig. 7). Total frequency for non Huang A1 (i.e. A2, A3, A4 and A5) was 36.8%.

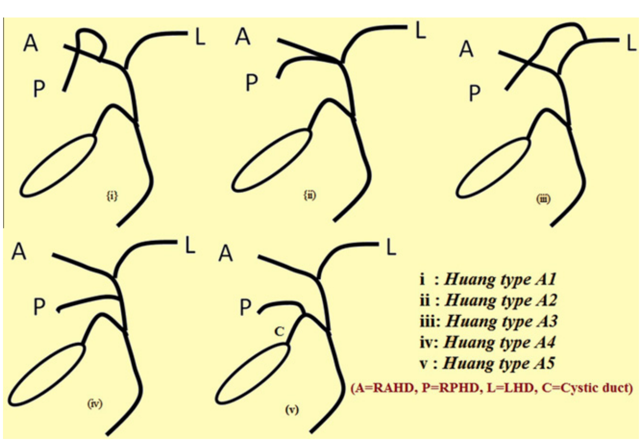

Fig. 1 Drawings show Huang classification.

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 (14). As we had 21 subjects with this character, 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 46 subjects of subtype S1 and 21 with subtype S2 with frequencies of 43.4% for S1 (n = 46) and 19.8% for S2 (n = 21).

The mean distance of RPHD insertion to right and left hepatic duct junction was 9.61 ± 4.72 mm (range = 4–23 mm) in type Huang A1, 9.39 ± 5.13 mm (range = 3–22 mm) in type Huang A3, and 9.11 ± 4.32 (range = 4–23 mm) in type Huang A4. No significant difference was detected in the distance between RPHD insertion to the junction of right and left hepatic duct in-between these Huang types.

Intraoperative cholangiograms and bile duct explorations of 21 operated donors had revealed Huang type A1 pattern in 14 (66.7%), type A2 pattern in 2 (9.5%), and type A3 pattern in 5 (23.8%) subjects. Twenty (95.2%) of those 21 subjects had similar classification in both intraoperative and MRC findings, while one case (4.8%) was assigned as Huang type A2 type at MRCP and found to be type A3 with (inserted at distal end of LHD) at intraoperative findings.

4. Discussion

The advent of minimally invasive therapeutic biliary intervention and hepatic surgery as hepatic resection and partial liver transplantation makes the accurate knowledge of intrahepatic bile ducts (IHDs) anatomy to become very crucial (23–25). MRCP is a non-invasive technique that can show biliary and pancreatic secretions as higher signal intensity structures against dark background with high sensitivity in biliary mapping reaching 90% for normal anatomy (14). Although the congenital variants of biliary anatomy do not represent a contraindication to liver donation, they must be identified before surgery to prevent ligation of major biliary branches of the recipient and/or the donor. Multiple biliary anastomoses during the implantation of the right lobe into the recipient can be required to avoid atrophy due to biliary obstruction (26). Another example is that when performing a left hepatectomy in a living related transplant donor, ligation of aberrant drainage of the RPHD or RAHD into the left hepatic duct will

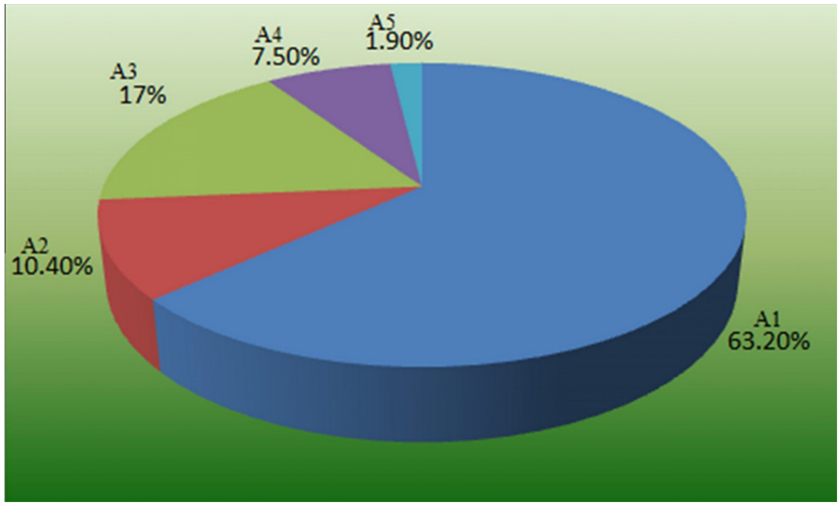

Fig. 2 Frequencies of different Huang types.

Table 2 Frequencies of biliary variants according to Huang classification.

Type	Number	Frequency (%)	
Huang A1			
Type S1	46	43.4	63.2
Type S2	21	19.8	
HuangA2	11	10.4	36.8
HuangA3	18	17	
Huang A4	8	7.5	
Huang A5	2	1.9	
Total	106	100	

produce biliary cirrhosis of segments VI and VII, or segments V and VIII, respectively (24).

In our study, evaluation focused on the distribution of biliary anatomical variants among adult Egyptian population using 3-T MRC. We classified the branching pattern of IHDs according to the Huang classification (20) based on the insertion of RPHD. Our results showed that in the majority of subjects, the anatomy of the IHDs was Huang type A1, or typical type. The predominance of type A1 was also estimated in many other populations (1,14,27–29). The dominance of type A1 was obvious in our study (63.2%) with its frequency near to the yellow race and North Americans. The difference in frequency of type A1 in comparison to other races (1,14,20,21,28–32) was not significant. The only exception was encountered in Germans (type A1 = 11%) but this can be attributed to low cohort study number (n = 18) (33).

The frequencies of the other types were as following: Huang A2, 10.4% (n = 11); Huang A3, 17% (n = 18); Huang A4, 7.5% (n = 8); and Huang A5, 1.9% (n = 2).

As 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 length of the right hepatic duct (RHD) has an essential role. Short RHD makes the anastomosis between donor's liver and recipient's bile duct or bowel difficult as well as more risky for bile duct injury during hepatic resection, accordingly, many subjects who would pre-surgically be considered for single anastomosis actually may need

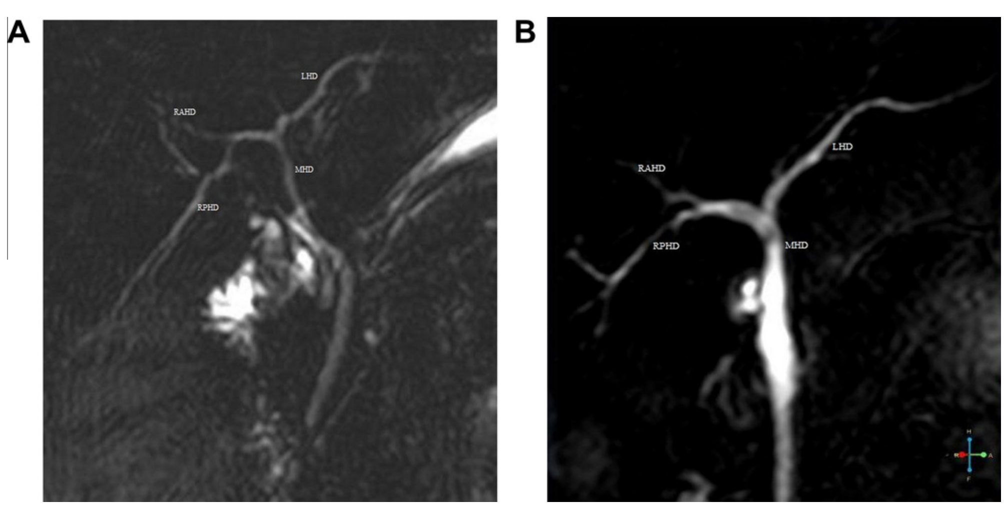

Fig. 3 MRC 3D TSE (A), RARE (B) (two different patients). Huang type A1: right posterior hepatic duct (RPHD) opens into the right anterior hepatic duct (RAHD) (MHD = main hepatic duct, LHD = left hepatic duct).

Fig. 4 MRC 3D TSE (A, B) (two different patients). Huang type A2 (trifurcation): right posterior hepatic duct (RPHD) opens into the hepatic confluence (RAHD = right anterior hepatic duct, LHD = left hepatic duct, MHD = main hepatic duct).

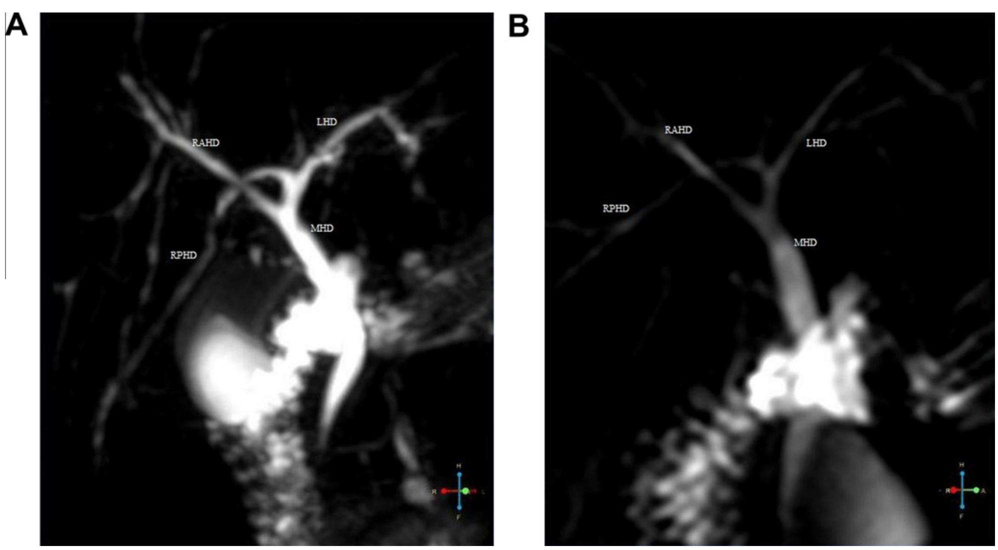

Fig. 5 MRC 3D TSE (A), RARE (B) (two different patients). Huang type A3: right posterior hepatic duct (RPHD) opens into left hepatic duct (LHD) (RAHD = right anterior hepatic duct, MHD = main hepatic duct).

surgical modifications as double anastomosis (20,23,24,27). 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, as a common junction of RAHD, RHPD and LHD (trifurcation) (14,21,23,27).

In our study we modified our classification of candidates with Huang type A1 according to the distance (d) between RPHD and the right and left hepatic duct junction into S1 (the distance (d) > 1 cm) and S2 (distance (d) ⩽ 1 cm) in addition to previously stated Huang A2, A3, A4 and A5 types. Thereafter, we had 46 subjects of subtype S1 and 21 subjects with subtype S2 with frequencies of 43.4% and 19.8%, respectively.

Huang type A3 had the second predominance in races other than Chinese populations (1,14,21,29,31), in this variant the RPHD drains into the left hepatic duct, this also was true in our Egyptian subjects, as Huang type A3 occupied the second order and showed a frequency of 17%. This variant can lead to inadvertent biliary tract injury in the donor (12), and it may need double anastomoses to avoid postoperative biliary leakage or segmental atrophy (14,21).

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 (24). In our series, Huang type A4 was encountered in 8 (7.5%) of our subjects. This type also may need double anastomoses to avoid post-transplantation biliary complications (14,21).

RPHD draining into the cystic duct (Huang type A5) must be paid attention especially during laparoscopic biliary surgery as it is of particular importance among the reasons of iatrogenic damage to bile ducts with subsequent complications as biloma, biliary cirrhosis, or bile leakage. This type has been reported in the literature with incidence 1–2% (23,32–34). In our series, we

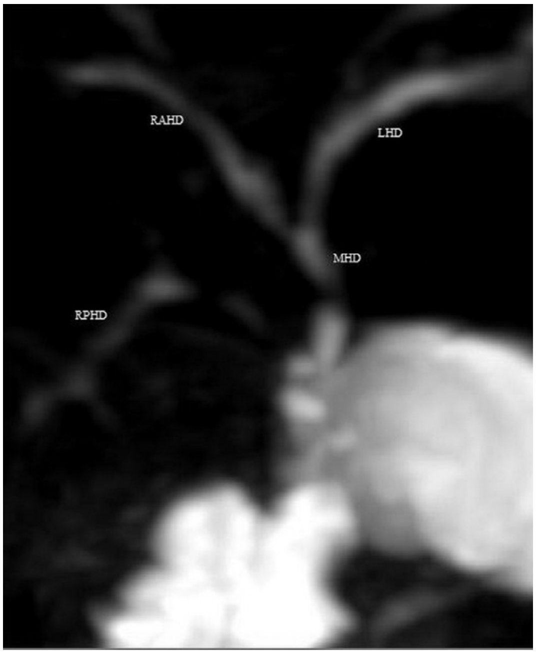

Fig. 6 MRC 3D TSE: Huang type A4: right posterior hepatic duct (RPHD) opens into main hepatic duct (MHD) (RAHD = right anterior hepatic duct, LHD = left hepatic duct).

had nearly same frequency as we encountered Huang A5 in two subjects (1.9%).

In our study, intraoperative cholangiograms and bile duct explorations of 21 operated donors were done. Twenty of those twenty-one subjects had similar classification in both intraoperative and MRC findings that assign accuracy of (95.2%) to MRC results, the last case was classified as type A2 at MRC and found to be type A3 with branching pattern at intraoperative findings.

Comparisons with frequencies of biliary variation in other population were collected in Table 3.

There were some limitations in our study. First, the study sample size was relatively small which may indicate the further studies with a large number of subjects. Second, there was some degree of selection bias, because 26 subjects in this study were potential liver donors. In addition, only 21 of our subjects were confirmed intra-operatively.

5. Conclusion

In this study, the incidence of variant biliary anatomy in general Egyptian population (36.8%) as well as the presence of Huang type A with short distance (< 1 cm) between RPHD insertion and junction of right and left hepatic duct (19.8%) enhance the importance of MRC as a pre-operative tool before hepato-biliary surgical maneuvers to reduce the post-operative biliary complications.

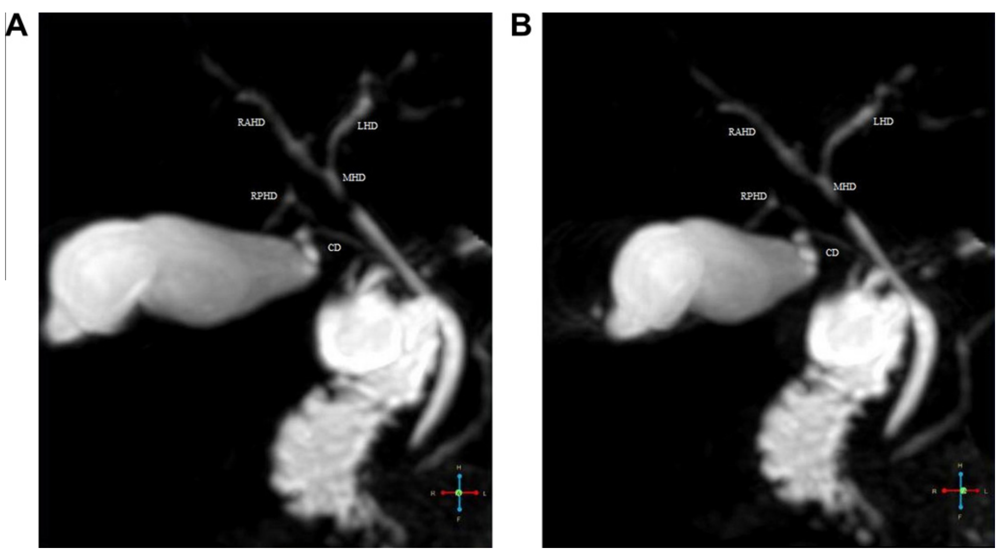

Fig. 7 MRC 3D TSE (A, B) (same patient). Huang type A5: right posterior hepatic duct (RPHD) opens into cystic duct (CD) (RAHD = right anterior hepatic duct, LHD = left hepatic duct, MHD = main hepatic duct).

Table 3 Approximate frequencies (%) of biliary variations in different populations according to Huang classification.

Population studies (reference)	A1	A2	A3	A4	A5
Egyptian population (current study)	64	10	17	7	2
Chinese (20,30)	63–66	17–19	3–11	6–11	2–3
Japanese (21,31)	65–73	5	12	4–7	3–5
North American (1,14)	63–73	0–12	8–13	8–13	0
Anatolian Caucasian (27,28)	55–76	1–14	6–21	1–10	0–5
Germans (35)	11	11	22	0	28

N.B. some of the above listed studies included biliary variants other than the five Huang types, e.g. Ohkubo Type F or G.

References

(1) Kapoor V, Peterson M, Baron R, Patel S, Eghtesad B, Fung J. Intrahepatic biliary anatomy of living adult liver donors: correlation of mangafodipir trisodium-enhanced MR cholangiography and intraoperative cholangiography. AJR 2002;179:1281–6.

(2) Donato P, Coelho P, Rodrigues H, Vigia E, Fernandes J, Caseiro-Alves F, et al. Normal vascular and biliary hepatic anatomy: 3D demonstration by multidetector CT. Surg Radiol Anat 2007;29: 575–582.

(3) Sahani D, Mehta A, Blake M, Prasad S, Harris G, Saini S. Preoperative hepatic vascular evaluation with CT and MR angiography: implications for surgery. Radiographics 2004;24(5): 1367–1380.

(4) 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;229:401–7.

(5) Salvolini L, Urbinati C, Valeri G, Ferrara C, Giovagnoni A. Contrast-enhanced MR cholangiography (MRCP) with GD-EOB-DTPA in evaluating biliary complications after surgery, Radiol Med. doi:10.1007/s11547-011-0731-0734.

(6) Lau WY, Lai ECH. Classification of iatrogenic bile duct injury. Hepatobiliary Pancreat Dis Int 2007;6:459–63.

(7) Ragozzino A, De Ritis R, Mosca A, Iaccarino V, Imbriaco M. Value of MR cholangiography in patients with iatrogenic bile duct injury after cholecystectomy. AJR Am J Roentgenol 2004;183:1567–72.

(8) Itamoto T, Emoto K, Mitsuta H, Fukuda S, Ohdan H, Tashiro H, et al. Safety of donor right hepatectomy for adult-to-adult living donor liver transplantation. Transpl Int 2006;19(3):177–83.

(9) Pecchi A, De Santis M, Di Benedetto F, Gibertini M, Gerunda G, Torricelli P. Role of magnetic resonance cholangiography in biliary complications of orthotopic liver transplantation. Radiol med 2010;115:1065–79.

(10) Valls C, Alba E, Cruz M, Figueras J, Andía E, Sanchez A, et al. Biliary complications after liver transplantation: diagnosis with MR cholangiopancreatography. AJR Am J Roentgenol 2005;184:812–20.

(11) Capussotti L, Ferrero A, Vigano L, Sgotto E, Muratore A, Polastri R. Bile leakage and liver resection: where is the risk? Arch Surg 2006;141(7):690–4.

(12) Catalano OA, Singh AH, Uppot RN, Hahn PF, Ferrone CR, Sahani DV. Vascular and biliary variants in the liver: implications for liver surgery. Radiographics 2008;28:359–78.

(13) Bassignani MJ, Fulcher AS, Szucs RA, Chong WK, Prasad UR, Marcos A. Use of imaging for living donor liver transplantation. Radiographics 2001;21(1):39–52.

(14) Limanond P, Raman SS, Ghobrial RM, Busuttil RW, Lu DSK. The utility of MRCP in preoperative mapping of biliary anatomy in adult-to adult living related liver transplant donors. J Magn Reson Imaging 2004;19:209–15.

(15) Yeh M, Breiman RS, Taouli B, Qayyum A, Roberts JB, 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;230:645–51.

(16) Masci E, Toti G, Mariani A, Curioni S, Lomazzi A, Dinelli M, et al. Complications of diagnostic and therapeutic ERCP: a prospective multicenter study. Am J Gastroenterol 2001;96: 417–423.

(17) Goyen M, Schroeder T, Ruehm S, Debatin F. MR-based assessment of potential living related liver donors. Eur Radiol Suppl 2004;14(7):36–40.

(18) Delaney L, Applegate KE, Karmazyn B, Akisik F, Jennings G. MR cholangiopancreatography in children: feasibility, safety, and initial experience. Pediatr Radiol 2008;38:64–75.

(19) Lee WK, Shannon SP. 3-Tesla magnetic resonance imaging (MRI) – is it ready for prime time clinical applications? Can J Med Radiat Technol 2007:37–50.

(20) Huang TL, Cheng YF, Chen CL, Lee TY. Variants of the bile ducts: clinical application in the potential donor of living related hepatic transplantation. Transplant Proc 1996;28:1669–70.

(21) 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;239:82–6.

(22) Les voies biliaires CJ. In: Chevrel JP, editor. Anatomie clinique, Le tronc. Paris: Springer; 1994. p. 416.

(23) 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.

(24) Mortele KJ, Ros PR. Anatomic variants of the biliary tree: MR cholangiographic findings and clinical applications. AJR Am J Roentgenol 2001;177:389–94.

(25) Park CH, Cho HJ, Kwack EY, Choi CS, Kang IW, Yoon JS. Intrahepatic biliary duct anatomy and its variations. J Korean Radiol Soc 1991;27:827–31.

(26) Caruso S, Miraglia R, Maruzzelli L, Gruttadauria S, Luca A, Gridelli B. Imaging in liver transplantation. World J Gastroenterol 2009;15(6):675–83.

(27) Karakas HM, Celik T, Alicioglu B. Bile duct anatomy of the Anatolian Caucasian population: Huang classiWcation revisited. Surg Radiol Anat 2008;30:539–45.

(28) Dusunceli E, Erden A, Erden I. Anatomic variations of the bile ducts: MRCP findings. Tani Girisim Radyol 2004;10:296–303.

(29) 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 2005;79:1417–21.

(30) Cheng YF, Huang TL, Chen CL, Chen YS, Lee TY. Variations of the intrahepatic bile ducts: application in living related liver transplantation and splitting liver transplantation. Clin Transplant 1997;11:337–40.

(31) Kitami M, Takase K, Murakami G, Ko S, Tsuboi M. Types and frequencies of biliary tract variations associated with a major portal venous anomaly: analysis with multi-detector row CT cholangiography. Radiology 2006;238:156–66.

(32) Ozsoy M, Zeytunlu M, Kilic M, Alper M, Sozbilen M. The results of vascular and biliary variations in turks liver donors: comparison with others. International Scholarly Research Network. Surgery ISRN. doi:10.5402/2011/367083.

(33) Turner MA, Fulcher AS. The cystic duct: normal anatomy and disease processes. Radiographics 2001;21:3–22.

(34) Champetier J, Letoublon C, Alnaasan I, Charvin B. The cysticohepatic ducts: surgical implications. Surg Radiol Anat 1991;13:203–11.

(35) Wietzke-Braun P, Braun F, Muller D, Lorf T, Ringe B, Ramadori G. Adult-to-adult right lobe living donor liver transplantation: comparison of endoscopic retrograde cholangiography with standard T2-weighted magnetic resonance cholangiography for the evaluation of donor biliary anatomy. World J Gastroenterol 2006;12:5820–5.