ANATOMIC BASES OF MEDICAL, RADIOLOGICAL AND SURGICAL TECHNIQUES

3-T MRI of the biliary tract variations

Hakan Önder · Muhammed Sıddık Özdemir ·
Güven Tekbaş · Faysal Ekici · Hatice Gümüş ·
Aslan Bilici

Abstract

Purpose The gallbladder and the biliary tract are structures in close connection with the adjacent organs and may show a number of variations and anomalies. It is therefore important for surgical purposes to know their anatomy and variations in detail. Various methods are used in the imaging of the variations of the biliary tract and its pathologies, including ultrasonography, computed tomography; direct cholangiographic methods like endoscopic retrograde cholangiopancreatography, percutaneous transhepatic cholangiography, intravenous cholangiography and T-tube cholangiography, as well as indirect methods like magnetic resonance cholangiopancreatography (MRCP) or cholescintigraphy. The aim of this study is to investigate the frequency of the anatomic variations of the biliary tract using 3-T MRCP and to compare the findings with the data in the literature.

Materials and methods For the purposes of this study, patients who underwent MRCP at our hospital (Dicle University Hospital) between November 2009 and February 2012 were investigated retrospectively. A total of 590 patients (between 6 and 88 years of age; mean age: 51 ± 9 years) were included in the study. The MRCP imaging was carried out with an magnetic resonance imaging (MRI) device supplied with 3-T magnetic power and by obtaining T2-weighted images through the single-shot fast spin echo technique using the standard body coil. The axial and coronal source images and the reformatted images were evaluated together in terms of the possible anatomic variations.

Results Among the 590 patients included in the study, of 233 (39.5 %) showed anatomic variations at different levels in the intra- and extrahepatic biliary tracts. Among these variations, a right posterior hepatic duct insertion to the left hepatic duct at the level of the bifurcation has been observed in 71 patients (12.1 %), trifurcation was observed in 30 patients (5.1 %) and insertion into the main hepatic duct at the proximal aspect of the cystic duct was observed in 18 patients (3.1 %). At the level of the cystic duct, medial insertion of the cystic duct was viewed in 58 patients (9.8 %), distal medial insertion was seen in 40 patients (6.8 %), a short cystic duct was detected in 10 patients (1.7 %), pancreatobiliary junction anomaly was viewed in two patients (0.4 %) and duplicate anatomic variations have been observed in 42 patients (7.2 %).

Conclusion MRCP studies conducted using 3-T MRI devices may reveal similar or greater numbers of variations when compared to the existing MRCP studies in the literature. 3-T MRI shows a couple of variations. Pointing out these anatomical variations before the surgical intervention may prevent possible iatrogenic traumas. Donors with unsuitable variations for liver transplant may be spotted out at an early phase through the MRCP and certain operations with a high morbidity rate may thus be avoided.

Keywords Bile duct anatomy · Biliary tract · Magnetic resonance cholangiopancreatography · 3-T magnetic resonance imaging · Variation

H. Önder (✉) · G. Tekbaş · F. Ekici · H. Gümüş · A. Bilici
Department of Radiology, Dicle University Medical Faculty,
Diyarbakır 21280, Turkey
e-mail: drhakanonder@hotmail.com

M. S. Özdemir
Department of Radiology, Cizre State Hospital, Şırnak, Turkey

Introduction

The biliary tract is anatomically divided into two sections as intra- and extrahepatic ducts. The distribution of the intrahepatic biliary ducts is in harmony with the segmental

anatomy of the liver. According to the classification by Couinaud, the liver is divided into eight segments, each one having its own vascularisation, and biliary and venous drainage systems [16]. The main hepatic branches maintaining the drainage of the right and left lobes are formed by the junction of the segmental ducts [22]. The right and left hepatic ducts merge to form the common hepatic duct. More distally, the cystic duct joins the common hepatic duct to form the coledochus. The coledochus joins the pancreatic duct and leads to the sphincter of oddi at the second part of the duodenum [16, 22].

The gallbladder and the biliary tract are structures in close connection with the adjacent organs and may show various variations and anomalies. It is therefore important for surgical purposes to know their anatomy and variations in detail [16]. The biliary tract is under the threat of iatrogenic damage during open or laparoscopic cholecystectomy or liver resection surgery and liver transplants from live donors. Also, the anatomic variations of the biliary system have been reported to lay the ground for the formation of gallstones, recurrent pancreatitis, cholangitis and biliary malignancies [9]. Various methods are used in the imaging of the variations of the biliary tract and their pathologies, including ultrasonography (USG), computed tomography (CT); direct cholangiographic 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. The uses of USG and CT for these purposes are limited and these methods bring extra advantages only if a dilatation is present in the biliary tract [6, 18, 21]. Intravenous cholangiography also has certain limitations, the leading one being the low quality of the anatomic imaging due to the inadequate opacification of the cystic duct [13]. The imaging of the biliary tract through direct contrast agent injection is performed in the PTC, ERCP, T-tube or intraoperative cholangiography techniques [18, 21]. MRCP is a magnetic resonance imaging (MRI) technique using T2-weighted sequences to evaluate the anatomy and pathologies of the pancreatobiliary system noninvasively and without contrast injection. With the help of this imaging technique, the intra- and extrahepatic biliary tracts can be evaluated rapidly, reliably and without the risk of complications [6].

3-T MRI has a higher signal-to-noise ratio than 1.5-T MRI. Until recently, MRI devices with a magnetic power of 1.5 T or less were used in the studies investigating the anatomic variations of the biliary system. In the present study, our aim is to investigate the frequency of the anatomic variations of the biliary tract using 3-T MRCP.

Materials and methods

Patient population

Patients who had undergone MRCP procedures at our hospital between November 2009 and February 2012 were retrospectively evaluated. The MRCPs included in the study were carried out in relation with stone formations, cholecystitis, cholangitis, malignancies, parasites and for various investigations on the biliary tract. All the male and female patients whose bile ducts could be viewed were included in the study without any age limit. Patients who had a history of surgery on the biliary tract except for cholecystectomy, whose images could only be inadequately evaluated due to significant respiratory artefacts during the imaging; and those with prosthetics incompatible with the MRI, pacemakers or metallic stents were excluded from the study. A total of 590 patients (between 6 and 88 years of age; mean age 51 ± 9 years) were enrolled for the purposes of the study. Approval was obtained from the Ethics Committee of the Dicle University Medical School before the initiation of the study.

Imaging

MRCP was carried out with an MRI device supplied with 3-T magnetic power (Philips, Eindhoven, Netherland) and using the standard body coil. Patients were informed about the MCRP imaging and the procedures were carried out in the radiology department of our hospital following a 6-h fasting period and after any metal items or objects on the patients which may produce artefacts were removed.

Before the imaging, T2-weighted images were obtained using the two-dimensional "single-shot fast spin echo" (SSFSE) technique as the pulse sequence. The choledochus was located in the images in the axial plane, and coronal images were obtained using the sense-magnetic resonance cholangiopancreatography-three dimensional-high resolution (S MRCP-3D-HR) sequence from the zone commencing a few centimetres above the porta hepatis and ending at the ampulla of Vater. Cross-sections of 1 mm were taken without any cross-sectional intervals. During the post processing, a radial maximal intensity projection (MIP) was performed in order to produce the three-dimensional images. Taking the point where the coledochus was located in the source images in the axial plane as the centre, slabs have been obtained from the coronal or coronal oblique planes, with 35–40 mm thick volumes and each passing through this centre. While each thick cross-section was taken, the duration of breath-hold for the patients was determined as 4.5 s.

Imaging parameters in this sequence were set as follows: repetition time (TR): shortest, echo time (TE): 740 msn,

band width (BW): 805 Hz/pixel, FA = 90°, FOV; FH = 30 cm, RL = 22.5 cm, AF = 8 cm, Acq matrix: 256 × 153 and NSA: 1. In order to reduce breathing artefacts, the sequences were synchronised with the patients' breathing using the trigger function of the device. In addition, coronal images were made using the sense single-shot-magnetic resonance cholangiopancreatography (Ssh-MRCP rad) sequence (breath-hold). In the coronal plane, the settings were as follows: TR: shortest, TE: 40 msn, BW: 408.1 Hz/pixel, FA = 90°, FOV; FH = 30 cm, RL = 30 cm, Acq matrix: 320 × 256 and NSA: 1.

After the imaging was completed, unwanted sections like the intestinal contents were removed from the three-dimensional reformatted images obtained using the MIP method. Thus, the images were rendered more cognizable. No oral or intravenous contrast agents were used during the procedure. It took about 20–25 min to prepare the patients and perform the procedure. No anaesthetic support was needed for any of the patients.

Evaluation of the 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 evaluation was carried out by two experienced radiologists. In the definition of the variations detected through MRCP, the following pre-defined criteria were used [18]:

Confluence of the right anterior and posterior ducts, and the common ducts of the segments 1, 2 and the segments 3, 4 at the quadrifurcation were taken into consideration [18].

The insertion of the right posterior hepatic duct to the common hepatic duct or the cystic duct at the distal aspect of the bifurcation was evaluated as an aberrant right hepatic duct variation; while its insertion into the left hepatic duct at a level close to the confluence of the right anterior hepatic duct was evaluated as a trifurcation. Drainage of the right posterior segmental duct into the left hepatic duct is another variation which may be observed at the level of the bifurcation [21, 22].

Insertion of the cystic duct into the one-third distal aspect of the extrahepatic bile duct was assessed as a long cystic duct or distal insertion; an insertion from the left was evaluated as a medial insertion, and a cystic duct length <5 mm was evaluated as a short cystic duct [1, 21, 22].

For a high localized gallbladder, the following criteria have been determined: at least half of the gallbladder located above the portal hilus, fundus located towards the superior aspect and the cystic duct directed cranially along its whole course.

The view produced by the right hepatic artery compressing the common hepatic duct frontally and causing a signal-free area within the duct similar to an intraluminal filling defect has been evaluated as vascular compression on the common hepatic duct [3].

For a pancreatobiliary junction anomaly, the criterion was the fusion of the common bile duct (choledochus) with the pancreatic duct at the proximal aspect of the duodenum to form a 15 mm or longer common duct [5, 18].

Pancreas divisum is an anatomical variation that occurs due to a lack in the fusion of the dorsal and ventral pancreatic ducts. The choledochus and the ventral pancreatic duct (Wirsung) drain into the major papilla, while the dorsal pancreatic canal (Santorini) drains into the minor papilla [12, 15]. For the purposes of the present study, the condition where the main pancreatic duct that drains the tail and body of the pancreas (Santorini) crosses the choledochus frontally and is inserted into the duodenum separately and more proximally from the choledochus was accepted as an adequate finding for the diagnosis of pancreas divisum [2].

The frequency in which the variations described in previous studies were detected in our study was expressed as percentage.

Results

Among the 590 patients included in the study, 200 were male (33.9 %), while 390 were female (66.1 %). The mean age was 54 ± 7 years in males and 50 ± 8 years in females. Variations at various levels were detected in 233 (39.5 %) of all the patients. Among these, 30 patients (12.5 %) had a history of cholecystectomy. The distribution of the variations among the patients are summarised in Table 1.

In this study, a total of 275 variations were observed. Among these, a single variation was found in 191 patients (32.3 %), while 2 variations were detected in 42 patients (7.2 %). The most commonly observed variation at the level of the bifurcation was the insertion of the right posterior segmental branch into the left hepatic duct in 71 patients (12.1 %) (Fig. 1). On the other hand, the most commonly observed variation at the level of the cystic duct was the medial cystic duct insertion in 58 patients (9.8 %) (Fig. 2).
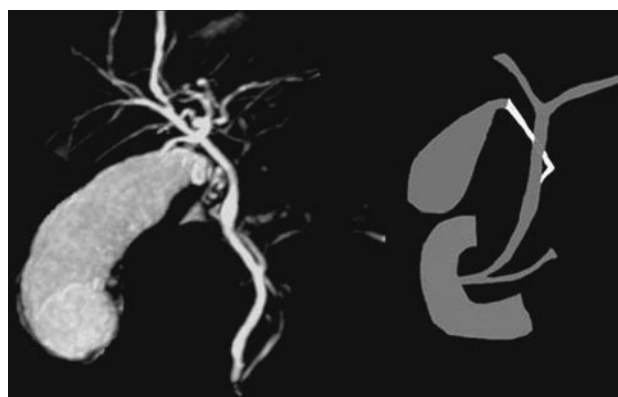
Details of the 42 patients, in which duplicate variations were detected, are summarised in Table 2. According to these results, the most commonly observed duplicate variations were the medial insertion of the cystic duct into the main hepatic duct due to the fusion of the right posterior segmental branch with the left hepatic duct (11 patients) (Fig. 3), distal medial insertion of the cystic duct into the main hepatic duct due to the fusion of the right posterior segmental branch with the left hepatic duct (7 patients), and the medial insertion of the cystic duct into the main hepatic duct with trifurcation (5 patients).

Table 1 Distribution of the variations in the patients, in whom single variations were detected using the MRCP

	Number of variations
Variations in the bifurcation level	
Right posterior hepatic duct insertion into the left hepatic duct	71
Trifurcation	30
Aberrant right hepatic duct (insertion into the main hepatic duct proximally at the cystic duct)	18
Quadrifurcation	10
Aberrant right hepatic duct (insertion into the cystic duct with a right lateral fusion with the main hepatic duct)	4
Aberrant right posterior duct (Insertion into the cystic duct with a medial fusion into the main hepatic duct)	1
Duplication variant (fusion of the gallbladder with the right hepatic duct and fusion with the left hepatic duct proximally at the ampulla)	1
Variations at the cystic level	
Medial cystic duct insertion	58
Distal medial insertion	40
Short cystic duct	10
Long cystic duct	8
Insertion of the cystic duct into the right hepatic duct	2
Medial fusion of the main hepatic duct into the cystic duct and insertion in combination into the ampulla	1
Variations at the level of the pancreatobiliary junction	
Pancreatobiliary junction anomaly	1
Pancreas divisum	1
Other variations	
Vascular compression on the common hepatic duct	17
High localized gall bladder	2
Total	275

Fig. 1 Right posterior segmental branch insertion into the left hepatic duct in MRCP (**a**) and the schematic view (**b**)

Fig. 2 Medial insertion of the cystic duct in MRCP (**a**) and the schematic view (**b**)

Discussion

Anatomical variations of the biliary tract were observed in 233 (39.5 %) of the 590 patients included in the study. When the variations are divided into groups as those at the bifurcation level, cystic duct level, pancreatobiliary junction level and those outside these classifications, it has been found out that the most frequently observed variation in general and at the bifurcation level was the drainage of the right posterior hepatic duct into the left hepatic duct before the bifurcation, which was observed in 71 patients (12.2 %). The most frequently observed variation at the level of the cystic duct was medial insertion observed in 58 patients (9.8 %). At the pancreatobiliary junction level, a pancreatobiliary junction anomaly was detected in 1 patient (0.2 %), while a pancreas divisum was viewed in 1 patient

(0.2 %). Among the other anomalies, vascular compression on the common hepatic duct was observed in 17 patients (2.9 %) and a high located gallbladder was observed in 2 patients (0.3 %). With duplicate variations in 42 cases, the total number of the detected variations was 275.

MRCP is a non-invasive imaging method with a low risk of complication and an accuracy rate matching ERCP in pancreatobiliary diseases. The method does not involve any ionising radiation, contrast agent injection or premedication [6]. The fact that it can be applied during acute attacks of pancreatitis and cholangitis is able to reveal the bile ducts both in the proximal and distal aspects of the stricture, gives the chance to view the extraductal structures as well as the conventional T1-T2-weighted images, and can detect the stricture in bilioenteric anastomoses constitute the strengths of this method in comparison to ERCP. On the other hand, the limitations of MRCP are its low resolution, inability to show minor ductal pathologies and the hindrance to perform therapeutic interventions during the

Table 2 Distribution of the variations in the patients, in whom duplicate variations were detected using the MRCP	Variations	Number of patients	Ratio to the total number of patients (%)
	Insertion of the right posterior segmental branch into the left hepatic duct and medial cystic duct insertion into the main hepatic duct	11	1.9
	Insertion of the right posterior segmental branch into the left hepatic duct and distal medial cystic duct insertion into the main hepatic duct	7	1.2
	Medial insertion of the cystic duct into the main hepatic duct with trifurcation	5	0.8
	Distal medial insertion of the cystic duct into the main hepatic duct and cystic artery compression on the main hepatic duct	3	0.5
	Proximal insertion of the cystic duct into the main hepatic duct and distal medial insertion of the cystic duct into the main hepatic duct	3	0.5
	Insertion of the right posterior segmental branch into the left hepatic duct and cystic artery compression on the main hepatic duct	2	0.3
	Insertion of the right posterior segmental branch into the left hepatic duct and distal lateral fusion of the cystic duct to the main hepatic duct (long cystic duct)	2	0.3
	Distal medial insertion of the cystic duct into the main hepatic duct with trifurcation	2	0.3
	Distal lateral insertion of the cystic duct into the main hepatic duct with trifurcation (long cystic duct)	1	0.2
	Variations where the cystic duct is proximally or medially inserted into the main hepatic duct	1	0.2
	Proximal insertion of the cystic duct into the main hepatic duct and short cystic duct	1	0.2
	Distal medial insertion of the cystic duct into the main hepatic duct with quadrifurcation	1	0.2
	Medial insertion of the cystic duct into the main hepatic duct with quadrifurcation	1	0.2
	Long cystic duct, distal lateral insertion of the cystic duct with the main hepatic duct and cystic artery compression on the main hepatic duct	1	0.2
	Combined insertion of the cystic duct and the main hepatic duct into the ampulla and distal medial insertion of the cystic duct into the main hepatic duct	1	0.2
	Total	42	7.2

Fig. 3 Fusion of the right posterior segmental branch with the left hepatic duct and medial insertion of the cystic duct into the main hepatic duct in MRCP (**a**), schematic view (**b**) and MIP images (**c**) (duplicate variations)

procedure [23]. In the literature, there are studies reporting a lower [6] or similar [4] number of variations compared to our study.

Although the anatomic variations of the biliary system are usually of no clinical importance, they may lead to confusions during diagnostic examinations. Also, these

variations may complicate endoscopic or percutaneous interventions, open or laparoscopic cholecystectomy operations and liver transplantations from live donors, leading to iatrogenic traumas [5, 16, 21, 22].

The right hepatic artery may compress on the common hepatic duct from outside and leads to an image similar to an intraluminal filling defect caused by a stone or stricture present in the duct [19, 20]. In a study performed on 475 patients using a 1-T MRI device, 12 patients (2.5 %) had this variation [4]. In our study, 17 patients (2.9 %) were observed to have this variation and the ratio was in line with the literature. This variation may be mistaken for a cystic artery during the operation and thus surgically closed, leading to serious complications like the disturbance of liver functions [16]. The typical view and location help the viewer to distinguish the condition from an actual filling defect [16]. However, if doubts related to the defect are still continuing, the hepatic artery crossing the common hepatic artery may be revealed with an MRI angiography performed during the same session [19, 20].

In a study conducted on 475 patients using a 1-T MRI device, a total of 115 patients (24.2 %) were observed to have various anatomic anomalies at different levels. Another study carried out on 122 patients with a 1.5-T MRI device revealed various anatomic anomalies at different levels of the intra- and extrahepatic bile ducts of 31 patients (25.2 %) [6, 18].The most commonly observed variations in both studies were the drainage of the right posterior hepatic duct into the left hepatic duct in 27 (5.7 %) and 8 patients (6.4 %), respectively. Again, the most commonly observed variation in two separate studies other than the above-mentioned ones was the drainage of the right posterior hepatic duct into the left hepatic duct. However, the ratios of the variations observed in these were higher than the previous ones with 13 and 19 % and these results were also in line with our findings [8, 17]. The most commonly viewed variation in our study was the drainage of the right posterior hepatic duct into the left hepatic duct and it was detected in 71 patients, with a frequency of 12.5 %. Also, the frequency of duplicate variations observed in 42 patients (7.2 %) in our study was significantly higher compared to the 11 patients (2.3 %) in the previous study conducted on 475 patients [6]. We are of the opinion that the use of the 3-T MRI with a higher resolution plays an important role in these different results.

In liver transplants from live adult donors, usually the right lobe of the liver is transplanted and the right bile duct is also included in the graft. In the choledococholedocostomy and choledochojejunostomy methods, the graft and the bile ducts of the receiver are anastomosed [11]. In normal biliary anatomy (bifurcation), it is relatively easier to perform a single biliary-enteric anastomose. However, in case of trifurcations or the variations where the right

posterior hepatic canal is inserted into the left hepatic canal or the main hepatic canal, two anastomoses are needed in order to prevent bile leaks or segmental atrophy which may develop subsequent to the surgery.

The technique requiring two anastomoses is more complicated and these individuals are not regarded as donors and usually screened out. The standard surgical techniques in use provide that the bifurcations where the right posterior hepatic duct is inserted at a point closer than 1 cm to the bifurcation are accepted as trifurcations [10, 11]. To the best of our knowledge, a variation we have come across the patient in our study (0.8 %), which involves the combined insertion of the cystic duct and the main hepatic duct into the ampulla is the first one observed in MRI studies, although it has been reported in surgical studies in the literature [14] (Fig. 4).

Intraoperative cholangiography is a traditional method used to view the biliary anatomy before right hepatic lobe resections [7]. Performed under optimum conditions, intraoperative cholangiography provides a high-quality view of the biliary tract. However, due to the inconvenient conditions during the surgery, this method may not always be performed successfully. A study revealed that intraoperative cholangiography performed on 20 patients has
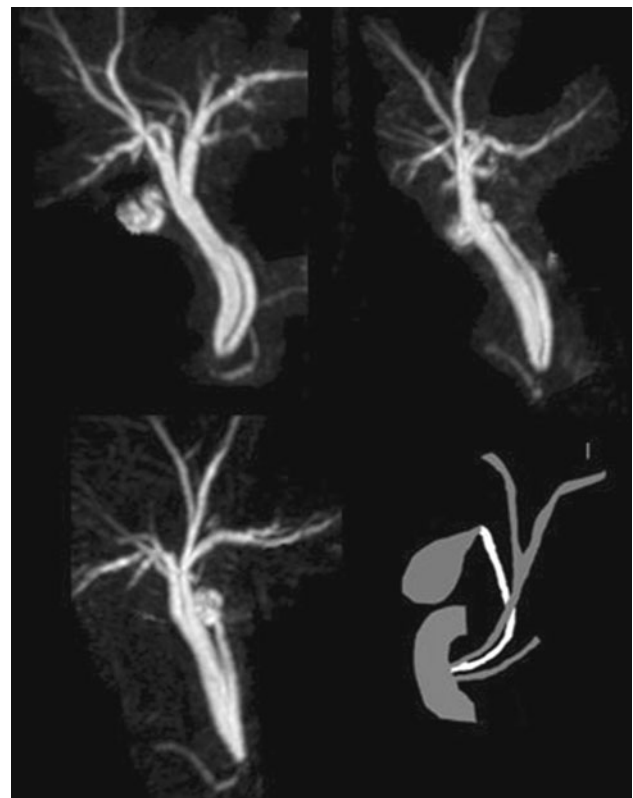

Fig. 4 The variation in MRCP where the cystic duct and the main hepatic duct are inserted to the ampulla in combination (**a**–**c**) and the schematic view (**d**)

provided high-quality results suitable for an appropriate evaluation of the left and right central hepatic ducts in nine patients (45 %). On the other hand, during an MRI cholangiography, the central ducts could be fully revealed in 25 out of 28 patients (89 %). Investigators claim that the MRI technology is still developing and it may replace intraoperative cholangiography during right lobe resections and shorten the duration of the surgery in the future [21]. In our study, the MRCPs of 85 patients (12.6 %) were in an inferior condition preventing assessment and were therefore excluded from the study. Since intraoperative cholangiography is not performed in our hospital, we did not have the chance to make a comparison with MRCP.

The limitations of the study resulted from the relative difficulty in the evaluation of the biliary tracts of the study patients with pathological findings. Also, since we could not compare 3-T MRCP and intraoperative cholangiography in this study, we could not evaluate if any of the patients who underwent MRCP needed intraoperative cholangiographies.

In conclusion, the 3-T MRCP we performed has revealed similar or higher numbers of variations compared to the studies with 1- and 1.5-T devices. Accordingly, since MRCP procedures performed with 3-T devices reveal more variations, the method may reduce iatrogenic traumas like the closure or resection of the wrong duct and thus significantly reduce the mortality and morbidity rates in open or especially laparoscopic cholecystectomy, hepatic segmentectomy or lobectomy operations and the ever-increasing transplantation surgeries. Also, donors with variations rendering them unsuitable for liver transplantations may be determined through MRCP and screened out to prevent operations with high morbidity risk.

References

1. Choi E, Byun JH, Park BJ, Lee MG (2007) Duplication of the extrahepatic bile duct with anomalous union of the pancreaticobiliary ductal system revealed by MR cholangiopancreatography. Br J Radiol 80(955):150–154
2. Cotton PB (1980) Congenital anomaly of pancreas divisum as a cause of obstructive pain and pancreatitis. Gut 21(2):105–114
3. David V, Reinhold C, Hochman M, Chuttani R, McKee J, Waxman I, Wang L, Li W, Kaplan R, Edelman RR (1998) Pitfalls in the interpretation of MR cholangiopancreatography. AJR Am J Roentgenol 170:1055–1059
4. De Filippo M, Calabrese M, Quinto S, Rastelli A, Bertellini A, Martora R, Sverzellati N, Corradi D, Vitale M, Crialesi G, Sarli L, Roncoroni L, Garlaschi G, Zompatori M (2008) Congenital anomalies and variations of the bile and pancreatic ducts: magnetic resonance cholangiopancreatography findings, epidemiology and clinical significance. Radiol Med 113:841–859
5. Dohke M, Watanabe Y, Okumura A, Amoh Y, Oda K, Ishimori T, Koike S, Hayashi T, Hiyama A, Dodo Y (1999) Anomalies and anatomic variants of the biliary tree revealed by MR cholangiopancreatography. AJR Am J Roentgenol 173:1251–1254
6. Düşünceli E, Erden A, Erden I (2004) Anatomic variations of the bile ducts: MRCP findings. Diagn Interv Radiol 10:296–303
7. Fulcher AS, Szucs RA, Bassignani MJ, Marcos A (2001) Right lobe living donor liver transplantation: preoperative evaluation of the donor with MR ımaging. AJR Am J Roentgenol 176:1483–1491
8. Gazelle GS, Lee MJ, Mueller PR (1994) Cholangiographic segmental anatomy of the liver. Radiographics 14(5):1005–1013
9. Heller SL, Lee VS (2005) MR imaging of the gallbladder and biliary system. Magn Reson Imaging Clin N Am 13(2):295–311
10. Huang TL, Cheng YF, Chen CL, Chen TY, Lee TY (1996) Variants of the bile ducts:clinical application in the potential donor of living-related hepatic transplantation. Transpl proc 28(3):1669–1670
11. Karakas HM, CelikT Alicioglu B (2008) Bile duct anatomy of the anatolian Caucasian population: Huang classification revisited. Surg Radiol Anat 30(7):539–545
12. Leyendecker JR, Elsayes KM, Gratz BI, Brown JJ (2002) MR cholangiopancreatography: spectrum of pancreatic duct abnormalities. AJR Am J Roentgenol 179:1465–1471
13. Martin RF, Rossi RL (1994) Bile duct injuries: spectrum, mechanisms of injury, and their prevention. Surg Clin North Am 74(4):781–807
14. Meredith G. Beaver (1929) Variations in the extrahepatic biliary tract. Reprinted from the Archives of Surgery August vol. 19, pp 321–326
15. Morgan DE, Logan K, Baron TH, Koehler RE, Smith JK (1999) Pancreas divisum: implications for diagnostic and therapeutic pancreatography. AJR Am J Roentgenol 173(1):193–198
16. Mortele K, Ros PR (2001) Anatomic variants of the biliary tree: MR cholangiographic findings and clinical applications. AJR Am J Roentgenol 177:389–394
17. Puente SG, Bannura GC (1983) Radiological anatomy of the biliary tract: variations and congenital abnormalities. World J Surg 7(2):271–276
18. Sai J, Ariyama J (2000) MR cholangiopancreatography: early diagnosis of pancreatobiliary disease, 1st edn. Springer, Tokyo, pp 23–28
19. Schwartz SI (1999) Gallbladder and extrahepatic system. In: Schwartz SI, Shires GT, Spencer FC et al (eds) Principles of surgery, 7th edn. McGraw-Hill, New York
20. Smadja C, Blumgarth LH (1994) The biliary tract and the anatomy of biliary exposure. In: Blumgarth LH (ed) Surgery of the liver and biliary tract. Churchill-Livingstone, New York, pp 11–21
21. Taourel P, Bret PM, Reinhold C, Barkun AN, Atri M (1996) Anatomic variants of the biliary tree: diagnosis with MR cholangiopancreatography. Radiology 199(2):521–527
22. Van Hoe L, Vanbeckevoort D, Steenbergen WV (2001) Atlas of MR cholangiopancreatcography, 1st edn. Springer-Verlag, Berlin, pp 54–59
23. Varghese JC, Farrell MA, Courtney G, Osborne H, Murray FE, Lee MJ (1999) Role of MR cholangiopancreatography in patients with failed or inadequate ERCP. AJR Am J Roentgenol 173: 1527–1533