Medical Journal of Bakırköy

Med J Bakirkoy 2025;21:83-89
DOI: 10.4274/BMJ.galenos.2024.2024.8-3

Research

Anatomical Study of Bile Ducts by Magnetic Resonance Cholangiopancreatography

Safra Kanallarının Manyetik Rezonans Kolanjiyopankreatografi ile Anatomik Değerlendirmesi

Tahir Fatih Dikici[1], Zeliha Fazlıoğulları[2], Ayşe Gamze Özcan[2], Mustafa Koplay[3], Ahmet Kağan Karabulut[2], İsmihan İlknur Uysal[4], Nadire Ünver Doğan[2]

[1]Alanya Alaaddin Keykubat University, Vocational School of Health Services, Department of Therapy and Rehabilitation, Antalya, Türkiye
[2]Selçuk University Faculty of Medicine, Department of Anatomy, Konya, Türkiye
[3]Selçuk University Faculty of Medicine, Department of Radiology, Konya, Türkiye
[4]Necmettin Erbakan University Meram Faculty of Medicine, Department of Anatomy, Konya, Türkiye

ABSTRACT

Objective: A variety of anatomical variations in the intrahepatic and extrahepatic bile ducts (BD) may cause different problems during surgical intervention. Therefore, the objective of this study was to investigate the prevalence and types of anatomical variations in BD in normal patients.

Methods: The present study evaluated magnetic resonance cholangiopancreatography (MRCP) images of 303 patients (146 men, 157 women). The objective of this study was to evaluate variations in the intrahepatic and extrahepatic BD and anatomical variations in the gallbladder. The biliary confluence angle, diameter of the common BD prior to its union with the pancreatic duct, diameter of the duct formed by their junction, and length of the short cystic duct (CD) were also evaluated.

Results: In this study, anomaly of the right posterior duct opening to the left hepatic duct (HD) was found in 12 cases (4%), trifurcation variation in 26 cases (8.6%), and abnormal variation of the aberrant right HD opening to the common HD in 15 cases (5%). Corresponding to the CD, a long CD variation was found in 20 cases (6.6%) and a short cystic channel variation in 7 cases (2.3%). In addition, a negative correlation was found between age and angle of confluence. A significant correlation was found between long CD variation and stone formation.

Conclusion: Anatomic investigation of the BD using the non-invasive MRCP technique and the definition of variations are of great importance in terms of assisting surgical planning, minimizing the likelihood of complications during operations, and facilitating transplantation surgery.

Keywords: Bile ducts, cholangiopancreatography, variation

ÖZ

Amaç: İntrahepatik ve ekstrahepatik safra kanallarında (BD) görülebilen çeşitli anatomik varyasyonlar, cerrahi girişimlerde değişik problemlere yol açabilmektedir. Bu nedenle çalışmamızda normal olgularda BD'nin anatomik varyasyonlarının görülme sıklığını ve tiplerini araştırmayı amaçladık.

Gereç ve Yöntem: Çalışmada manyetik rezonans kolanjiyopankreatografi (MRCP) çekilen 303 olgunun (146 erkek, 157 kadın) görüntüleri değerlendirmiştir. Bu olgularda intrahepatik ve ekstrahepatik BD'nin varyasyonları ile safra kesesinin anatomik varyasyonları belirlenmiştir. Ayrıca biliyer konfluens açısı, ductus choledochus'un ductus pancreaticus ile birleşmeden önceki çapı ve birleşimi ile oluşan kanalın çapı ve kısa sistik kanal uzunluğu ölçülmüştür.

Bulgular: Çalışmada 12 olguda (%4) ductus hepaticus sinister'e açılan ductus segmentalis posterior dexter anomalisi, 26 olguda (%8,6) trifurkasyon varyasyonu, 15 olguda (%5) ductus hepaticus communis'e açılan aberran sağ hepatik kanal varyasyonu belirlendi. Yirmi olguda (%6,6) uzun sistik kanal varyasyonu, 7 olguda (%2,3) kısa sistik kanal varyasyonu tespit edildi. Ayrıca yaş ile konfluens açısı arasında negatif yönde bir ilişki, uzun sistik kanal varyasyonu ile taş oluşumu arasında anlamlı ilişki olduğu bulunmuştur.

Sonuç: Günümüzde kullanılan MRCP tekniği ile non-invaziv olarak BD'nin anatomik değerlendirmesi ve varyasyonlarının belirlenmesi; cerrahi planlamaya yardımcı olması, operasyonlar sırasında oluşabilecek komplikasyonların en aza indirilmesi ve transplantasyon cerrahisinde yardımcı olması yönünden önemlidir.

Anahtar Kelimeler: Safra yolları, kolanjiopankreatografi, varyasyon

Address for Correspondence: Zeliha Fazlıoğulları, Selçuk University Faculty of Medicine, Department of Anatomy, Konya, Türkiye
E-mail: z_topal@yahoo.com; ztopal@selcuk.edu.tr **ORCID ID:** orcid.org/0000-0002-5103-090X

Cite as: Dikici TF, Fazlıoğulları Z, Özcan AG, Koplay M, Karabulut AK, Uysal İİ, et al. Anatomical study of bile ducts by magnetic resonance cholangiopancreatography. Med J Bakirkoy. 2025;21:83-89

Received: 13.09.2024
Accepted: 21.10.2024
Publication Date: 25.03.2025

INTRODUCTION

Bile is produced in the liver and transported to the duodenum via the bile ducts (BD). The ducts are divided into two categories: Intrahepatic and extrahepatic BD. The BD up to the porta hepatis is designated as intrahepatic BD, whereas the BD after the porta hepatis is classified as extrahepatic BD (1). The anatomy of the intrahepatic BD was consistent with the segmental anatomy of the liver, as defined by the Couniaud classification. The two channels are formed by the union of the segmental ducts. Of these channels, the right hepatic duct (HD) drains the right lobe of the liver and the right half of the caudate lobe, while the left HD drains the left lobe of the liver, the quadrate lobe, and the left half of the caudate lobe. The fusion of these two channels forms the common HD. In addition, the angle formed at the junction of these two channels is referred to as the biliary confluency angle (2). The common BD is formed by the opening of the cystic duct (CD) into the common HD, occurring approximately in the middle portion of the porta hepatis and the ampulla of Vater. The common BD joins with the pancreatic duct (PD) and opens into the second duodenum section. The incidence of normal anatomy of the biliary system is 58% (3). The gallbladder and BD are formations that exhibit considerable variations and anomalies and have close connections in their vicinity. These situations may present challenges for surgeons. The variation in the branching of BD ranges from 24% to 37%. BD variations can be grouped according to their location, including those found at the hepatic bifurcation, CD, and pancreatobiliary junction, as well as other less common variations (4-6). Therefore, surgeons who will be working in the region should be well-versed in the anatomy and variations of this region and exercise caution in the presence of potential discrepancies (7). Magnetic resonance cholangiopancreatography (MRCP) is a magnetic resonance imaging (MRI) technique using the T2 sequence to permit the non-invasive evaluation of the anatomy and pathologies of the pancreaticobiliary system. This method enables rapid, accurate, and non-complication evaluation of the BD without the use of contrast material (8). Anatomical variations in intra-or extrahepatic BD can cause various problems during surgical procedures. It is important to know the formation patterns and anatomical variations of BD to minimize complications that may occur during surgery and to prevent possible errors that may occur during radiological evaluation. In this study, we aimed to investigate the frequency and types of anatomical variations in BD in normal patients.

METHODS

The study included images from 615 patients who underwent MRCP at the Department of Radiology between 2014 and 2016. Ethical approval for the study was obtained from the Local Ethics Committee of the Selçuk University Faculty of Medicine (approval no: 2015/312, date: 08.12.2015). MRCP examinations were performed using standard body perception with a 1.5 Tesla power MRI unit (Magnetom Aera, Siemens, Erlangen, Germany). These examinations were performed with patients fasting for at least 5-6 hours to ensure gallbladder filling and gastrointestinal emptying. T2-weighted images were acquired as a sequence using the 2-dimensional single-shot fast spin echo technique. Evaluation was performed using maximum intensity projection images in the coronal and axial planes. Of the 615 retrospectively reviewed images, 312 patients were excluded from the study if they had undergone surgery to the liver, pancreas, gallbladder, or duodenum, if the anatomic reference points could not be followed due to tumor, or if optimal imaging was not possible. The MRCP images of the remaining 303 patients were analyzed. In these examinations, age, sex, presence or absence of stones in the biliary system, presence of variation at various levels, dilatation, and diameter of the common BD were examined. The following criteria were used to evaluate the identified variations: Variations defined at the level of bifurcation: An anomalous aberrant right HD variation in which the right posterior duct opens directly to common HD or CD; trifurcation variation formed by the right posterior duct at the junction level of the right anterior duct and left HD and the right posterior duct. This is an anomaly of the right posterior duct draining into the left HD.

The opening of the CD into the extrahepatic BD from the left side was defined as medial insertion, the opening of the extrahepatic BD from the distal 1/3 was defined as long CD or distal insertion, and the length of the CD 5 mm was defined as short CD variation. The length of the CD was measured, and short CD variations were found and recorded. The upper localization variation of the gallbladder was defined as when the conditions of at least 1/2 of the gallbladder above the level of the portal hilus, the fundus directed upward, and the CD directed cranially along its course were met. The localization of the transfer was defined by the long axis of the gallbladder perpendicular to the long axis of the common BD and the fundus being in the same plane as the infundibulum in the axial sections. In addition, the appearance of the fundus on the left side of the common BD was also reported as a left

localization variation of the fundus. The separate opening of common BD and PD into the duodenum is a reported variation. When the minor duodenal papilla, proximal to the PD, opened into the duodenum, it was termed pancreatic divisum. The angle formed at the junction of the right and left HDs is defined as the biliary confluence angle. In our study, cases with trifurcation variations were not included in the measurement of confluence angle. Additionally, in cases with aberrant right hepatic variation and drainage anomaly of the right posterior duct to the left HD, the angle formed by the right anterior duct and the left HD was measured and evaluated as the confluence angle. Angle measurements were performed on the MRCP image taken in the coronal view and by measuring the angle at its widest level. The diameter of the common BD before its union with the PD and the diameter of the duct formed by its union were measured. Forty-five cases with dilatation of the common BD due to various reasons and 42 cases in which the MRCP image was not optimized in this region were not included in the diameter measurement. In 7 cases with variations in which the common BD and PD entered the duodenum separately, the diameter of the common BD immediately before entering the duodenum was measured.

Statistical Analysis

Comparisons between two groups were performed using the Mann-Whitney U test when parametric assumptions were not met, and the Student's t-test (Independent Samples t-test) when they were met. Data were summarized as mean, standard deviation, and percentage, and the chi-square test was used to compare categorical variables. A p-value of <0.05 was considered significant. The data were analyzed using IBM SPSS Statistics 21 software.

RESULTS

Of the 303 cases reviewed in our study, 146 (48.2%) were male and 157 (51.8%) were female. The age of the patients ranged from 18 to 92 years (mean 54.49±18.83). The mean age of the male and female patients was 56.12 and 52.97 years, respectively. In 204 of the 303 reviewed cases (67.3%), stones were found at different levels of the gallbladder and BD, and stones were more common in women (35%) than in men (32.3%).

One or more variations were found at different levels of the biliary system in 93 (30.7%) of the 303 cases included in this study. More than one variation was found in 12 (12.9%) cases in which variations were detected. It was determined that 4% of the total 303 cases had multiple variations. In 4 of the 12 cases in which more than one variation was found, long CD and medial insertion variation (mediodistal insertion) were found together.

The most common variation was trifurcation (8.6%). An anomalous right posterior duct draining into the left HD was observed in 12 patients (4%), and aberrant right HD variation was observed in 15 patients (5%) (Figure 1, Table 1).

When CD was evaluated according to its opening into the common HD, the longest CD (6.6%) was the most common. In 5 of these cases (17.8%), both variations occurred together, and the percentage of mesiodistal insertion variation in the total number of cases was 1.7% (Figure 2, Table 1). The mean CD length in cases with short CD variation was measured as 3.63±0.8 mm. When evaluating the location of the gallbladder, we found that it was the most common site of transfer. At the pancreaticobiliary level, in 7 cases (2.3%), the PD and common BD opened into the first part of the small intestine through separate channels. Among these variations, the ratio of pancreas divisum, which was detected in 2 cases (28.5%) patients, to the total number of patients was 0.7% (Figure 3, Table 1). In our study, the biliary confluence angle was measured in 277 cases, excluding 26 cases with trifurcation variations, and the mean value was 77.32°±23.39°. In 216 patients, the diameter of the common BD before it opens into the duodenum and joins the PD (diameter 1) and the diameter of the duct formed after the junction (diameter 2) were measured. In 7 cases where common BD and PD entered the duodenum separately, the diameter of the common BD immediately before entering the duodenum (diameter 3) was calculated (Table 2).

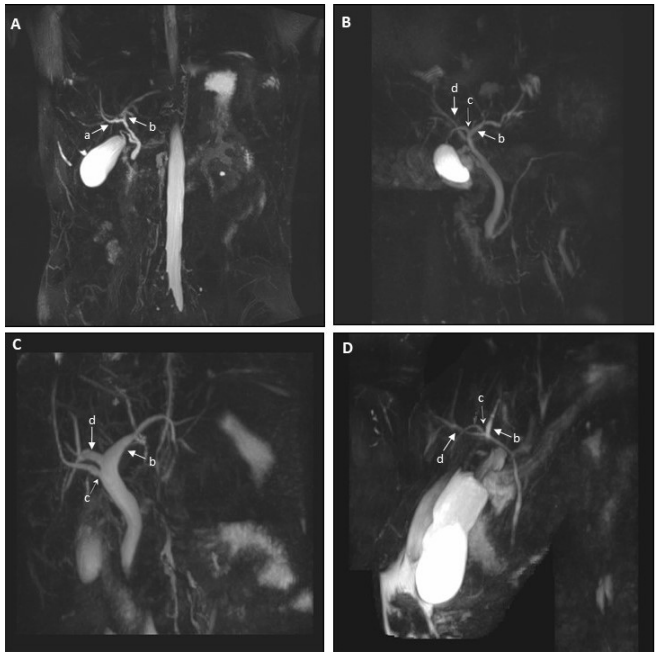

Figure 1. A) Normal bile ducts, **B)** Anomaly of the right posterior duct draining into left hepatic duct, **C)** Aberrant right hepatic duct variation, **D)** Trifurcation variation (**a:** Right hepatic duct, **b:** Left hepatic duct, **c:** Right posterior duct, d: Right anterior duct)

Table 1. Number and percentage of identified variations

Variations	Number of variations	Percentage (%)
Anomaly of the right posterior duct opening to the left hepatic duct	12	4
Aberrant right hepatic duct	15	5
Trifurcation	26	8.6
Long cystic duct	20	6.6
Medial insertion	8	2.6
Mediodistal insertion	5	1.7
Short cystic duct	7	2.3
Transferred location of gallbladder	7	2.3
Variation in the gallbladder fundus located on the left side	1	0.3
Superior localization of the gallbladder	4	1.3
The common bile duct and pancreatic duct were opened separately into the duodenum	7	2.3
Pancreas divisum	2	0.7
Multiple variation	12	4
Total	**93**	**30.7**

Table 2. Mean, minimum, and maximum values

	N	Min.	Max.	Mean ± SD
Age	303	18	92	54.49±18.83
Confluence angle	277	21.4°	152.7°	77.33°±23.39°
Diameter 1 (mm)	216	1.56	8.64	3.80±1.33
Diameter 2 (mm)	216	2.81	13.05	5.75±1.47
Diameter 3 (mm)	7	2.7	4.55	3.64±0.74
Short cystic duct (mm)	7	2.34	4.94	3.64±0.82

Min.: Minimum, Max.: Maximum, SD: Standard deviation, mm: Millimeter

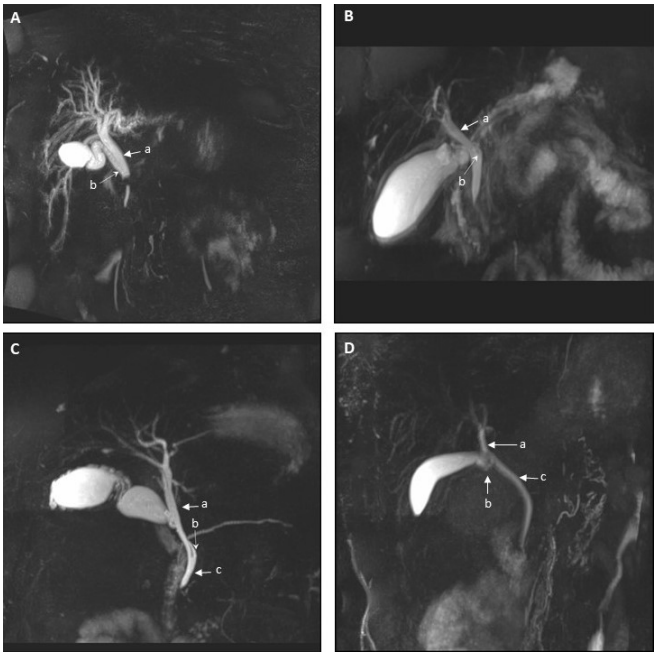

Figure 2. A) Long cystic duct variation, **B)** Medial insertion variation, **C)** Mediodistal insertion variation, **D)** Short cystic duct variation (**a:** Common hepatic duct, **b:** Cystic duct, **c:** Common bile duct)

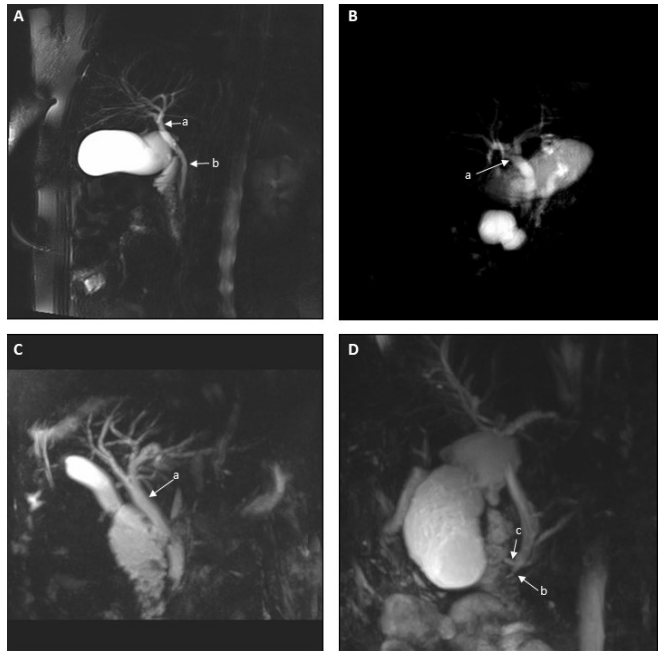

Figure 3. A) Transferred localization of the gallbladder, **B)** Variation in the gallbladder fundus located on the left, **C)** Superior localization of the gallbladder, **D)** Pancreatic divisum variation (**a:** Common hepatic duct, **b:** Common bile duct, **c:** Pancreatic duct)

Table 3. Studies in the literature

	Method	N	Number of Variations	Percentage variation (%)
Cabada Giadás et al. (15)	CT Cholangiography	101	23	22.7
Düşünceli et al. (5)	MRCP	475	115	24.2
Lee et al. (16)	MRCP	170	130	76.4
De Filippo et al. (17)	MRCP	350	148	42.3
Deka et al. (18)	MRCP	299	126	42.2
Renzulli et al. (19)	MRCP	1004	369	36.7
The present study	MRCP	303	93	30.7

CT: Computed tomography, MRCP: Magnetic resonance cholangiopancreatography

In 7 cases with variations in which the common BD and PD entered the duodenum separately, the mean diameter of the common BD just before entering the duodenum (diameter 3) was 3.63 mm.

Correlations between the detected variations, presence of stones, age, sex, confluence angle, diameter 1, diameter 2, diameter 3, and short CD length were studied separately. A statistically significant negative correlation was found between confluence angle and age ($p<0.05$). In other words, as age increases, the confluence angle decreases. Considering the previously defined correlation between diameter 1 and diameter 2 and age, a significant positive correlation was found ($p<0.05$). A significant correlation was found between long CD variation and stone formation and between long CD variation and diameters 1 and 2. In other words, people with long CD variations are more likely to have stones in their BD. The incidence of both right posterior anomaly opening into the left HD and mesiodistal insertion variation was higher in men than in women.

DISCUSSION

Anatomical variations of the gallbladder and BD are major risk factors for surgery in this region. In addition, these variations, other than just the risk of damage, may be risk factors for many biliary tract and pancreatic diseases, such as common BD stones, recurrent pancreatitis, and cholangitis (9,10). Damage to the varicose BD during surgical intervention may result in postoperative bile leakage or infection, and atrophic or hypertrophic changes may be observed as a result of obstruction due to improper connection of this variegated duct (11,12). Ignoring the variable structures within Calot's triangle, which are at the highest risk of damage during cholecystectomy, especially the aberrant right HD variation, by the surgeon may result in ligation or dissection of the wrong duct (3,13). Various imaging studies have been conducted showing anatomical variations of the BD, and the incidence rate is 24%-37% (4,5). Among the methods used to visualize BD, US and conventional single-slice computed tomography are of limited use and inadequate for the study of non-dilated BD. Another method, intravenous cholangiography, cannot provide detailed anatomical imaging. Among the contrast methods, percutaneous transhepatic cholangiography and Endoscopic Retrograde Cholangiopancreatography (ERCP) are considered the gold standards. However, they are invasive, operator dependent, expensive, and associated with significant complications (4,13,14). In the study conducted by Cabada Giadás et al. (15) using three-dimensional helical CT, another imaging modality, anatomical variation at different levels of the biliary system was found in 22.7% of 101 cases. With this method, anatomical structures in the BD can be evaluated with high success rates, but the disadvantages of this method are the high side effects of the contrast agent and the use of ionizing radiation (15-19) (Table 3).

MRCP is preferred over other methods because it has a 90% accuracy rate compared with ERCP, is non-invasive, does not use contrast media, is independent of the practitioner, is inexpensive, does not involve ionizing radiation, and does not carry the risk of complications (8,20). Vitellas et al. (21) reported that MRCP had an accuracy of 98% for aberrant HD and 95% for CD variations. Taourel et al. (4) found that MRCP and ERCP were highly sensitive and specific for BD variations. We included patients who underwent MRCP because it is non-invasive and does not expose patients to ionizing radiation.

Many studies in the literature have examined the anatomical variations of the BD. The rates of variation in these studies vary. In their study using MRCP images from 350 patients, De Filippo et al. (17) found that the BD variation rate was 42.3%. In our study, the rate was 30.7%. In the meta-analysis study conducted by Cucchetti et al. (22), the anatomical variations of intrahepatic BD in the literature of cases undergoing liver transplantation in Europe between 1980 and 2010 were reviewed. According to this study, a normal anatomical biliary system was found in 64.5% (22).

In our study, a similar result was obtained, as a normal biliary system was found in 69.3%.

In the study that reviewed 6 different studies conducted by Deka et al. (18), it was found that 57.8% of the 299 cases whose MRCP images were examined had a normal anatomical BD. Additionally, this study concluded that there was no association between gender and variations. We found a significant relationship between sex and right posterior duct anomaly opening to the left HD and mesiodistal insertion variation.

Mariolis-Sapsakos et al. (23) conducted a study examining only the anatomical variations of the right HD on 73 cadavers, and it was reported that the right HD had normal anatomy in 65.75% of the cases. In our study, normal right HD anatomy was observed in 82.5% of the patients. We believe that this difference between studies is due to ethnic origin.

Uysal et al. (24) examined only intrahepatic ductal variation using MRCP images of 1011 cases and detected intrahepatic ductal variation at a rate of 24.3%. Among these variations, right posterior duct anomaly opening into the left HD was recorded at a rate of 4.15%, aberrant right HD at a rate of 7.2%, and trifurcation at a rate of 8%. In our study, similar to the study of Uysal et al. (24), trifurcation variation was found in 8.6% of cases and right posterior duct anomaly opening to the left HD was 4%.

In a study of 1041 patients, Renzulli et al. (19) investigated the anatomical variations of the BD using the MRCP method. In this study, variations at different levels of BD were detected in 635 cases (36.7%). The most common variation was the right posterior duct anomaly, with approximately 16.2% opening into the left HD.The most common BD anomaly in most studies is the right posterior duct anomaly draining into the left HD (4,23). However, in some studies, including our study, trifurcation variation was the most common BD anomaly (24).

Although there are different results when evaluating the opening of the CD into the extrahepatic BD, in most studies, the CD was longer than the short CD. In our study, the long CD was larger than the short CD. There are only few studies on the location of the gallbladder, and similar to our study, the transfer location and upper location of the gallbladder are in close proportion (4). In our study, unlike the literature, the variation in which the fundus of the gallbladder is on the left and the variation in which the common BD and PD open separately to the duodenum were evaluated for the first time. Haliloglu et al. (25) investigated the relationship between biliary confluence angle and age, sex, and body mass index in 40 patients and found that the confluence angle was independent of these parameters. Similar to this study, we did not find a statistically significant difference between the confluence angle and sex.

Study Limitations

Our study has several limitations. First, because our study was retrospective, we only included patients who underwent MRCP for various reasons in the study group. Therefore, our study population does not fully reflect the community. Second, the MRCP method was not compared with more invasive methods, such as intraoperative cholangiography and surgery.

CONCLUSION

Gallbladder and BD show 24%-37% variation. Knowledge regarding these variations is extremely important for surgical interventions in this region. In our study, the trifurcation variation was the most common. However, aberrant right HD variation carries the greatest risk of damage because it lies in Calot triangle. In addition, the risk of stone formation is high in patients with long CD variations. In long-term CD variations, the increase in the diameter of the common BD before and after its union with the PD should be considered in the treatment of such diseases. We believe that our findings will guide surgeons in surgical interventions in this region and help in planning the treatment of patients, as it is a risk factor for many biliary tract and pancreatic diseases, such as common BD stones, recurrent pancreatitis, and cholangitis.

ETHICS

Ethics Committee Approval: The study Ethical approval for the study was obtained from the Local Ethics Committee of the Selçuk University Faculty of Medicine (approval no: 2015/312, date: 08.12.2015).

Informed Consent: Since this study was retrospective, patient consent was not required.

FOOTNOTES

Authorship Contributions

Concept: T.F.D., Z.F., A.K.K., İ.İ.U, N.Ü.D., Design: T.F.D., Z.F., M.K., A.K.K., İ.İ.U, N.Ü.D., Data Collection or Processing: T.F.D., Z.F., M.K., Analysis or Interpretation: T.F.D., Z.F., A.G.Ö., Literature Search: T.F.D., Z.F., Writing: T.F.D., A.G.Ö.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

REFERENCES

1. Standring S. Gray's anatomy e-book: the anatomical basis of clinical practice: Elsevier Health Sciences; 2016. p: 1173-7.
2. Moore KL, Dalley AF, Agur AMR. Clinically oriented anatomy. 6th ed. Wolters Kluwer: Lippincott Williams & Wilkins; 2014. p: 277-80.
3. Mortelé KJ, Ros PR. Anatomic variants of the biliary tree: MR cholangiographic findings and clinical applications. AJR Am J Roentgenol. 2001;177:389-94.
4. Taourel P, Bret PM, Reinhold C, Barkun AN, Atri M. Anatomic variants of the biliary tree: diagnosis with MR cholangiopancreatography. Radiology. 1996;199:521-7.
5. Düşünceli E, Erden A, Erden İ. Biliyer sistemin anatomik varyasyonları: MRKP bulguları. Tanısal ve Girişimsel Radyoloji. 2004;10:296-303.
6. Janssen BV, van Laarhoven S, Elshaer M, Cai H, Praseedom R, Wang T, et al. Comprehensive classification of anatomical variants of the main biliary ducts. Br J Surg. 2021;108:458-62.
7. Songur A, Çağlar V, Gönül Y, Özen OA. Gallbladder and biliary tract anatomy. Journal of Surgical Arts. 2009;2:12-9. Turkish.
8. Arda K, Aktaş E, Çiledağ N. Manyetik rezonans kolanjiyopankreatografi. Güncel Gastroenteroloji. 2010:39-5.
9. Dähnert W. Radiology review manual. Lippincott: Williams & Wilkins; 2010.
10. Naeem MQ, Ahmed MS, Hamid K, Shazlee MK, Qureshi F, Asad Ullah M. Prevalence of different hepatobiliary tree variants on magnetic resonance cholangiopancreatography in patients visiting a tertiary care teaching hospital in Karachi. Cureus. 2020;12:e12329.
11. Sutton D. Textbook of radiology and imaging. Churchill Livingston: China; 2000.
12. Sarin YK. Biliary ductal and vascular anomalies associated with choledochal cyst. Journal of Indian Association of pediatric Surgeons. 2005;10:86-8.
13. Turner MA, Fulcher AS. Chapter 75- Gallbladder and biliary tract: normal anatomy and examination techniques. In: Textbook of gastrointestinal radiology, Gore RM, Levine MS, editors. Philadelphia: WB Saunders; 2000.
14. Caoili EM, Paulson EK, Heyneman LE, Branch MS, Eubanks WS, Nelson RC. Helical CT cholangiography with three-dimensional volume rendering using an oral biliary contrast agent: feasibility of a novel technique. AJR Am J Roentgenol. 2000;174:487-92.
15. Cabada Giadás T, Sarría Octavio de Toledo L, Martínez-Berganza Asensio MT, Cozcolluela Cabrejas R, Alberdi Ibáñez I, Alvarez López A, et al. Helical CT cholangiography in the evaluation of the biliary tract: application to the diagnosis of choledocholithiasis. Abdom Imaging. 2002;27:61-70.
16. Lee CM, Chen HC, Leung TK, Chen YY. Magnetic resonance cholangiopancreatography of anatomic variants of the biliary tree in Taiwanese. J Formos Med Assoc. 2004;103:155-9.
17. De Filippo M, Calabrese M, Quinto S, Rastelli A, Bertellini A, Martora R, et al. Congenital anomalies and variations of the bile and pancreatic ducts: magnetic resonance cholangiopancreatography findings, epidemiology and clinical significance. Radiol Med. 2008;113:841-59. English, Italian.
18. Deka P, Islam M, Jindal D, Kumar N, Arora A, Negi SS. Analysis of biliary anatomy according to different classification systems. Indian J Gastroenterol. 2014;33:23-30.
19. Renzulli M, Brandi N, Brocchi S, Balacchi C, Lanza C, Pettinari I, et al. Association between anatomic variations of extrahepatic and intrahepatic bile ducts: do look up! J Anat. 2023;242:683-69.
20. Tuncel E. Klinik Radyoloji. 1. Baskı. İstanbul: Nobel&Güneş Tıp Kitabevi; 2008.
21. Vitellas KM, Keogan MT, Spritzer CE, Nelson RC. MR cholangiopancreatography of bile and pancreatic duct abnormalities with emphasis on the single-shot fast spin-echo technique. Radiographics. 2000;20:939-57; quiz 1107-8, 1112. Erratum in: Radiographics 2000;20:1494.
22. Cucchetti A, Peri E, Cescon M, Zanello M, Ercolani G, Zanfi C, et al. Anatomic variations of intrahepatic bile ducts in a European series and meta-analysis of the literature. J Gastrointest Surg. 2011;15:623-30.
23. Mariolis-Sapsakos T, Kalles V, Papatheodorou K, Goutas N, Papapanagiotou I, Flessas I, et al. Anatomic variations of the right hepatic duct: results and surgical implications from a cadaveric study. Anat Res Int. 2012;2012:838179.
24. Uysal F, Obuz F, Uçar A, Seçil M, Igci E, Dicle O. Anatomic variations of the intrahepatic bile ducts: analysis of magnetic resonance cholangiopancreatography in 1011 consecutive patients. Digestion. 2014;89:194-200.
25. Haliloglu N, Erden A, Erden İ. Normal biliary confluence angle in classical junction type: assessment with MR cholangiopancreatography. Ankara Üniversitesi Tıp Fakültesi Mecmuası. 2009;62:163-5.