IJAE
Vol. 124, n. 3: 487-498, 2019
ITALIAN JOURNAL OF ANATOMY AND EMBRYOLOGY

Anatomic variations of the upper biliary confluence and intra-hepatic ducts in East-central Tunisian population

Mohamed Salah Jarrar[1,2,*], Wafa Masmoudi[1], Mohamed Hedi Mraidha[1], Nader Naouar[2], Malek Barka[1], Sabri Youssef[1], Fehmi Hamila[1], Slah-Eddine Ghannouchi[2], Rached Letaief[1]

[1] Department of General and Digestive Surgery, Farhat Hached University Hospital, Sousse
[2] Department of Anatomy, Faculty of Medicine, Sousse

Abstract

Introduction The anatomy of the biliary tract includes a considerable number of variations that may be explained by the hepato-biliary tract embryology. The in-depth knowledge of this anatomy is essential for a good interpretation of conventional radiology imaging, and, especially for a good practice of hepato-biliary surgery. Several imaging techniques allow us to study the biliary tract anatomy. Our **purpose** is to study of modal anatomy (most frequent) and anatomic variations of biliary tract through interpretation of post-operative cholangiograms. **Materials and Methods** It is a retrospective monocentric observational study. It concerned every patient who had a hepato-biliary and/or pancreatic surgery in Farhat Hached University Hospital from 2007 till 2016, and who have had at least one post-operative cholangiography. A data form has been filled for every patient. **Results** Out of a total population of 293 patients, we encountered 17.4% of variations of the upper biliary convergence divided into 7 patterns. Concerning intrahepatic bile ducts, we observed branching variations for segments 4, 5, 6 and 8 in respectively 3.5%, 4.1%, 1.7% and 1.7% of cases. **Conclusion** Both intra- and extrahepatic biliary anatomy is complex with the existence of many common and uncommon anatomic variations. Intra-operative cholangiography constitutes an accurate tool to detect these anatomic variants and is therefore crucial in the practice of hepato-biliary surgery especially after the advent of a variety of new techniques in this field. However, it also necessitates a more widespread and appropriate knowledge of these anatomic variations.

Keywords

Anatomic variations, Cholangiography, Intrahepatic ducts, Upper biliary confluence.

Authors' contribution

Mohamed Salah Jarrar wrote the paper, interpreted the cholangiograms and drew the figures.

Wafa Masmoudi did the data collection and the statistical analysis.

Mohamed Hedi Mraidha, Malek Barka and Sabri Youssef interpreted the cholangiograms.

Rached Letaief interpreted the cholangiograms and revised the paper.

Fehmi Hamila interpreted the cholangiograms and revised the paper.

Nader Naouar revised the paper.

Slah-Eddine Ghannouchi revised the paper.

* Corresponding author. E-mail: hammadi.jarrar@gmail.com

http://www.fupress.com/ijae
DOI: DOI: 10.13128/ijae-11677

Introduction

Accurate assessment of the hepatic vascular and biliary anatomy is essential to ensure safe and successful hepatobiliary surgery. If bile duct anatomy is misrecognized, intra-operative difficulties and complications may occur. Variations in the anatomy of the biliary tree have long been recognized. Couinaud (1957) described bile ducts anatomic variations since 1957. Thereafter, many other authors proposed other classifications, with a more complex anatomy each time, to match modern surgery requirements (Chaib, 2014; Champetier, 1994; Huang et al., 1996; Jurkovikj, 2011; Karakas et al., 2008; Kim et al., 2010; Kitami et al., 2006; Ohkubo et al., 2004)These new classifications revealed significant variability in frequencies which led to questioning the validation of the frequencies of main variations for different geographical populations. Knowledge on true frequencies for each geographical and racial population has a great meaning, as it may influence surgical practice.

In this research, we tried to study biliary anatomy of a Tunisian population of the Center-east and to determine the frequencies of anatomic variations of the upper biliary confluence (UBC) and intrahepatic biliary tree through post-operative cholangiographies.

Materials and Methods

It is a retrospective monocentric observational study. This study concerned every patient who had a hepatobiliary and/or pancreatic surgery. It included patients hospitalized since January 1st 2007 until December 31st 2016, going thus through a period of ten years. The patients were operated on in Farhat Hached University Hospital or in another hospital and transferred afterwards to our Center, and have had at least one postoperative cholangiography.

Were not included in our study: patients operated on for a hepatobiliary pathology and who didn't have a post-operative cholangiography, files that were incomplete, non-interpretable cholangiograms, incomplete cholangiograms (Hepatectomy, Technical problem, artefacts...), and other means of biliary imaging such as magnetic resonance imaging (MRI) and endoscopic retrograde cholangiopancreatography (ERCP).

Post-operative cholangiography is performed through a cystic duct drain, a T-tube drain, or other drainage tubes such as Pezzer's tube. A preliminary or initial radiograph of the abdomen (scot film) is taken in the supine position with the right upper quadrant of the abdomen centered to the midline of the grid. A water soluble organic contrast medium is gently and slowly introduced, employing general asepsis precautions. First images of the common bile duct filling are taken after a small injection (about 2 milliliters). These sequences are best for visualizing common bile duct content. Fractional injections of the contrast medium are continued gradually (about 3 to 5 milliliters) until contrast medium squirts into the duodenum. In the next sequence, filling is continued until intra-hepatic bile ducts are visualized. The patient is then adjusted in the right posterior oblique (RPO) position to obtain a lateral projection of the common bile duct off the spine and to demonstrate the branching of the hepatic ducts in this plane. Indeed, it is crucial for accurate interpretation of cholangiograms to understand that at a supine position, right hepatic bile ducts are overlapping while

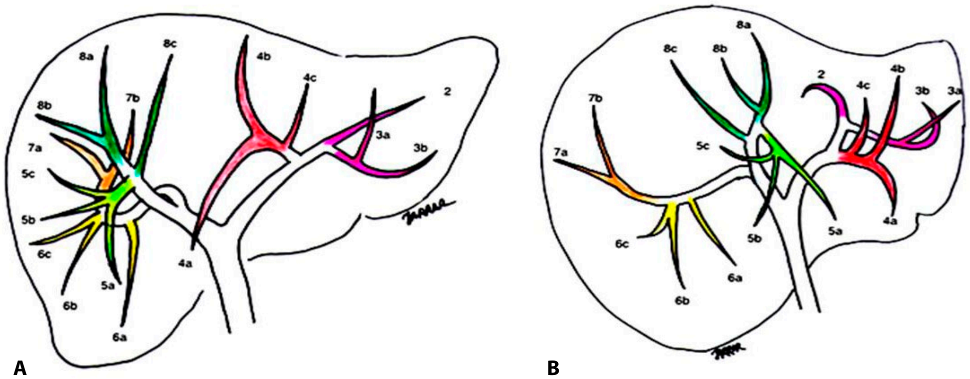

Figure 1. Intra-hepatic bile ducts view according to patient's position. a. Supine position. b. Right posterior oblique position. Numerals refer to Couinaud's segments: 3a: superior branch, 3b: inferior branch, 4a: inferior branch, 4b: superior branch, 4c: dorsal branch, 5a: ventral branch, 5b: dorsal branch, 5c: lateral branch, 6a: ventral branch, 6b: dorsal branch, 6c: lateral branch, 7a: ventral branch, 7b: dorsal branch, 8a: ventral branch, 8b: lateral branch, 8c: dorsal branch.

left hepatic ducts are visible. On the contrary, in the RPO position, left hepatic ducts are overlapping and right hepatic ducts are individualized better (figure 1) (Hautefeuille, 1998). We studied anatomic variants of intra and extra-hepatic bile ducts, intra-operative difficulties and post-operative course. We filled in a data form for every patient's file. This data form was specially conceived for the purpose of this study and consisted of two sections. The first section included information about the patient, the surgery and the hospital stay. The second one concerned the analysis of the post-operative cholangiography. We established a layout of modal anatomy and anatomic variations based on the classification of Couinaud (1957), picked arbitrarily as reference. Interpretation of the cholangiograms was reviewed systemically by a surgeon and an anatomist with a 10-year-expertise, and we referred to a third party in case of disagreement. We studied variations of the upper biliary confluent. Different patterns for each item have been drawn to help fill in the form. A white page was added to draw an eventual variation that was not described in the pre-existent patterns.

Results

Throughout the period between the 1st of January 2007 and the 31st of December 2016, we counted 351 files of patients operated for a hepatobiliary and/or pancreatic pathology and who have had postoperative cholangiography. Among them, 58 did not respond to inclusion criteria or had non-inclusion criteria. We kept thus 293 exploitable files.

Sixty-eight point six percent (68.6%) of the population were women (n=201), and 31.4% were men (n=92) with a sex ratio M/F of 0.46. In our population, the mean age was 49 years, the minimum age was 11 and the maximum age was 89.

Table 1. Surgical indications.

Diagnosis	n	%
Cholecystolithiasis	45	15.3%
Acute cholecystitis	42	14.3%
Acute pancreatitis	14	4.7%
Hydatid cyst	100	34.1%
Common bile duct lithiasis	7	2 %
Cholecystolithiasis+ common bile duct lithiasis	31	10.5%
Acute lithiasic cholangitis	22	7.5%
Acute cholecystitis + acute cholangitis	6	2%
Hydatid cholangitis	14	4.7%
Mirizzi's syndrome	3	1%
Bilio-enteric fistula	3	1%
Others	6	2%

Table 2. Surgical procedures.

Surgical procedure	n	%
Cholecystectomy	276	94.2%
Choledocotomy	85	29%
Cyst unroofing	92	31.4%
Internal transfistulary drainage	11	3.7%
Pericystectomy	9	3.1%
Perdromo procedure	7	2.4%
Bipolar drainage	5	1.7%
Antrectomy+ gastrojejunostomy	1	0.3%
Blio-enteric fistula disconnexion	2	0.7%
Peritoneal lavage	1	0.3%

One hundred five (35.8%) of our patients had a laparoscopic surgery while 188 (64.2%) had an open surgery. Tables 1 and 2 summarize the surgical indications and procedures.

A cystic duct drain (Pedinielli drain) was used in 201 procedures (68.6%) and a Kehr's T-tube was used in 88 procedures (30%). Other types of drainage were also used: fistula drainage (n=3; 1%) and Pezzer tube (n=1; 0.3%).

The upper biliary confluence (UBC) had a modal presentation (type A) according to Couinaud classification (1957) in 242 cholangiograms (82.6%). In 51 patients (17.4%), we encountered 7 other branching patterns listed in figure 2:

- Type B=APL (trifurcation): 18 cases (6.1%)

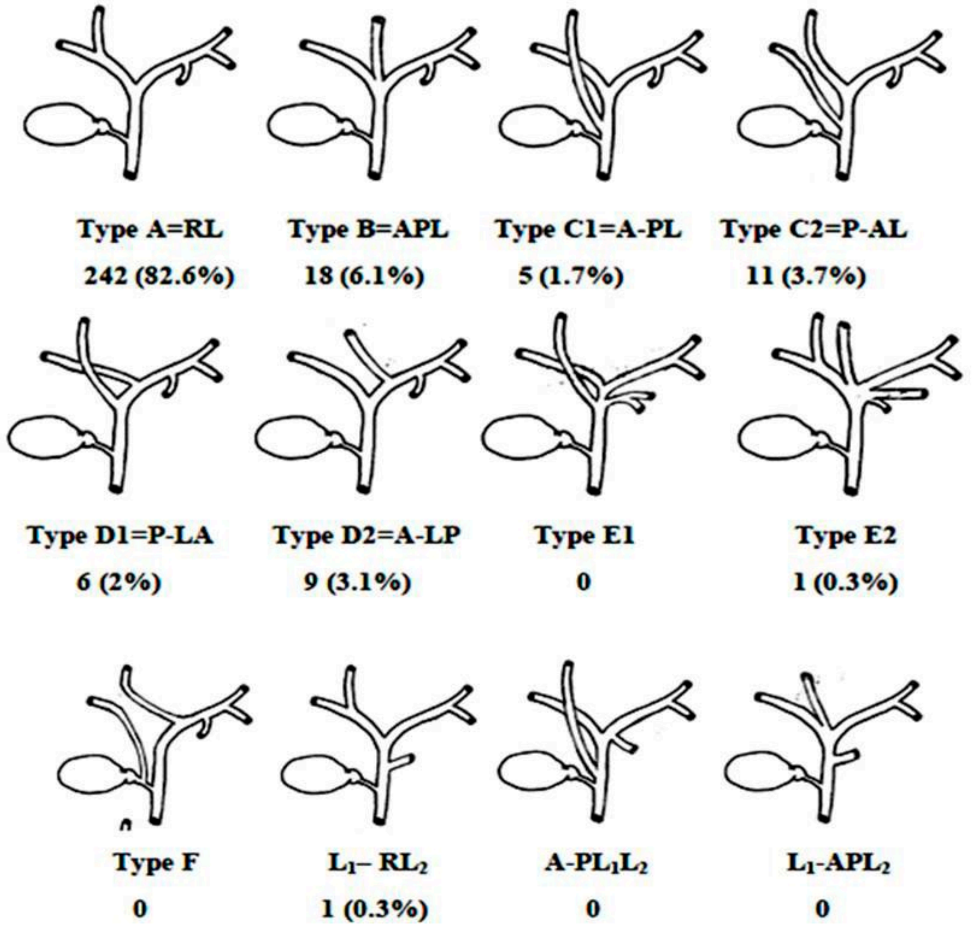

Figure 2. UBC branching. A: right anterior hepatic duct, P: right posterior hepatic duct, L: left hepatic duct. When the branches come off at different levels, a hyphen is inserted between the appropriate letters. For example, "A-PL" indicates that the first branch from below is A (right anterior duct) and that the next branches are P (right posterior duct) and L (left hepatic duct) at the same level.

- Type C1=A-PL: 5 cases (1.7%)
- Type C2=P-AL: 11 cases (3.7%)
- Type D1=P-LA: 6 cases (2%)
- Type D2=A-LP: 9 cases (3.1%)
- Type E2: 1 case (0.3%)
- Type L_1-RL_2: 1 case (0.3%).

The fifth segment duct was unseen in 3 cases (1%), the sixth segment in 2 cases, segment VIII duct was not visualized on cholangiograms in 2 cases and the fourth segment duct was unseen in 5 cases.

When seen, the intra-hepatic ducts presented 8.8% of variations:

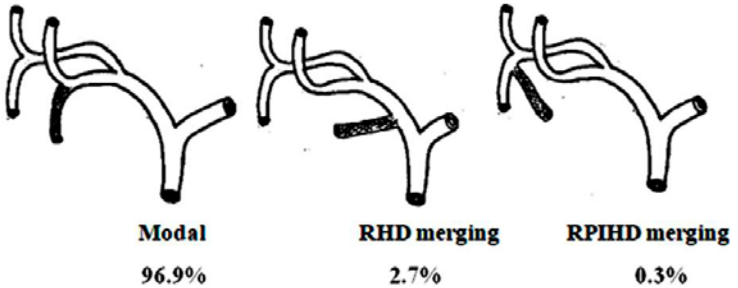

Figure 3. Fifth segment duct branching. RHD: Right hepatic duct; RPIHD: Right postero-inferior hepatic duct.

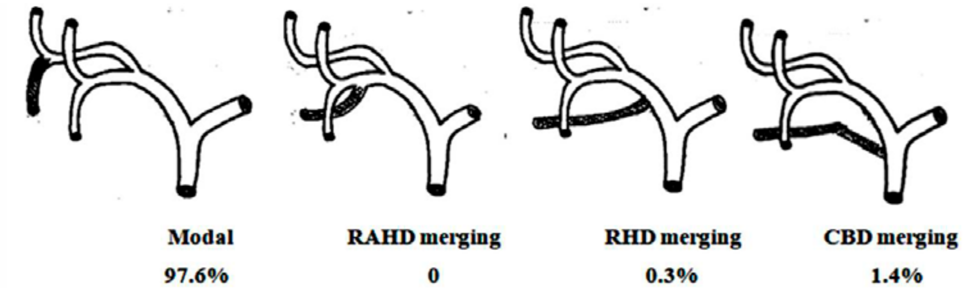

Figure 4. Sixth segment duct branching. RAHD: Right anterior hepatic duct; RHD: Right hepatic duct; CBD: Common bile duct.

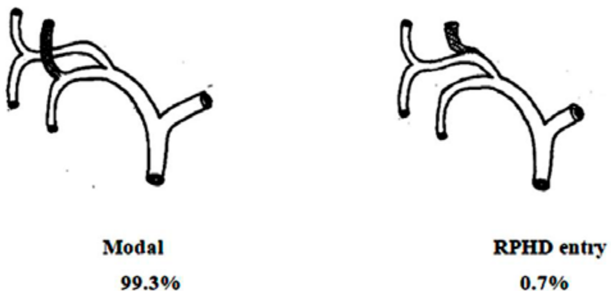

Figure 5. Eighth segment duct branching. RPHD: Right posterior hepatic duct.

- The fifth segment duct had a modal presentation in 281 cholangiograms (95.9%). It had a branching in the right hepatic duct in 8 cases, and in the right postero-inferior hepatic duct in 1 case (figure 3).
- The sixth segment duct had a modal presentation in 286 cholangiograms (98.3%). It had a branching in the right hepatic duct in 1 case, and in the common bile duct in 4 cases (figure 4).

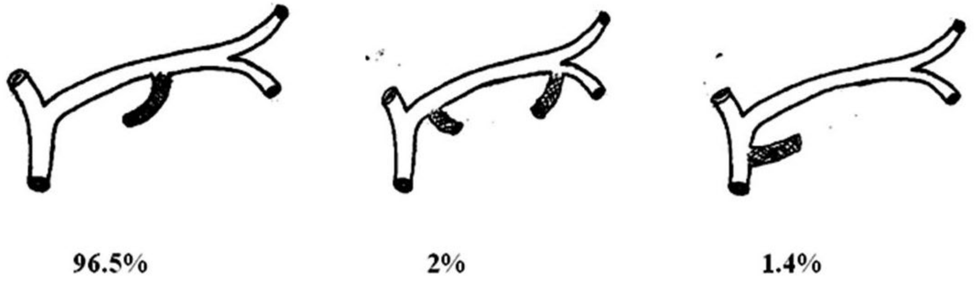

Figure 6. Fourth segment duct branching.

- Beside the modal presentation of the eighth segment duct in 288 cases (98.3%), we observed 2 cases of right posterior hepatic duct entry (0.7%) (figure 5).
- The fourth segment duct had a modal presentation in 278 cholangiograms (96.5%) (figure 6).

Discussion

Variations in the anatomy of the bile ducts have long been recognized. Clinical radiological diagnostics, gastro-enterological and surgical practice often encounter findings of variable anatomy and topography of the elements that create the biliary tree. Several authors helped defining the notions of normal (modal) and accessory or aberrant anatomy, by different imaging modalities such as ERCP, magnetic resonance cholangiography (MRC), intraoperative cholangiography and also by corrosion cast studies on autopsy specimens (Huang et al., 1996). In our study, evaluation was focused on the post-operative cholangiograms of a Tunisian population of the Center-east.

We listed a total of 51 patients (17.4%) with anatomic variations of the UBC and 8.8% of variation of intra-hepatic ducts.

The mean age in literature varied in North-African studies from 35 to 46 years (Abdelgawad and Eid, 2012; Elhjouji et al., 2009; Tawab and Taha Ali, 2012). In other international studies it varied from 30 to 57 years with a range of 16 to 89 years (Choi et al., 2003; Cucchetti et al., 2011; Deka et al., 2014; Karakas et al., 2008; Ohkubo et al., 2004). The age of our 293 subjects ranged from 11 to 89 years, with a mean of 49 years. We found no correlation between age and the presence of anatomic variants. This is perfectly explained if we admit the embryological development aberrations to be the origin of variations.

Few data are available about the regional, ethnical disparities or other demographical characteristics regarding hepatic biliary abnormalities. Living donor liver transplantation surgery is being widely performed in the Far East where organ donations do not compensate the requirement. Therefore, the majority of the studies on liver variations were performed on Asian race. For the specific subtype Asian race, no major differences were found in regard to frequencies of variations and modal anatomy was predominant with a frequency of 63-73% (Karakas et al., 2008). In their study of an Anatolian Caucasian population, Karakas et al. (2008) noted that modal anatomy frequency was significantly lower than that of Asian population (55% versus 63–73%), but was very similar to North Americans (57%). In a meta-analysis of literature, Cucchetti et al. (2011) showed that Europeans and Americans share similar prevalence rates of typical biliary anatomy. From an ethnicity point of view, this finding is not surprising since both populations can be considered Caucasian. On the contrary, Asians seem to have a slightly higher prevalence of typical anatomy. This meta-analysis is concordant with Karakas' results (2008), but also states that these differences should be taken into account with caution, in regard to interpretation bias. This same study though, did not include in its pool any African, or Middle-East population, probably due to lack of studies about them. Indeed, only a few authors in these regions studied the subject, and our research seems to be the first to study a Tunisian population. Modal anatomy in North African population according to these studies varied from 60% to 80%, but population size was limited to a small sample (20 to 106 subjects) which might not be representative of general population. Table 3 compares some of the North African studies with our present study.

The upper biliary confluence (UBC) anatomy has been subject to a prolific research. Different classifications of anatomic variants have been described: Couinaud (1957), Champetier (1994), Huang et al. (1996), Choi et al. (2003) and Ohkubo et al. (2004).

Huang classification would be considered "the simplest" and was the most widely used system by authors. It is based on the variable insertion of right posterior hepatic duct and is composed of five distinct anatomic types. Champetier classification (1994), in comparison to Huang classification, deals only with the variations and not with the dominant (modal) Huang type A. It has an additional type (E) in which both right posterior hepatic duct and right anterior hepatic duct open to cystic duct (figure 7).

Choi et al. (2003) added in his classification two patterns including accessory ducts as well as one variation of the LHD. Ohkubo et al. (2004) divide the bile ducts according to the position of the right posterior hepatic duct insertion relative to portal vein level; so types A to C are supraportal, and types D and E are infraportal patterns.

An Indian study by Deka et al. (2014) tried to compare these different classifications and states that Ohkubo classification system is the most applicable as it considers most clinically relevant variations pertinent to hepatobiliary surgery, unclassified variants were the least, and both right and left ductal systems could be classified. We used Couinaud classification as reference in our research rather than the others classifications that were conceived for the purpose of living-donor liver transplant. The drawback of Couinaud classification is that is does not take into account accessory

Table 3. Modal anatomy and variations of upper biliary confluence according to North African authors.

Series	Country	n	Modal anatomy	Anatomic variations
Elhjouji (2009)	Morocco	70	72.9%	27.1%
Abdelgawad (2012)	Egypt	20	80%	20%
Tawab (2012)	Egypt	106	63.2%	36.8%
Barsoum (2013)	Egypt	50	60%	40%
Our series	**Tunisia**	**293**	**82.6%**	**17.4%**

Table 4. Upper biliary confluence variants according to authors.

Series	n	Country	Type A (%)	Type B (%)	Type C1 (%)	Type C2 (%)	Type D1 (%)	Others (%)
Huang (1996)	958	Taiwan	63	19	11	6	-	2
Ohkubo (2004)	110	Japan	65	5	12	7	-	11
Choi (2003)	293	South Korea	64	9	11	6	-	7
Karakas (2008)	112	Turkey	55	14	21	10	-	
Deka (2014)	299	India	57.8	8	3	6.6	17,4	35.5
Cuccettti (2011)	200	Italy	64.5	14		8	12	1.5
Tawab (2012)	106	Egypt	64	10	17	7	-	2
Our series	**293**	**Tunisia**	**82.6**	**6.1**	**1.7**	**3.7**	**2**	**3.7**

ducts. An accessory bile duct is an additional bile duct draining the same area of the liver, whereas an aberrant bile duct is the only bile duct draining a particular hepatic segment. In our study, modal anatomy (Couinaud type A) of the UBC was present in 82% of cases, which is a higher rate than of that described in most literature articles. Couinaud type B, or the so called triple confluence was the second most frequent modality (6.1%). Table 4 shows the frequency of different variations of the UBC in different studies.

Most of the authors did not study separately intra-hepatic segmental bile ducts and focused only on right hepatic duct, left hepatic duct, right anterior hepatic duct and right posterior hepatic duct variations as these two were the most relevant elements in surgical practice.

Huang et al. (1996), Champetier (1994), Choi et al. (2003), Ohkubo et al. (2004) and Karakas et al. (2008) did not include segmental bile ducts variants in their classifications concerning the right liver.

Concerning the left liver, Ohkubo's left intra-hepatic ducts classification was mainly about segment IV branching patterns (Ohkubo et al., 2004). However, when two or more segment IV ducts are present and drain separately into the left ductal system, classification is not possible. This specific aspect was studied by Kawarada et al. (2000) who also proposed a separate classification based on cast studieshilar bile duct carcinoma can easily spread to the bile duct branches of the caudate lobe (B1.

Huang et al. (1996) also described variants of the left intra-hepatic ducts, his classification has the advantage of including segment I duct variations. He is the only author known to us that has described segment I duct variants.

Very rare are segments II and III ducts variants. Only Choi type 6 (figure 58) and Huang type B5 (figure 57) describe a pattern in which segments II and III ducts drain separately in the common bile duct, these variants were up to 1% and 3% respectively.

Using the classifications mentioned above would lead to several cases of unclassified variants, a situation which we mended by adding another section for segmental ducts variants, following the description of Valette and De Baere (2002).

In our study, 4.4% of population had variants only in the intra-hepatic bile tracts (UBC excluded). Five point eight percent had variants in both intra-hepatic and extra-

Table 5. Frequency of intra hepatic bile ducts variations according to authors.

	Seg V	Seg VI	Seg VIII	Seg IV	Seg II and III	Seg I
Valette (2002)	9%	12%	20%	30%	-	-
Ohkubo (2004)	-	-	-	24%	-	-
Choi (2003)	-	-	-		1%	
Huang (1996)	-	-	-	24%	3%	17%
Our series	3%	1.7%	0.7%	3.4%	-	-

hepatic bile tracts. Segment V duct variants were up to 3%, segment VI duct variants 1.7%, segment VIII duct 0.7% and segment IV duct 3.4%. We didn't encounter segment II and III ducts variants.

Table 5 summerizes frequencies of intra-hepatic bile ducts according to some authors.

Recent technical advancement of various types of hepatectomy, such as laparoscopic hepatectomy and donor hepatectomy for living-donor liver transplant, has increased the number of surgical plans that can be made only after surgeons have achieved a complete understanding of the branching of the bile duct. Variations of the bile duct would be essential for the screening of donors and the selection of methods of hepatectomy. If variations of the bile duct would not be confirmed or would be overlooked prior to surgery, this would lead to the occurrence of bile duct complications in both recipients and donors. On the other hand, some variants such as short right hepatic duct were predictors of a more complex surgery (bench ductoplasty or multiple anastomoses) (Ayuso et al., 2004; Barsoum et al., 2013; Catalano et al., 2008; Karakas et al., 2008). However, an insufficient number of studies have been conducted to examine whether variations of biliary tree affect the outcomes and the course of daily-routine procedures such as laparoscopic cholecystectomy and whether this would increase risks for injury to the bile ducts.

We believe our study has a few points that add to its pertinence. It has, indeed, included a large population sample, representative of the Tunisian Center-east (293 patients). It is the first study, to our knowledge, to be conducted in our country, and one among few in North-Africa. This work may seem at first, to be mainly about anatomy, but it also takes interest in its practical repercussions and it treats about a subject of current "trend" that is hepatobiliary surgery; a field with constant development and updates each day. We used as support to our text original sketches and figures, along with literature figures, and we enriched it with original iconography of the collected cholangiograms.

The main limitation of this study is interpretation bias. Indeed, cholangiograms interpretation was sometimes difficult due to poor quality, technical limitations, artefacts, incomplete or severed images, as most of these cholangiograms were not applied for identification of bile duct anatomy, but for suspicion of common bile duct stone. Many non exploitable cholangiograms were excluded reducing thus the population size. Interpretation is also operator-dependent. In a study led by a United Kingdom team (Sanjay et al., 2012), it was proven that accuracy of detection of both normal and variants of normal anatomy was poor in all grades of surgeon irrespective of a policy of routine or selective IOC. Some authors would have cholangiograms interpreted by two independent experienced investigators and sometimes a third investigator was consulted in case of disagreement (Choi et al., 2003). In our case, interpretation was systematically reviewed and corrected by a 10-year-experience surgeon and anatomist and we referred to a third party in case of disagreement. The second limitation of this study is methodological. Indeed, it is a retrospective, non-randomized study, using a data collection sheet filled from medical records that were not all complete and exploitable. Sometimes, we found insufficient clinical, radiological and operative data. Difficulties were also encountered during data collection due to incomplete or sometimes unavailable files (archiving issues). We suggest that large-scale prospective control study should be needed.

Conclusion

Both intra- and extra-hepatic biliary anatomy is complex with the existence of many common and uncommon anatomic variations. Intra- and post-operative cholangiography constitutes an accurate tool to detect these anatomic variants and is therefore crucial in the practice of hepatobiliary surgery especially after the advent of a variety of new techniques in this field. Other means of biliary mapping such as MRC and ERCP are also available for pre-operative diagnosis. However, all these thechniques necessitate a more widespread and appropriate knowledge of anatomic variations.

Acknowledgement

The authors declare that they have no conflict of interest and no financial support.

References

Abdelgawad MS, Eid M (2012) Biliary tract variants in potential right lobe living donors for liver transplantation: Evaluation with MR cholangiopancreatography (MRCP). Egypt J Radiol Nucl Med 43: 53–57

Ayuso JR, Ayuso C, Bombuy E et al (2004) Preoperative evaluation of biliary anatomy in adult live liver donors with volumetric mangafodipir trisodium enhanced magnetic resonance cholangiography: MRC Evaluation of Biliary Anatomy in LLDs. Liver Transpl 10: 1391–1397

Barsoum NR, Samie AA, Adel L, Asaad RE (2013) Role of MRCP in assessment of biliary variants in living donor liver transplantation. Egypt J Radiol Nucl Med 44: 131–136

Catalano OA, Singh AH, Uppot RN et al (2008) Vascular and Biliary Variants in the Liver: Implications for Liver Surgery. RadioGraphics 28: 359–378

Chaib E, Kanas AF, Galvão FHF, D'Albuquerque LAC (2014) Bile duct confluence: anatomic variations and its classification. Surg Radiol Anat 36: 105–109

Champetier J. Les voies biliaires (1994) Anatomie Clinique - Tronc. Springer, Paris
Choi JW, Kim TK, Kim KW et al (2003) Anatomic variation in intrahepatic bile ducts: an analysis of intraoperative cholangiograms in 300 consecutive donors for living donor liver transplantation. Korean J Radiol 4: 85–90
Couinaud C (1957) Le foie. Etudes natomiques et chirurgicales. Masson, Paris
Cucchetti A, Peri E, Cescon M et al (2011) Anatomic variations of intrahepatic bile ducts in a european series and meta-analysis of the literature. J Gastrointest Surg 15: 623–630
Deka P, Islam M, Jindal D et al (2014) An analysis of biliary anatomy according to different classification systems. Indian J Gastroenterol 33: 23–30
Elhjouji A, Ali AA, Alahyane A et al (2009) Variations anatomiques des voies biliaires et conséquences chirurgicales: à propos de 19 cas. J Afr Hépatol Gastroenterol 3: 137–142
Hautefeuille P (1998) Reading the anatomy of cholangiograms. J Chir 135: 275–278
Huang TL, Cheng YF, Chen CL et al (1996) Variants of the bile ducts: clinical application in the potential donor of living-related hepatic transplantation. Transplant Proc 28 :1669–1670
Jurkovikj D (2011) Some Anatomic-Topographic Features of Common and Right Hepatic Ducts and their Constituents. Maced J Med Sci 4: 44-53
Karakas HM, Celik T, Alicioglu B (2008) Bile duct anatomy of the Anatolian Caucasian population: Huang classification revisited. Surg Radiol Anat 30: 539–545
Kawarada Y, Das BC, Onishi H et al (2000) Surgical anatomy of the bile duct branches of the medial segment (B4) of the liver in relation to hilar carcinoma. J Hepatobiliary Pancreat Surg 7:480–485
Kim SY, Byun JH, Lee SS et al (2010) Biliary Tract Depiction in Living Potential Liver Donors: Intraindividual Comparison of MR Cholangiography at 3.0 and 1.5 T. Radiology 254: 469–478
Kitami M, Takase K, Murakami G et al (2006) Types and frequencies of biliary tract variations associated with a major portal venous anomaly: analysis with multidetector row CT cholangiography. Radiology 238 :156–166
Ohkubo M, Nagino M, Kamiya J et al (2004) Surgical Anatomy of the Bile Ducts at the Hepatic Hilum as Applied to Living Donor Liver Transplantation: Ann Surg 239: 82–86
Sanjay P, Tagolao S, Dirkzwager I, Bartlett A (2012) A survey of the accuracy of interpretation of intraoperative cholangiograms. HPB 14: 673–676
Tawab MA, Taha Ali TF (2012) Anatomic variations of intrahepatic bile ducts in the general adult Egyptian population: 3.0-T MR cholangiography and clinical importance. Egypt J Radiol Nucl Med 43: 111–117
Valette PJ, De Baere T (2002) Biliary and vascular anatomy of the liver. J Radiol 83: 221–234