ARTICLE ORIGINAL

Anatomic variations of the extrahepatic biliary tree. A monocentric study and review of the literature

Variantes anatomiques des voies biliaires extrahépatiques. Etude monocentrique et revue de la littérature

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RÉSUMÉ

Introduction: L'étude de l'anatomie des voies biliaires extra-hépatiques a démontré l'existence d'un nombre non négligeable de variantes qui s'expliquent par l'embryologie hépato-biliaire. La bonne connaissance de cette anatomie est primordiale pour l'interprétation des examens radiologiques, et pour une bonne pratique de la chirurgie hépato-biliaire et pancréatique. Plusieurs moyens d'imagerie permettent d'étudier l'anatomie des voies biliaires, dont la cholangiographie classique qui reste encore pratiquée et très utile.

Objectif : Etudier l'anatomie modale (la plus fréquente) et les variantes anatomiques des voies biliaires extra-hépatiques à travers l'interprétation des cholangiogrammes postopératoires et d'examiner leur implication sur la pratique chirurgicale.

Méthodes : Il s'agit d'une étude observationnelle rétrospective monocentrique. Elle concernait tous les patients ayant subi une chirurgie hépato-biliaire ou pancréatique au Service de Chirurgie Générale et Digestive du Centre Hospitalo-Universitaire Farhat Hached de Sousse entre 2007 et 2016, et ayant bénéficié d'une cholangiographie postopératoire. Un formulaire de données a été rempli pour chaque patient.

Résultats: Sur une population totale de 293 patients, nous avons répertorié 158 patients (53.9%) présentant des variantes anatomiques des voies biliaires extrahépatiques. Le conduit cholédoque avait une implantation modale dans le second duodénum dans 96.2% des cholangiographies, et dans le genu inferius dans 3.8% des cas. Le conduit pancréatique principal avait une implantation en forme de V dans 87.1% des cholangiogrammes, une implantation en U dans 4.2% des cas et une implantation en Y dans 7.1% des cas. La voie biliaire principale avait un aspect modal dans 71.3% des cholangiogrammes, avec 28.7% de variantes anatomiques, organisées en 4 modèles. Le conduit cystique avait une présentation modale dans 80.9% des cas, et nous avons enregistré 6 autres modèles de branchement (19.1% des cas). Aucune différence significative n'a été observée entre la présence de variantes anatomiques d'une part et l'âge, le sexe, le taux de conversion, les incidents peropératoires, les complications postopératoires et la durée hospitalisation postopératoire ou globale d'autre part.

Conclusion; Avec l'existence de nombreuses variations anatomiques courantes et rares, l'anatomie biliaire reste complexe et passionnante. La cholangiographie conventionnelle constitue un outil plus ou moins précis pour détecter ces variantes anatomiques et est donc très utile dans la pratique de la chirurgie hépato-biliaire même après l'avènement de nouvelles techniques dans ce domaine. Cependant, elle nécessite une connaissance plus étendue et plus approfondie de ces variantes anatomiques, qui restent assez fréquentes, et représentent une source de difficultés chirurgicales.

Mots clés: Anatomie, Variantes anatomiques, Voies biliaires extra-hépatiques, Chirurgie.

SUMMARY

Introduction The study of the anatomy of the extrahepatic bile ducts has demonstrated the existence of a significant number of variants which can be explained by hepato-biliary embryology. A good knowledge of this anatomy is essential for the interpretation of radiological examinations, and for a good practice of hepato-biliary and pancreatic surgery. Several imaging methods are used to study the anatomy of the bile ducts, including classical cholangiography, which is still practiced and very useful.

Aim: To study the modal anatomy (the most frequent) and the anatomical variants of the extrahepatic bile ducts through the interpretation of postoperative cholangiograms and to examine their implication on the surgical practice.

Methods: This is a monocentric, retrospective observational study. It concerned any patient who underwent hepato-biliary or pancreatic surgery at the Department of General and Digestive Surgery of Farhat Hached University Hospital of Sousse between 2007 and 2016, and who received postoperative cholangiography. A data form was fulfilled for each patient.

Results: Out of a total population of 293 patients, we identified 158 patients (53.9%) with anatomic variants of the extrahepatic bile ducts. The common bile duct was modally implanted in the second duodenum in 96.2% of cholangiographies and in the genu inferius in 3.8% of cases. The main pancreatic duct had a V-shaped implantation in 87.1% of cholangiograms, a U-shaped implantation in 4.2% of cases and a Y-shaped implantation in 7.1% of cases. The common bile duct had a modal aspect in 71.3% of cholangiograms, with 28.7% of anatomic variants, organized in 4 models. The cystic duct had a modal presentation in 80.9% of cases, and we recorded 6 other branching models (19.1% of cases). No significant difference was observed between the presence of anatomic variants on the one hand, and age, sex, conversion rate, intraoperative incidents, postoperative complications, postoperative hospital stay and overall hospital stay on the other hand.

Conclusion: Conventional cholangiography constitutes a more or less precise tool for detecting these anatomic variants and is therefore very useful in the practice of hepato-biliary surgery even after the advent of new techniques in this field. However, it also requires a more extensive and in-depth knowledge of these anatomic variants, which nevertheless remain quite frequent, and represent a source of surgical difficulties.

Key-words: Anatomy, Anatomic variations, Extrahepatic bile ducts, Surgery.

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INTRODUCTION

Variations in the anatomy of the bile ducts have long been recognized. They were described by Couinaud [1] since 1957. A classification of biliary variations in China, according to endoscopic retrograde cholangiopancreatography (ERCP), was proposed by Huang [2]. Then other classifications were established, with more and more complex anatomy each time, in order to adapt to the demands of modern surgery. [3–7]. The variability of these classifications prompts us to wonder about the existence of a relationship between the anatomic variations and the ethnic origin of a population. Knowledge of the anatomic reality of each geographic and racial population is of significant importance, as it can influence surgical practice. Through this work, we tried to study the anatomy extra-hepatic biliary tree of the population of the Center-east of Tunisia and to determine the frequencies of biliary anatomic variations in post-operative cholangiographies.

METHODS

Our work is a retrospective monocentric observational study, conducted in Farhat Hached University Hospital of Sousse (Tunisia), and going through a period of ten years from January 2007 until December 2016. It included all patients who have had a hepato-biliary and/or pancreatic surgery within the determined period and who had at least one post-operative cholangiography. The patients were operated on either in our hospital or in other centers and transferred secondly. The cholangiographies were performed through a cystic duct drain, a T-tube drain or other drainage tubes such as a Pezzer's tube. Non-inclusion criteria were the absence of post-operative cholangiograms, incomplete patient files, non-interpretable or incomplete cholangiograms due to hepatectomy which greatly modifies the biliary cartography, structure's overlays and blurs that make photos uninterpretable, low quality of the cholangiograms etc. We specially conceived a data form for the purpose. It consisted of a first section collecting general information about the patient and the procedure, and a second section for the analysis of cholangiograms that consisted in a layout of modal anatomy and its variations based on the literature gatherings. The different patterns were drawn schematically to help the interpretation, and a white section was left to draw different patterns that were not described in the layout. We studied variations of the main

bile duct aspect and implantation, the cystic duct aspect and implantation, and the patterns of each intra-hepatic bile duct. Our interpretation of the cholangiograms was systematically reviewed by an experienced surgeon and anatomist, and a third party (a radiologist) was consulted in case of argument. We used the Epi-info software (Version 8) as a data analysis tool.

RESULTS

Three-hundred fifty-one files of patients with hepato-bilairy/pancreatic surgery were collected through the determined period, among which we selected 293 files after running inclusion and non-inclusion criteria.

This population had a mean age of 43 years with extremes of 11 and 83 years, and consisted predominantly of women, 68.6% (n=201) against a male percentage of 31.4% (n=92). Sex ratio M/F was 0.46. Pathologies described in the files which lead to surgery indication consisted mainly of biliary lithiasis pathology and echinococcosis cases, and are described in further details in table 1.

Table 1. Surgical indication

Diagnosis	n	%
Cholecystolithiasis	45	15.3%
Acute cholecystitis	42	14.3%
Acute pancreatitis	14	4.7%
Hydatid cyst	100	34.1%
CBD lithiasis	7	2 %
Cholecystolithiasis+ CBD 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 %

CBD: common bile duct

Other indications for surgery were for a common bile duct cyst in 2 cases, and a polycystic liver disease in one case. Laparoscopic surgery was performed in 35.8% of cases (n=105), open surgery in 64,2% (n=188), with a conversion to laparotomy rate of 27.6% (n=29).Two hundred seventy-six patients (94.2%) had a cholecystectomy, 85 patients (29%) had choledochotomy, 92 (31.4%) had cyst unroofing, 11 (3.7%) had internal transfistulary drainage (ITFD), 10 (3.4%) had a pericystectomy, 7 (2.4%) had

a transparietohepatocystic fistulisation (Perdromo procedure), 5 (1.7%) had bipolar drainage, 2 (0.7%) had subtotal cholecystectomy, 1 had antrectomy plus gastrojejunostomy, 2 had bilio-enteric fistula disconnexion and 1 had peritoneal lavage. Opacification of the biliary tract was obtained using a cystic duct drain (Pedinielli drain) in 201 procedures (68.6%), and a Kehr's T-tube in 88 procedures (30%). Other types of drainage included fistula drainage and Pezzer tube in one case each.

We listed a total of 158 patients (53.9%) with extrahepatic bile ducts anatomic variations.

Among them, 17 patients (5.8%) had variants in both intra-hepatic and extra-hepatic bile tracts.

Common bile duct (CBD) implantation was unseen in 6 cases. When seen, it had an implantation in the second duodenum in 276 cholangiographies and in the inferior duodenal flexure in 11 (figure 1). We didn't encounter any other variation of CBD implantation.

The pancreatic duct (PD) remained unseen in 223 cholangiograms (76.1%). When seen, it had a V-shaped implantation in 61 cholangiograms (87.1%), 3 times a U-shaped implantation (4.2%) and 5 times a Y-shaped implantation (7.1%) (figure 2). One case of ansa pancreatica was registered [8].

The CBD had a modal aspect in 209 cholangiograms (71.3%). We encountered four other aspect variations in 84 cases (28.7%) with (figure 3): straight aspect in 20 cases (6.8%), hook aspect in 18 cases (6.1%), double curve aspect in 42 cases (14.3%)and triple curvei 4 cases (1.4%).

Type A: 2nd duodenum: n= 276 (96.2%)

Type B: Inferior duodenal flexure: n= 11 (3.8%)

Type C: 3rd duodenum: n= 0

Figure 1. CBD implantation

V- shaped implantation
87.1%

U- shaped implantation
4.2%

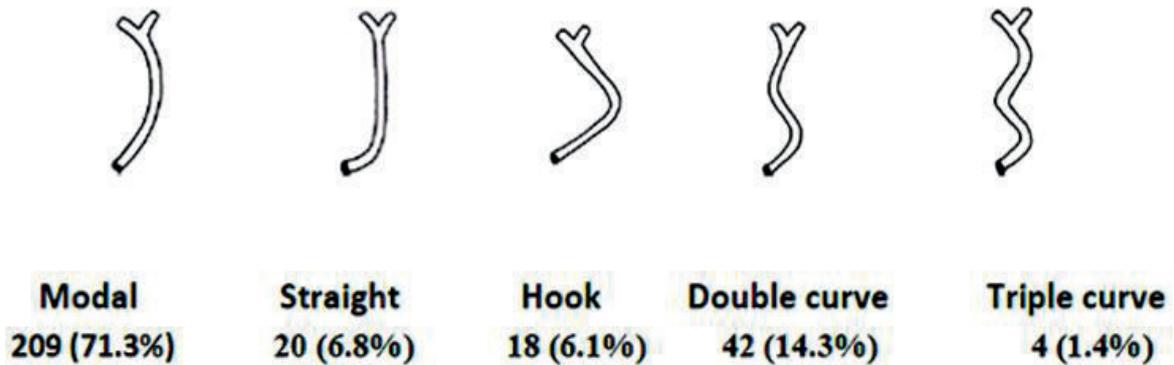Y- shaped implantation
7.1%

Fig. 2. Pancreatic duct implantation

Figure 3. CBD aspect

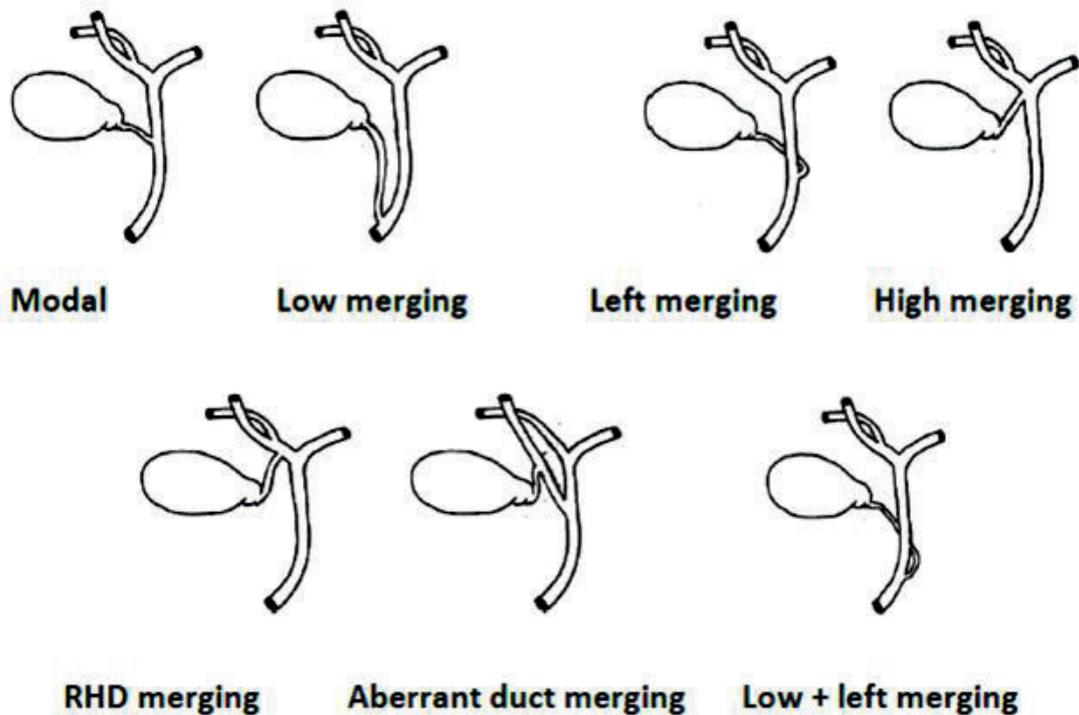| Modal	Straight	Hook	Double curve	Triple curve
209 (71.3%)	20 (6.8%)	18 (6.1%)	42 (14.3%)	4 (1.4%)

Figure 4. Cystic duct branching

The cystic duct was unseen in 4 cases. When it was seen, it had a modal presentation in 234 cholangiograms (80.9%). We registered 6 other branching patterns listed as follows (figure 4): low merging in 3 cases (1%), left merging in 39 cases (13.5%), high merging in 3 cases (1%), right hepatic duct (RHD) merging in 2 cases (0.7%), low and left merging in 7 cases (2.4%) and aberrant duct merging: 1 case (0.3%).

No significant difference was observed between the presence of anatomic variants and age, gender,

DISCUSSION

Surgical practice has long encountered anatomic variation in the biliary tree. The notion of modal and aberrant anatomy was first described by Couinaud in 1957 through examination of liver corrosion casts on post mortem specimens. Since, several imaging methods (such as MRC and ERCP) added to this technique to help visualizing the anatomy of the bile ducts. With the recent technical advancement of hepatic surgery, recognizing and considering anatomic variation in the surgical technique is now a must for success of surgery [9]. In our study, evaluation was focused on the post-operative cholangiograms of a Tunisian population of the Center-east.

Variations arise from aberrations of embryological development [10]. The liver, gallbladder, and biliary tree arise as a ventral bud (hepatic diverticulum) from the most caudal part of the foregut early in the fourth week. This outgrowth extends into the septum transversum as rapidly proliferating cell strands, and divides into two parts as it grows between the layers of the ventral mesentery: the larger cranial part (pars hepatica) is the primordium of the liver, and the smaller caudal part (pars cystica) expands to form the gallbladder, its stalk becoming the cystic duct [11, 12]. The pars cystica grows in length and represents the primordium of the gallbladder, the cystic duct, and common bile duct (ductus choledochus). For up to 8 weeks of gestation, the extra-hepatic biliary tree further develops through lengthening of the caudal part of the hepatic diverticulum. The pars cystica of the hepatic diverticulum begins initially from the anterior side of the future duodenum. At approximately the fifth week, the duodenum rotates to the right, so that the attachment of the developing common bile duct becomes displaced to its definitive position on the dorsal side of the duodenum. The hepatic duct (ductus hepaticus) develops from the cranial part (pars hepatica) of the hepatic diverticulum. In the 34-day embryo, the common hepatic duct is a broad, funnel-like structure in direct contact with the developing liver, without a recognizable left or right hepatic duct. During the fifth week, a rapid entodermal proliferation takes place in the dilated funnel-shaped structure above the junction of common bile duct and cystic duct; this proliferation gives rise to several folds, resulting in several channels at the porta hepatis (transverse fissure of the liver). It is speculated that this remodeling at least partially explains the existence of the several variants in the configuration of the right and left hepatic ducts [13]. The distal portions of the right and left hepatic ducts develop from the extra-hepatic ducts and are clearly defined tubular structures by 12 weeks of gestation. The proximal portions of the main hilar ducts derive from the first intra-hepatic ductal plates. The ductal plate is the term given to the layer of cells surrounding the portal vein branches like a cylindrical sleeve [14]. The extra-hepatic bile ducts and the developing intra-hepatic biliary tree maintain luminal continuity from the very start of organogenesis throughout further development (figure 5) [13].

The mean age in literature varied in North-African studies from 35 to 46 years [15, 16, 17]. In other international studies it varied from 30 to 57 years with a range of 16 to 89 years [5, 6, 18-20]. The age of our 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, as shown precedently. Variant extra-hepatic biliary anatomy has been reported to be related to gender, in particular, the maljunction of the pancreatico-biliary tract [19, 21, 22]. In an Italian study, it was reported that a variant anatomy was significantly more common in females (45% vs. 26% in males; p=0.005) [19]. This difference could be explained probably by a different embryologic development in the two sexes. Lack of data cannot though confirm this theory. In the present study, the majority of subjects were females: 68.6% of women versus 31.4 % of men, with a sex ratio of 0.45. Variant anatomy was not related to gender.

About disparity of prevalence and types of biliary abnormalities according to regions, ethnicity or demographic features, few studies are available. We found that the majority of researches were conducted in the far east, where living donor liver transplantation is being widely performed, and that modal anatomy was predominant within the subtype Asian population. A paper by Karakas [6] compared an Anatolian Caucasian population with the Asian population and reported that modal anatomy was less frequent in Anatolian Caucasians compared to Asians (55% versus 63-73%) but had similar prevalence compared to North Americans (57%). Another meta-analysis by
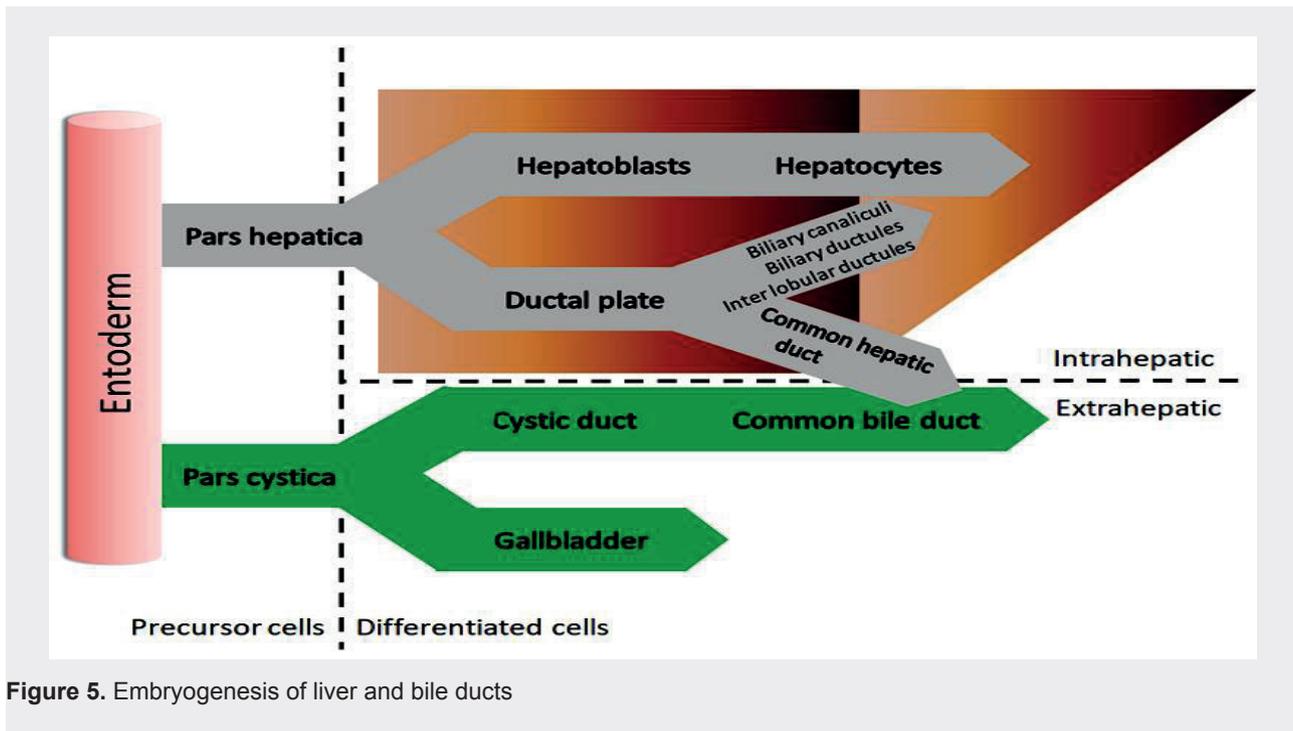
Figure 5. Embryogenesis of liver and bile ducts

Cuccetti joined Karakas' results showing that Asian population had higher prevalence of modal presentation. It also showed similar results of modal anatomy prevalence between north American and European populations [19]. We are not surprised by this result as ethnically speaking, both can be considered Caucasians, although taken with caution due to interpretation bias. On the other hand, few studies were available about Middle-Eastern or North-African populations (of which we cite Elhjouji (2009), Abdelgawad (2011), Barsoum (2013)) and our work seems to be the first to be conducted on a Tunisian population. Although the samples were small-sized (20 to 106 subjects), according to these authors, modal anatomy was present in 60% to 80% of the population [15-17].

According to Renard, the modal disposition of extra-hepatic ducts is found only in 35% of cases [23]. The most common anatomic variants in the branching of the biliary tree involve the cystic duct branching, the upper biliary confluence and the right posterior duct and its fusion with the right anterior or left hepatic duct [24]. Our results showed anatomic variants of the extra-hepatic bile tract in 158 patients (53.9%). Modal anatomy was present in 46.1% of cases. The most frequent variations were a double-curved CBD (14.3%) and a loop entry of the cystic duct (13.3%).

According to Renard [23], the CBD drains in the 2nd duodenum in 75% of the times. It can also drain into the inferior duodenal flexure (19.5%), 3rd duodenum (1.5%) and exceptionally in the 4th duodenum. Our results showed a higher incidence of 2ndduodenum implantation reaching 96.2%. Inferior duodenum flexure implantation incidence was of 3.8%. No other anatomic variants were found. Anatomy of the pancreaticobiliary junction (PBJ) is subject to several variations. Renard described three "normal" variants [23]:

• Type 1: junction of the PD and CBD through a common canal in the duodenal papilla. This is the most frequent presentation found in 80-85% of subjects.

• Type 2 (5-10%): PD and CBD drain separately in one unique duodenal papilla.

• Type 3 (10%): each duct drain separately in the duodenum.

Pancreaticobiliary maljunction (PBM) is a congenital anomaly defined as a junction of the pancreatic and bile ducts located outside the duodenal wall, usually forming a markedly long common channel (Y-shaped pattern), and are usually associated with cystic dilatation of the common bile duct [23]. These anomalies have not been subject

to our study. And although we registered two cases of choledochal cysts, the PD was unseen in the cholangiogram in both cases. Post-operative cholangiography is, indeed, not a suitable imaging technique for visualizing PBJ, as our study showed opacification of the pancreatic duct only in 23.9% of cases, among which 87% had a V-shaped implantation, 7% had a Y-shaped implantation and 4% had a U-shaped implantation.

The CBD usually has an arciform course with a right concavity [25]. Although other aspects (straight, hook, double curve or triple curve) have been described by some authors [23], no statistical incidence have been calculated and no surgical implication was associated to these course variants. In our study, these variations were up to 28.7%, the most frequent one being a double curve aspect.

Cystic duct variations are quite frequent and very important to recognize during cholecystectomy. The classical textbook description of an angular lateral junction with the CBD represent only 17% of cases [23]. The course and pattern of entry of the cystic duct into the common hepatic duct (CHD) is extremely variable. The level of junction is determined by the timing of the process of separation of pars hepatica from pars cystica. Malrotations of the cystic duct are due to faulty transfer of the choledocho-duodenal junction during rotation of the duodenum. The twist of the duct during its formation may be either clockwise or anti-clockwise causing the cystic duct to take a spiral course either in front of, or behind the CHD [11]. Drainage of the cystic duct into the RHD has been reported in 0.6 to 2.3%

[11]. The danger here is that the RHD may be mistaken for the cystic duct and tied off and divided where it joins the left hepatic duct. Drainage into the left hepatic duct is extremely rare. According to Renard, cystic duct has a low junction with CBD in 25% of cases, a high junction in 20%, and a spiral junction (either right, left or medial) in 8 to 20% [23]. Figures 6, 7 and 8 explain demonstrate branching patterns of the cystic duct according to some authors. In our study, 2-D cholangiogram interpretation had its limitation to determine course in the antero-posterior plan. We found a modal junction in 89.9% of cases, a low merging in 3 cases (1%), a loop left merging in 13.5% of cases, a low and left merging in 7 cases (2.4%), 3 cases of high merging (1%), 2 cases where the cystic duct drained in the RHD (0.7%) and one case of merging in an aberrant duct. Table 2 shows the frequency of different variations of the extrahepatic biliary ducts in different studies.

Table 2. Frequencies of extrahepatic biliary ducts variants according to authors

Series	Overall EHD	CBD implantation	PBJ	Cystic duct implantation
Renard [23]	35%	25%	15%	8-20%
Uchiyama [30]	-	-	-	4%
Lamah [11]	-	-	-	8-14%
Our series	54%	4%	13%	19%

EHD: extrahepatic ducts; CBD: common bile duct; PBJ: pancreaticobiliary junction
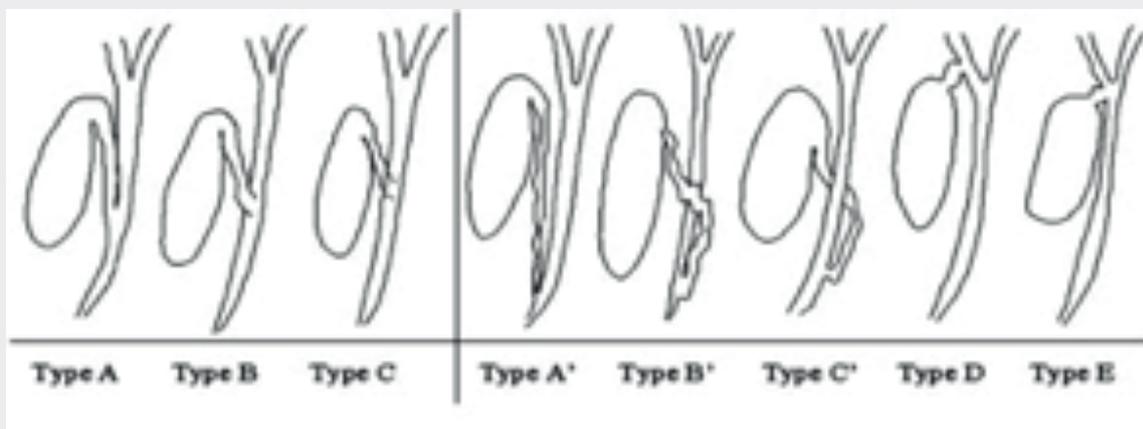

Figure 6. Cystic duct branching pattern variations according to Uchiyama [30]
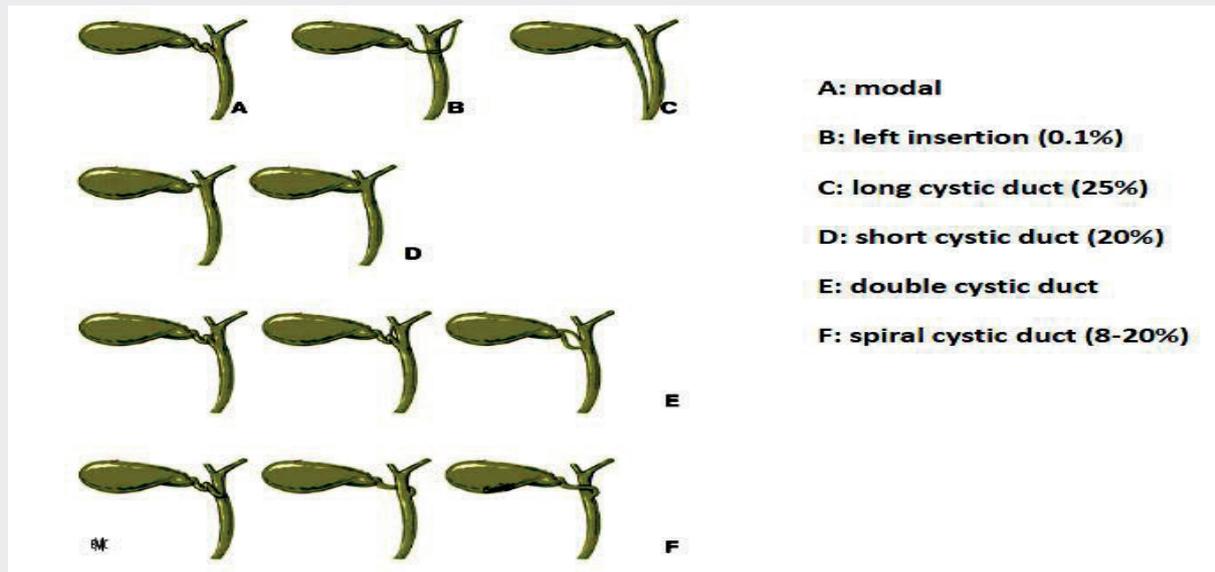
A: modal

B: left insertion (0.1%)

C: long cystic duct (25%)

D: short cystic duct (20%)

E: double cystic duct

F: spiral cystic duct (8-20%)

Figure 7. Cystic duct branching pattern variations according to Renard [23]

3a parallel course of cystic duct with low entry into common hepatic duct

3b high fusion of cystic duct with common hepatic duct

3c anterior loop of cystic duct

3d posterior loop of cystic duct

3e cystic duct entering right hepatic duct

3f cystic duct entering left hepatic duct

3g caducean cystic duct
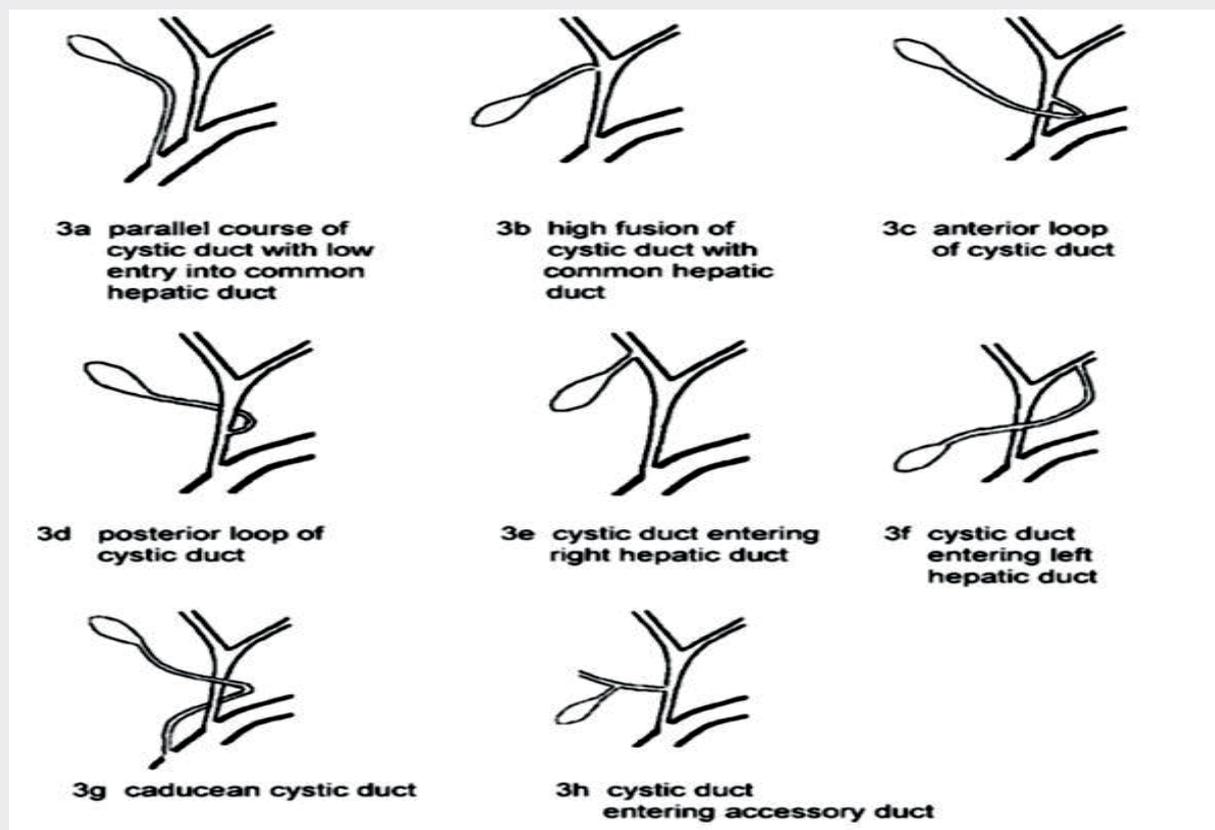
3h cystic duct entering accessory duct

Figure 8. Cystic duct branching pattern variations according to Lamah [11]

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 RHD were predictors of a more complex surgery (bench ductoplasty or multiple anastomoses) [6, 26, 27]. 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. Although causes of laparoscopic conversion and bile duct injury may be divided into technical factors, anatomic factors and pathologic factors [28, 29], an abnormal bile duct route is nevertheless still considered to be the most important factor among all anatomic factors. As compared with extra-hepatic bile ducts that have normal routes, intraoperative injury to the hepatic duct occurs 3.2 to 8.4 times more frequently in patients with extra-hepatic bile ducts with some form of abnormal route, whether open cholecystectomy or laparoscopic cholecystectomy is performed [30]. According to Ayuso the laparoscopic cholecystectomy surgical technique was more difficult when the cystic duct merged at the left posterior side of the common hepatic duct as compared with merging on the right side or anteriorly. It was even more difficult when an aberrant cystic duct merged with the RHD [27]. In our study, we found no correlation between the presence of anatomic variants and the frequency of conversion, post-operative complications or the operating time and hospital stay, even when we compared "high risk" groups with other types.

The main limitation of our work remains interpretation bias. Cholangiograms interpretation is indeed firstly operator-dependent, and secondly, sometimes made difficult because of poor quality, incomplete images, artefacts etc. In fact, most of these cholangiograms were done in suspicion of bile duct stones and not specifically to identify biliary anatomy. Trying to remedy to this problem, our interpretation was systemically reviewed by an experienced surgeon and anatomist, and a third party was consulted in case of disagreement. Another limitation was methodology for it is a retrospective, non randomized study. The files we used were sometimes lacking data about clinical, radiological or operative findings. We had

to exclude non-exploitable files or cholangiograms. Adding to that some unavailable files because of archiving issues, our population sample was quite reduced. Yet, we believe our work had the merit of including a large population that could be representative of the Tunisian center-east. And although the main subject is about anatomy, we believe it comes as a necessity to follow and to add to the advancement of hepato-biliary surgery.

CONCLUSION

Conventional cholangiography constitutes an accurate tool to detect 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. ERCP and MRC are also useful for pre-operative biliary mapping. In all cases, a good knowledge of the anatomic variations of the biliary tree is an essential prerequisite for a good interpretation of these radiological examinations. The anatomy of the liver has proven to be complex and variable. Jacques Belghiti even states that "Liver anatomy can change". A comprehensive understanding of normal and aberrant anatomy is the cornerstone of surgery. Although the expertise offered by our radiology and anesthesiology colleagues is important, it is incumbent upon every surgeon who performs liver surgery to be well prepared.

REFERENCES

1- Couinaud C. Le foie. Etudes natomiques et chirurgicales. Paris : Masson & Cie, 1957.

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

3- Champetier J. Les voies biliaires. Anat. Clin. Tronc, Paris: Springer; 1994, p. 416–7.

4- Kitami M, Takase K, Murakami G, Ko S, Tsuboi M, Saito H, et al. 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.

5- 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.

6- Karakas HM, Celik T, Alicioglu B. Bile duct anatomy of the Anatolian Caucasian population: Huang classification revisited. Surg Radiol Anat

2008;30: 539–45.

7- Jarrar MS , Masmoudi M, Mraidha MH, Naouar N, Barka M, Youssef S, et al. Anatomic variations of the upper biliary confluence and intra-hepatic ducts in East-central Tunisian population. Ital J Anat Embryol. 2019;124(3): 487-98.

8- Jarrar MS, Khenissi A, Ghrissi R, Hamila F, Letaief R. Ansa pancreatica: an anatomic variation and a rare cause of acute pancreatitis. Surg Radiol Anat. 2013;35(8): 745-8.

9- Jurkovikj D. Some Anatomic-Topographic Features of Common and Right Hepatic Ducts and their Constituents. Maced J Med Sci. 2011;4(1): 44-53.

10- Hayes MA, Goldenberg IS, Bishop CC. The developmental basis for bile duct anomalies. Surg Gynecol Obstet. 1958;107: 447–56.

11- Lamah M, Karanjia ND, Dickson GH. Anatomical variations of the extrahepatic biliary tree: Review of the world literature. Clin Anat. 2001;14: 167–72.

12- Ando H. Embryology of the Biliary Tract. Dig Surg. 2010;27: 87–9.

13- Roskams T, Desmet V. Embryology of Extra- and Intrahepatic Bile Ducts, the Ductal plate. Anat Rec Adv Integr Anat Evol Biol. 2008;291: 628–35.

14- Van Eyken P, Sciot R, Callea F, Van der Steen K, Moerman P, Desmet VJ. The development of the intrahepatic bile ducts in man: a keratin-immunohistochemical study. Hepatol Baltim Md. 1988;8: 1586–95.

15- Elhjouji A, Ali AA, Alahyane A, El Khader A, Baba H, Oueldjeddou C, et al. Variations anatomiques des voies biliaires et conséquences chirurgicales: à propos de 19 cas. J Afr Hépatol Gastroenterol. 2009;3: 137–42.

16- Abdelgawad MS, Eid M. Biliary tract variants in potential right lobe living donors for liver transplantation: Evaluation with MR cholangiopancreatography (MRCP). Egypt J Radiol Nucl Med. 2012;43: 53–7.

17- Barsoum NR, Samie AA, Adel L, Asaad RE. Role of MRCP in assessment of biliary variants in living donor liver transplantation. Egypt J Radiol Nucl Med. 2013;44: 131–6.

18- Choi JW, Kim TK, Kim KW, Kim AY, Kim PN, Ha HK, et al. Anatomic variation in intrahepatic bile ducts: an analysis of intraoperative cholangiograms in 300 consecutive donors for living donor liver transplantation. Korean J Radiol. 2003;4: 85–90.

19- 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.

20- Deka P, Islam M, Jindal D, Kumar N, Arora A, Negi SS. An analysis of biliary anatomy according to different classification systems. Indian J Gastroenterol. 2014;33: 23–30.

21- Tashiro S, Imaizumi T, Ohkawa H, Okada A, Katoh T, Kawaharada Y, et al. Pancreaticobiliary maljunction: retrospective and nationwide survey in Japan. J Hepatobiliary Pancreat Surg. 2003;10: 345–51.

22- Kamisawa T, Takuma K, Anjiki H, Egawa N, Kurata M, Honda G, et al. Pancreaticobiliary maljunction. Clin Gastroenterol Hepatol Off Clin Pract J Am Gastroenterol Assoc. 2009;7: S84-88.

23- Renard Y, Sommacale D, Avisse C, Palot JP, Kianmanesh R. Anatomie chirurgicale des voies biliaires extrahépatiques et de la jonction biliopancréatique. EMC - Tech Chir - Appar Dig. 2014;9(3) :1-21

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

25- Blidaru D, Blidaru M, Pop C, Crivii C, Seceleanu A. The common bile duct: size, course, relations. Romanian J Morphol Embryol Rev Roum Morphol Embryol. 2010;51 :141–4.

26- 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.

27- Ayuso JR, Ayuso C, Bombuy E, De Juan C, Llovet JM, De Caralt TM, et al. 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. 2004;10: 1391–7.

28- Jarrar MS, Fourati A, Fadhl H, Youssef S, Mahjoub M, Khouadja H, et al. Risk factors of conversion in laparoscopic cholecystectomies for lithiasic acute cholecystitis. Results of a monocentric study and review of the literature. Tunis Med. 2019;97(2): 344-51.

29- Hu ASY, Donohue PO, Gunnarsson RK, de Costa A. External validation of the Cairns Prediction Model (CPM) to predict conversion from laparoscopic to open cholecystectomy. Am J Surg. 2018;216(5) :949-54.

30- Uchiyama K, Tani M, Kawai M, Ueno M, Hama T, Yamaue H. Preoperative evaluation of the extrahepatic bile duct structure for laparoscopic cholecystectomy. Surg Endosc. 2006;20: 1119–23.