Morphological Variability of the Left Intrahepatic Biliary Tree
Study on corrosion casts

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The bile duct system has one intrahepatic and as well extrahepatic distinct components, both subject to large anatomical variability. The left component of the bile duct is much more rarely when compared with than the right side. On the 100 pieces of hepatic corrosion casts, we analysed the confluence modality of II, III and IV segmental ducts, to form the lateral and medial branches, and finally the left hepatic duct. Depending on the confluence modality of these ducts and branches to form the left hepatic duct, we revealed three morphological types. In the majority of cases (Type I - 86% of cases) the confluence of segmental duct II and segmental duct III form the lateral branch and the confluence of lateral and medial branches form the left hepatic duct. In most of these cases, the confluence of segmental ducts II and III (to form the lateral branch), is located on the left side of the lateral portal branches origin branches origin, and the confluence of lateral and medial branches (to form the left hepatic duct) is located at the right of the origin of the medial portal branches. Relations of the intrahepatic biliary ducts system with the portal vein element have major practical importance in liver resection surgery and transplantation.

Keywords: corrosion casts, left intrahepatic bile duct system, major variations

According with classical textbooks [1], the biliary tree collects and delivers bile from the liver to the second part of the duodenum, conventionally being divided into two distinct parts: intrahepatic and extrahepatic biliary trees. The intrahepatic ducts are formed from bile ductules that join to form first the segmental ducts, second division branches and third to form right and left hepatic ducts. The right second order biliary branches [the anterior branch and the posterior branch] are formed by confluence the right hepatic duct. The left second order biliary branches [medial branch and lateral branch] form by confluence the left hepatic duct. In the last part of the hepatic ducts are draining the right/left caudate lobe ducts [2,3]. The confluence of the two right and left hepatic ducts, forms the superior biliary confluent, at the level of common hepatic duct origin [2]. The intrahepatic biliary system elements are associated with the intrahepatic portal and hepatic arterial branches path, and they have a segmental character [4-7]. Studies on morphological variability of the of bile ducts system demonstrate that most variations of intrahepatic biliary confluence of elements are located at right hepatic lobe [8-11].

Knowledge the variations of bile ducts of the liver left lobe are particularly important when using left hepatic parenchyma to achieve liver transplantation. In this paper, the authors examine the variations of the medial and lateral biliary branches confluence to form the left hepatic duct. For this study, we analyzed corrosion casts of liver without pathological changes.

Experimental part

In the present study, one used 100 human intrahepatic bile duct system corrosion casts achieved in the Department of Anatomy of the "Victor Babes" University of Medicine and Pharmacy, Timisoara, prepared in the period 1997-2012. Of these, 50 revealed only the intrahepatic bile ducts systems, and 50 all the elements of afferent pedicle which it was associated and biliary system. The injection of the liver vasculo-ductal systems liver was performed with Technovit 7143 plastic compound (Heraeus Kulzer GmbH, Wehrheim, Germany). The corrosion of the liver parenchyma was performed with technical hydrochloric acid. The studied liver vasculo-ductal corrosion casts were photographed (Nikon D3, Tokyo, Japan, AF-S Nikkor Lens f/1.4G). All procedures for harvesting the liver pieces and making of corrosion casts were approved by the Ethics Committee of the "Victor Babes" University of Medicine and Pharmacy, Timisoara.

Results and discussions

In 100 pieces of human intrahepatic bile duct system corrosion cast, we analysed the confluence modality of II, III and IV segmental ducts, to form the lateral and medial branches, and finally the left hepatic duct. Depending on the confluence modality of these ducts and branches to form the left hepatic duct, we revealed three morphological types: a modal type (type I) on 86 corrosion casts (86% of cases) and two morphological types (types II-III) with major morphological variations corrosion on 14 corrosion

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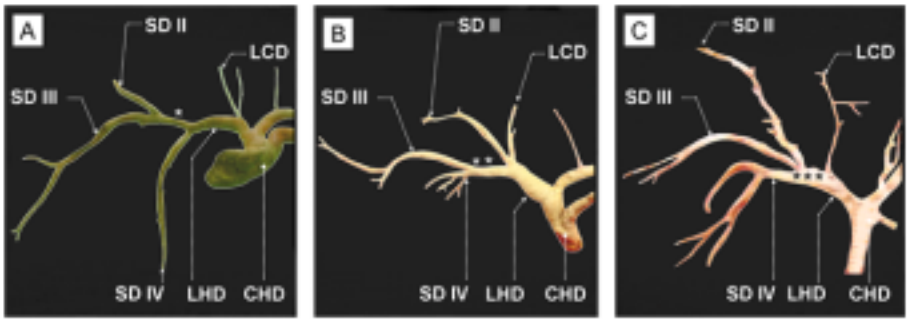

Fig. 1. Corrosion casts of intrahepatic bile ducts system. Posterior view. A - Modal type (Type I), B - Type II, C - Type III. CHD - common hepatic duct, LHD - left hepatic duct, LCD - left caudate duct, SD II - segmental duct II, SD III - segmental duct III, SD IV - segmental duct IV. * lateral branch, ** common duct of segment II and segment III, *** confluence of SD II, SD III and SD IV to form LHD.

casts (14% of cases). The analysis of three morphological types reveals the following characteristics:

- Type I (modal type - 86 corrosion casts, 86% of cases), in which the confluence of segmental duct II and segmental duct III form the lateral branch; the confluence of lateral and medial branches form the left hepatic duct (fig.1A).

- Type II (13 corrosion casts, 13% of cases), in which the III segmental duct drain in the medial branch; the II segmental duct form single the lateral branch; the confluence of medial and lateral branches form the left hepatic duct (fig.1B).

- Type III (1 corrosion casts, 1% of cases), in which the IV segmental duct form single the medial branch; the lateral branch is absent that morphological entity, in the sense that II and II segmental ducts drain directly in the distal end of the left hepatic duct together with the medial branch (form only by IV segmental duct).

Mariolis-Sapsakos et al. [12] highlighted that the most common morphological variations of the bile ducts and branches confluence are placed in the right hepatic lobe. Studies of Matusz [8] and Standring [1] didn't revealed the presence of morphological variations on the left hepatic duct formation. Choi et al. [13] carried a study on 300 consecutive intraoperative cholangiograms for living donor liver transplantation, and revealed in 1% of cases the drainage of segments II and III ducts individually into the right hepatic duct or in the common hepatic duct.

The confluence of the segment III duct with the medial branch (type II appearance in our study) has been highlighted in the lower percentage (2%) by Shahl et al. [14]. The same author highlights a higher percentage (2%) of the drainage of the II and II segmental ducts directly in the distal end of the left hepatic duct together with the medial branch (IV segmental duct).

Usually, intrahepatic bile ducts system elements are placed above and below the intrahepatic portal system elements. Of the 100 pieces of corrosion casts, a number of 50 analyzed pieces contained portal, arterial and the bile ducts system elements (44 pieces TI, TII five pieces, one piece TIII). On these we analyzed the confluence of the biliary elements, depending on the level of portal branching elements.

We highlighted that in most cases the TI (32 pieces - 64% of cases) the confluence of segmental ducts II and III (to form the lateral branch), is located of the lateral portal branches origin, and the confluence of lateral and medial branches (to form the left hepatic duct) is located at the right of the origin of the medial portal branches. Most cases belonging TII (5 pieces - 80% of cases) have placed the point of confluence of the medial branch and III segmental duct in front of the umbilical portion of the left portal branch. The same location has the junction of the biliary ducts in the T III (one piece - 100% of cases). This is particularly important in planning and conducting segmentation liver resections.

According with Ivan et al. [2], intrahepatic bile ducts corrosion casts study is one of the most important ways of training medical students and residents; although MDCT angiography images are much easier to achieve, given the existence of adequate facilities [15], they do not provide three-dimensional images of the plastination preparations and of the corrosion casts [2,16-19].

Conclusions

Although morphologic variations of the bile ducts system is less frequent in the left hepatic lobe, their knowledge is particularly important. Relations of the intrahepatic biliary ducts system with the portal vein element have major practical importance in liver resection surgery and transplantation.

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References

1. STANDRING S. Gray's Anatomy: The Anatomical Basis of Clinical Practice. 41th ed. Edinburgh: Elsevier Churchill Livingstone; 2016.

2. IVAN, C, NICA CC, DOBRESCU, A, BELIC O, MATUSZ, P, OLARIU, S., Using Human Intrahepatic Bile Duct System Corrosion Casts in Training of the Medical Students and Residents, Mat. Plast.,**52**, no.1, 2015, p. \50.

3. MATUSZ P. Right/left symmetry of the intrahepatic distribution and terminology of the hepatic artery proper and the intrahepatic bile duct system: proposals to revise the Terminologia Anatomica. Surg Radiol Anat., 2011, 33(1):71-74.

4. HULSBERG P, GARZA-JORDAN JDE L, JORDAN R, MATUSZ P, TUBBS RS, LOUKAS M. Hepatic aneurysm: a review. Am Surg., 2011, 77(5):586-591.

5. IOANOVICIU, SO, IVAN, C, MATUSZ, P, OLARIU, S, LIGHEZA,N D. Morphological variability of the hepatic portal vein medial branches. Study on corrosion casts. Mat. Plast.,**52**, no. 1, 2015,p. 113-

6. IOANOVICIU, SD, IVAN C, MATUSZ, P, OLARIU, S, LIGHEZAN, D. Morphological variability of the hepatic portal vein posterior branch: Study on corrosion casts. Mat. Plast., **52**, no. 2, 2015, p. 263

7. LIGHEZAN, DF, MATUSZ P, IACOB, N, MICLAUS, GD, PUSZTAI, AM, HORDOVAN E-C, BANCIU, CD, BOIA, M. Hepatic portal vein branching variations on corrosion casts and imagistic investigations. Mat. Plast., **52**, no. 3, 2015,p. 360.

8. MATUSZ, P. Tipologii de desfãþurare spaþialã þi interrelaþii morfologice privind elementele de angio- °i bilioarhitecturã hepaticã, Tezã de doctorat. UMF Timiþoara; 1994.

9. BLUMGART LH, HANN LE. Surgical and radiologic anatomy of the liver, biliary tract and pancreas. In: Blumgart LH editor in chief. Surgery of the liver, biliary tract, and pancreas. 4th ed. Volume 1. Philadelphia: Saunders, Elsevier; 2007. p. 3-29.

10. CHAMPETIER J. Les voies biliaires. In: Chevrel JP editor. Anatomie clinique. Le tronc. Paris, Berlin, Heidelberg, New York, Londres, Tokyo, Hong Kong: Springer Verlag; 1994. p.407-20.

11. KARALIOTAS CCH, PAPACONSTANTINOU T, KARALIOTAS CHC. Anatomical variations and anomalies of the biliart tree, vein and

arteries. In CCh Karaliotas, ChE Broelsch, NA Habib Editors, Liver and biliary tract surgery. Wien: Springer; 2006:35-48.
12. MARIOLIS-SAPSAKOS T, KALLES V, PAPATHEODOROU K, GOUTAS N, PAPAPANAGIOTOU I, FLESSAS I, KAKLAMANOS I, ARVANITIS DL, KONSTANTINOU E, SGANTZOS MN. Anatomic variations of the right hepatic duct: results and surgical implications from a cadaveric study. Anat Res Int., 2012, 2012:838179.
13. CHOI JW, KIM TK, KIM KW, KIM AY, KIM PN, HA HK, LEE MG. an analysis of Anatomic variation in intrahepatic bile ducts: intraoperative cholangiograms in 300 consecutivedonors for living donor liver transplantation. Korean J Radiol., 2003, 4(2):85-90.
14. SHAH OJ, ROBBANI I, SHAH P, ZARGAR SA, JAVAID G, YATTOO GN, SHAH A, MUSTAFA F. Left-sited hepatic resection for hepatolithiasis: a longitudinal study of 110 patients. HPB (Oxford), 2012, 14(11):764-771.
15. MATUSZ P, MICLAUS GD, PLES H, TUBBS RS, LOUKAS M. Absence of the celiac trunk: case report using MDCT angiography. Surg Radiol Anat., 2012, 34(10):959-963.
16. BEDREAG, O, BUT, A.R, HOINOIU, B, MICLAUS, G.D, URSONIU, S, MATUSZ, P, DOROS, CI. Using pig tracheobronhial corrosion casts in training of the medical students and residents. Mat. Plast., **51**, no. 4, 2014, p. 447.
17. SORA, MC., MATUSZ, P. General considerations regarding the thin slice plastination technique. Clin Anat., 2010, 23(6):734-736.
18. SORA, MC., MATUSZ, P. Study of the vascular architecture of bones using the plastination technique. Clin Anat., 2012, 25(2):258-259.
19. SORA, MC., JILAVU, R., MATUSZ, P. Computer aided three dimensional reconstruction and modelling of the pelvis, by using plastinated cross sections, as a powerful tool for morphological investigations. Surg Radiol Anat., 2012, 34(8):731-736

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