Morphological Variability of the Hepatic Portal Vein Medial Branches

Study on corrosion casts

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The hepatic portal vein (HPV) is the central element of liver afferent pedicle. The intraparenchymal distribution of HPV determines the liver segmentation. The medial branches (MBs) serving left medial division (LMD) of the liver present the greatest morphological variability. On a total of 125 pieces of liver corrosion casts, one examined the intraparenchymal distribution of portal MBs and the segmentation of LMD. Regarding the intraparenchymal distribution of the branches in the LMD of the liver, we showed three distinct morphological types: Type I (81.6% of cases) where are present several small MBs with oblique downward trajectory; Type II (15.2% of cases) that has two distinct MBs, originating in the distal part of the PHV left branch, with slightly upward trajectory; Type III (3.2% of cases) that has three MBs, originating in the distal part of the PHV left branch, the higher with upward trajectory, the lower with downward trajectory, and the middle branch with variable trajectory and originated from the PHV left branch or in one of the first two MBs. Knowledge of this morphological types of portal MBs is important for clinical and surgical practice.

Keywords: corrosion casts; hepatic portal vein; medial branches; variability; morphological typologies.

Clinical and intraoperative ultrasonography, liver metastasis radiofrequency ablation, laparoscopic surgery, open hepatic surgery (especially hepatic resection and ablation of liver metastasis) are based mainly on the anatomical hepatic segmentation [1 - 7]. An earlier report [8] revealed that delineation of the liver segmental anatomy is essential for localisation of focal hepatic pathology before surgical or percutaneous interventions.

Cantlie [9] was the first who revealed the intraparenchymatous arrangement of the vascular and ductal elements of the right and left lobes of the liver. After him, McIndoe and Conseller [10] studied the bi-laterality of the liver intraparenchymal structures. Matusz [11] analyzed the evolution of research on liver segmentation, highlighting the studies of: Rex in 1888, Hjorstjö in 1948, Healey and Schroy in 1953, Couinaud in 1954 and 1957, Reiferscheid in 1957 and Platzer and Maurer in 1966. In 1957, Couinaud [12] described the hepatic segmentation comprising eight segments. Based on this segmentation, Terminologia Anatomica [13] homologates eight segments of the liver. The arterial and ductal elements related to the liver's afferent pedicle, distribute to these eight liver segments [7, 11, 14-16], and hepatic veins are located within the fissures between divisions and segments [7, 17, 18].

According to Donato et al. [19], there are several anatomical variations in the hepatic segmentation, which must be known, in order to perform efficient medical and surgical procedures. These variations are mainly due to variations in intraparenchymal distribution of hepatic portal vein (HPV) branches.

The most common and wider morphological variations of liver segmentation are shown in the left medial division (LMD). It consists of a single segment (segment IV) [12, 13, 20-22], two segments (segments IVA and IVB, respectively) [23-27] or three segments (segments IVA, IVA and IVC [28]).

This study seeks to highlight the segmentation of the LMD of the liver depending on the intraparenchymal distribution of portal MBs on a significant number of liver corrosion casts.

Experimental part

In the present study, 125 human intrahepatic portal vein system corrosion casts, achieved in the Department of Anatomy of the "Victor Babes" University of Medicine and Pharmacy Timisoara, were investigated. The corrosion pieces were prepared during 1997-2012. Liver pieces were harvested from human cadavers who had no history of liver diseases or abdominal surgical procedures. Injection of the liver vascular-ductal systems was performed in the first period (1997-2005) with AGO II mass (nitrocellulose paste), and in the second period (2006-2012) with Technovit 7143 plastic compound (based on methacrylate copolymers). The corrosion process of the liver parenchyma was performed with hydrochloric acid (technical purity). All procedures for performing the liver corrosion casts were approved by the Ethics Committee of the "Victor Babes" University of Medicine and Pharmacy, Timisoara. The studied liver corrosion casts were classified according to the present type of major portal MBs variation.

Results and discussions

In all 125 pieces of liver corrosion casts, the origin of the left branch of HPV was firstly highlighted. There were three ways of the HPV left branch origin: (i) the bifurcation of the HPV trunk in right branch and left branch (96.8% of cases); (ii) trifurcation of the HPV trunk in anterior, posterior and left branches (2.4% of cases); (iii) bifurcation of the HPV

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trunk in posterior and anterior branches; the left branch originates from the first part of the anterior branch (0.8% of cases).

From umbilical portion of the left branch arise the medial and lateral branches. Regarding the intraparenchymal distribution of the branches in the LMD of the liver, three distinct morphological types were showed:

- Type I (81.6% of cases) that are present several small MBs with oblique downward trajectory (fig.1),

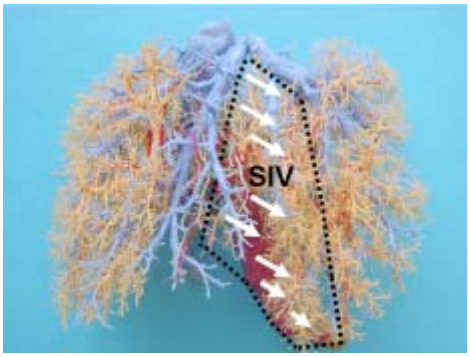

Fig.1. Liver corrosion casts with highlighting of all intraparenchymal vascular-ductal elements. Anterior view. Type I of portal medial branches, with multiple small portal branches at the level of left medial division (segment IV). SIV - segment IV, white arrows - medial branches

- Type II (15.2% of cases) that has two distinct MBs, originating in the distal part of the PHV left branch, with slightly upward trajectory (fig.2),

Fig.2. Liver corrosion casts with highlighting the left branch of the hepatic portal vein. Anterior- lateral left view. Type II of portal medial branches, with two distinct medial branches at the level of left medial division (segments IVA and IVB). HPV - hepatic portal vein trunk, LBr - left branch, II - branch of segment II, III - branch of segment III, IVA - branch of segment IVA, IVB - branch of segment IVB

- Type III (3.2% of cases) that has three MBs, originating in the distal part of the PHV left branch, the higher with upward trajectory, the lower with downward trajectory, and the middle branch with variable trajectory and originated from the PHV left branch or in one of the first two MBs (fig.3).

In all three morphological types, the portal MBs originate below the level of the superior lateral branch (branch for segment II). Type I is the modal type, approved by the Terminologia Anatomica [13]. This morphological condition with one segment (segment IV) in the LMD was described also by Couinaud [12, 20], Diaconescu [21] and Nomina Anatomica [22]. Type II, with the presence of two distinct MBs, and the presence of two segments in the

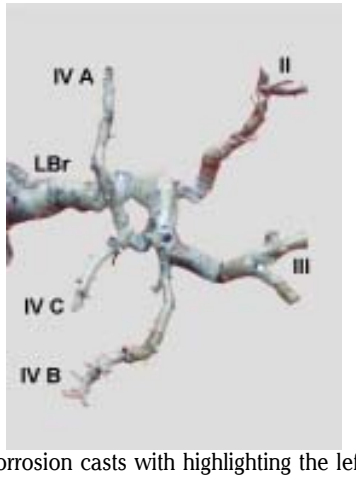

Fig.3. Liver corrosion casts with highlighting the left branch of the hepatic portal vein. Anterior- lateral left view. Type III of portal medial branches, with three distinct medial branches at the level of left medial division (segments IVA, IVB and IVC). LBr - left branch, II - branch of segment II, III - branch of segment III, IVA - branch of segment IVA, IVB - branch of segment IVB, IVC - branch of segment IVC

LMD (IVA and IVB segments) was also described by Healey et al. [24], Reiferscheid [25], Ciobanu [26] Lanz and Wachsmuth [27]. Type III with three portal MBs and the presence of three segments in the LMD was described by Hjorstjö [23] and Platzer et al. [28].

According to Zhang et al. [29], the LMD of the liver (segment Segment IV) is the "Achilles's heel" in split and living-donor transplantation. The arterial and also the venous drainage of the LMD of the liver are variable. The LMD, usually vascularized by the left branch of the hepatic artery proper, can receive their arterial blood also from the right branch of the hepatic artery proper. The venous outflow is mainly to the left and middle hepatic veins, but can be served also by tributaries of the right hepatic vein [30].

In Couinaud's classification [12, 20], LMD is a single segment, segment IV. In 1982, Bismuth et al. [31] developed the concept of subsegments and considered that segment IV could be divided into left medial superior (IVA) and left medial inferior (IVB) subsegments. This condition was previously described also by Healey et al. [24], Reiferscheid [25] and Ciobanu [26]. In 1993, Lanz and Wachsmuth [27] confirmed this presentation.

By defining multiple segments (sub-segments) in the LMD of the liver, was put into discussion the level and orientation of the boundary between hepatic subsegments IVA and IVB. Early reports [29, 32] showed that the intersegment boundary between segments IVA and IVB is an oblique plane, but in irregular position, which causes variable volume of segments IVA, IVB and IVC when it exists (fig.4). We highlighted the same condition in our

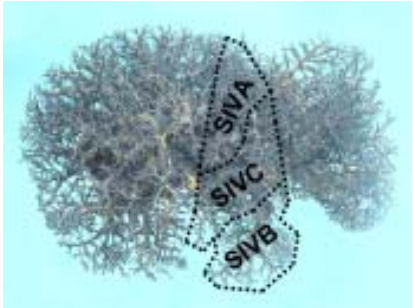

Fig.4. Liver corrosion casts with highlighting of the hepatic portal vein and the intraparencymal biliary system. Anterior view. Type III of portal medial branches with the level and orientation of the boundary between hepatic segments of the medial left

studied corrosion casts. In our corrosion casts, the tributary of a left and middle hepatic veins lying at the boundary between segments IVa and IVb in all pieces have two or three segments in the LMD. This condition was highlighted in 62.7% of examined specimens by the Physique Investigation Group of Chinese Society for Anatomical Science in 1986 [33], and in 100% of cases in the study of Zhang et al. in 2008 [29].

Highlighting and consideration of segments IVA, IVB and IVC allow limited resections at the LMD of the liver. The determinant anatomic element of these segments is represented by morphological aspects of the portal MBs.

Conclusions

Study of intraparenchymatous distribution of the HPV branches can be achieved in good conditions on corrosion preparations. The most frequently (81.6% of cases) the LMD of the liver is served by multiple small MBs (branches that form a unique segment - segment IV); rarely LMD is served by two MBs (branches forming two segments - segments IVA and IVB - 15.2% of cases), or three MBs (branches that form three segments - segments IVA, IVB and IVC - 3.2% of cases). Knowledge of these morphological types of portal MBs is important for clinical and surgical practice.

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