

Hepatic Portal Vein Branching Variations on Corrosion Casts and Imagistic Investigations

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The elements of afferent pedicle of the liver have a segmental distribution to the liver parenchyma. Divergence part of the hepatic portal vein is the main element of intraparenchymatous spatial distribution vasculo-ductal systems. On 500 divergence (intraparenchymal) portions of hepatic portal vein (125 pieces of liver corrosion casts, 125 ultrasound images, 125 images of MDCT angiography and 125 images of MR angiography), it was highlighted a number of six morphological types of intraparenchymatous part of hepatic portal vein, which are presented as follows. Symmetric bifurcation (standard portal vein anatomy) (Type I - 76.2%) in which the main portal vein trunk divides into right and left portal branches. Trifurcation, (Type II - 10.4%) in: the left branch, the (right) anterior branch, and the (right) posterior branch. Quadrifurcation, (Type III - 0.2%) in: anterior and posterior branches in the right part, and lateral and medial branches in the left part. Asymmetric bifurcation, (Type IV - 7.4%) in which the (right) posterior branch is the first branch of the main portal vein trunk. Asymmetric bifurcation of the right branch, (Type V - 4.4%) in which the branch for segment V or VIII (anterior branch) is the first branch of the right branch. Asymmetric bifurcation of the right branch, (Type VI - 1.4%) in which the branch for segment VI or VII (posterior branch) is the first branch of the right branch. Knowledge of these aspects is important both to investigate morphological imaging, and in performing partial resection and liver transplantation.

Keywords: hepatic portal vein branches; morphological types; corrosion casts; ultrasound images; MDCT angiography; MR angiography; clinical and surgical implications

The elements of afferent pedicle of the liver have a segmental distribution to the liver parenchyma. Divergence part of the hepatic portal vein is the main element of intraparenchymatous spatial distribution vasculo-ductal systems. In accordance with Terminologia Anatomica [1], the hepatic trunk of the portal hepatic vein splits into left and right branches. Left branch gives rise to lateral branches (for segments II and III) and medial branches (for the segment IV). Right branch give rise to: anterior branch (from which arises portal branches for segments V and VIII) and posterior branch (from which arise portal branches for segments VI and VII). From the transverse part of the left branch arise the caudate branches. Between the liver afferent pedicle elements, the hepatic portal vein reveals the lowest frequency of anatomical variations. Harvesting of liver parenchyma for transplantation take into account primarily the distribution of intraparenchymatous hepatic portal vein branches and secondly the parenchymal venous drainage ways.

Knowledge of systematic and topographic anatomy data is particularly useful for explaining aspects of pathogenesis, diagnostic and therapeutic principles in various diseases with different locations [2-7]. In assessing segmental anatomy of the liver parenchyma, one must consider interleaving elements associated with the efferent pedicle (hepatic veins) [8-15]. Associated to hepatic portal vein branches, in the liver parenchyma distributes the branches of the hepatic artery proper and intrahepatic bile ducts system elements [16-18].

Through various morphological (corrosion casts) and imaging methods (ultrasound exams, MDCT angiography and MRI angiography) were analyzed the primary branching pattern of the hepatic portal vein trunk. Knowledge of these aspects is important both to investigate morphological imaging, and in performing partial resection and liver transplantation.

Experimental part

In the present study, one used 500 divergence (intraparenchymal) portions of hepatic portal vein, of which: 125 pieces of liver corrosion casts, performed by injection of the hepatic vasculo-ductal systems with Ago II plastic compound (product based on nitrocellulose E950), and corrosion of hepatic parenchyma with technical hydrochloric acid (made in the Department of Anatomy of the "Victor Babes" University of Medicine and Pharmacy Timisoara), 125 ultrasound images made in Neonatology Clinic (SonoScape) and Internal Medicine IV (Siemens Sonoline G50) of the "Victor Babes" University of Medicine and Pharmacy Timisoara, 125 images of MDCT angiography performed on a 64-slice multidetector CT scanner (SOMATOM Sensation, Siemens Medical Solutions, Forchheim, Germany), and 125 MR angiography, performed in the Neuromed Diagnostic Imaging Centre Timisoara, using a 1.5-tesla MR scanner (fig.1).

Initially, a total of 132 pieces of liver corrosion casts and 295 abdominal examination through imaging methods

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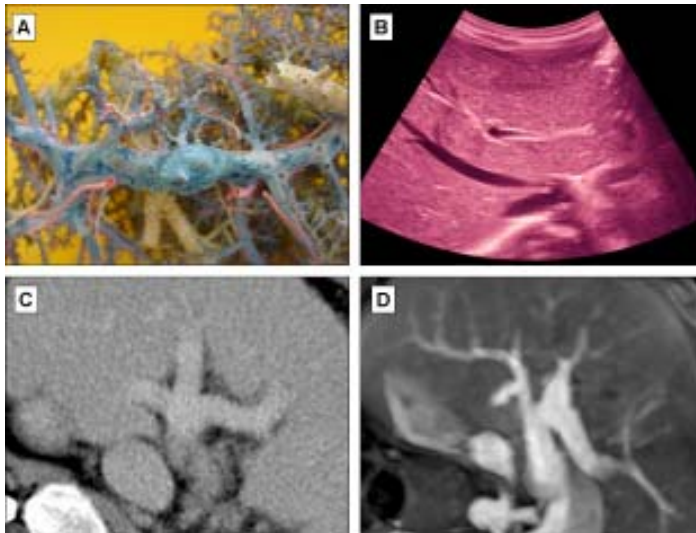


Fig.1. The methods of investigation of the divergence part of hepatic portal vein. A - The piece of corrosion cast; B - ultrasound image; C - MDCT angiography images; D - MR - angiography images. [Color figure can be viewed in the online issue, which is available at www.revmaterialeplactice.ro]

(ultrasound, MDCT angiography and MR angiography) were studied. There was excluded a total of 7 liver corrosion casts with impaired injection of the main hepatic portal elements, and a total of 13 patients who presented large central liver tumors, that have changed the intraparenchymal vascular architecture, 4 patients with portal embolization, 3 patients with partial resection of hepatic parenchyma and 2 patients with not classificable portal vein divergence portion.

Results and discussions

Therefore, a total of 500 portal vein systems were available for interpretation (125 corrosion casts and 375 intrahepatic portal vein images). It highlighted a number of six morphological types of intraparenchymatous part of hepatic portal vein (fig.2. and fig. 3):

- Type I - symmetric bifurcation (standard portal vein anatomy) (381/500 cases - 76.2%), in which the main portal vein trunk divides into right and left portal branches. The right branch gives rise to anterior and posterior branches (that supply the segments V and VIII and segments VI and VII, respectively). The left branch gives rise to lateral and medial branches (that supply the segments II and III, and segment IV, respectively). All deviation from this standard distribution was included in the group of anatomical variant.

- Type II - trifurcation, (52/500 cases - 10.4%), in which the main portal vein trunk divides into three branches: the left branch, the (right) anterior branch, and the (right) posterior branch.

- Type III - quadrifurcation, (1/500 cases - 0.2%) in which the main portal vein trunk, divides into four branches: the

anterior and posterior branches in the right part, and the lateral and medial branches in the left part; in this type the right and left portal branches are absent as morphological entity.

- Type IV - asymmetric bifurcation, (37/500 cases - 7.4%), in which the (right) posterior branch is the first branch of the main portal vein trunk, and that it is divided in segments VI and VII branches. The second branch arising from the main portal vein is a common trunk of anterior and left branches. From anterior branch arise the segmental branches V and VIII. From the left branch arises the lateral branches (for segments II and III), and from the medial branch arises the portal branches for segment IV.

- Type V - asymmetric bifurcation of the right branch, (22/500 cases - 4.4%), in which the branch for segment V or VIII (anterior branch) is the first branch of the right branch, and the second branch (posterior branch) in a common trunk for others three right segmental branches.

- Type VI - asymmetric bifurcation of the right branch, (7/500 cases - 1.4%), in which the branch for segment VI or VII (posterior branch) is the first branch of the right branch, and the second branch (anterior branch) in a common trunk for others three right segmental branches.

In order to successfully perform interventional radiology procedures, trans-hepatic portal vein embolization, percutaneous hepato-biliary interventions and surgical procedures for partial resection or liver transplantation, the standard distribution or anatomical variations of the hepatic portal vein distribution must be described precisely [19-21].

Radiologists, hepatologists or surgeons must have a clear understanding of variant anatomy to perform these

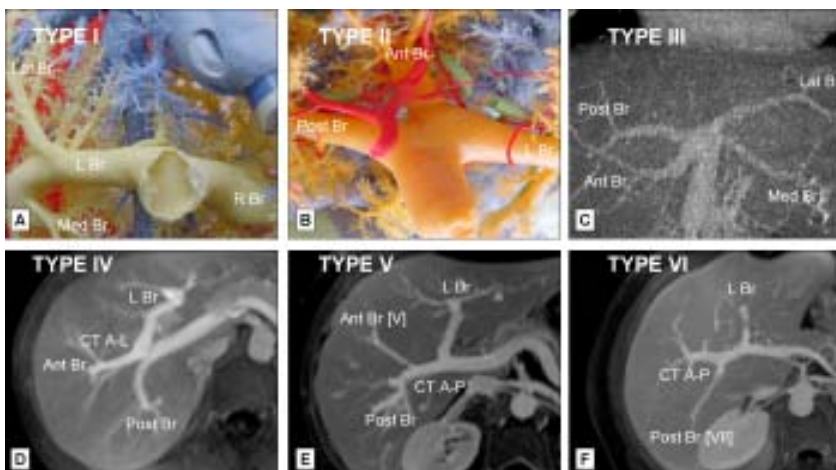


Fig.2. Morphological types of intraparenchymatous part of hepatic portal vein. A - Type I - corrosion cast; B - Type II - corrosion cast; C - Type III - MDCT angiography; D - Type IV - MR - angiography; E - Type V - MDCT angiography; F - Type VI - MDCT angiography. [Color figure can be viewed in the online issue, which is available at www.revmaterialeplactice.ro]

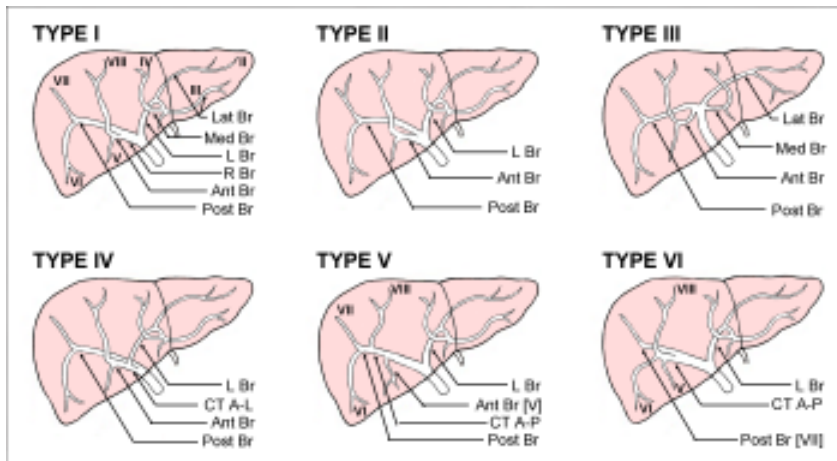


Fig.3. The morphological types of intraparenchymatous part of hepatic portal vein. L Br - Left branch; R Br - Right branch; Ant Br - Anterior branch; Post Br - Posterior branch; Lat Br - Lateral branch; Med Br - Medial branch; CT A-L - Common trunk anterior-lateral; CT A-P - Common trunk anterior-posterior; II - VIII - hepatic segments. [Color figure can be viewed in the online issue, which is available at www.revmaterialeplactice.ro]

procedures. According with Covey et al. [19], the hepatic portal vein is formed in the second month of gestation by selective involution of the vitelline veins, which have multiple bridging anastomoses anterior and posterior to the duodenum. All the anatomical variation of the branching pattern of the hepatic portal vein have an explanation in the early embryological development of the liver in the sense that the alterations in the pattern of obliteration of these anastomoses can result in several variants. Study of literature [22] has shown the prevalence of variant portal venous anatomy ranges from 0.09% to 24%. The anatomical variation associated to hepatic portal vein elements in afferent pedicle does not follow linear, meaning the variations of the hepatic artery proper reach up to 45% [23], and the intrahepatic bile duct system up to 19.25% [24]. The symmetric bifurcation of portal trunk (standard portal vein anatomy) is reported in the surgical anatomical literature between 65% [19] and 94% [25]. On the 500 examined cases, we showed the symmetric bifurcation right branch - left branch in 76.2%. Portal trunk trifurcation in our study represents the most common anatomic variant (10.4% of cases). This morphological type varies between 4% [25] and 11.1% [26]. We met only one case of quadrifurcation of hepatic portal vein trunk (0.2% of cases) in a case heterotaxia syndrome. Koc et al., [26] on a total of 1384 cases reviewed, highlighted 3 cases (0.2%) with portal quadrifurcation. Asymmetric bifurcation in which the (right) posterior branch is the first branch of the main portal vein trunk is described in the literature between 9.7% [26] and 23.5% [22]. On the studied cases, we encountered this anatomical variation in 7.4% of cases. Asymmetric bifurcation of right branch has been described in the literature with a frequency that varies between 3.1% [26] and 7% [19]. In casuistry of Koç et al. [26], majority is the situation in which the branch for segment VI or VII (posterior branch) is the first branch of the right branch. In his casuistry, Covey et al. [19] suggested that majority is the situation in which the branch for segment V or VIII (anterior branch) is the first branch of the right branch. In our casuistry, the asymmetric bifurcation of the right branch in which the branch for segment V or VIII (anterior branch) is the first branch of the right branch have an incidence of 4.4% of cases, and the asymmetric bifurcation of right branch in which the branch for segment VI or VII (posterior branch) is the first branch of the right branch have an incidence of 1.4% of cases.

According to Pang et al. [21], the normal anatomy (Type I) is suitable for donation, and only one anastomosis is required between the donor and recipient portal veins; also in case with trifurcation of the portal vein trunk, (Type II), a single portal lumen can be acquired from the (right) anterior

and posterior branches. The asymmetric bifurcation in which the (right) posterior branch is the first branch of the main portal vein trunk (Type IV), makes surgery more complicated [21, 22, 27]. Both asymmetric bifurcation types (Type V and Type VI) of right branch, which are considered to be an absolute contraindication for surgery [21]. Also, the quadrifurcation of portal trunk in case of heterotaxy syndrome have absolute contraindication for liver transplant surgery, by severity of impairment associated (heart, lung, pancreas and others) [28].

Conclusions

Divergence part of the hepatic portal vein is the main element of intraparenchymatous spatial distribution vasculo-ductal systems. On a total of 500 portal vein systems, we highlighted a number of six morphological types of intraparenchymatous part of hepatic portal vein. The standard portal vein anatomy - the symmetric bifurcation was highlighted in 76.2% of cases. The anatomical variations of the hepatic portal vein branching pattern were highlighted in 23.8% of cases. From these, the trifurcation - in which the main portal vein trunk divides into three branches, *i.e.* the left branch, the (right) anterior branch, and the (right) posterior branch - is the most frequent (10.4% of cases). The quadrifurcation of the hepatic portal vein trunk, and the asymmetric bifurcation of the right branch is considered to be an absolute contraindication for transplantation surgery. Knowledge of these aspects is important both to investigate morphological imaging and in performing partial resection and liver transplantation.

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