

Anatomy of the Human Liver, Role of the Segmentary Portal Branch V

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Abstract

This Review is about the liver anatomy research around the world. Novelty findings in embryologic, tomographic images and dissection lead to a new concept: the liver has seven portal segments, and the segment V play an important role. The liver is a highly vascular organ. However, literature features only schematic descriptions of the intrahepatic anatomy based on theories that currently confuse radiologists and surgeons.

Keywords: Liver anatomy • Hepatic portal • Vein segmentary branches • Segmentation

Introduction

Different authors have claimed their own portal segmentation, with segment V creating the most confusion. This study aims to shed light on the anatomy of this segment and how it determines the number of portal segments of the liver [1]. For the development of this work, a review of the literature was carried out, without excluding the date of publication, with the inclusion of references in the study of the segmental anatomy of the liver. Finally, a total of sixty one texts were included.

Embryological development of liver

Two small portal branches emerged from the portal sinus at week five to supply the caudate lobe; one week later, the Inferior Cava Vein (ICV) gives off the venous drainage from the caudate lobe. The square lobe receives the portal branches from the portal sinus and from the intrahepatic portion of the umbilical vein during week six. At eight weeks, the portal diameter is 10%-15% of the umbilical vein. The portal branches come out in a monopodial way; on the left side, the branches are born spirally and are thin. We observed that the monopodial branching pattern of the umbilical vein is, however, clearly at odds with the supposedly dichotomous branching pattern of the portal vein that underlies Couinaud's segmental liver anatomy. The bile ducts are canalized and the segmental arteries appear at tenth week". They described three portal segments on the right side of the liver and plotted seven portal segments for the entire liver [2].

The entrance door to the liver, the lower hilum, is a parenchymal channel formed by each and every one of the seven portal segments, which arrive here to receive their vascular pedicle and drain their bile

production; it is completely covered by peritoneum. The Porta hepatis is centrally located in the middle third of the visceral surface; it has an "L" shape rotated ninety degrees to the left; it presents a transverse part, another anterior part, and they form a 90 degree angle of anterior medial sinus; the hepatic portal vein is divided here into right (A12.3.12.002) and left (A12.3.12.005) branches; the hepatic artery proper is divided into right (A12.3.12.030) and left (A12.3.12.035) branches; the common hepatic duct is formed by the union of the right hepatic (A05.8.01.062) and the left hepatic (A05.8.01.065); these branches form the first vascular division; then, on the edge of this parenchymal channel, these two "primary branches" emit seven terminal secondary branches, forming seven vascular pedicles for seven portal segments [3].

Literature Review

Segment IV (A05.8.01.042) receives a segmental branch (6 mm) that arises to the right of the terminal bulb of the umbilical part of the left portal branch; in addition, there are two or three subsegmental branches that emerge from the right of the aforementioned bulb or from the upper edge of the transverse part of the left portal branch. The branch for segment V (10 mm of diameter) arises from the left portal branch in 21% of cases reported 20-35 % of these cases]; it emerges from the right portal branch in 79%; the branch for segment V, after deepening 2 cm in its segmental parenchyma, gives anterior, lateral, posterior and medial branches which encompass the parenchyma between the right portal fissure (A05.8.01.036) and the main portal fissure (A05.8.01.035) from the inferior border of the liver (A05.8.01.024) to the inferior cava vein (A12.3.09.001). The branch for segment V is the only one existing for the right medial division

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(A05.8.01.046) of the liver. The right portal branch (1-3 cm long and 16 mm of diameter) emits the branch for segment V (A05.8.01.047) in 79% of cases. Durand concludes in presenting this liver segmentation based on his definition of portal segment: Segmental account starts with the left portal branch; it gives off the segment I (posterior segment) branch, segment II (left lateral segment) branch, segment III (left anterior lateral segment) branch, segment IV (left medial segment) branch, segment V (right medial segment) branch that emerges from right portal branch in 79 % of cases or from left portal branch in 21%; right portal branch gives off segment VI (right anterior lateral segment) branch and segment VII (right posterior lateral segment) branch.

Portal segmentary branch V

In 80% of the observed cases, the portal branch for segment V emerged from the superior margin of the right portal branch, at 1 cm from the division of the hepatic portal vein. In 20% of cases, it emerged from the left portal branch in these cases, the left portal branch delved into the superior part of the parenchyma, formed a curve of right superior convexity, where the branch V originated from, and then continued its horizontal direction. The above takes place at 5 mm from the portal bifurcation. In all these cases, the segmental branch V had an elevation towards the hepatic dome trying to position over the right edge of the gallbladder. Once it passed the plane of the hepatic veins, this voluminous branch branched alternately, and one by one, into two or more anterior branches, two or more lateral branches, two or more posterior branches and two or more medial branches, with the latter having the highest elevation. These branches with different directions encompassed the territory between the right portal fissure (whose plane was inclined 60 degrees to the right in relation to the sagittal plane of the liver) and the main portal fissure (whose plane was inclined 30 degrees to the left in relation to the sagittal plane of the liver), from the hepatic inferior border to the inferior vena cava from behind. This large territory explains the highest thickness of this portal branch (10 mm diameter at its origin). Thus, it is observed that in a region from a thin parenchymal strip (corresponding to the spot between the right margin of the gallbladder and the anterior right angle of the liver) to the half of the cystic fossa, and from the inferior edge of the liver to the hilar plate, the voluminous segment V opens up in the shape of an inverted cone, whose walls diverge 90 degrees, until they reach the above mentioned surface (between the right hepatic vein and the intermediate vein), with its posterior portion over the right half of segment I (caudate lobe) (A05.8.01.044). We have identified segmental portal branch V as one of the 7 portal segmental branches that can be approached at a portal hepatis level. We have not found any portal branch that justifies the existence of an eighth segment [4].

Arterial irrigation for segment V originated from the right branch of the proper hepatic artery (A12.2.12.030) in 94% of cases, from the left branch of the proper hepatic artery (A12.2.12.035 in 1% of cases and from a branch of the superior mesenteric artery (A12.2.12.053), anastomosed to the proper hepatic artery, in 5% of cases. The biliary drainage of segment V was conducted in the right hepatic duct (A05.8.01.062) along with segment VI and VII in 71% of cases. It was determined as the only element forming the right hepatic duct in 29% of cases. This is due to the VI-VII trunk drained into the left hepatic duct (A05.8.01.065) in 21% of cases, this drainage never exceeded 1 cm of distance from the formation of the common hepatic duct. It also

drained into the common hepatic duct in 6% of cases and into the cystic duct (A05.8.02.011) in 2% of cases.

Furthermore, the plane that divided the right hemi-liver from the left hemi-liver had variations depending on the spot the segmental branch V emerged from. When portal branch V emerged from the right portal vein (80%), the plane of the main portal fissure divided the right lobule from the left lobule, this was a plane with a 30-degree inclination to the left in relation to the sagittal plane of the liver, with a straight linear direction from the center of the vesicular fossa to the left margin of the inferior cava. When segmental portal branch V emerged from the left portal branch, the dividing plane between the hemi-livers was the right portal fissure, with a 60-degree inclination to the right in relation to the hepatic sagittal plane. This continued along a curved line of right convexity from an equidistant point between the right vesicular margin and the right antero-inferior hepatic angle to the right margin of the inferior cava, thus, in this last case (20%), the left portion was larger than the right one [5,6].

Discussion

Different authors have provided different numbers regarding portal segmental branches when describing the liver segmentation. The definition of portal segment is the portion of hepatic parenchyma irrigated by a terminal branch of the portal vein (second portal division), along with a terminal branch of the proper or replaced hepatic artery and a biliary drainage duct. These veins, due to their terminal nature, do not anastomose with the veins of neighboring segments, creating inter-segmental fissures; in addition, each segment makes up the porta hepatis channel, where its vascular pedicle is received. In this way, the segment has three distinct features: first, having a terminal vascular pedicle; second, being limited by fissures and third, making up the porta hepatis. The primary branches (left and right) of the hepatic portal vein branch into the 7 segmental portal branches (secondary and terminal branches) in the porta hepatis; in turn, upon expanding in the parenchyma in a centrifugal manner, the pedicles give a cone shape to the segments, with the vertex making up the porta hepatis.

The segmental portal branch V is the thickest and widest of the 7 portal segmental branches. It penetrates the parenchyma and positions at the right of the gallbladder, in direction of the hepatic zenith, and after elevating 2 cm, it branches alternately, one by one, into two or more anterior branches, two or more lateral branches, two or more posterior branches and two or more medial branches, with the latter being the ones that reach the highest in the hepatic dome. Also, the branches of segmental stem V are distributed from the inferior portal pedicle to the hepatic dome, from the right portal fissure to the main portal fissure, and from the inferior edge of the liver to the inferior vena cava. This parenchymal extension explains the width of this segmental portal branch. The posterior half of segment V (from the inferior hilum to the posterior) is placed on the superior side of the right half of segment I (the posterior half of segment IV is placed on the left half).

The main portal fissure passes over the median line of segment I, from anterior to posterior, without dividing it. For these reasons, the posterior half of segments IV and V are not observed in the visceral surface of the liver, but segment I is observed instead. Another significant finding is the branching of segmental portal branch V from

the right portal branch in 80% of cases, determining that portal segments I, II, III and IV are left segments and segments V, VI and VII are right segments. In 20% of cases, segmental branch V emerges from the left portal branch; in that case, segments I, II, III, IV and V are left segments and segments VI and VII are right segments. In addition, this intermediate portal branch was certainly distributed in the space located between the left segment IV and the right segments VI and VII, that is, between the right portal fissure and the main portal fissure, complying with the features that define a segment: Having a terminal vascular pedicle, being separated from the rest by fissures (vertical fissures in this case), and making up the porta hepatis. In our opinion, in the study discussed, branch V emerged from the right portal branch in 83% of cases and from the left portal branch in 17% of cases. This leads us to consider another concept: when the segmental portal branch V emerges from the right portal branch, the fissure dividing the right hemiliver from the left hemiliver is the main portal fissure. When the segmental portal branch V emerges from the left portal branch, the right portal fissure divides both hemilivers; in these cases, the left hemiliver has more volume than the right hemiliver.

Conclusion

The right and left branches of the hepatic portal vein branch out (monopodically, one by one) seven terminal segmental branches for seven hepatic portal segments. Segmental branch V irrigates the right medial division of the liver (there is no other portal branch that suggests the existence of an eighth segment). 3 Segmental branches

I, II, III and IV always emerge from the left portal branch, and segmental branches VI and VII always emerge from the right portal branch, while segmental branch V may emerge from either the right or left portal branch. This vascular variation is important for radiological and surgical procedures and does not alter the topographic order of the seven hepatic segments.

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