UNIVERSITY "OVIDIUS" CONSTANŢA
FACULTY OF MEDICINE
DEPARTMENT OF NORMAL AND PATHOLOGICAL MORPHOLOGY

MORPHOLOGICAL ASPECTS OF THE HEPATIC PORTAL VEIN

- ABSTRACT OF PhD THESIS -

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INTRODUCTION

The liver has within the circulatory system a particular situation. He is interposed between the portal venous system and right heart, which gives it a great operational significance. In addition to providing its metabolic and antitoxic functions, the liver is a blood reservoir. In some right heart diseases (circulatory failures) blood accumulates in the liver and is stagnant - sometimes blood accumulated in the liver is 20% of the total volume of blood - which leads to an increase of its volume (hepatomegaly).

Portal vein carries to the liver all blood from subdiaphragmatic digestive tract, pancreas, spleen, extrahepatic biliary tract, visceral peritoneum and abdominal lymph nodes. Also, in intrahepatic branches of the hepatic portal vein flows the blood brought by the fibrous tunic of liver, the walls of intrahepatic vessels (Vasa vasorum) and the bile duct branches. Is a typical example of port system constituted by a vein interbedded between two capillary networks, lying between the capillaries of drained digestive territories and the hepatic lobe, which determines the particular pressure regimes. Significant pathology of the port system, both acquired and congenital, manifesting itself essentially by portal hypertension, raised multiple anatomical and embryological works, as well in imaging and surgery fields, in recent years. New knowledge gained requires, in a tractate of clinical anatomy, to combine classic descriptions with new and recent achievements in these fields.

Hepatic portal vein has not an equivalent artery. It drains blood from the territory irrigated by five large arteries: the three branches of the celiac trunk (left gastric artery, common hepatic artery and splenic artery) and two mesenteric arteries, upper and lower, to each of these arteries corresponding a single vein, besides hepatic artery, that has no parallel vein.

Topography and morphology of the liver make it more difficult to be accessed by clinical exploration. During surgery, intrahepatic vascular pedicle situation and liver segmentation can be determined simply from the well established data of the cadaver anatomy (Ton That Tung, 1979). But current means of exploration of the liver, before and during surgery, especially the latest (Sexton and

Zennan, 1983) and in particular, ultrasound during surgery (Bismuth and Castaing 1985, Valleix 1987, and Champetier 1987), allows to be recognized individual anatomical variations, particularly those involving the liver veins. This precise recognition of liver anatomy enables a better adaptation, in each case, of the surgical measures. We have to specify that in the exposition made we've had observed Terminologia Anatomica (1988) and that at the end of each chapter I mentioned selective bibliography to which we referred in the text.

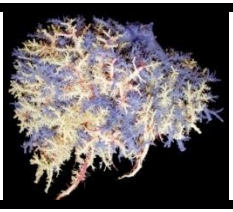
The relative significant number of cases that we worked allowed us turning personal results through scientific papers at national and international scientific meetings: the 19th session of scientific papers, Constanţa 2009; national congress of Romanian Society of Anatomy, with international participation, Târgu Mureş 2009, Constanţa 2010, Cluj-Napoca 2011, Constanţa 2012, with abstracts published in the abstract book of the congress, the 92nd Congress of the French Association of morphology 2010, abstract published in Morphologie review, issued by Elsevier publishing house, 12th Congress of the European Association of Clinical Anatomy, Padova, 2011, with abstract published in the journal Surgical and Radiologic Anatomy, issued by Springer-Verlag publishing house; one paper was published in Ars Medica Tomitana, 2011 (Scopus indexed journal) and two papers in Romanian Journal of Functional and Clinical, Macro- and Microscopic Anatomy and Anthropology, 2012.

We want to thank to our colleagues in the discipline of anatomy, for their assistance in making the thesis, the discipline of anatomy possessing a rich material on arterio-venous vasculature of the liver: dissections, obtained by injection of plastic molding followed by corrosion injections of contrast agent. Also we want to thank to Associate Professor Radu Baz, with which we realized CT cases and to Associate Professor Eugen Dumitru, in whose clinic were performed thw scans.

Finally, we have warmest thanks to Professor Petru Bordei, scientific coordinator of the thesis, whose essential support we received during the period of thesis elaboration.

MATERIAL AND METHODS OF WORK

For determining morphological characteristics of hepatic portal vein and its branches of origin and end, our study was performed on a number of 242 own cases, of which: 64 with injection of plastic molding followed by corrosion, 14 with injection of contrast agent (barium sulfate) followed by radiography, 48 with dissection of fromalinized and fresh livers, 64 of Doppler ultrasound and 52 of CT reconstructions.

NO.	METHOD	NO. LIVERS	PHOTO
1.	Plastic injection	64	
2.	Dissection	48	
3.	Ultrasound	64	

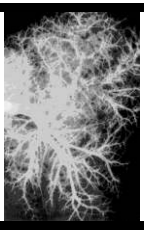
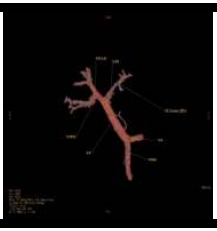
4.	Contrast agent injection	14	
6.	CT	52	
	Total	242	

TABLE NO. 2 - METHODS OF WORK USED ON HUMAN LIVER

As shown above, were used as working methods injection of plastic molding followed by corrosion, dissection, Doppler color ultrasound, injection of contrast agent, followed by radiography and CT reconstruction. Injection of contrast agent and plastic molding were made only on fresh livers.

We used as plastic molding Technovit 7143, which is not toxic and is prepared very easily and quickly, and because the monomer is colored it does not require the use of dyes that can adversely affect the polymerization process. In addition, it has a reduced polymerization time, allowing corrosion to a short period after injection.

Corrosion was made from the beginning with sodium hydroxide to produce a rapid corrosion, of good quality, especially hot by heating the solution to 80-90º. In case of corrosion by sulfuric acid or technical hydrochloric, there are some disadvantages: besides the acid high price of cost, it is needed a long time, corrosion being slow and requiring a large amount of acid.

In case of the 64 plastic casts were injected:

NO.	VV.H.	VPH	AHP		NO.	CORROSION
1	-	+	-		27	
2	+	+	-		22	
3	+	+	+		12	
4	+	+	+	+	3	
TOTAL					64	

TABLE NO. 3 - INJECTION WITH PLASTIC MOLDING IN HUMAN LIVER

There were recorded: morphometry (length, caliber) of hepatic venous trunk and of its branches of origin and end; angles of confluence and termination of vessels; the way of branching and morphological characteristics of portal venous branches in relation to hepatic segmentation; portal vasculature in relation to gender and individual morphological type, to establish relationships between vein morphology and human morphological type, being made

measurements of subjects to whom were performed ultrasounds; in most cases pursued was studied liver parenchyma to remove suspicion of liver diseases and especially to signalize the presence of porto-hepatic intrahepatic anastomoses. Morphometric data were processed by computer, using a modern software, KS 400, located in the laboratory of anatomy.

Doppler color ultrasounds were performed on young subjects, healthy (medicine students in first and second year of study), within the Clinic Medical Emergency Hospital Constanţa, by kindness of Associate Professor Ph.D. Eugen Dumitru.

Simple angiography we studied belong to anatomy laboratory and angio CT-s we had the opportunity to examine came from Medimar Exploration Center of the Emergency Hospital in Constanţa, headed by the doctor Bărdaş Mariana, being made on a tomography computer GE LightSpeed 16 Slice CT. We also had available angiographies performed in Constanţa Pozimed Diagnostic Center, led by Associate Professor Ph.D. Radu Baz on a tomography computer GE LightSpeed VCT64 Slice CT.

The first issue to address in this study was the large amount of data collected for each case, so the best solution for recording this volume of data has been working with a database using a specialized language. We chose Microsoft Visual FoxPro and therefore it was designed a relational database with multiple tables and graphs, using as a link between them a unique identification key of records.

Statistical tests *(t test - student)* are the verification of mathematical statistical hypothesis. Verification is done on a sample of data selected so as to be representative for the entire lot, and the hypothesis tested to be then applied to the whole population of data (if true).

RESULTS AND DISCUSSION

FORMATION OF HEPATIC PORTAL VEIN.

Formation of hepatic portal vein was followed in 38 cases, finding four types of formation:

1. most often, in 31 cases (81.58% of cases), portal vein is formed by *anastomosis* of the *superior mesenteric vein with splenic vein,* inferior mesenteric vein ending in splenic vein at an outsized distance to the mesenterico-splenic confluence;

Figure 42 - hepatic portal vein formed by confluence of mesenteric superior vein and splenic vein, inferior mesenteric vein ending in splenic vein near the origin of the portal vein.

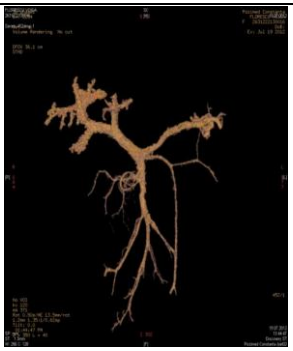


Figure 43 - hepatic portal vein formed by confluence at the same level of the three veins: superior mesenteric, inferior mesenteric and splenic.

- in 4 cases (10.53% of cases), portal vein is formed by *anastomosis at the same level of*

superior mesenteric vein, inferior mesenteric vein, and splenic vein;

- in 3 cases (7.89% of cases), portal vein is formed by *anastomosis* of *superior and inferior mesenteric veins,*

forming a *mesenteric trunk* that is in anastomosis with splenic vein to form the portal vein trunk;

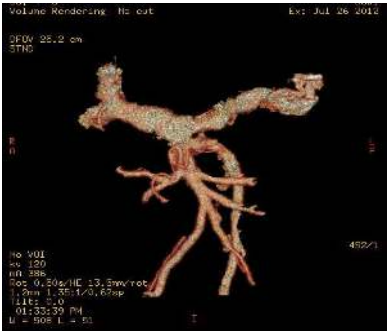


Figure 44 - hepatic portal vein formed by confluence of mesenteric trunk (consisting of superior and inferior mesenteric veins) with splenic vein.

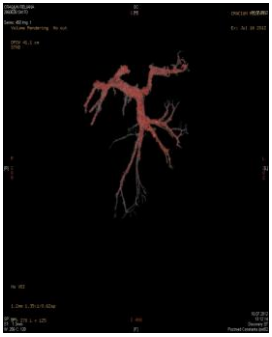


Figure 45 - hepatic portal vein formed by confluence of mesenteric trunk (resulted by merging three mesenteric veins: superior, medium and inferior) with splenic vein.

• In one case (2.63% of cases) we met *three mesenteric veins* (superior, medium and inferior), which by confluence formed *mesenteric trunk,* then it in anastomosis the splenic vein forming the portal vein.

Between superior mesenteric and splenic veins formed an angle very variable, ranging between 70-165º, (3) finding that the angle between the superior mesenteric vein and splenic vein is between 75-130º (on average 96º). Also (3) finds that the angle between the splenic vein and portal trunk is 90-140º (on average 113º), after my findings this angle ranging from 77.1º to 128.7º, and between superior mesenteric vein and portal vein trunk formed always an obtuse angle, between 94-128 0 º.

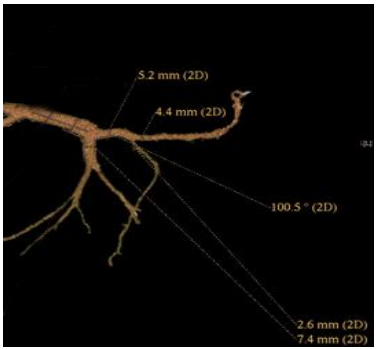


Figure 48 – Caliber of superior and inferior mesenteric veins and of splenic vein and the angles formed between them.

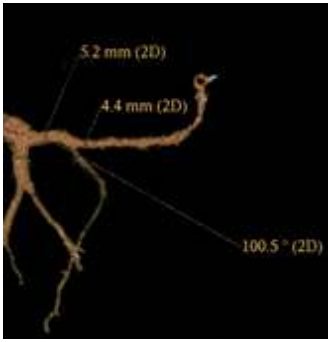


Figure 49 – Before ending of inferior mesenteric vein, splenic vein has a caliber of 4.4 mm, and after the confluence with this, the caliber of splenic vein reaches 5.2 mm.

Splenic vein comes in confluence with inferior mesenteric vein at the level of the vertebrae L1-L2. After ending of inferior mesenteric vein in splenic vein, caliber of the latter increases from 0.2 to 0.8 mm.

We found the origin of hepatic portal vein in relation to the spine lying on the anterior front of the spine, at the level of vertebral bodies L1-L2. We have not met any case in which the portal venous trunk to be formed at the level of L1-L2 intervertebral disc.

With regard of hepatic portal vein formation, of the 4 ways that we met, the first three correspond to the first three variants of Couinaud (1.2), but the fourth is not cited in the literature. We did not met the case described by (1.2) as a fourth way with double end of inferior mesenteric vein in superior mesenteric and, version which he himself neglected, describing only 3 types.

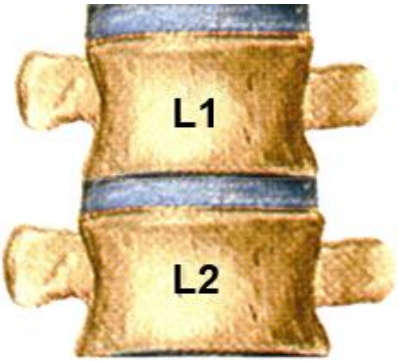


Figure 50 - The formation of hepatic portal vein in relation to the spine

AUTHOR	No. cases	I	II	III	IV
Douglas (1950)	92	38%	29.3%	32.7%	-
Purcell (1951)	100	44%	53%	3%	-
Couppié (1957)	200	47.5%	45.5%	7%	-
Barry (1968)	103	30%	29%	41%	-
Papadopoulos (1981)	50	70%	24%	6%	-
Kamina (1996)	74%	-	-	-	-
Personal cases (2012)	38	81.58%	7.89%	10.53%	2.63%

TABLE NO. 6 - TYPES OF PORTAL VEIN FORMATION

Venous anastomosis was made most often right to the midline of the spine, but we have seen cases where it was on the midline and more rarely when the anastomosis was made to the left of this line, but very close to the midline, the place of formation depending on the curvature of the lumbar spine.

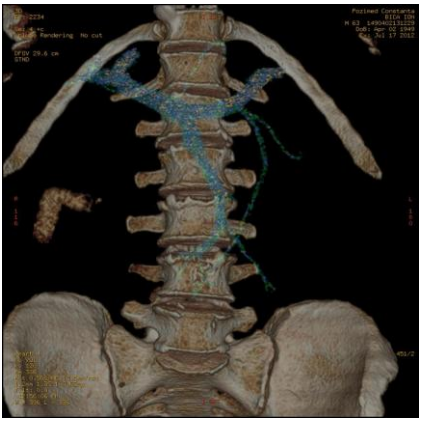


Figure 126. Portal vein formed at the level of L1 vertebra midline by anastomosis of splenic and superior mesenteric vein.

Caliber of portal vein trunk.

Caliber by ***ultrasound*** we found between 7 to 14.3 mm, in 30 cases (75% of cases) with more than 10 mm, and only 10 in cases (25% of cases) less than 10 mm.

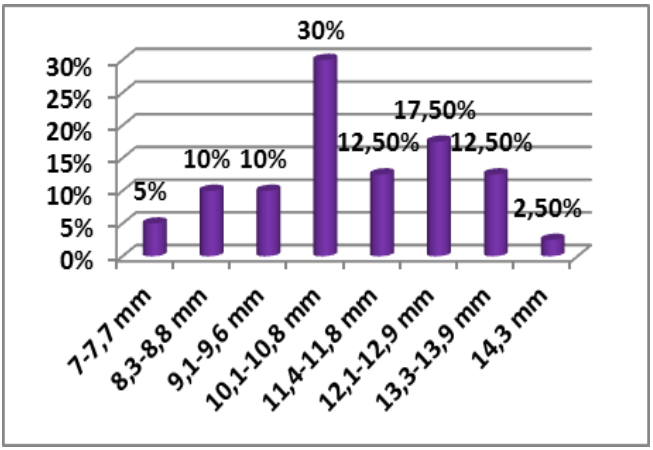


FIGURE NO. 2 – CALIBER OF PORTAL VEIN TRUNK SET BY ULTRASOUND.

Figure 52 - portal vein of men: venous trunk has a caliber of 1.23 cm.

Figure 53 - portal vein of women: venous trunk has a caliber of 0.88 cm.

Portal venous trunk caliber by ***angio-CT*** we have measured in 32 cases, finding it in range from 8.8 to 16.4 mm.

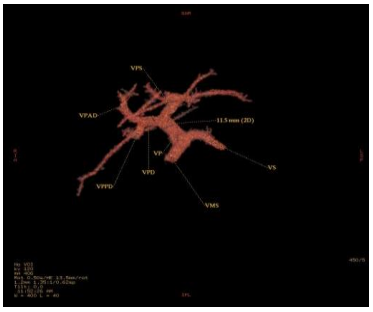


Figure 55 - portal venous trunk with caliber of 11.5 mm.

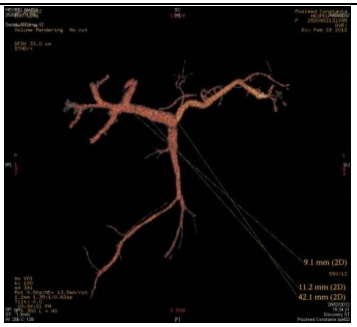


Figure 56 - portal venous trunk has at origin a caliber of 11.2 mm and 9.1 mm at end.

AUTHOR	CALIBER	LENGTH
Testut	15 mm	8-10 - (to 12 cm)
Rouvière	15 mm	10 cm
Seymour, Delorme	-	10 cm
Chevrel	20 mm	5-12 cm (average 8)
Léger	23 mm (origin)	-
(radiol)	19 mm (end)	-
Papilian	12-15 mm	5 to 5.8 cm
Matusz	15 mm (origin) 20 mm (end)	8-10 cm
F ranceschini	10-17 mm (13.9)	-
Kamina	8 mm	-

Weinreb	12-15 mm	-
Castaing, Smail	15-20 mm	8-10 cm
Ongoiba	5-16 mm (origin) 6-16 mm (end)	6.1 to 7 cm
Personal cases	7 to 14.3 mm	4.08 to 6.58 cm

Table no. 9 - MORPHOMETRY portal vein liver.

Most authors say that portal vein has a caliber smaller at origin than at end (11,12) the difference being up to 5 mm, and for (22) about 1 mm. Leger (18,19), by radiological means, found the caliber at origin of 23 mm and 19 mm at end, so it is a difference of 4 mm, with which the portal venous caliber decreases from origin to end.

On a number of only 8 cases, represented by angio-CT, we measured the portal venous trunk caliber both at origin and end finding in 4 cases that the venous caliber is greater at origin with 0.3 to 2.1 mm and also in the 4 cases the venous caliber was larger at end with 0.5 to 0.9 mm, perhaps due the radiological incidence used.

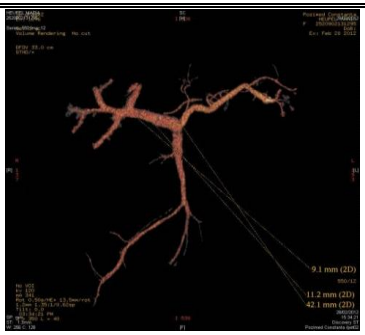


Figure 56 - portal venous trunk has at origin a caliber of 11.2 mm and 9.1 mm at end.

Figure 57 - portal venous trunk with length of 55.5 mm.

We found ***portal venous trunk length*** between 40.8 to 65.8 mm, being much smaller than in many authors findings (1,6,8,9,11,12,21 and Delorme, Seymour, cited by 22), with differences ranging from 3.2 to 5.2 mm

Values are similar to those found by (22), but they do not find length less than 60 mm. (22) found that males portal venous trunk length is greater than females on average by 7.6 mm. We found that

these differences are somewhat smaller, 2 to 4.8 mm, the size being relative to individual morphological type, and also conditioned by place of formation and end branching of hepatic portal vein.

In most cases, 196 of the 212 cases studied (92.45% of cases), hepatic portal vein ends by bifurcation, the portal vein trunk branching into two diverging branches, one right and one left, ending of portal vein by trifurcation being encountered in 14 cases (6.60% of cases).

Figure 60 – Trifurcated portal vein, middle branch having caliber equal to left branch.

(20) found trifurcation of portal vein in 3/32 cases (9.37% of cases), and ending with 4 branches in one case (3.12% of cases), case that presents a third caudate portal branch with a caliber of 4 mm and a fourth branch with a caliber of 6 mm, for the gallbladder fossa. Ending with 4 branches of portal venous trunk was described by (1.2). (22) states that the modal portal vein divides into two branches that reach the liver in 96.7% of cases (58/60), and in 3.3% of cases (2/60) there are three branches.

AUTHOR	BIFURCATION	T RIFURCATION	4 BRANCHES
Franceschini	87.51%	9.37%	3.12%
Ongoiba	96.7%	3.3%	-
Personal cases	93.4%	6.6%	-

TABLE NO. 10 – WAY OF ENDING HEPATIC PORTAL VEIN.

It is found that the percentages that we found on the way to end the portal vein are different, but the differences are relatively small; in case of bifurcation is 3.3 percent lower compared to (22) and higher with 5,89 percent compared to (20). In case of trifurcation, we found 3.3 percent higher than (22) and 2.77 percent lower than (20). Neither we nor (22) did not met the ending with 4 branches of portal vein.

In cases of bifurcation ending of hepatic portal vein the angle that it forms the right branch with the left branch of hepatic portal vein we found to be between 75-180º. Comparing with the specialty literature data, by Hjortsto (23), between left and right branch it is formed an angle of 99-100º, and by (1.2) and (4.5), between the two branches it is formed an angle of 90-100º in 72% of cases. Only (20), in 32 cases, gives details about the values of angles formed between the ending branches of bifurcation of the portal vein, the angle of 180º being found in a percentage close to that found by us, 34.4% of cases, only with 1.1 percent higher, and the angle of 120º being found in 12.5% of cases, while we found an angle between 93-120º in a higher percentage, of 9.72%. Also, we found the angle of 90º in a higher percentage, of 11.26 percent. To be noted that (20) does not cite cases in which the angle is less than 90º. He found that the most common bifurcation angle has a value of 150º in 46.9% of cases.

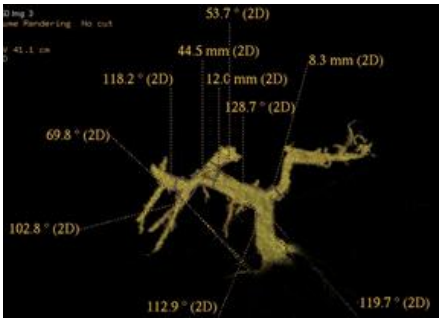
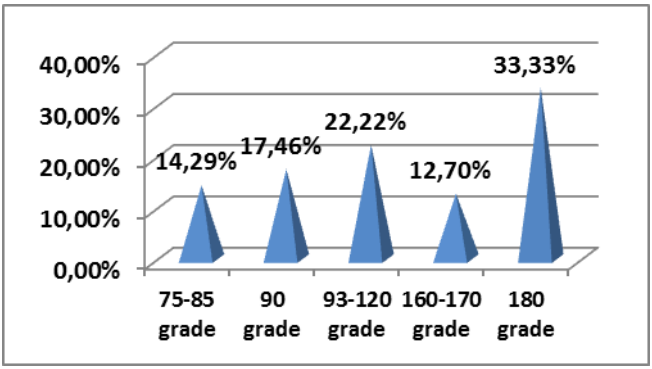


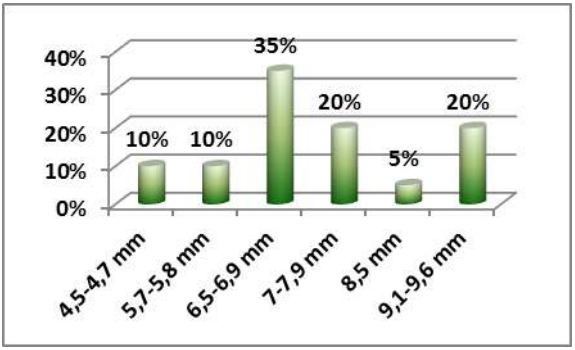
Figure 61 - Between the two ending branches of the portal vein it is formed an angle of 128.7º. Between the right branch of portal vein and venous trunk it is formed an angle of 112.9º, and on the left side the angle is 119.7º

In 4 cases of 5 cases of ending trifurcation of portal vein between the right and middle branch was formed an angle of 60-80º. In one case this angle is 165º.



GRAPH NO. 6 - THE ANGLE FORMED BETWEEN THE TWO BRANCHES OF BIFURCATED VENOUS PORTAL TRUNCH.

We found that the ***right branch of portal vein had a caliber*** of between 4.7 to 11.7 mm, determined by means of ***ultrasound,*** lower values being found in women, the minimum value (4.7 mm) being found in women, and the maximum value (11.7 mm) in men. For (20), the caliber of right branch of portal vein, on 32 cases, is between 7-12 mm, with an average of 9.7 mm. By means of ***angiography*** we found the caliber of right branch of portal vein within the range from 8.2 to 12.4 mm.



GRAPH NO. 11 – VARIATIONS OF THE CALIBER OF RIGHT BRANCH OF PORTAL VEIN OBTAINED BY MEANS OF ULTRASOUND IN WOMEN.

Figure 67 - right branch of portal vein has a caliber of 6.6 mm (women).

Figure 68 - right branch of hepatic portal vein in women is 9.6 mm.

Length of the right branch of portal vein was between 6-22 mm.

Left branch of hepatic portal vein was a ***ultrasound caliber*** between 4.5 to 11.9 mm, lower values were found in women, the minimum value (4.5 mm) was found in women, and the maximum value (11.9 mm) in men.

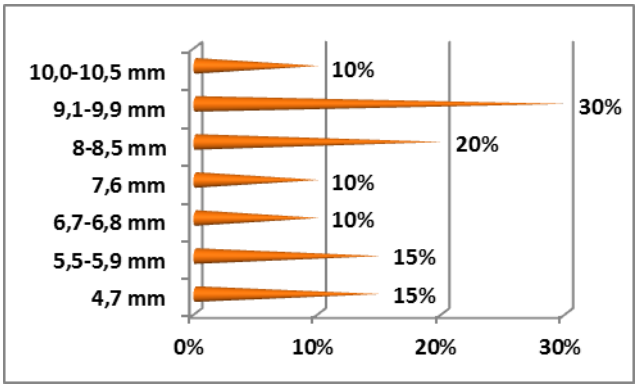
For (4,5,6,7,8,9,11,12) left branch of portal vein has a caliber much lower and longer than the right. For (4,5,6) left branch is also more horizontal.

(20) found the left branch of portal vein diameter with an average of 7.2 mm, with a diameter between 5-10 mm, our results being lower by only 0.5 mm, (20) not mentioning a caliber less than 5 mm, and in regard to maximum caliber our results are higher by 1.9 mm, (20) not mentioning a caliber larger than 10 mm for left branch.

By angiography, left branch of portal vein caliber found is within the range from 6.8 to 10.6 mm.

Figure 130. left branch of portal vein in men of 10.5 mm caliber.

Figure 131. left branch of portal vein in women of 10.7 mm caliber.



GRAPH NO. 7 – VARIATIONS OF THE CALIBER OF LEFT BRANCH OF PORTAL VEIN OBTAINED BY MEANS OF ULTRASOUND IN WOMEN.

We measured the ***length of left branch of portal vein*** in 46 cases, finding that it was ranged from 25-59 mm, not meeting any case less than 25 mm in length. *Transverse portion* had a length between 10-44 mm, most frequently with 25-35 mm (78% of cases). For (11, 12), left branch length is 40-50 mm, the transverse portion 2-3 cm long and umbilical portion with an average length of 2 cm. For (13), transverse portion has a length of 30-50 mm.

Angle between transverse and umbilical portion we found to be between 90-110º, not meeting any case in which it is pointed, being always right or obtuse (more common). For Gans, cited by (11), this angle has a value of 95-125º 0, (11.12), citing the possibility that this angle is right, version (13) cited as the most frequent, not mentioning obtuse angle.

Comparing the ***morphometry of terminal branches of the portal vein,*** we found that right branch of hepatic portal vein had a caliber larger than the left in 25 cases (62.5% of cases). *In women right branch of hepatic portal vein* ram was more voluminous than the left in 14 cases (70% of cases), with values ranging from 0.1 to 4.2 mm. *In men right branch of hepatic portal vein* was more voluminous than the left branch as in 13 cases (65% of cases), with values ranging from 0.1 to 4.3 mm, in 6 cases (30% of cases) was more voluminous than the left branch with 0.2 to 0.8 mm, and in one case (5% of cases) the two veins were equal in size (7 mm). Our results are in contradiction to those in specialty literature, which

mostly give that the right branch is most common, more voluminous compared to the left, confirming my results only for women.

Figure 132. Portal vein in women: right branch is 6.6 mm and left branch 11.4 mm.

Figure 133. Portal vein in men: right branch is 10.3 mm and left branch 11, 9 mm.

Compared with the length of left portal branch, right branch had in all 36 cases followed a length less than the left branch, with differences ranging from 5.08 to 46.41 mm.

In women, caliber of left portal branch is between 43.65 to 98.7% of portal venous trunk caliber, except for two cases where right branch of portal vein had a higher caliber than venous trunk caliber, representing 92 30% and 93.41% of the left branch caliber, in only one case the two veins having an equal caliber (9.6 mm).

In men is observed that variations in caliber of left portal branch are lower than in women and also the ratio of the caliber of this vein and portal trunk of origin has higher values, ranging from 63.31 to 96.75%.

Figure 64 - left branch of portal vein with a caliber of 7.3 mm in men

Figure 65 - left branch of portal vein with a caliber of 11.2 mm in men.

Also, in men we found 3 cases where left branch of portal vein had a higher caliber than portal venous trunk caliber, representing 80.77%, 94.32% and 94.39% of left venous branch caliber.

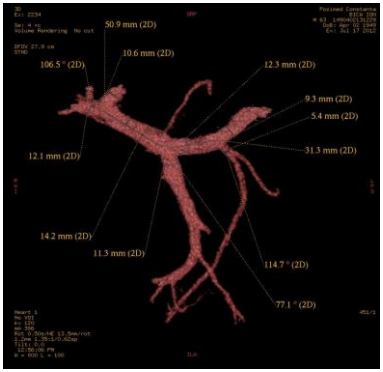


Figure 66 left branch of portal vein with a caliber of 10.6 mm and right branch of 12.1 mm.

HEPATIC PORTAL VASCULATURE SEGMENTATION

PORTAL VEINS OF RIGHT HEPATIC LOBE.

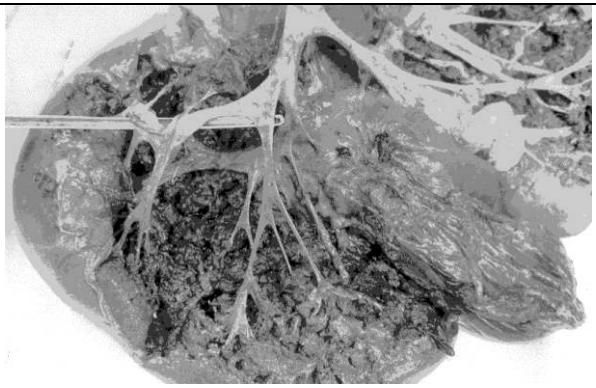


Figure 100 - right branc of portal vein in bifurcation, both branches being superposed, superficial and in depth.

Right branch of portal vein can be ended, most commonly by bifurcation of anterior branch, ending with subsegmentation of superior and inferior branches (for segments V, VI) and posterior branch, forming an acute angle with anterior branch, usually continued in direction of right portal branch. After a short horizontal trajectory, posterior branch forms an obtuse angle posterior-superior, and from this level rises to the superior and inferior branches for segments VII, VIII and in part I and VI (to its posterior part). The two ending branches of the right portal vein can be overlaid spatially, superficial and in depth, vascularizing together areas of segments VI and VII.

When the branch is ending by trifurcation, the first branch is for the right side of the square lobe through the deep branch, the other branch of the bifurcation, previously and superifical disposed to the first, for hepatic segment V (superficial side); the second branch is deep, trifurcated, for the deeper side of segments V, VI, VII, VIII; the third branch, oblique upward supero-lateral right, bifurcated into a branch which bifurcates to the superficial side of segments VI and VII, the other branch being dedicated to segment VIII (its superficial side).

Figure 101 - Overlapping of superior and inferior branches of the right branch of portal vein

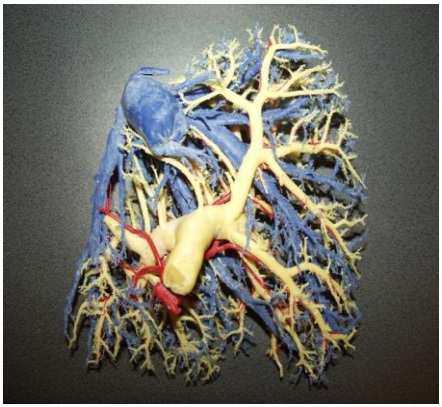


Figure 102 – right portal vein ended by trifurcation.

Rarely, the right branch can end up by more than three branches, its ramifications ensuring vasculature of right hepatic lobe segments, one branch for each segment, the branch of segment VIII participating also at caudate segment vasculature.

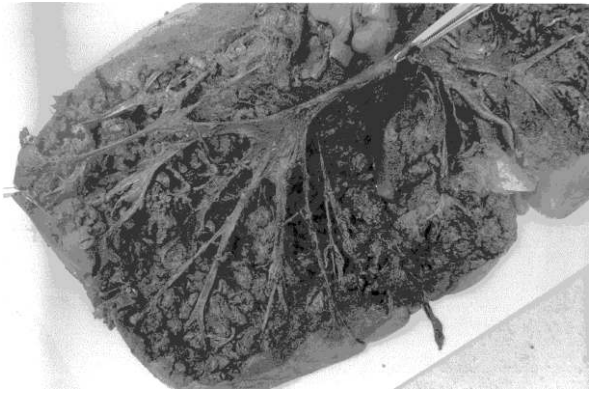


Figure 103 - right branch of portal vein ended by 6 branches serving over by lobe segments, segment VIII vein partially serving the caudate lobe.

PORTAL VEINS OF LEFT HEPATIC LOBE.

Usually, the left portal branch raises its posterior branch for hepatic segment II at the level of continuation of transverse part of the portal vein with the left umbilical, branch that is voluminous, but often, with a lower caliber compared with umbilical branch.

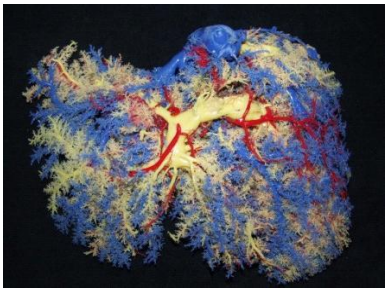


Figure 104 - left branch of portal vein. To limit of transverse and umbilical portions a voluminous branch is detached for hepatic segment II, which gives thin branches also to the caudate lobe; his umbilical portion ends with a bunch of branches, of which three are for hepatic segment III and 8 branches for segment IV .

Ending of left portal vein is represented by its umbilical part for hepatic segment III, the branch having an almost vertical direction. When the umbilical part ends "in the bunch" by a number of 5-8 branches, it serves by 2-3 branches also the left part (1/3 or even 1/2) of square lobe.

PORTAL VEINS OF HEPATIC CAUDATE LOBE

In the 52 cases studied, we found a number of 161 caudate branches with caliber over 1 mm, (20) finding 113 branches for 32 cases, and (27) finding 153 veins in 29 cases. The 161 veins for 52 cases give 3.1 venous branches per case, a percentage lower than in (20) – 3.53 veins / case and a much lower percentage than in (27) – 5.28 veins / case. Of the 161 arteries, in the left branch of portal vein had their origins 64 arteries (39.75% of the caudate arteries), while (20) gives a percentage of 87.5%. In the right branch of portal vein we found that had their origins 46 veins (28.57% of total caudate arteries), which we have divided into veins with origin in the venous trunk, prior to its branch, 22 veins (13,66% of caudate arteries) and with origin in the posterior branch, 29 veins (18.01% of

the of caudate arteries). For this origin (20) gives a percentage of 62.5% of caudate veins. In the portal vein we found that had their origins 46 veins (28.57% of the caudate arteries), in the portal vein trunk having their origins 22 veins (13.66% of total caudate arteries) and 24 veins (14 91% of total caudate arteries) with origin in the portal bifurcation. For this variant, (20) gives a percentage of 68.75% of caudate veins, a similar percentage giving also (3, 4).

Figure 108 - medium caudate branch with origin from a common trunk with the left caudate branch, the common trunk having its origin in the portal venous trunk. Right caudate branch, vertical, gives a branch to the medium caudate area .

We did not found any case where caudate portal branches to arise only from the left portal branch, as cited by (20) in 3% of cases (28) giving a percentage of 40%. We found cases where caudate veins originated only from the left portal vein and its branch, the right portal vein having not any portal venous branches.

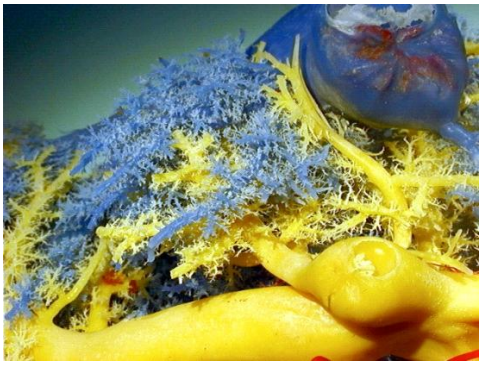


Figure 134 - plastic molding with observing of two branches of important caliber for the caudate lobe, originating in the portal vein trunk

Figure 107 – Portal bifurcated vein in which the right caudate branch arises from right ending branch, and medium caudate branch from the origin of left portal branch, near its origin.

Figure 109 - 2 medium caudate branches: one with origin in the portal bifurcation and the other originating from the initial portion of the right portal branch. 2 left caudate branches, one originating in left portal branch and the other originating in portal venous trunk. Right caudate branch has its origin in posterior branch of the right portal branch.

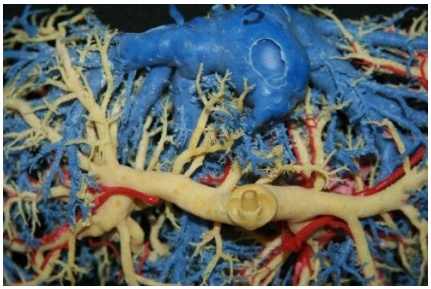


Figure 111 – caudate branch with origin at the level of the portal bifurcation. Medium caudate branch originating in the left portal branch, near the portal bifurcation. 2 left caudate branches originating from the left portal branch, lateral left caudate branch giving a branch, with prior trajectory to the caudate medium left branch, to the anterior part of medium zone.

According to Foucou (26) small veins entering the caudate lobe are vertical, and after Heloury (27) there are on average 5 branches arising from the bifurcation level for segment I vascularization. These branches, according to Laux (28), frequently arise from left branch, which is consistent with the findings of (11, 12, 20).

PORTAL VEINS OF HEPATIC SQUARE LOBE

Figure 136 - square lobe is vascularized by a venous branch originating from the umbilical portion of the left branch and a branch of anterior branch of the right branch, that vascularizes 2/3 right of square lobe.

When the single, voluminous branch, has its origin in left portal vein, it comes from umbilical portion, vertical to it, that vascularizes 2/3 left of square lobe.

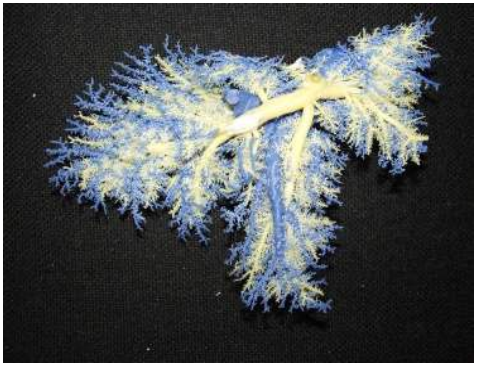


Figure 113 - Trifurcated portal vein. Medium vein vascularizes entirely the square lobe. Near its origin, from medium vein is a branch off to the hepatic right lobe, segment VIII.

Sometimes, rarely, to the square lobe vasculature may participate only left portal vein, which can give 2-3 branches which have their origin in its transverse portion, a branch may sometimes have its origin in the portal venous trunk.

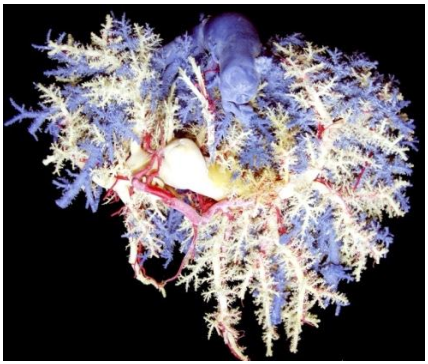


Figure 115 - square lobe is vascularized by three large branches originating from the transverse portion of the left portal branch.

The existence of physiological anastomoses between the hepatic veins and hepatic portal vein branches, long disputed, it became a certainty in the last 20-25 years.

NO.	AUTHOR	NO. CASES
1	Mori (1987	12
2	Kudo (1993)	33
3	Cosme Jimenez (1994)	48
4	**Personal cases (2012)**	**7**

TABLE NO. 11 - FREQUENCY OF PORTO-HEPATIC ANASTOMOSES.

From personal findings, we can say that frequency of anastomoses has a relatively high percentage, being 14.58% of dissection cases and 3.30% of all cases studied. Of all anastomoses, 5 cases were in the left hepatic lobe (2.36% of cases and 62.5% of all cases of porto-hepatic anastomoses), so they are more common on the left and at the same time left anastomoses are larger than right anastomoses.

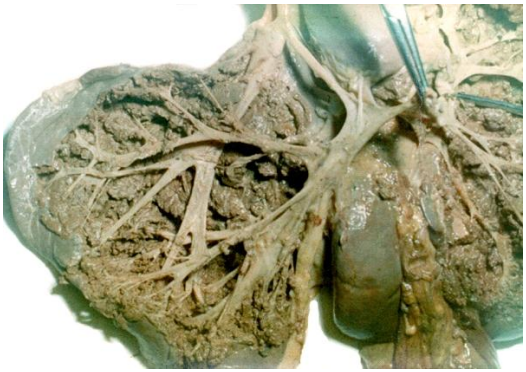


Figure 117 - voluminous anastomosis between left hepatic branch of portal vein and left hepatic vein

CONCLUSIONS

It is difficult to assign a schema of hepatic portal vasculature because of the large number of individual variations, issue reported by most authors, from the formation and intrahepatic branching to the way both in terms of morphometry and in the number branches and territories served.

Detailed knowledge of portal branches at the level of the liver hilum, as well as intrahepatic, is absolutely necessary, given the high frequency of surgery at the hepatic level: hepatic trauma, cysts, tumors that often invade the hepatic parenchyma, which requires segmentectomy therapy or hepatic lobectomy. Harvesting liver or liver lobe (left) for liver transplantation from deceased donor or living donor, requires a good knowledge of its arteriovenous vasculature.

Modern means of imaging exploration (ultrasound, angiography, MRI) provide valuable information on these issues. Notions of trajectory and direction of the portal vein and its branches are important for achieving oblique and transverse sections, both in ultrasound and the MRI.

It can be considered that hepatic portal vein is formed by the superior mesenteric and splenic veins, the inferior mesenteric vein being affluent of splenic vein or, less commonly, of superior mesenteric vein, thus having a much smaller caliber compared to the other two veins. Terminologia Anatomica (1988) does not use the name *mesenterico-splenic trunk,* because after ending superior mesenteric vein in splenic vein, there is a slight increase in size.

Most authors state that the portal vein is smaller in caliber at origin than at ending, the difference being of 1-5 mm. Leger, radiologically, found caliber at origin of 23 mm and 19 mm at the end, so it is a difference of 4 mm, with which decreases portal venous caliber from origin to end, the decreasing caliber of portal vein in direction of portal flow evoked by Weinreb. This issue we met in 4 cases of angiography, the end being of smaller caliber with 0.3 to 2.1 mm, and we believe that this may be due of radiological incidence used. This divergence with anatomical measurements is explained by that the end is closer to film than vein origin: that difference does not appear to MRI.

It has to be noted the high predominance of cases of end branching of portal vein by bifurcation (over 90% of cases), but without finding any case of ending of portal vein with four branches, as in cases cited by Couinaud and Franceschini.

Although in the specialty literature consulted are only cited the sharp angles between the portal bifurcation branches without specifying their values, except Franceschini, who cites these values, but not finding bifurcation angles below 90º. Wr never met bifurcation angles below 75º. In cases of trifurcation ending of portal vein, in most cases (about 80% of cases) between the right and medium branch it is formed an acute angle.

In regard to the caliber of the right portal branch, all authors find it always more voluminous than the left branch, but our findings show that a in percentage rather significant (37.5% of cases) the right branch is less voluminous than the left, and in 10% of cases the two veins were equal in caliber.

Morphometry of portal venous trunk and its ending branches depends on gender, but also on individual morphological type. For venous trunk in women the caliber ranged from 7 to 12.6 mm, and in men from 8.3 to 14, 3 mm, so with differences at men for minimum caliber of 1.3 mm and 1.7 mm for maximum caliber.

We found a caliber for right branch of portal vein from 4.5 to 9.6 mm in women and from 6 to 11.7 mm in men, differences being also in favor of men, 1.5 mm minimum caliber and 2,1 mm for maximum caliber.

In relation to morphological type we found that portal vein in women of sagittal type has a caliber greater than frontal type with a minimum caliber of 2.4 mm and a maximum caliber of 0.4 mm. In men, sagittal type has a minimum caliber less than frontal type with 1.8 mm and for the maximum caliber sagittal type has a caliber of 0.4 mm higher than the frontal type. We encountered similar differences in both genders and for the two ending branches, which had a smaller minimum caliber in sagittal type (excepting left portal branch to sagittal type, that was higher) and a higher minimum caliber in sagittal type (excepting left portal branch to frontal type, that was higher).

Diameter of portal vein and its branches is an important parameter, being one of the key parameters in the diagnosis of portal hypertension. According to some authors, normal portal vein diameter measured at the hilum should not exceed 12-15 mm.

In regard to the length, on the cases studied, the right branch was always shorter than the left portal branch, most frequently (38.89% of cases) from 11.16 to 18.65 mm. For the right branch we have not found a length of less than 6 mm.

It seems that the best criterion for assessing the caudate portal branches is one that takes into account the distribution territory, as well as their origin. These caudate portal branches are of particular importance in hepatic surgery. The indications of caudate lobe extirpation, once rare, have become more common, generally associated with right or left lobectomies, which requires a good knowledge of its vasculature.

Differences between different authors in the percentages found on various parts of the portal vein and its branches, are due to: different number of cases on which was worked, geographical area in which the study was conducted, the working methods used (dissection, injection of contrast or plastic substances) and measurement methods used (centimeter, ultrasound, CT).

Conflicting values of the caliber in various authors are because there are differences between measurements made after anatomical dissection or plastic injection and those made by means of ultrasound. In case of radiological measurements, differences in comparison to anatomical measurements can be explained by the fact that the ending is nearer to the radiological film and the increase factor is given by the machine projection rays (Franceschini, Mizumoto).

Also, the differences were due to the small number of cases on which was worked. In classical anatomical descriptions, the number of cases is very limited (1-10) and in some cases the number of cases is not clear (as specified by Ongoiba), resulting in difficulties in comparing the results between personal results and specialty literature.

In closing we want to say that in case of a particular anatomical study approach, especially in vascular field, is almost impossible to cover all the aspects that characterize it, and whenever can be added new things that have not been sufficiently studied or omitted or whom have been given a new interpretation. I consider that this study, since has drawn conclusions base on own cases, is interesting not only to the morphologist, but especially for practicing surgeon.

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