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A morphological study on portal vein variations in Indian cadavers

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Abstract
Introduction: The surgical treatment of neoplastic and traumatic lesion and grafting of liver by respective measures has increased in frequency and magnitude during recent years. With recent developments in surgery for effective grafting of liver. The morphological mensurative data of the portal venous system is important, as regards portal hypertension and surgical aspects related to portocaval anatomosis.
Aim & Objectives: The aim of present study was to identify anatomical variations of portal vein, which might help for surgeons in resection and grafting of liver during surgeries.
Materials & Methods: The study was conducted in the Department of Anatomy Index Medical College & Research center Indore M. P. on sixty adult human livers by dissection method. The liver parenchyma was removed with the help of forceps & ramification patterns of *portal veins* were studied.
Observations & Results: The Portal vein had normal standard pattern in 30% cases and the rest 70% showed variations in one or the other form. The splenic vein was variant in 76.6% cases. The superior mesenteric vein showed variation in 73.3% cases. The mode of termination of the inferior mesenteric vein was variable in 60% of cases. The intrahepatic ramification pattern of portal vein was observed in all the segments of liver. The findings were tabulated according to the measurements taken, analyzed and were statically evaluated using SPSS -16.0 version.

Keywords: splenic vein, superior mesenteric vein, variations portal vein

Introduction
The surgical treatment like as a trauma, metastasis and grafting of liver by respective measures. The external & internal morphology of liver is important for various techniques of surgery. Anatomy of liver is divided into right and left lobes, by the attachment of the falciform ligament anteriorly & superiorly, fissure for the ligamentum teres inferiorly and fissure for the ligamentum venosum posteriorly.
Anatomy of liver can be described using two different aspects - morphological anatomy & functional anatomy and now the real anatomy, when ultrasound allows a precise intraoperative display in individual cases.
External appearance of liver it has four lobes are distinguished: right, left, quadrate, and caudate. On the diaphragmatic surface, ligamentum falciforme divides the liver into the right and left anatomic lobes. On the visceral surface ligamentum venosum & round ligament fissures provide a demarcation. The quadrate lobe is demarcated on the visceral surface by the gallbladder fossa, portahepatis, & ligamentum teres.
The caudate lobe is demarcated by the inferior vena cava groove, porta hepatis, and venous ligament fissure. The right portion of the caudate lobe lengthens into the right lobe by the caudate process, which forms the epiploic foramen superior boundary [1].
N. A. Goldsmith & R. T. Woodburne (1957) classification of liver based on the arrangement of portal and hepatic veins, N. A. Goldsmith & R. T. Woodburne and division of the liver into four segments, each having two sub segments with *second order* of portal vein branches [2], while C. Couinaud (1954 – 1957) suggested that the liver should be divided into eight segments, based on *third order* portal vein distribution. & C. Couinaud showed that branches of hepatic artery, duct and portal vein are enclosed in Glissons capsule and ramification pattern of hepatic vessels considerably [3].
The branches of the hepatic artery and the bile ducts, each of which divides so as to distribute in the same segmental and subsegmental fashion as the branches of the portal vein. The hepatic veins drain into the inferior vena cava mainly through three tributaries namely, right, left and middle hepatic veins.

Materials & Methods
The study was conducted in the Department of Anatomy, Index Medical College & Research center, Indore on sixty adult human livers and liver were obtained from cadavers with obvious pathology will be from the study. The materials included in the study were:
1. Sixty human livers
2. Vernier calipers
3. Surgical instruments
4. Calibrated divider
5. Probes
6. Eye loops
7. Measuring tapes

Methodology
The livers were removed from adult human cadavers who were already fixed by the perfusion of 10% formalin solution through the femoral artery & were preserved for minimum one week. The cadavers and the livers had to

comply with the following requirements: [1] minimum age 18 years [2], free of pathological conditions macroscopically. The size of liver varied considerably which was not included in the study because it has been demonstrated that there is no relationship between liver size and the intrahepatic vascular pattern.

Observation & Result

The study was conducted in the Department of Anatomy Index Medical College & Research center Indore M.P. The study was done on 60 cadaveric livers from department after fixation with formalin for the variations associated with hepatic veins.

The observation recorded in the present study refers to topographical anatomy of structures at the hepatic hilum and the variations related to the right hepatic vein. The intrahepatic ramification patterns of hepatic veins were observed in all the segments of liver.

Variations in one or other form were observed in the tributaries of SV (76.66%), followed in order of frequency by SMV (73.33%) and in PV (70%).

Table 1: Pattern of Division of Portal Trunk

Pattern	No. of Cases
Bifurcation	52 (86.32%)
Trifurcation	8 (13.28%)

Length of the portal vein - Length of the portal vein in the present study, right portal vein 8 – 28 mm (average 15.33mm) & left Portal vein 10 - 40 mm.

Breadth of portal vein - The average breadth of PV at midpoint between its formation and termination was found to be 14-19.5mm. The maximum breadth observed was 18 mm in 4 cases (13.33%) and minimum being 8 mm in 2 cases (6.66%). Maximum number of cases was observed in the breadth range of 14-16 mm that is, in (43.33%) cases, out of which 11 (36.66%) cases were having breadth of 15 mm.

Formation of portal vein - In the present study, the PV was formed by the union of splenic & SMVs behind the neck of the pancreas, in front of inferior vena cava in the majority of cases (90%). However, it was found to be formed by the union of splenic, superior mesenteric and inferior mesenteric in 3 (10%) cases. In 18 (60%) cases, the portal was formed at the level of the second lumbar vertebra, while in 12 (40%) cases; it was formed at the level of lower border of the first lumbar vertebra.

Termination of portal vein - at portahepatis as a single trunk in 21 (70%) cases & it divided into right and left branches before termination in 9 (30%) cases

Splenic vein (SV) - The SV was formed near the splenic hilum by the convergence of a no. of trunks (5-1 in no). In one of the cases, one trunk arose independently from the upper pole of spleen and joined the main trunk almost in its middle.

Superior mesenteric vein (SMV) - Superior mesenteric vein is commenced in the right iliac fossa by the union of veins from terminal ileum and pancreas in the present study. However, a wide range of variation has been observed in its tributaries.

Inferior mesenteric vein (IMV) - Inferior mesenteric vein was found to drain into SMV in 12 (40%) cases. In 1 (3.33%) cases, there were two right colic veins uniting with each other, joined the right gastroepiploic & inferior Pancreaticiduodenal veins were ultimately drained into SMV.

Table 2: Ramification Pattern of the Right Branch of Portal Vein (RPV)

Ramification Pattern	Branches	Cases (%)
No RPV trunk	RA & RP directly coming from main portal trunk.	13.28%
RPV present a. bifurcation type b. trifurcation type	RA & RP Trifurcation into 1. RA, RPS & RPI. 2. RAS, RAI & RP.	86.32% 76.36% 9.96% 6.64% 3.32%

RAS- Rt. Anterosuperior RAI- Rt. Anteroinferior RP- Rt. Posterior RA- Rt. Anterior RPV- Rt. Portal vein RPI- Rt. Posteroinferior RPS- Rt. Posterosuperior

The branches of the portal vein were intrasegmental. Variations were observed at the point of division of the main portal trunk & two patterns i.e. bifurcation (86.32%) and bifurcation (13.28%) were seen. The bifurcation pattern was more common.

The right portal vein ramification had two patterns i.e. bifurcation (76.36%) and trifurcation (9.96%). Trifurcation showed two patterns; one had RAS, RAI & RP (3.32%) and another had RPI, RPS and RA (6.64%). The bifurcation pattern was most frequent. The right anterior showed three patterns: arch-like (13.28%), bifurcation (76.68%), trifurcation (6.64%). Same was true for right posterior but one more pattern i.e. Quadrifurcation was seen.

The left portal vein had transverse and the umbilical portion. The ramification of the branches to the left superior segment (segment IT) & the left inferior segment (segment III) from the left portal vein showed three patterns: Type I (53.3%), II (24.9%) and III (21.6%). type I was most frequently observed. The distribution of the branches to the medial segment of the liver was studied.

Table 3: Ramification Pattern of the Right Posterior

Pattern	Cases (%)
Arch-Like Pattern	24.9%
Bifurcation	59.76%
Trifurcation	4.98%
Quadrifurcation	3.32%

Discussion

The present study explores the structures of the portahepatis & the pattern of the intra-hepatic distribution of the portal vein, hepatic veins, hepatic ducts and hepatic artery, by manual dissection. The various segments were identified with the help of ramification patterns of the portal vein and the bile ducts and the hepatic artery which were seen following the portal vein closely keeping in mind the requirement for the transplantation of liver during the surgery.

In the portahepatis, the structures, i.e. the portal vein, bile duct and the hepatic artery were seen maintaining the normal position in all the cases.

Portal Vein

The portal vein exhibited many variations in the present study. The hepatic segments could be identified according to the intrahepatic ramifications. Portal vein was dividing at the porta hepatis i.e. extrahepatically in all the cases. This

was in accordance with the report given by Mizumoto. Who quoted that the portal vein was dividing near the hepatic hilum?

The diameter of the portal vein ranged from 9.5 to 14mm, 11.2=1.17mm. This diameter was 13.9mm (10 to 17mm) in the study by Franceschini L J 1995 [5] & 1.5cm to 2cm by Segall H N *et al* 1923 [4].

Table 4: Comparison of Diatmeter of Portal Vein with Literature

Studies done	Diameter
Present study	14-19.5mm
Segall H.N. (1923) [4]	1.5-2cm
Franceschini L.J (1995) [5]	10-17mm

Table 5: Comparison of Length of Right and Left Portal Vein with Other Reseachers

Studies	Right	Left
Present study	8-28mm,15=5.33mm	10-40mm
Gupta S.C. *et al* (1977) [6]	1.5-2.0mm	1-5
Woodburne R T *et al* (1957) [3]	0-3.0mm	3.5

In the present study the bifurcation of the portal vein was seen in 86.32%. This percentage was reported to be 88% by Gupta S C^0. The comparison of the prevalence of bifurcation as given by various researchers is shown in table no.06 Another pattern seen in our study was the trifurcation of the portal vein into the right anterior, right posterior and the left branch (13%). This pattern conformed to the findings of other workers. The comparison of the prevalence of trifurcation by difference workers is shown in table no.06

The knowledge of the pattern of the ramification is important for the hepatic transplantation. There can be absence of bifurcation of the portal vein and the left portal vein may absent. This may cause a difficulty in performing right hepatectomy. The knowledge of the ramification pattern is important for resection of liver.

The factor determining the branching of the portal vein was the internal diameter of the branches. The right portal vein was found to be shorter than the left portal vein, in all the cases in the present study. This finding conformed to that of other workers. The length of the right portal vein ranged from 8 to 28mm, 15=5.33mm. This measurement was reported as up to 3.0cms by Goldsmith N A *et al* 1957 [2] and 1.5 to 2.0cms by Gupta S.C. *et al* 1977 [6]. The diameter of the right portal vein was 5 to 13mm, 8=13mm. This was 9.7mm (7-12mm) in the study done by Franceschini L J 1995 *et al*. [5]

Table 6: Prevalence of Bifurcation and Trifurcation of Portal Vein as Shown by Various Researchers

Study	Percentage of bifurcation	Percentage of trifurcation
Present study	86.32	13
Gupta S C. *et al* (1977) [6]	88	12
Cheng Y F *et al* (1996) [8]	70.93	14.97
Healey J E *et al* (1954) [9]	100	--
Kune G.A. (1969) [10]	82	18
Kogure K *et al* (2002) [11]	89.5	10.5
Varotti G *et al* (2004) [12]	86.4	63
Chaib E *et al* (2007) [13]	98.3	152

Table 7: Variations Related to the Right Posterior Branch of the Portal Vein in Different Studies

Studies Done	No. of Case	Arch-Like	Bifurcation	Trifurcation	Quadrifurcation
Present study	**60**	**24.9%**	**59.76%**	**4.98%**	**3.32%**
Hata F. *et al* [14] (1999)	197	32.0%	27.9%	6.6%	-
Takayasu K (1985) [15]	30	-	-	93.0%	-
Inoue T (1986) [16]	164	40.8%	59.2%	-	-
Makuuchi M (1986) [17]	37	22.0%	54.0%	-	-
Yamamoto K (1987) [18]	100	10.0%	58.0	-	-
Kinoshita H (1988) [19]	202	62.4%	37.6%	-	-
Couinaud C (1989) [20]	111	63.8%	28.8%	8.1%	-

Conclusion

The branches of the portal vein were intrasegmental. Variations were observed at the point of division of the main portal trunk & two patterns i.e. bifurcation (86.32%) and bifurcation (13.28%) were seen. The bifurcation pattern was more common.

2. The right portal vein ramification had two patterns i.e. bifurcation (76.36%) and trifurcation (9.96%). Trifurcation showed two patterns; one had RAS, RAI and RP (3.32%) and another had RPI, RPS and RA (6.64%). The bifurcation pattern was most frequent. The right anterior showed three patterns: arch-like (13.28%), bifurcation (76.68%), trifurcation (6.64%). Same was true for right posterior but one more pattern i.e. quadrifurcation was seen.

3. The left portal vein had transverse and the umbilical portion. The ramification of the branches to the left superior segment (segment IT) & the left inferior segment (segment III) from the left portal vein showed three patterns: Type I (53.3%), II (24.9%) and III (21.6%). type I was most frequently observed. The distribution of the branches to the medial segment of the liver was studied.

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