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# Study of surgical anatomy of portal vein of liver segments by cast method and its clinical implications

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**Abstract:** Portal vein provides about three-fourths of liver's blood supply. Portal vein is formed behind the neck of pancreas, at the level of the second lumbar vertebra and formed from the convergence of superior mesenteric and splenic veins. The purpose of this study is to review the normal distribution and variation, morphometry of portal vein and its branches for their implication in liver surgery and preoperative portal vein embolization. It is also helpful for radiologists while performing radiological procedures. A total of fresh 40 livers with intact splenic and superior mesenteric vein were collected from the mortuary of Forensic Department, JSS Medical College and Mysuru Medical College. The silicone gel was injected into the portal vein and different segments were identified and portal vein variants were noted. The morphometry of portal vein was measured by using digital sliding calipers. The different types of portal vein segmental variants were observed. The present study showed predominant type I in 90% cases, type II 7.5% cases, and type III 2.5% cases. Mean and standard deviation (SD) of length of right portal vein among males and females were 2.096±0.602 cm and 1.706±0.297 cm, respectively. Mean and SD of length of left portal vein among males and females were 3.450±0.661 cm and 3.075±0.632 cm, respectively. The difference in the Mean among the males and females with respect to length of right portal vein and left portal vein was found to be statistically significant ($P$=0.010). Prior knowledge of variations regarding the formation, termination and tributaries of portal vein are very helpful and important for surgeons to perform liver surgeries like liver transplantation, segmentectomy and for Interventional Radiologists.

**Key words:** Portal vein, Cast method, Venous segments, Morphometry, Liver transplantation

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## Introduction

Portal vein is formed behind the neck of pancreas, at the level of the second lumbar vertebra and is formed from the convergence of superior mesenteric and splenic veins. Its origin lies in the transpyloric plane in the lower border of the body of the first lumbar vertebra and upper border of the body of the second lumbar vertebra. The portal vein divides into right and left branches at the hilum of the liver. The left portal vein has a longer extrahepatic course (4–5 cm) than right portal vein, tends to lie more horizontal, and is often smaller in calibre.

It has a horizontal portion that runs along the inferior surface of segment IV and invariably gives branches to segment I and sometimes to segment IV. The left branch of the portal vein continues within the liver, giving off a segment II branch laterally before taking a more anterior and vertical course in

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the umbilical fissure. Here, it gives off branches to segments III and IV and receives the obliterated left umbilical vein (ligamentum teres).

The majority of the portal venous supply to segment IV comes from the left portal vein and occasionally from the right branch of the portal vein or its branches to segment V or VIII. The right branch of the portal vein is only 2–3 cm in length and usually divides into right medial (anterior) sectoral division supplying segments V and VIII and a right lateral (posterior) sectoral division supplying segments VI and VII [1]. Embryologically, the portal vein is formed in second month of gestation by selective involution of the vitelline veins, which have multiple bridging anastomoses anterior and posterior to abdomen-cranial intrahepatically, middle behind duodenum, caudal in front of duodenum. Superior mesenteric vein joins with right vitelline vein and splenic vein joins with left vitelline near its anastomoses. The proximal ventral anastomoses becomes left branch of portal vein, the dorsal anastomoses becomes the portal vein. The distal anastomoses usually disappears. Alteration in pattern of these anastomoses result in portal vein variations [2].

### *Anatomical variations in portal vein (Covey et al. [3])*

- Type I: main portal vein divides into right and left portal branches. The right portal vein then gives rise to anterior and posterior sectorial branches that supply liver segments V and VIII and segments VI and VII, respectively (standard portal vein anatomy).

- Type II: trifurcation of main portal vein into right anterior, right posterior, and left portal vein branches.

- Type III: right posterior portal vein is first branch of main portal vein and left portal vein is terminal branch, arising after origin of right anterior portal vein (Z type anatomy) [3].

Variations of portal vein are frequent and they account for 20%–35% of the population. The variations must be diagnosed before hepatectomy, liver transplantations and also before portal vein embolization. The preoperative awareness of variations will help to prevent complications like hemorrhage, difficult anastomosis in the recipient, ischemia in the graft and allograft failure. The present study aims to determine the portal vein variants and its clinical implications among Mysuru based population.

## Materials and Methods

A total of fresh 40 livers with intact splenic and superior mesenteric vein were collected from the mortuary of Department of Forensic Medicine, JSS Medical College and Mysuru Medical College.

### *Corrosion cast method*

Once the visceral organs were removed during postmortem, liver with intact splenic and superior mesenteric vein were identified and extra fatty tissue was removed by fine dissection. Liver with intact portal vein and its branches were collected from the postmortem bodies within 12 to 24 hours after death. Fresh livers were washed in running tap water for about 30 minutes to 1 hour. Using 10-ml syringe saline solution was flushed slowly through the portal vein to remove residual blood. The livers were placed in the acetone for dehydration. Silicone gel was injected into the portal vein using silicon gun injector. The silicon injected inside gets solidified within 12 to 24 hours. The livers were finally kept in KOH solution. After complete corrosion of silicon cast, it was kept in a gentle stream of tap water till the debris was washed away. The different segments were identified and any portal vein variants were noted (Fig. 1). The morphometry of portal vein was measured using digital sliding calipers.

### *Statistical method*

Independent *t* test was used for evaluation of prevalence of portal vein variations with respective to sex. $P<0.05$ was accepted as statistically significant.


**Fig. 1.** Showing portal vein segmental cast of liver.


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## Results

In the present study, normal (type I) variant was seen in 36 of 40 cases (90%). Trifurcation (type II) variant was seen in three of the cases (7.5%). Right posterior vein as first branch of main portal vein (type III) variant was seen in one of the cases (2.5%). Mean and standard deviation (SD) of length of main portal vein in males and females 3.73±0.822 cm and 3.641±0.712 cm, respectively. Mean and SD of length of right and left portal vein is shown in Table 1.

## Discussion

Embryologically, portal vein is derived from two vitelline veins and left umbilical vein. The intrahepatic branching pattern occurs due to selective involution and fragmentation of vitelline veins within the proliferating endodermal liver cords starting from the third to sixth week and is completed by the 12th week of intrauterine life. Whilst hepatic parenchyma and hepatic vasculature develop independently, by 35th day of gestation the developing vasculature has to adapt to the fast growing hepatic parenchymal growth. Variant anatomy arises as a consequence of abnormal obliteration of the connections that exist between the vitelline and umbilical veins *in utero* [4].

In a study done by Rajput et al. [5], on ramification pattern of portal vein in right lobe of liver by corrosion method revealed that the length of right portal vein varied from 0.5 to 1.8 cm. In 87% cases, right portal vein bifurcated into right anterior and right posterior portal vein, while trifurcated in rest of 13% of cases. Anterior-superior (P8) branch showed three type of ramification: bifurcation type (72%), P8 one pedicle type (8%), and P8 trifurcation type (20%). Anterior-inferior (P5) branch showed three type of ramification pattern: P5 common type (72%), P5 P8 anterior type (28%) but P5 P8 posterior type was not observed. Right posterior portal vein showed three types of ramification pattern: type I Fan shaped (64%), type II (28%), and type III trifurcation type (8%) [5].

Maheswari [6] studied intrahepatic branching pattern of portal vein in 50 liver specimens. Dissection was done in 38 adult and three fetal liver specimens, contrast study was done in seven liver specimens and corrosion cast was done in two liver specimens. They found normal bifurcation of portal vein which was observed in 41 liver specimens. In six specimens (12%), portal vein divides into right anterior, right posterior segments and left branch (pattern I). In two specimens (4%), right posterior segmental branch arises directly from portal trunk and then portal trunk divides into right anterior segmental and left branch (pattern II). In one specimen (2%), the right anterior segmental branch arose from left branch of portal vein (pattern III) [6].

Raut and Bahetee [7] studied on variations in the formation of portal vein on 40 embalmed cadavers (22 males and 18 females) during routine dissection. The different types of portal vein formation were noted. Study showed that predominant type II in 47.5% population, type Ia in 30% and type Ib in 22.5 [7].

Gupta et al. [8] conducted a study on the intrahepatic branching patterns of the portal vein by corrosion cast method in 85 human livers. The study revealed that 88% cases bifurcation and 12% cases were trifurcation [8].

Sahoo et al. [9] reported a rare case of absent portal vein bifurcation in a young female patient on contrast-enhanced computed tomography study of abdomen. There was single intrahepatic portal vein entering right lobe of liver, with gradual decreasing caliber, coursing from right lobe to left lobe of liver and giving rise to segmental branches [9].

Arora et al. [10] studied on ramification of portal vein in right lobe of liver by corrosion cast method. Posterior division of right portal vein displayed three types of distribution pattern: type I in nine of 15 specimens (60%); type II, three of 15; and type III, three of 15 specimens (20%). In 12 of 15 specimens (80%), anterior division of right portal vein ramified at acute angle to the posterior division and in remaining three specimens anterior division ramified at right angles to the posterior division [10].

The comparative data of present observations with those of previous workers is shown in Table 2.

Awareness of portal vein variation, is most relevant in liver transplantation surgery. Trifurcation variant increase

**Table 1.** Comparison of length of portal vein with respective to sex

| Parameter | Mean±SD (cm) | | Mean | *P*-value[a] |
|---|---|---|---|---|
| | Male | Female | | |
| LLPV | 3.450±0.661 | 3.075±0.632 | 0.375 | 0.772 |
| LRPV | 2.096±0.602 | 1.706±0.297 | 0.389 | 0.010[b] |

SD, standard deviation; LLPV, length of left portal vein; LRPV, length of right portal vein. [a]Independent t test. [b]Significant.

**Table 2.** Comparison of LRPV as observed by earlier workers

| Parameter | Gupta et al. [8] | Arora et al. [10] | Ger [11] | Mishra et al. [12] | Present study |
|---|---|---|---|---|---|
| LRPV (cm) | 0.5–2.0 | 0.5–1.0 | 1.0–2.6 | 1.3–2.3 | 1.2–3.4 |
| LLPV (cm) | - | - | - | - | 2.5–4.8 |

LRPV, length of right portal vein; LLPV, length of left portal vein.

the complexity as intraoperative clamping become difficult. Type III variant has its own surgical importance in recipient as well as in donor. In recipient, two portal vein anastomoses have to be performed on two separate veins thus resulting in complexity of the procedure. In most cases, trans jugular intrahepatic portosystemic shunt should be created between the right hepatic vein and right portal vein.

Portal vein variations are frequent, awareness of portal vein variations is important in surgical resection and transplantation. In case of complex interventional procedures, these variations should be described precisely in the radiological report because of their considerable impact on subsequent surgical and interventional radiology procedures. Therefore, prior knowledge of portal vein variation can reduce the incidence of complications during hepatobiliary surgeries.

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