



## Anatomical Study of Portal Vein Variations and its Clinical Significance

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### Abstract

**Introduction:** Liver is the largest abdominal organ and performs a large number of metabolic functions. It is involved in any number of clinical conditions ranging from simple hepatitis, cirrhosis to dreadful malignancy. Portal vein contributes approximately 80 % of its blood supply and determines the segmental anatomy along with hepatic artery and hepatic duct. The present research was conducted to know the Portal vein normal anatomy and variations from formation to intrahepatic branching pattern.

**Materials and Methods:** The study was conducted in 25 embalmed adult human cadavers by conventional dissection method.

**Results:** Variant formation of Portal vein was noted in 8% of cadavers. Bifurcation and trifurcation of Portal vein was observed in 21 (84%) and 4 (16%) specimens respectively. Portal vein trifurcation pattern of type 1 was observed in 8% and type 2 in 8% specimens. Right portal vein was absent and replaced by its branches in 4 specimens. Bifurcation and trifurcation of right portal vein was observed in 18 and 3 specimens respectively. Accessory branches to caudate lobe (4%) and quadrate lobe (8%) from right portal vein were observed.

**Conclusion:** Prevalence of vascular variations are high in right hemi-liver. Detailed knowledge of the same will help radiologists and surgeons in imaging of liver segments, selection of donors, segmental resection, portal vein embolization, shunt procedures etc and plays a crucial role in success of both medical and surgical treatment of hepatic pathology.

**Keywords:** Estimate right liver volume, Hepatic segments, Liver Transplantation, Right portal vein, Segmental resection, Trifurcation.

### Introduction

Portal vein is formed by the union of superior mesenteric vein and splenic vein [1]. This union takes place behind the neck of pancreas at L2 vertebral level. It drains the blood from the gastrointestinal tract, gallbladder, pancreas and spleen to the liver for filtration and processing. It usually ramifies into right portal vein and left portal vein at porta hepatis [2]. RPV is shorter (2-3cm) and wider, ramifies into anterior and posterior branches. Anterior and posterior branches again divide into superior and

inferior supplying segments VIII, V and VII, VI respectively [1]. Branch to caudate lobe (segment I) may arise from right anterior division [2]. MPV trifurcates into many patterns which is a common variant [3,4,5]. Type 1 PV divides into right anterior, right posterior and left portal vein. Type 2- right posterior branch originates directly from the trunk and then divides into right anterior and left portal vein. Type 3- right anterior from left portal vein. RPV may trifurcate or quadfurcate [5,6]. Benign and malignant tumours can affect the liver and also

common site for secondary metastases. Liver biopsy, tumour excision and various surgical procedures implies the purpose of understanding vascular supply of liver segments.

### Materials And Methods:

The study was conducted in 25 liver specimens obtained from embalmed adult human cadavers in Institute of Anatomy, Madras Medical College, Tamil Nadu, India after getting approval from the Institutional Ethics Committee. Portal vein was traced as per the guidelines given in Cunningham's Manual. Liver specimens were dissected in piece meal under water. Main portal vein was observed for its formation, branching pattern and RPV was observed for its termination and any accessory branches to caudate and quadrate lobe. The observations were photographed.

### Results

In 23 (92%) cadavers, portal vein was formed by the union of SMV and SV. In 1 (4%) cadaver IMV opens at the confluence of SMV and SV. IMV ends in SMV instead of draining into SV in 1 (4%) cadaver.

The division of portal vein was extra-hepatic (at porta hepatis) in all. Portal vein bifurcated into right and left branch in 21 (84%) specimens. Trifurcation of portal vein was observed in 4 (16%) specimens. Among the trifurcation pattern type 1 was observed in 2 (8%) (Figure 1) specimens and type 2 in 2 (8%) specimens.

Right branch of portal vein originated from MPV in 21 (84%) specimens and was replaced by its branches in 4 (16%) specimens. The RPV bifurcated in 18(85.68%) specimens. In 3 (14.32%) specimens, trifurcated into RAD, right posterosuperior and right posteroinferior (Figure 2). Accessory branches to segment I and IV were observed in 4% and 8% respectively.

### Discussion

Management of traumatic rupture of the mesentery, penetrating injuries, portal vein thrombosis and surgeries related to pancreas, duodenum requires thorough knowledge of MPV formation [2]. During development of PV any deviation in bridging anastomoses results in variations [7,8]. Ligation of its extrahepatic division is very important to control haemorrhage in major liver surgeries.

Estimate right liver volume proportions in the donors with type 3 MPV variation were significantly lower than those in the donors with type 1 and type 2. Type 3 trifurcated pattern donors presented with ERLV percentage below 30% of the total liver volume [9]. Portal trifurcation is considered as relative contraindication for liver donor transplantation and isolation of the branches will be possible only by exposing the parenchyma and the hilar plate (unroofing of the portal vein). Prevalence of type 1 trifurcation branching pattern is 10-15% and the RPV is replaced by its branches [8,10,11,12]. The incidence of branching pattern of the portal vein in the present study is nearer with the study of Margaret et al, Mostafa Atri, Zafer koc et al, Akgul et al.

Liver transplantation requires reconstruction of PV. In type1 and type3 trifurcation, two portal vein anastomoses are done which increases the risk of postoperative thrombosis. If these branches are closer, reconstruction with the bifurcation of the recipient's portal vein is easily performed. Occasionally RAD may arise from LPV which is an important variant to be remembered while doing left sided resection. In PV trifurcation, the portal vein puncture site created during Trans-jugular intraparenchymal portosystemic shunt, placement will be acute and difficult to stent.

A rare entity of single intra-hepatic portal vein without bifurcation is reported. In this case MPV enters the right lobe of liver, gives branches and turns left to provide vascularity for left lobe [13]. Major liver surgery is contraindicated here. Awareness of this variation in the hilar portal ligation will prevent hepatic failure and death [8,11,14].

The right lobe transplantation is preferred usually due to several benefits like simpler surgical management, adequate liver volume to the recipient compared with left side graft [13]. The most suitable anatomy for right lobe living donor liver transplantation is RPV bifurcation, in which the right anterior and right posterior veins originate from it. Proximal origin of one or more right segmental branches from right portal vein was also reported. Right portal vein variations are important surgically as multiple reconstruction or anastomoses are required and to assure the safety of both donors as well as recipients. Right portal vein branching pattern incidence in the present study coincides with the observations

specified by Rajput et al, Atasoy C and Ozyurek et al (Table 1).

If LPV originates from right anterior branch, resection of right hemi-liver is warranted. A rare case where right anterosuperior segmental branch (VIII) taken origin from Left portal vein was also been reported, and here the right anterior branch supplied only segment V [15].

Bile duct variations should be checked out if there are any variations in portal vein [13]. Portal vein relations with hepatic veins gives an appropriate plane of resection.

### Conclusion

Variations in the formation, termination and intrahepatic branching of portal vein was not infrequent. Accurate evaluation of vascular anatomy and variations in preoperative workup is possible nowadays with the help of non-invasive advanced imaging studies which provides 3dimensional images. Surgical success pertaining to different modern surgical and interventional procedures can be achieved by avoiding undue complications.

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### Legend

- MPV/PV – Main Portal Vein/Portal Vein
- RPV – Right Portal Vein
- SMV – Superior Mesenteric Vein
- SV – Splenic Vein
- IMV – Inferior Mesenteric Vein
- ERLV - Estimate Right Liver Volume
- RAD – Right Anterior Division
- LPV - Left Portal Vein
- RPD – Right Posterior Divisio

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**Table 1: Comparison of Branching Pattern of RPV with previous studies**

Author	Bifurcation	Trifurcation	Quadfurcation
Atasoy C and Ozyurek (2007)	83.2%	12.2%	0.8%
Rajput et al (2014)	87%	13%	0%
Chaitra BR et al (2018)	35.70%	06%	21.40%
Present Study	85.68%	14.32%	0%

**Figure 1: Trifurcation of Portal Vein-Type I**

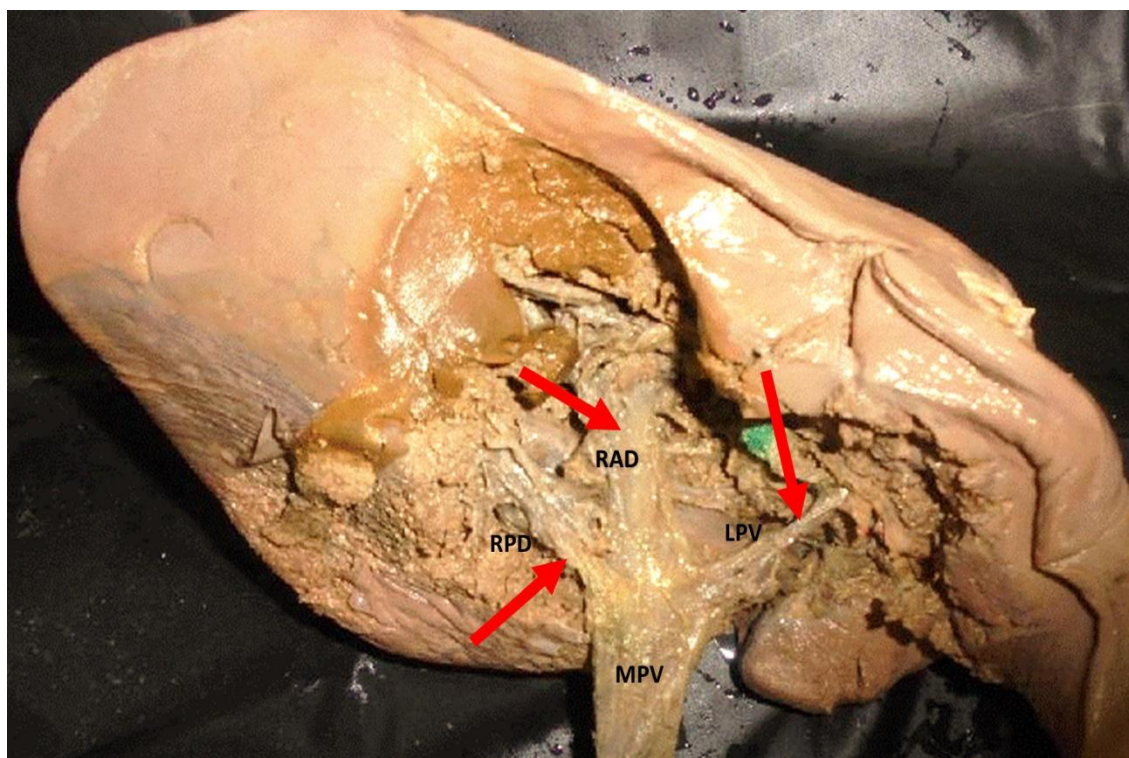


Figure 2: Trifurcation of Right Portal Vein

