Original Research Paper

Volume : 5 | Issue : 11 | November 2016 • ISSN No 2277 - 8179 | IF : 3.508 | IC Value : 69.48

# Variations in intrahepatic portal vein ramification in humans by 64 slice CT study

Anatomy

**KEYWORDS:** Liver, portal vein, Intrahepatic branching, Liver segmentation, CT portography

| | |
|---|---|
| **Kapil Kumar Malviya** | Department of Anatomy, IMS, BHU, Varanasi-221005 |
| **S K Pandey** | Department of Anatomy, IMS, BHU, Varanasi-221005 |
| **Ashish Verma** | Department of Radiology, IMS, BHU, Varanasi-221005 |
| **Surendra Kumar Pandey** | Department of Forensic Medicine, IMS, BHU, Varanasi-221005 |
| **Anand Mishra** | Department of Anatomy, IMS, BHU, Varanasi-221005 |

**ABSTRACT**

*Liver transplantation, has become the ultimate solution for liver diseases such as chronic and acute liver failure, primary hepatic malignancy and inborn errors of metabolism therefore surgeons are concentrating on developing and performing live donor liver transplantations (LDLTs). Intra-hepatic portal vein anatomy and their branching has been a major concern for LDLT. In the present study 40 living cases were screened for the intrahepatic branching pattern of the portal vein. Single branching of portal vein was seen in 2 case (5%), bifurcation was seen in 28 cases (70%), trifurcation pattern was seen in 6 cases (15%), whereas in another variation the right posterior branch is the first branch of portal vein and was seen in 3 cases (7.5%). The absence of right posterior branch of portal vein was seen in 1 case (2.5%). The present study documented the variation in branching pattern of portal vein by 64 slice CT scan.*

**Introduction**

Liver transplantation, recently, has become the ultimate solution for liver diseases such as chronic liver failure, acute liver failure, primary hepatic malignancy, and inborn errors of metabolism (Merkle et al.2008). For satisfactory outcome of liver transplantation, surgeons are concentrating on developing and performing live donor liver transplantations (LDLTs), particularly for young pediatric patients (Moon et al.2009).. Because LDLT may cause morbidity in an otherwise healthy donor, donor's safety is a primary concern, and selection protocols are of crucial importance to exclude unsuitable candidates for either medical or anatomical reasons( lemke et al.2006). Donor selection and evaluation have become highly specialized, because donor safety is imperative and cannot be compromised .Thus, preoperative imaging evaluation of the hepatic vascular anatomy is crucial for surgical planning and has been shown to minimize mortality and morbidity for both donor and recipient, and to minimize post transplant complications ( lemke et al.2006) . The multidetector computed tomography (MDCT) protocol permits the assessment of the hepatic parenchymal morphology and volume, in conjunction with detailed and accurate analysis of the biliary and vascular anatomy. The branching pattern of the main portal vein (MPV) plays a critical role in donor selection and surgical planning for right lobe hepatectomy (Bassignani et al.2001; Chen et al.2007; Kamel et al 2001). Previous studies have reported that the prevalence of variant portal venous anatomy ranges from 0.09% to 34.5%. In these studies, MPV variations are classified into three major groups. Type 1 is a conventional portal anatomy, in which the MPV bifurcates into the right portal vein (RPV) and the left portal vein (LPV), after which the RPV branches into the right anterior portal vein (RAPV) and the right posterior portal vein (RPPV). Trifurcation of the MPV into the LPV, RAPV and the RPPV is classified as type 2 anatomy. Type 3 branching consists of an RPPV origin separated from the MPV and a single trunk for the LPV and the RAPV (Atasoy et al.2006; Erbay et al.2003; Lee et al.2011; Soyer et al.1995).

Intra-hepatic portal vein anatomy has been described many years ago firstly on cadaveric liver dissection by Couinaud. These branching pattern of portal vein plays a critical role in evaluation before surgical intervention, transplantation, and interventional procedures of the liver (Atasoy and Ozyurek 2006; Covey et al. 2004; Erbay et al. 2003).

Modern imaging techniques such as portography, arteriography, three-dimensional (3D) technique such as multi-slice computed tomography (CT) or magnetic resonance imaging (MRI) gives information about the entire liver vascular structures, and offers an interactive platform for surgeons and interventional radiologists to decide preoperatively the best treatment options (Atasoy and Ozyurek 2006; Koc et al. 2007). Recent developments in liver surgery, with living donor transplantation (Bassignani et al. 2001) or complex liver resection, and interventional radiology with portal vein embolization (PVE) techniques (de Baere et al. 1993; Denys et al. 2002) has made mandatory the precise and reliable preoperative imaging of liver vascular anatomy.

Recently portal vein anatomy has gained even greater significance due to faster development in the field of hepatic surgery such as hepatic resection, segmentectomy and split hepatic grafting for liver transplantation.

**Material and method**

All the living cases were clinically evaluated before being subjected to CT Portography. CT liver Portography was carried out with GE (General Electric) Light speed VCT 64- slice MDCT machine and 4.4 version advantage workstation (Fig-1). Following technical parameters were adopted for each scan. Cases were put supine on CT table. An 18 G intravenous needle was placed preferably in right antecubidal vein. The intravenous channel was connected to pressure injector. Portography was performed by injecting 40- 60 ml (1 ml /kg body weight) of Iodinated contrast medium (Omnipaque 350) at the rate of 4.5 -5 ml /sec followed by a saline chase of 50 ml at the same rate. Scanning was done during the platue phase of vessels enhancement. Portal phase was taken after 20 seconds of intra-bolus injection. We used test bolus injection method in which, a small amount of contrast (omnipaque 15-2- ml) was injected for synchronization.

**Result**

40 living cases were screened for the intrahepatic branching pattern of the portal vein. Various intrahepatic branching pattern of portal

vein was seen. (Table-1 here)

| Type | Portal vein branching | Number/percentage of cases |
|---|---|---|
| 1. | No branching (no Bifurcation) | 2 (5%) |
| 2. | Standard anatomy (Bifurcation) | 28 (70%) |
| 3. | Trifurcation | 6 (15%) |
| 4. | Right posterior portal vein(RPPV) as first branch of main portal vein | 3 (7.5%) |
| 5. | Bifurcation but absence of RPPV | 1(2.5%) |

Single branching of portal vein was seen in 2 case (5%), in which portal vein does not divides into lobar branches rather it directly divides into segmental and subsegmental branches to supply the each segment and turns left to supply the left lobe. (Fig-1A&B here)

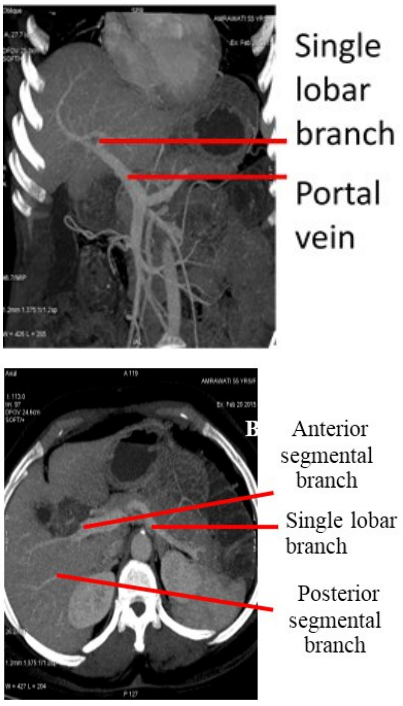
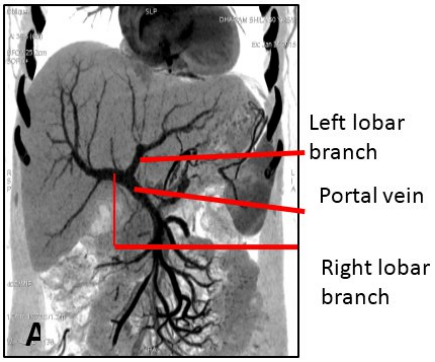



**Fig 1 A& B: 64 slice CT portography showing a single branch of portal vein supplying both right and left lobe**

Most common pattern seen is portal vein bifurcation in 28 cases (70%), in which portal vein divides into the left and right lobar branches. The right lobar branch divides into right anteriosuperior, anterioinferior, posteriosuperior and posterioinferior segmental branches and then divides into subsegmental branches. The left lobar branch divides into mediosuperior, medioinferior, laterosuperior and lateroinferior segmental branches. (Fig-2A&B here)



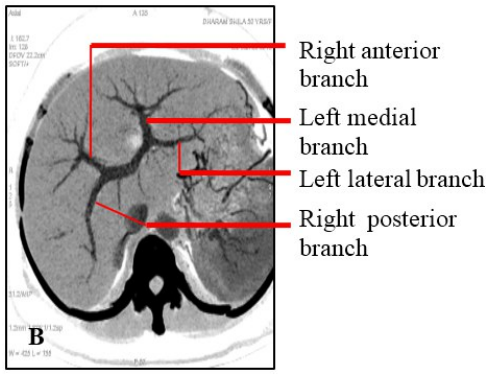




**Fig 2 A&B: 64 slice CT portography showing normal bifurcation and normal branching of portal vein**

The trifurcation pattern was seen in 6 cases (15%), where the main portal trunk divides into right anterior, right posterior and left lobar branches. The right anterior and posterior lobar branches divide into right anteriosuperior, anterioinferior, posteriosuperior and posterioinferior segmental branches. The left lobar branch divides into left mediosuperior, medioinferior, laterosuperior and lateroinferior segmental branches. (Fig 3A&B here)

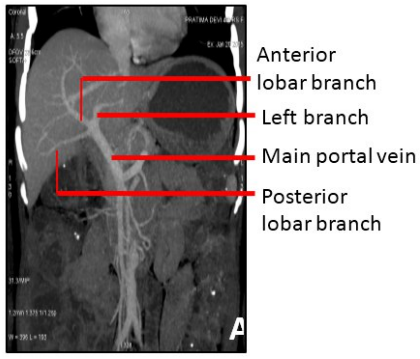



**Fig 3 A: 64 slice CT portography showing trifurcation of portal vein**

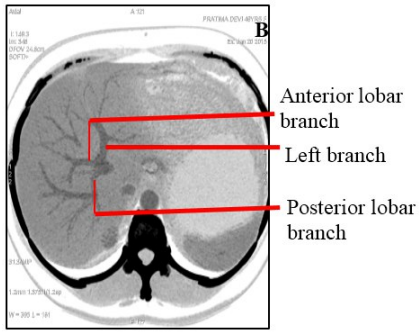



**Fig 3 B: showing branching of portal vein in which main trunk divides into three branches**

In another variation the right posterior branch is the first branch of portal vein and was seen in 3 cases (7.5%) and then main trunk further divides into the right anterior and left branches. The right anterior branch divides into anteriosuperior and anterioinferior branches. The right posterior branch divides into posteriosuperior and posterioinferior branches. The left branch divides into mediosuperior, medioinferior, laterosuperior and lateroinferior branches. (Fig4 here)

Volume : 5 | Issue : 11 | November 2016 • ISSN No 2277 - 8179 | IF : 3.508 | IC Value : 69.48

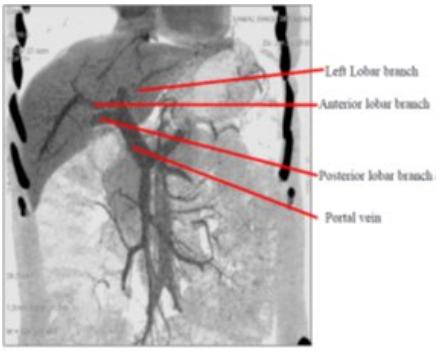



**Fig 4 A: 64 slice CT portography showing right posterior branch as first branch of portal vein**

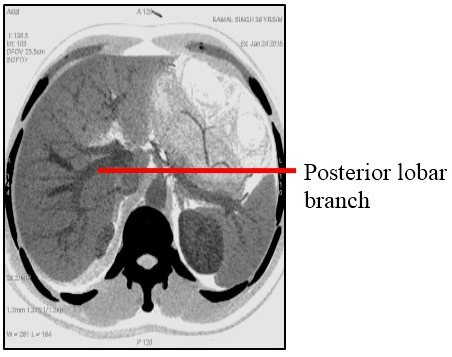



**Fig 4B: showing intrahepatic branching of posterior lobar vein**

The absence of right posterior branch of portal vein was seen in 1 case (2.5%), in which anterior branch supplies the both anterior and posterior segment of right lobe. The left lobe is supplied by the medial and lateral branches of the left portal vein. (Fig-5A&B here)

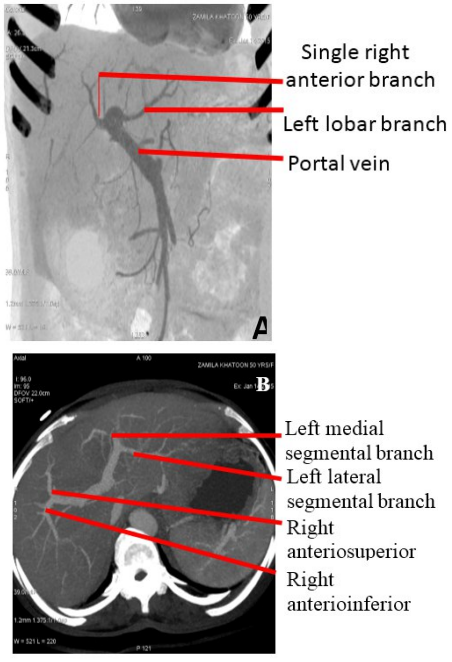



**Fig 5 A&B: 64 slice CT portography showing absence of right posterior branch**

## Discussion

The portal vein variations are asymptomatic, but the knowledge on the normal portal venous anatomy, normal variations and congenital anomalies helps in an accurate depiction on the cross sectional imaging. The common anatomical variations of portal vein observed in 64 slice CT scan is summarized in the table (Okten et al. 2012). (Table-2 here)

| Type | Portal vein variation |
|---|---|
| 1. | Standard anatomy (Bifurcation) |
| 2. | Trifurcation |
| 3. | Right posterior portal vein as first branch of main portal |
| 4. | Miscellaneous |

These variants can be better demonstrated in detail by multislice CT scan with 3D reconstruction. The most common branching pattern of the portal vein is its division at the porta hepatis into the right and the left lobar branches. The right lobar branch first gives off branches to the caudate lobe and then it divides into the anterior and posterior branches, which further subdivide into the superior and inferior segmental branches to supply the right lobe of the liver (Manjunatha et al. 2012). The left lobar branch first has a horizontal course to the left and then it turns medially towards the ligamentum teres, supplying the lateral segments (segments II and III) of the left lobe.

The more common variations of portal vein are trifurcation of the main trunk and the right posterior portal vein as the first branch of the main portal vein (Atasoy and Ozyurek 2006; Covey et al. 2004). Rare portal vein variations which have been reported are duplication, quadrification and congenital absence of the Portal Vein and an accessory Portal Vein. Another rare variant being a single portal vein entering the right lobe of the liver and then coursing into the left lobe giving segmental branches along its entire course (Baba et al. 2000; Pomfret et al. 2001).

In the present study, 64 slice CT scan has been done in 40 living cases to demonstrated the intrahepatic course of the portal vein.

In 64 slice CT scan, 2 case (5%) shows no bifurcation of portal vein, single branch supply the the right and left lobe of the liver by dividing in segmental and subsegmental branches. In 28 cases (70%) show the normal bifurcation of portal vein, in which portal vein divides into the right and left lobar branches at liver hilum, enter the right and left lobe of liver and divides into the segmental and subsegmental branches respectively. Trifurcation of portal vein is seen in 6 cases (15%), in which main portal vein trunk directly divides into the right anterior, right posterior and left lobar branches, which further divides into segmental branches in each lobe respectively. The right posterior lobar branch as first branch of portal vein is seen in the 3 cases (7.5%), in which right posterior branch originates first then after trunk further divides into the right anterior and left lobar branches. The absence of right posterior branch is seen in 1 case (2.5%), in which right lobar branch not divides into the anterior and posterior branches.

The variation in branching pattern of portal vein results from the abnormal development of portal vein where either there is failure of regression of part of right and left vitelline vein or the caudal and cranial anastomosis between the right and left vitelline vein fails to disapperar in intrauterine life.

## Conclusion

Significant variation is observed in the intrahepatic branching pattern of portal vein by 64 slice CT scan study. This should be borne in mind by the operating surgeons while doing hepatic lobe resection or using the donor liver graft for liver transplantation

## Bibliography

1. Atasoy C, Ozyurek E (2006) Prevalence and types of main and right portal vein branching variations on MDCT. AJR Am J Roentgenol 187(3):676-81
2. Baba Y, Hokotate H, Nishi H, Inoue H, Nakajo M (2000) Intrahepatic portal venous variations: demonstration by helical CT during arterial portography. J Comput Assist Tomogr 24:802-08
3. Bassignani MJ, Fulcher AS, Szucs RA, Chong WK, Prasad UR, Marcos A (2001) Use of imaging for living donor liver transplantation. Radiographics 21(1):39-52
4. Chen WH, Xin W, Wang J, Huang QJ, Sun YF, Xu Q (2007) Multi-slice spiral CT angiography in evaluating donors of living-related liver transplantation.

Hepatobiliary Pancreat Dis Int 6(4):364-9
5. Couinaud CPM (1957b) Le foie etudes anatomiques et chirurgicales
6. Covey AM, Brody LA, Getrajdman GI, Sofocleous CT, Brown KT (2004) Incidence, patterns, and clinical relevance of variant portal vein anatomy. AJR Am J Roentgenol 183(4):1055-64
7. De Baere T, Roche A, Vavasseur D, et al. (1993) Portal vein embolization: utility for inducing left hepatic lobe hypertrophy before surgery. Radiology 188(1):73-7
8. Denys A, Madoff DC, Doenz F, et al. (2002) Indications for and limitations of portal vein embolization before major hepatic resection for hepatobiliary malignancy. Surg Oncol Clin N Am 11(4):955-68
9. Erbay N, Raptopoulos V, Pomfret EA, Kamel IR, Kruskal JB (2003) Living donor liver transplantation in adults: vascular variants important in surgical planning for donors and recipients. AJR Am J Roentgenol 181(1):109-14
10. Kamel IR, Kruskal JB, Pomfret EA, Keogan MT, Warmbrand G, Raptopoulos V (2001) Impact of multidetector CT on donor selection and surgical planning before living adult right lobe liver transplantation. AJR Am J Roentgenol 176(1):193-200
11. Koc Z, Oguzkurt L, Ulusan S (2007) Portal vein variations: clinical implications and frequencies in routine abdominal multidetector CT. Diagn Interv Radiol 13(2):75-80
12. Lee WK, Chang SD, Duddalwar VA, et al. (2011) Imaging assessment of congenital and acquired abnormalities of the portal venous system. Radiographics 31(4):905-26
13. Lemke AJ, Brinkmann MJ, Schott T, Niehues SM, Settmacher U, Neuhaus P, Felix R(2006) livingdonor right liver lobes: preoperative CT volumetric measurement for calculation of intraoperative weight and volume. Radiology. 240(3):736-42
14. Manjunatha YC, Beeregowda YC, Bhaskaran A (2012) An Unusual Variant of the Portal Veinbiliary. Journal of Clinical and Diagnostic Research 6(4):731-733
15. Merkle E, Fleiter T, Boll D, Haaga JR, Lanzieri CF, Gilkeson RC.(2008) Liver: normal anatomy, imaging, techniques, and diffuse diseases. CT and MR imaging of the whole body 5th ed. Elsevier ; 1318–1340.
16. Moon DB, Sung-Gyu L (2009). Liver transplantation overview hepatobiliary surgery and liver transplantation. ; Seoul, Korea: Department of Surgery, Asan Medical Center, University of Ulsan College of Medicine.
17. Okten RS, Kucukay F, Dedeoglu H, et al. (2012) Branching patterns of the main portal vein: effect on estimated remnant liver volume in preoperative evaluation of donors for liver transplantation. Eur J Radiol 81(3):478-83
18. Pomfret EA, Pomposelli JJ, Lewis WD (2001) Doing live donor adult liver transplantation by using right lobe grafts: the donor evaluation and the surgical outcome. Arch Surg 136:425–33
19. Soyer P, Bluemke DA, Choti MA, Fishman EK (1995) Variations in the intrahepatic portions of the hepatic and portal veins: findings on helical CT scans during arterial portography. AJR Am J Roentgenol 164(1):103-8