

# An Imaging Study of a Ramification Pattern of Right Posterior Portal Vein Branch

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## Abstract

**Background:** Our aim was to study the ramification pattern of the Right posterior portal vein branch and to compare our findings to Couinaud classification of the liver.

**Study design:** The study protocol was approved by the institutional review board and written informed consent was obtained from all patients before procedures were performed. Our study includes 104 patients, all were Chinese who underwent helical Computed Tomography during Arterial Portography (CTAP). Subsequently, 3 dimensional portograms were reconstructed to verify the ramification patterns of the portal vein. Portal branching patterns of the right hemiliver were assessed.

**Results:** In all 104 patients examined, three distinct types of anatomical branching patterns of the Right posterior portal vein branch were observed:

- Type I: In 52 patients out of 104 (50%), the Right posterior portal branch represents a single trunk forming an arch like pattern and sending multiple branches to segment 6 and segment 7, see Figure 1 and Figure 2.
- Type II: In 9 out of 104 patients (9%), the Right posterior portal vein branch showed trifurcation into posterosuperior, posteroinferior, and intermediate branches. The intermediate branch occupied the segmental border between segments S6 and S7, see Figure 3 and Figure 4.
- Type III: In 43 out of 104 patients (41%), the Right posterior portal branch bifurcates into Posterosuperior P7 and Posteroinferior P6 third order portal branches as described by C. Couinaud in his homonymous segmental liver classification, see Figure 5 and Figure 6.

**Conclusions:** According to Couinaud classification, the Right posterior portal branch bifurcates into third order Postero superior P7 and Posteroinferior P6 portal branches to supply segments S7 and S6.

Our findings showed however, that it happened only in 41% of the cases. In 50% of the findings, the right posterior portal branch represented a single trunk forming an arch like pattern sending multiple branches. The smallest group of 9% showed trifurcation into posterosuperior, posteroinferior, and intermediate branches.

Therefore we conclude that there is a discrepancy between the Atlas model of liver segmentation and our imaging findings. Based on these findings we can consider a right lateral sector as a unique segment in 50% of cases.

**Keywords:** Right posterior portal vein branch; Right lateral sector; Liver segmental anatomy; Right hemiliver

## Introduction

Our aim was to study the ramification pattern of the Right posterior portal vein branch and to compare our findings to Couinaud classification of the liver.

Though several scientists (Hjortso 1951; Elias & Petty 1952; Healey & Schroy 1953; Goldsmith & Woodburne 1957) [18,19,20,10] have conducted research on the anatomical division of liver, the segmental division of the liver based on portal vein ramification pattern proposed by Couinaud (1957) is the universally accepted.

In our days, the majority of the surgeons conceptualize the segmental anatomy of the liver in the manner described by Couinaud [1]. The three main hepatic veins divide the liver into four sectors which are designated as the left lateral, left paramedian, right paramedian and right lateral sectors based on portal ramifications.

These 4 sectors are each supplied by second order portal branches: the left lateral sector is supplied by the left laterosuperior portal vein, the left paramedian sector by the umbilical portion of the left portal

vein, the right paramedian sector by the right anterior portal vein and the right lateral sector by the right posterior portal vein. Each of the eight segments of the liver is defined by its distinct and separate arterial and portal supply as well as its biliary drainage (portal pedicle). The portal pedicles are surrounded by Glisson's sheath.

In our multimodality meeting procedures such as US, CT, MR images and reconstructed 3D images of the portal vein tree with the help of the helical tomography, help us to delineate preoperatively the

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sectoral and the segmental anatomy of the liver and accordingly our excisions. During the past decade there was an abundant research for delineating sectoral and segmental anatomy on US, CT, MR images [2-8,15]. Advances in helical tomography have allowed the reconstruction of accurate and realistic 3D images from arbitrary angles [9]. During our interventions in the right hemiliver we encountered ramification patterns of the right posterior portal branch that were in discrepancy with the Atlas model. These operative findings triggered our interest to study preoperatively with 3D reconstructed images the ramification patterns of the Right posterior portal branch.

## Methods

### Patients

Between Mar 2006 and Nov 2006 138 consecutive patients all were Chinese underwent CT scans. Of these, 104 patients enrolled in our study group, had no previous surgery and ranged in age from 19 to 74 years (mean 51). The patients had the following diagnoses: pancreatic tumors (n = 41), liver tumors (n = 32), haemangiomas (n = 3), lithiasis of the choledochus (n = 6), liver cirrhosis (n = 14), cancer of the gallbladder (n = 4), hepatic cyst (n = 1), Donator (n = 1), tumor of the duodenum (n = 2).

The study protocol was approved by the institutional review board and written informed consent was obtained from all patients before procedures were performed.

### CT Imaging

All studies were performed using commercially available helical CT scanners (Somatom plus 4, Siemens, Erlangen, Germany; or Aquilion, Toshiba Medical Systems. For CTAP, 90 ml iohexol (300mg of iodine per ml) diluted to one half concentration with saline was injected at a rate of 3ml/s during a CT scan of the entire liver. The scan delay after the start of iohexol injection was 20 seconds.

Neither serious nor minor complications occurred during and after procedures in any patient.

### Image processing and analysis

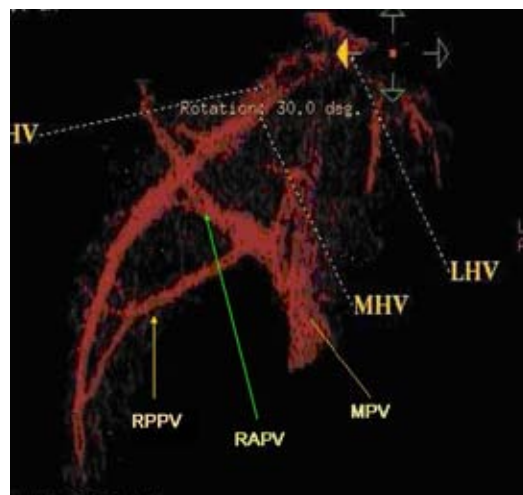
Three dimensional (3D) images were reconstructed from CT data downloaded to an independent work station using software for perspective volume rendering (3D Virtuoso, Siemens). The original consecutive axial CT images and 3D images were blinded and independently interpreted by authors. Any discrepancies that occurred were resolved by consensus.

## Results

### Right posterior portal branching patterns

In all 104 patients examined, three distinct types of anatomical branching patterns of the Right posterior portal vein branch were observed:

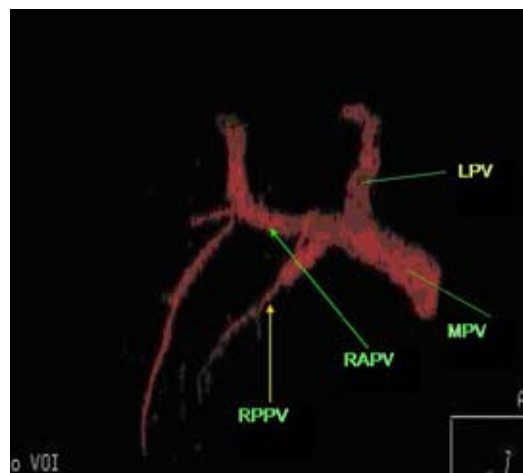
- Type I: In 52 patients out of 104 (50%), the Right posterior portal branch represents a single trunk forming an arch like pattern and sending multiple branches to segment 6 and segment 7, see Figure 1 and Figure 2.
- Type II: In 9 out of 104 patients (9%), the Right posterior portal vein branch showed trifurcation into posterosuperior, posteroinferior, and intermediate branches. The intermediate branch occupied the segmental border between segments S6 and S7, see Figure 3 and Figure 4.
- Type III: In 43 out of 104 patients (41%), the Right posterior portal



**Figure 1: Type I unique right posterior portal branch**

#### Legend:

RAPV:	Right anterior portal vein branch,
RPPV:	Right posterior portal vein branch,
RHV:	Right hepatic vein,
MHV:	Middle hepatic vein,
LHV:	Left hepatic vein,
MPV:	Main portal vein



**Figure 2: Type I unique right posterior portal branch**

#### Legend:

RAPV:	Right anterior portal vein branch,
RPPV:	Right posterior portal vein branch,
MPV:	Main portal vein,
LPV:	Left portal vein

branch bifurcates into Posterosuperior P7 and Posteroinferior P6 third order portal branches as described by C. Couinaud in his homonymous segmental liver classification, see Figure 5 and Figure 6.

## Discussion

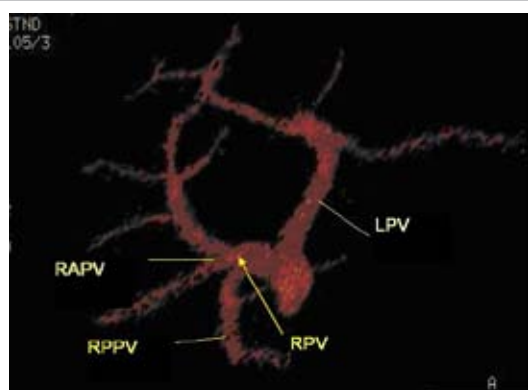
The classification proposed by Healey and Schroy [10] divided the liver into 4 segments which are designated as the lateral, medial, anterior, and posterior segments longitudinally along the three vertical fissures.

According to C. Couinaud, the liver is divided into 4 sectors which are designated as the left lateral, left paramedian, right paramedian and right lateral sectors based on portal ramifications. These 4 sectors

are each supplied by second order portal branches. That is, the left lateral sector is supplied by the left laterosuperior portal vein, the left paramedian sector by the umbilical portion, the right paramedian sector by the right anterior portal vein, and the right lateral sector by the right posterior portal vein.

Subsequently, the liver is divided in 8 segments by adding the caudate lobe as segment 1. Each of the eight liver segments is defined by its distinct and separate arterial and portal supply as well as its biliary drainage (portal pedicle).

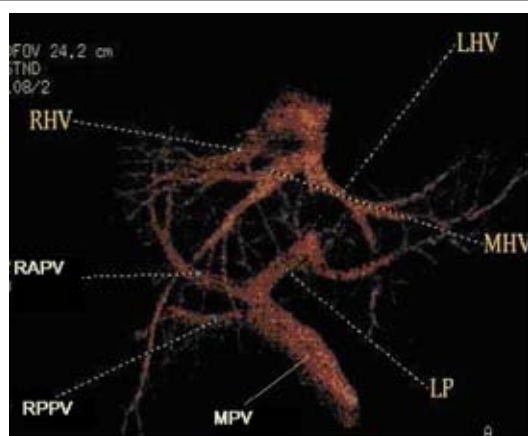
The portal pedicles are surrounded by the vasculobiliary sheath, distinguishing this structure from the hepatic veins. An important difference needs to be noted is that no intrahepatic anastomoses exist between the portal, arterial, and biliary structures of adjacent segments whereas the hepatic veins have large and numerous intrahepatic anastomoses. In addition, several segments are bordered by the same



**Figure 3: Type II Trifurcation**

**Legend:**

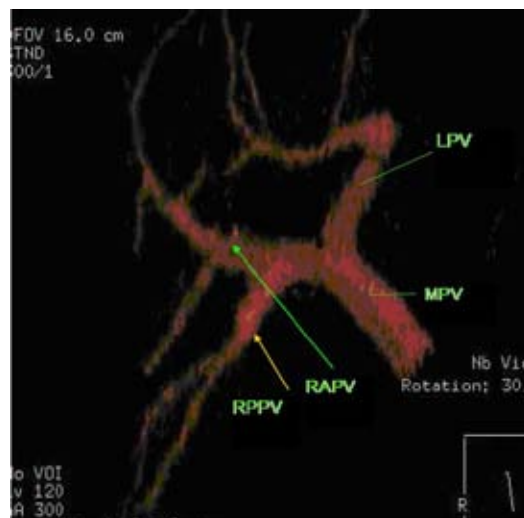
RAPV: Right anterior portal vein branch,  
RPPV: Right posterior portal vein branch,  
RPV: Right portal vein,  
LPV: Left portal vein,



**Figure 4: Type II Trifurcation**

**Legend:**

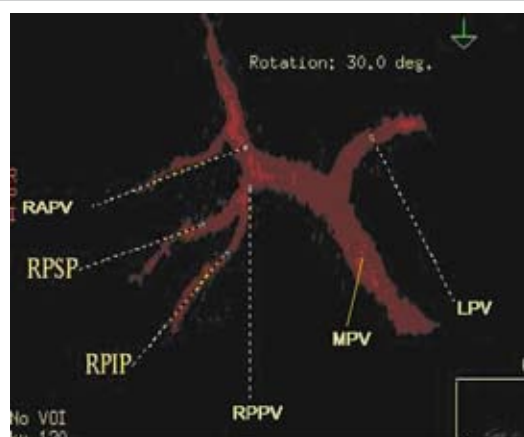
RAPV: Right anterior portal vein branch,  
RPPV: Right posterior portal vein branch,  
RHV: Right hepatic vein,  
MHV: Middle hepatic vein,  
LHV: Left hepatic vein,  
LP: Left portal branch,  
MPV: Main portal vein



**Figure 5: Type III or Couinaud classification**

**Legend:**

RAPV: Right anterior portal vein branch,  
RPPV: Right posterior portal vein branch,  
LPV: Left portal vein,  
MPV: Main portal vein



**Figure 6: Type III or Couinaud classification**

**Legend:**

RAPV: Right anterior portal vein branch,  
RPPV: Right posterior portal vein branch,  
RPSP: Right posteriosuperior portal branch,  
RPIP: Right posteroinferior portal branch,  
LPV: Left portal vein,  
MPV: Main portal vein

hepatic vein and the hepatic veins have abundant anatomic variations as shown in several studies [12,13].

Based on the above we can understand how important is the detailed and granulated knowledge of the liver segmental anatomy for performing safe hepatectomies and segmentectomies. Hence any blind incision will inevitably lead to depriving the region of its arterial and portal blood supply and the creation of bile stasis or leakage as a result from a lack of intrahepatic anastomoses between the portal, arterial and biliary structures of adjacent segments.

Our finding showed that there is a “hole” in the Atlas model of the liver segmentation. Only 41% of the cases had the Couinaud similar pattern classification. In 9% of the cases the right posterior portal

branch trifurcates and in the remainder 50% of the cases, the right posterior portal branch does not bifurcate into posterosuperior P7 and posteroinferior P6 branch but represents a single trunk forming an arch like pattern sending multiple branches. This characteristic defines the right lateral sector as unique segment and changes the whole concept of the Couinaud classification. Based on these characteristics, Akihiro Cho et al., proposed a reclassification of the liver anatomy [15].

Due to this discrepancy, we need to individualize the segmental liver anatomy of every patient by using helical tomograms and 3D reconstructed portograms and by knowing the real borders of the segments we will be able to perform safer segmental hepatectomies and harvest safely sector for living related liver transplantation [16]. Comparing our findings to the Japanese Cho [15] and to the Indian Arora et al. [17], we can conclude that this anatomic variation is a common finding in the Asian population. New studies comparing Asian, Caucasian and African racial groups need to be done.

*Surgeons must not march as a bunch of lemmings into a sea of intellectual acceptance.*

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