

# Anomalous branching pattern of the portal vein: right posterior portal vein originating from the left portal vein

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## Abstract

**Purpose** To introduce a rare variant branching pattern of the portal vein with clinical relevance.

**Methods** A 55-year-old man was examined by contrast-enhanced computed tomography to investigate the cause of fever and mildly elevated hepatic enzyme levels.

**Results** Based on computed tomography, liver abscesses were identified which may have caused the fever and elevated hepatic enzyme levels. And a variation in the branching pattern of the portal vein was also detected in this patient, which has not been reported previously; the right posterior portal vein originated from the end of the horizontal part of the left portal vein. Identification of this rare branching pattern of the portal vein prior to hepatectomy, liver transplantation, and portal vein embolization is considered important to prevent complications.

**Conclusions** A rare variant in which the right posterior portal vein originated from the left portal vein was identified. Recognition of this variant may be important prior to surgical or interventional radiological strategies.

**Keywords** Portal vein · Variation · Hepatectomy · Liver transplantation · Portal vein embolization

## Introduction

Malignant tumors such as hepatocellular carcinoma and cholangiocellular carcinoma arise in the liver or liver hilum. Hepatocellular carcinoma is the second most frequent cause of malignancy-related death in the world [4]. There are several treatment modalities for this disease including hepatectomy, liver transplantation, radiofrequency ablation, and transarterial chemoembolization [5]. As for cholangiocellular carcinoma, surgery is the only curative treatment modality [7]. Recognition of variations in the vascular system and biliary tract prior to these treatments is important to prevent complications.

The portal vein is associated with a lower prevalence of variations compared with the hepatic artery, hepatic vein, and biliary tract. With the advancement of computed tomography (CT) technology, these variations can be evaluated more precisely. According to recent reports, variations in the branching pattern of the portal vein are detected in 27–35 % of patients [1, 3, 8]. These variations are classified into specific major subtypes, and using CT, we identified a rare variant in the branching pattern of the portal vein that does not classify into these major subtypes and has not been reported previously.

## Case report

A 55-year-old man was examined by contrast-enhanced CT using a 320-row multidetector CT scanner (Aquilion ONE; Toshiba Medical Systems, Tochigi, Japan) to identify the cause of the fever and mildly elevated liver enzyme levels. His blood chemistry data were as follows: aspartate aminotransferase 41 U/l, alanine aminotransferase 48 U/l, alkaline phosphatase 331 U/l, gamma-glutamyl transferase

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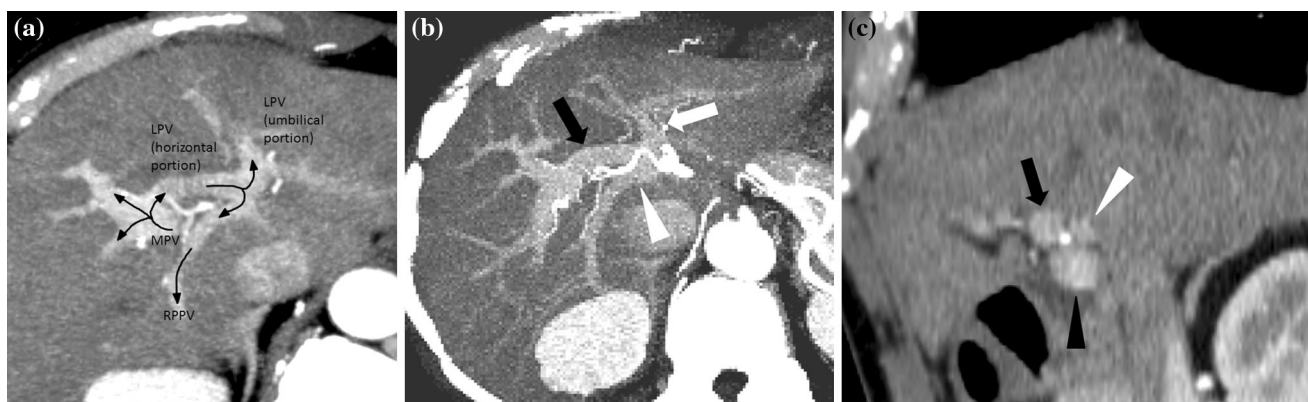
69 U/l, total bilirubin 0.5 mg/dl, and albumin 3.0 g/dl. Liver abscesses were identified by CT, which may have caused the fever and elevated liver enzymes. Incidentally, a variation in the branching pattern of the portal vein was also identified. At the hepatic hilum, the portal vein trifurcated into a branch which perfuses ventral part of anterior segment of right lobe, a branch which perfuses dorsal part of anterior segment of right lobe, and left portal vein. The right posterior portal vein originated from the end of the horizontal portion of the left portal vein (Fig. 1a, b). A branch of segment I ramified at the origin of the right posterior portal vein. The right posterior portal vein was running in the hepatic hilum toward the right lobe parallel to the main portal vein and horizontal segment of the left portal vein (Fig. 1c). There was no variant in the proximal part of the main portal vein, and it ran dorsal to the pancreas (i.e., not a prepancreatic postduodenal or preduodenal pattern). There was no remarkable anomaly in other organs in the abdomen.

## Discussion

Anomalies in the branching pattern of the portal vein have been detected by CT in 27–35 % of the population [1, 3, 8]. The branching pattern of the main portal vein is classified as type I if the main portal vein bifurcates into the right portal vein and left portal vein, as type II if the main portal vein trifurcates into the right anterior portal vein, right posterior portal vein, and left portal vein, and as type III if the right posterior portal vein originates from the main portal vein, after which the main portal vein ramifies into

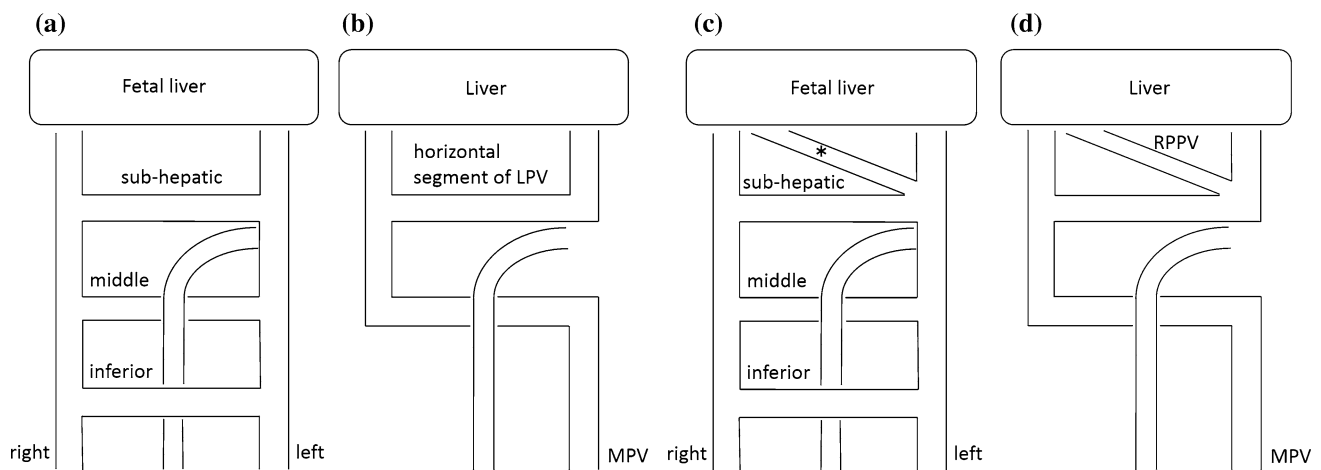
the right anterior portal vein and left portal vein [1, 3, 8]. Some other variations in the branching pattern of the portal vein have been characterized [8, 9]: segment VII originating from the right portal vein, segment VI originating from the right portal vein, and the absence of portal vein bifurcation in which a single portal vein runs across the liver parenchyma from the right lobe to the left lobe. To the best of our knowledge, a variant in which the right posterior portal vein originates from the left portal vein has not been reported previously. Since the left lobe of the liver and the posterior segment of the right hepatic lobe are anatomically distant and the anterior segment of the right hepatic lobe exists between them, this branching pattern of the portal vein seems unnatural.

Variations in the branching pattern of the portal vein are clinically important, especially when planning for surgical or interventional radiological procedures, even though they may not be associated with symptoms or other comorbid anatomical variances. Portal vein embolization is sometimes performed prior to surgery to prevent hepatic failure after dissection of a large volume of the liver. Using this technique, some branches of the portal veins that perfuse part of the hepatic parenchyma (which will be resected) are embolized. This induces hypertrophy of the unembolized part of the liver (which will become a remnant of the liver). The right portal vein is typically embolized, because the large volume of liver would be resected in right lobe resection. If this anatomical variant is not identified prior to portal vein embolization, and only the right anterior portal vein is embolized in patients with the anomaly observed in our report, the effect of this procedure may be insufficient. Also, there were two strong bending points in this anomaly:



**Fig. 1** **a** Contrast-enhanced CT image of the oblique axial plane using the partial maximum intensity projection method. The main portal vein trifurcates at the liver hilum. The right posterior portal vein originates from the end of the horizontal portion of the left portal vein. Arrows indicate the direction of blood flow in the portal vein. **b** Contrast-enhanced CT image of the axial plane using the thicker partial maximum intensity projection method. The right posterior portal vein (white arrowhead) does not ramify directly from the main portal vein or branches perfusing the anterior segment of the right

liver lobe. Black arrow and white arrow indicate the horizontal portion of the left portal vein and the umbilical portion of the left portal vein, respectively. **c** Contrast-enhanced CT image of the sagittal plane. At the hepatic hilum, the main portal vein (black arrowhead), left portal vein (black arrow), and right posterior portal vein (white arrowhead) are parallel. LPV (horizontal portion) umbilical portion of the left portal vein, MPV main portal vein, RPPV right posterior portal vein



**Fig. 2** Schemes for the origin of the portal vein during gestation. **a** Typically, two vitelline veins (*right* and *left*) with three intervitelline anastomoses (sub-hepatic, middle, and inferior) exist. **b** Some of these vessels regress during gestation to form the adult portal vein, and the sub-hepatic intervitelline anastomosis becomes

the horizontal segment of the left portal vein. **c** An extra vessel (*asterisk*) might have originated from the left angle of the sub-hepatic intervitelline anastomosis to the fetal liver. **d** This vessel may become the right posterior portal vein. LPV left portal vein, MPV main portal vein, RPPV right posterior portal vein

origin of the left portal vein and origin of the right posterior portal vein. Therefore, careful planning is required to approach the right posterior portal vein. And in patients who require embolization of the left portal vein, care should be taken not to embolize the right posterior portal vein. This information is also important during surgical procedures. The intermittent Pringle maneuver is performed to reduce bleeding during hepatectomy. If the variant is not recognized prior to hepatectomy, and the right posterior portal vein is not clamped, there is a risk of bleeding from the branch of the right posterior portal vein. Recognition of this variant prior to living donor liver transplantation (LDLT) is also important [6]. For adults, LDLT is typically performed for the right lobe of the liver to meet the metabolic demand of the recipient. This type of variant is associated with multiple openings of the portal vein in the graft, which would complicate the surgery.

Embryologically, two vitelline veins exist on the right and left sides of the primitive gut at 4 weeks of gestation [2]. Three anastomoses are formed between these two vitelline veins at 5 weeks of gestation: superior or sub-hepatic, middle (located dorsal to the primitive gut), and inferior (located ventral to the primitive gut) (Fig. 2a). Around 6–10 weeks of gestation, upon rotation of the gut, some parts of the vitelline veins and intervitelline anastomoses regress: the caudal part of the right vitelline vein, the left vitelline vein between sub-hepatic and middle intervitelline anastomoses, and inferior intervitelline anastomosis. The middle intervitelline anastomosis becomes part of the main portal vein, and the sub-hepatic intervitelline anastomosis becomes the horizontal part of the left portal vein. And the cranial part of the right vitelline vein becomes the right portal vein (Fig. 2b). In our report, the

posterior segment of the right lobe was not perfused by the branches directly ramified from the main portal vein. Instead, the right posterior portal vein was running from the end of the horizontal portion of the left portal vein to the right side of the hepatic hilum. Its length was relatively long compared with the normal right portal vein. And in the liver hilum, the main portal vein, horizontal part of the left portal vein, and right posterior portal vein were parallel. It is difficult to determine the precise mechanism of how the anomaly observed in our report originated; however, from these facts, it might be possible that an extra vessel possibly originated from the left angle of the sub-hepatic anastomosis to the fetal liver (Fig. 2c), where it became the right posterior portal vein (Fig. 2d).

We showed a rare variation in the branching pattern of the portal vein: the right posterior portal vein originated from the left portal vein. Recognition of this anomaly prior to surgery or interventional radiology would be important for preventing complications.

#### Compliance with ethical standards

**Conflict of interest** The authors declare that they have no conflict of interest.

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