Hepatic Vein Invasion by Hepatocellular Carcinoma: CT Manifestations with Angiographic Correlation

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This essay illustrates the various CT findings of the hepatic venous invasion of the hepatocellular carcinoma with an angiographic correlation. The thrombosed hepatic vein is directly visualized as a dilated tubular structure or multiple nodules of the similar attenuation to that of the parenchymal tumor, connecting the parenchymal tumor and the inferior vena cava on contrast enhanced CT scans. Enhancement of the thrombosed vein on spiral CT scans obtained in early arterial phase can suggest thrombosis caused by tumor invasion rather than a simple thrombosis. When the thrombosed hepatic vein is not directly visualized and replaced by a large tumor, the tumor thrombi within the inferior vena cava or right atrium can suggest the presence of the hepatic venous invasion.

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It has been well known that the hepatocellular carcinoma (HCC) has a greater propensity for the venous invasion than other primary or metastatic liver neoplasm with a reported incidence of 32—70% in portal vein and 13—23% in hepatic vein (1-2). Survival rate is significantly different between HCC patients with and without vascular invasion (3). The main mode of extrahepatic metastasis of HCC is thought to be hematogenous and the lung is by far the most frequent site of metastasis. A significant correlation has been proved between intrahepatic vascular invasion and extrahepatic pulmonary metastasis (1). The tumor thrombi within the hepatic vein may extend into the IVC and right atrium, and then, the cancer cells and debris detached from thrombi may flow into the pulmonary artery and spread into the systemic circulation. Invasion of the hepatic vein in HCC patients provides valuable information regarding the extent of the tumor, feasibility of the resection, planning of the intervention, and the prognosis.

Although the angiography is the conventional radiographic method of the preoperative assessment of the angioinvasion of the tumor, tumor thrombi within intrahepatic vein and the IVC can also be demonstrated by the ultrasound and CT. The classical appearance of the thrombosed vein is well known as a dilated unopacified vein with a wall enhancement on contrast enhanced CT, but the small thrombosed branches of the hepatic vein may have rather atypical findings that can not easily be diagnosed (2). To our knowledge, there have been no detailed descriptions about various CT findings of the thrombosed hepatic vein associated with HCC.

This pictorial essay illustrates the various appearances of the hepatic vein invasion of the HCC on conventional and spiral liver CT, with an angiographic correlation.

Normal hepatic venous anatomy on CT scans

The liver can be divided into eight segments according to the vascular territory and each segment is drained via intrasegmental veins (4). Therefore, hepatic veins are all intersegmental or interlobar in position and provide landmarks for distinguishing the segments of the liver (Fig. 1a). Late phase spiral CT scans (10mm collimation at 1:1 pitch table speed) obtained 3—4 minutes after initial administration of 100 mL of the contrast medium ensures reliable demonstration of even small vascular rami of the liver (Fig. 1b—d). Hepatic veins can also be well visualized on conventional CT scans after bolus administration of the
Fig. 1. Normal segmental anatomy of the liver
a. The intersegmental hepatic veins join into three main trunks, right (RV), middle (MV), and left (LV) hepatic veins, which divides the liver into four sections. The numbers represent the individual hepatic segment proposed by Couinaud [7].
b-d. Transverse sectional views of hepatic veins on the level of the venous angle in the liver (b), directly above bifurcation of the portal vein (c), and below it (d).

contrast medium. Normally the three main branches of the hepatic veins drain into the IVC at the posterior and superior margin of the liver. Therefore, right, middle, and left main hepatic veins can usually be demonstrated on one section (Fig. 1b). They divide the liver into four sectors. The right main hepatic vein runs in a coronal plane at the superior aspect of the right intersegmental fissure, which divides the right lobe on the one side into anterior segment 5 and 8 as well as into dorsally located posterior segments 6 and 7. Then, it drains along the right lateral margin of the IVC. The middle main hepatic vein forms a border between the left and right lobes and marks off a vertical plane that ends caudally at the bed of the gall bladder. It enters the anterior left aspect of the IVC. The left main hepatic vein courses partly in the longitudinal fissure and thus separating the quadrate lobe (segment 4) from left lateral segment 2 and 3. The left main hepatic vein enters the anterior left portion of the IVC either alone or after joining with the middle main hepatic vein (Fig. 1a). The caudate lobe drains via multiple small veins directly into the IVC from the posterior margin of the caudate lobe. Smaller accessory veins may also enter directly into the IVC (Fig. 3). The IVC courses axially through the hepatic parenchyma and can be identified as a sharply marginated, oval structure.

CT findings of the tumor extension into the hepatic vein

A thrombosed hepatic vein can directly be visualized on CT scans or it can be recognized indirectly although hepatic vein itself is not identified.

Directly visualized thrombosed hepatic vein
Thrombosed hepatic vein is demonstrated as a dila-
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A tubular structure of the similar attenuation to that of the parenchymal tumor (Fig. 2, 3). When the course of the thrombosed hepatic vein is not parallel to the scan plane, it appears as hypo-attenuated, round or ovoid.

Fig. 2. Thrombosed left main hepatic vein.
  a. The left hepatic vein (asterisks) is seen as a rectangular shape of low attenuation, connected to the parenchymal tumor on contrast enhanced CT scan.
  b. There is an eccentric filling defect (open arrow) toward the mass within inferior vena cava on a scan obtained at 1 cm higher level than a.
  c. A celiac angiogram reveals thrombosed left (arrow) and middle main hepatic vein and inferior vena cava.

Fig. 3. Thrombosed inferior accessory hepatic vein
  a. There is a tubular structure of low attenuation (arrow heads), connected to the thrombosed inferior vena cava. A small hepatocellular carcinoma is seen in segment 6 (arrow).
  b. Celiac arteriogram shows thrombosed inferior accessory hepatic vein (arrowheads) and inferior vena cava (curved arrows).
  c. Inferior vena cavogram demonstrates large filling defect at the level of entrance of inferior accessory hepatic vein, corresponding to the 'thread and streaky' or cavernous appearance of the thrombosed inferior vena cava in b.
nodular lesions mimicking daughter nodules (2). Careful examination reveals their continuity and connection of the parenchymal tumor and IVC on serial scans (Fig. 4, 6). On spiral CT scan, early enhancement of the thrombosed hepatic vein is seen on scans obtained in early arterial phase, and then, it changes to the usual appearance of thrombosed vein of low attenuation on delayed scans (Fig. 5). Such an enhancing pattern is quite similar to that of the parenchymal HCC itself, which can suggest tumor invasion of the hepatic vein, rather than a simple venous thrombosis.

![Fig. 4. Thrombosed branch of right hepatic vein mimicking daughter nodules.](image)

a-c. There is a small nodule (arrowhead in a) of the same attenuation with parenchymal tumor, which is traced proximally to the right hepatic vein (arrowheads in c) on serial scans. d. Superior mesenteric arteriogram shows thrombosed right hepatic vein in its proximal portion (arrows). However, the thrombosed peripheral hepatic vein shown in the CT scans is not clearly delineated.

Nonvisualized hepatic vein replaced by the parenchymal tumor

Sometimes, the hepatic vein itself is not delineated in its expected location due to a large tumor, in spite of the adequate contrast enhancement. However, the eccentric tumor thrombi within the IVC or right atrium can suggest the tumor extension via hepatic vein from the parenchymal tumor (Fig. 7). Therefore, particular attention to tracing individual hepatic veins in its exact location, trying to find out thrombosed hepatic veins of low attenuation, their connection to the parenchymal
tumor, and tumor thrombi within the IVC is important.

**Pitfalls**

False positive diagnosis of the venous thrombosis on the enhanced CT scan can be made (Fig. 8), because of: a. mix with unopacified blood from other branches, b. laminar flow of the blood that makes iodided contrast media to flow on the periphery of the vein, and c. layering phenomenon due to density difference of the contrast media and blood. These erroneous diagnoses can be avoided by delayed scan and complimentary ultrasound or angiography (5).

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**Fig. 5. Early enhancement of thrombosed vein on spiral CT scans**

a, b. Scans obtained 30 seconds after initial contrast injection show early enhancement of the middle hepatic vein (arrow), connecting a large hepatocellular carcinoma and inferior vena cava. The right and left hepatic veins are not enhanced yet.

c, d. Delayed scans, obtained 6 minutes after initial contrast injection, reveal nonenhancing thrombosed middle hepatic vein (arrow), in contrast to the intact other hepatic veins with excellent enhancement.

e. A celiac arteriogram reveals thrombosed vein of the 'thread and streaky' appearance (arrowheads) at the medial aspect of the hypervascular mass.
Fig. 6. Thrombosed peripheral right hepatic vein.

a-c. There is a diffuse hepatocellular carcinoma in the right lobe and a small nodular lesion is seen adjacent to collapsed inferior vena cava (arrow a), that is traced inferiorly to the linear structure (arrows in c), suggesting the dilated thrombosed peripheral hepatic vein (arrows in Fig. 7a-b).

d. In the celiac angiography, a diffuse hypervascular mass with numerous arteriovenous fistulas is seen in the liver. There is a 'thread and streaky' appearing thrombosed hepatic vein (arrowheads) along the inferior margin of the mass corresponding to the linear structure in c.
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Fig. 7. Thrombosed hepatic vein replaced by diffuse hepatocellular carcinoma.

a. A contrast enhanced CT scan obtained in the early arterial phase (35 seconds after initial contrast injection) shows mass in the dome of the liver and a filling defect (arrow) within the right atrium suggesting a tumor thrombus.
b. On delayed scan (6 minuets), right lobe of the liver is replaced by a diffuse hepatoma and the right hepatic vein is not delineated within the mass. An arrow indicates the thrombosed inferior vena cava.
c. A digital subtraction angiogram of the celiac artery shows a hypervascular mass and a thrombosed hepatic vein (arrow).

Fig. 8. 'Pseudothrombus' artifact within the inferior vena cava produced by rapid infusion of contrast material through an arm vein.

a. Large, prominent filling defect in intrahepatic inferior vena cava with an excellent contrast enhancement of aorta and hepatic veins is seen on a scan obtained 35 seconds after initiation of contrast injection. Focal collection of contrast material within artifact distinguishes it from true thrombus (arrow head).
b. Inferior vena cavogram demonstrates normal inferior vena cava.
간세포암의 간정맥 침범 : 혈관조영술 소견과 비교한 CT 소견

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본 임상화보에서는 간절막을 침범한 간세포암의 다양한 컴퓨터단층촬영 (CT) 소견을 혈관조영술 소견과 함께 보여주고자 한다. 종양에 의한 혈전이 친 간정맥은 조영증강 후 CT에서 간 실질의 간세포암과 같은 음영의, 늘어난 관형 구조물 또는 여 러개의 결절 모양으로 보이고 간실질내의 종괴와 하대정맥을 연결하는 소견을 보인다. 특히 나선식 CT의 동맥기 영상에서 보이는 간정맥 혈전의 초기 조영증강은 단순한 혈전이 아닌 종양에 의한 혈전임을 시사하는 소견이다. 간정맥이 커다란 간 종양내에 포함되어 구별이 되지 않는 경우, 하대정맥과 우심방내의 혈전이 종양의 간정맥 침범을 간접적으로 시사하는 소견이다.

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