Imaging of Hepatic Venous Outflow Obstruction

Poster No.: C-1091
Congress: ECR 2014
Type: Educational Exhibit
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Keywords: Varices, Cirrhosis, Shunts, Angioplasty, Ultrasound, MR, CT, Veins / Vena cava, Liver, Abdomen
DOI: 10.1594/ecr2014/C-1091

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Learning objectives

- To identify the spectrum of abnormalities causing hepatic venous outflow obstruction
- To understand imaging findings including hepatic morphologic changes, perfusion abnormalities, collateral vessels and hepatic nodules related to hepatic venous outflow obstruction.
Background

Definition, classification and causes:

Hepatic venous outflow obstruction (Budd-Chiari syndrome) occurs due to partial or complete occlusion of the Inferior Vena Cava (IVC) or Hepatic veins (HV) and can be classified into primary or secondary causes.

Hepatic venous outflow obstruction is classified as primary when the obstruction is related to an endoluminal venous problem, such as thrombosis, stenosis, or intraluminal webs. Secondary hepatic venous outflow obstruction is related to malignant invasion of the IVC and HV or compression of the IVC and HV by a large cyst (parasitic and non-parasitic) or abscess. It may also occur by compression or kinking of the hepatic veins after hepatic resection or transplantation.

The prevalence of hepatic venous outflow obstruction differs according to the geographical area. In the Western population it is more commonly caused by thrombosis due to inherited or acquired hypercoagulable conditions such as oral contraceptive use, pregnancy, polycythemia vera, or protein C deficiency. Less commonly it may be due to thrombosis related to chemotherapy, radiation or post bone marrow transplantation. Membranous obstruction of IVC is common in Asia or South Africa.

Liver biopsy in hepatic venous outflow obstruction may be normal due to the inhomogeneous distribution of disease. A normal biopsy result, therefore, does not exclude this pathology. Imaging studies combined with clinical information are often essential in reaching a definitive diagnosis.

Clinical manifestations:

Clinical manifestations of hepatic venous outflow obstruction may be fulminant (5%), acute (20%), subacute or chronic (60%). Hepatic venous outflow obstruction is asymptomatic in about 15-20% of cases and occurs when there is thrombosis of a single hepatic vein or adequate collateral vessels.

Fulminant presentation is rare and involves the rapid development of elevated liver enzymes, hyperbilirubinaemia, coagulopathy and hepatic encephalopathy.
The **acute** form usually develops within 1 month and manifests with the rapid onset of abdominal pain, liver enlargement, jaundice and ascites.

**Subacute** hepatic venous outflow obstruction is the most common clinical type. Decompressive collaterals develop in subacute hepatic venous outflow obstruction\(^1\).

**Chronic** hepatic venous outflow obstruction is characterized by cirrhosis and development of portal hypertension. 50% of patients with chronic hepatic venous outflow obstruction have renal failure and 5-15% of these patients have esophageal bleeding\(^1\).

**Treatment :**

Treatment depends on the underlying aetiology and severity of the disease. Medical treatment includes diuretic or paracentesis for ascites, balloon tamponade or sclerotherapy for variceal bleeding and anticoagulant drug therapy to treat a bland thrombus. Membranectomy or percutaneous stent placement with balloon angioplasty might be performed for membranous IVC occlusion. In severe portal hypertension, a surgical shunt or transjugular intrahepatic porto-systemic shunt can be created in preparation for liver transplantation\(^1\).
Findings and procedure details

Imaging plays an important role in early diagnosis of hepatic venous outflow obstruction and in accurately assessing the extent of the disease.

The range of imaging features in hepatic venous outflow obstruction depends on the acuteness, severity and location of the obstruction (lobar, segmental, or diffuse venous obstruction)\(^5\).

The imaging findings can be divided into 4 main categories:

1. **Morphological changes of the liver,**
2. **Attenuation changes of the involved liver parenchyma,**
3. **Vascular changes including development of intrahepatic venous, systemic and portosystemic collaterals,** and
4. **Hypervascular liver nodules (regenerative nodules and hepatocellular carcinoma).**

**1. Morphological changes of the liver:**

The liver usually has normal morphology in acute hepatic venous outflow obstruction. In chronic hepatic venous outflow obstruction, the liver demonstrates morphological changes of caudate lobe hypertrophy and peripheral atrophy. Nodularity of the hepatic surface may show progression to cirrhosis\(^6\). Hepatic venous outflow obstruction is usually accompanied by ascites and splenomegaly.

**2. Attenuation changes of the involved liver parenchyma:**

a) **Acute hepatic venous outflow obstruction - Figures 1, 2 and 3**

In acute hepatic venous outflow obstruction, there is usually diffuse peripheral hypoattenuation in the liver parenchyma on CT or MR imaging. The central part of the liver demonstrates strong enhancement. In the portal venous phase, a “flip-flop” pattern arises with washout and subsequent low attenuation of the central part of the liver while attenuation in the peripheral part of the liver gradually increases due to the accumulation of contrast material from the capsular veins\(^3\).

On MRI, the peripheral portion of the liver shows reduced signal intensity on T1 weighted images and heterogeneous increased signal intensity on T2 weighted images (edema).
b) Chronic hepatic venous outflow obstruction - *Figures 4, 5, 6 and 7*

Hepatic attenuation changes are variable depending on the severity of the venous obstruction. The most common attenuation patterns in chronic hepatic venous outflow obstruction are areas of linear, irregular, or wedge-shaped hypoattenuation predominantly located in the peripheral portion of the liver on contrast-enhanced CT or MRI\(^8\). Other possible attenuation changes include ill-defined heterogeneous attenuation and diffuse hypoattenuation\(^8\).

In the chronic stage on MRI images, the peripheral portion of the liver may be hypointense on T1 and T2 weighted images (fibrosis).

**Specific situations:**

**Hepatic abscesses - *Figures 8 and 9***

Hepatic abscesses are frequently associated with portal or hepatic vein thrombosis and may mimic the appearance of malignant liver tumors such as hepatocellular carcinoma. These two entities can be distinguished clinically by the presence or absence of fever, elevated white blood cell count, and risk factors for hepatocellular carcinoma\(^12\).

*Venous thrombosis* associated with liver abscess is invariably seen as non-enhancing hypoattenuating linear or branching structures without luminal distension. This can be differentiated from *malignant* tumor thrombosis where there is venous luminal distention and enhancement with neovascularity.

Regional parenchymal attenuation changes associated with portal vein thrombosis is different from that seen in hepatic vein thrombosis. Regional attenuation changes in hepatic vein thrombosis is often hypoattenuating whereas regional hyperattenuation in the arterial and/or portal venous phase is usually seen in portal vein thrombosis. *Portal vein obstruction* seldom induces hypoattenuation in the portal venous phase.

**Segmental hepatic venous congestion in post transplant right lobe liver grafts - *Figures 10 and 11***

The anterior sector congestion (segment V and VIII) occurs in a right lobe graft without a middle hepatic vein. This may be due to insufficient drainage, stenosis or occlusion of a reconstructed large hepatic vein by using an interposed vein graft\(^13\). Posterior sector congestion (segment VI and VII) can be seen in ligation or anastomotic stenosis of the right inferior accessory hepatic vein.
The congested area generally shows iso- or slight hypo-attenuation on arterial phase (AP) images. The appearance on portal venous phase imaging correlates with the clinical scenario: hyperattenuation correlates with good recovery without atrophy while hypoattenuation is associated with a high bilirubin level and subsequent atrophy⁴.

3. Vascular changes including development of intrahepatic venous, systemic and portosystemic collaterals - *Figures 12, 13, 14, 15 and 16*

a) HV and IVC:

There may be lack of visualization of one or more hepatic veins and/or IVC stenosis or thrombosis. The IVC may be compressed by the enlarged caudate lobe. The hepatic veins and IVC may appear narrowed and hypoattenuating with hyperattenuating walls on CT imaging³.

On grey scale sonography, the hepatic veins may be replaced by a fibrous, echogenic cord¹ and there may be absent or reversed flow in the hepatic veins on Doppler evaluation.

Vascular patency can be evaluated on multiphase contrast-enhanced 3D MR angiography, T2-weighted sequences or post contrast T1-weighted MR sequences. Acquisition of T2*- weighted gradient-recalled echo sequences is useful for showing absence of flow in the HV and IVC⁹.

Chronic thrombosis of the IVC can progress into calcification.

The porta-hepatis may be displaced anteriorly. In 9-20% of patients, there is associated portal vein thrombosis as the result of underlying thrombophilia and stagnation of portal flow⁶.

b) Intrahepatic and systemic collateral veins:

Identification of intrahepatic and extrahepatic collateral vessels is highly suggestive of chronic hepatic venous outflow obstruction.

**Intrahepatic venovenous collateral vessels** are identified by their curved or comma shaped appearance. **Delayed phase CT should be performed to identify intrahepatic collateral vessels.**
Visualization of a dilated caudate vein (>3 mm in diameter) on grey-scale sonography strongly suggests the diagnosis of hepatic venous outflow obstruction. A dilated caudate vein can also be seen in cardiac cirrhosis but in this context there is also dilatation of the HV and IVC. The identification of collateral vessels with drainage into the subcapsular or intercostal veins is highly sensitive and specific for the diagnosis of hepatic venous outflow obstruction.

A "spiderweb" pattern of collateral vessels in hepatic vena-cavography is pathognomonic of hepatic venous outflow obstruction.

**Extrahepatic collateral veins** in hepatic venous outflow obstruction are different from the portosystemic collateral sites seen in liver cirrhosis. Extrahepatic collateralized routes include the left renal-hemiazygos pathway, inferior phrenic-pericardiophrenic collaterals, and superficial collaterals of the abdominal wall.

c) Other:

The diameter of the hepatic artery is usually enlarged compared with that of the splenic artery. On angiography, the hepatic arteries are usually dilated and associated with arterioporal shunts.

4. Hypervascular liver nodules (regenerative nodules and hepatocellular carcinoma) - *Figures 17, 18, 19, 20, 21 and 22*

Development of regenerative nodules, which usually range between 1-4 cm in size, is a response to decreased hepatic perfusion, which progresses to atrophy with compensatory nodular hyperplasia in the area of the liver with an adequate blood supply. There is no evidence that large regenerative nodules degenerate into malignancy. Regenerative nodules are bright on T1-weighted MR images and predominantly isointense or hypointense relative to the liver on T2-weighted images. The few cases of hyperintense nodules on T2-weighted images are likely due to lesion infarction. On the arterial phase, the nodules homogeneously enhance with or without a hypoattenuating rim and no washout on the PVP. In the hepatobiliary phase of Gd-EOB-DTPA-enhanced MRI, the nodules are iso- or hyperintense. On contrast-enhanced ultrasound, the nodules are hypervascular and do not show washout. The arterial-phase enhancement pattern is often centrifugal similar to focal nodular hyperplasia.

**Differential diagnosis for regenerative nodules:**
a) The main differential diagnosis is Hepatocellular carcinoma (HCC). It is important to differentiate regenerating nodules from HCC. If regenerating nodules are misdiagnosed as multifocal hepatocellular carcinoma patients might be rejected from receiving a liver transplantation or may be offered inappropriately aggressive therapy such as transcatheter arterial chemoembolization. HCC is usually T1 hypointense in relation to the liver and T2 hyperintense along with evidence of heterogeneity on AP imaging, encapsulation, portal or hepatic venous invasion and washout on the PVP or delayed phase images. Regenerative nodules are mostly multiple and relatively small and uniform in size. Iso- or hyperintensity in the hepatobiliary phase Gd-EOB-DTPA-enhanced MRI can help differentiate regenerative nodules from HCC.

A single nodular tumor with a peripheral location appears to have a higher probability of HCC. Serum alpha-fetoprotein (AFP) level may be elevated in patients with HCC.

b) Other differential diagnoses for regenerative nodules include adenomas and hypervascular metastases.

It is impossible to distinguish some cases of adenomatosis from large regenerative nodules unless there is imaging or histologic evidence of fat, hemorrhage or calcification.

Vascular metastases are variable in size and heterogeneity and are hypointense on T1-weighted images and moderately hyperintense on T2-weighted images. Many of these patients are also known to have a primary malignancy.

Differential diagnosis: Liver cirrhosis:

Longstanding venous obstruction is often misdiagnosed as liver cirrhosis. There are several CT findings that can aid in differentiating hepatic venous outflow obstruction from alcoholic or post hepatitis liver cirrhosis:

1. Prominent systemic collaterals as well as intrahepatic collaterals
2. Peripherally located linear, irregular or wedge shaped hypoattenuating areas consistent with venous infarcts
3. Lack of visualization or thrombosis of the hepatic veins or intrahepatic IVC
4. Rounded IVC with thrombus inferior to the level of obstruction due to sluggish flow.
Fig. 1: Acute hepatic venous outflow obstruction due to acute thrombosis of hepatic veins (blue arrows). A. Portal venous phase CT shows an enlarged diffusely hypoattenuating liver with preserved enhancement of the caudate lobe (*). B. On portal venous phase CT of lower level to A, is an unopacified right portal vein (short arrows) as it functions as a draining vein (hepatofugal flow).


Fig. 2: Secondary acute hepatic venous outflow obstruction in a patient with pathological proven malignant fibrous histiocytoma. The tumor lies within the left renal vein and extends to involve the inferior vena cava. Along its cranial component, the tumor extends superior to the IVC filter into the inferior cavoatrial junction. There is thrombosis of the right hepatic vein (blue arrow) and diffuse hypoattenuation of the posterior segment of the right lobe of the liver.
Fig. 3: Acute thrombosis of left hepatic vein and partial thrombosis of middle hepatic vein with a history of recent chemotherapeutic drug infusion near the origin of left and middle hepatic veins. A & B. Two levels of portal venous phase CT images demonstrate a sharply demarcated region of decreased enhancement including the thrombosed left hepatic vein (blue arrow) intersected by the left portal vein (dotted line). Subtle hypoattenuating changes are also noted in the partially thrombosed middle hepatic vein tributaries (red arrow).


Fig. 4: Partial chronic hepatic venous outflow obstruction found incidentally in a patient scanned for right lower quadrant pain. Portal venous phase CT demonstrates chronic occlusion of the right and middle hepatic veins (short arrows) with reticular hypoattenuating changes and atrophy of the right lobe of the liver and compensatory
hypertrophy of the left lobe. The left hepatic vein (long arrow) is not occluded. If the left hepatic vein flow develops new thrombosis, the patient may develop acute decompensation.


Fig. 5: Subacute hepatic venous outflow obstruction secondary to polycythemia vera. There are bilateral pleural effusions as well as diffuse ascites. There is lack of opacification in all the hepatic veins with hypoattenuating changes in the liver. Note the dilated azygos/hemiazygos collateral systemic vessels.

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**Fig. 6:** Same patient as Fig. 5. The attenuating changes in the liver return to normal post portocaval shunt (shown on CT and US).

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**Fig. 7:** Subacute hepatic venous outflow obstruction in a 27-year old woman. A. Single portal venous phase CT scan with a clinical suspicion of lupus serositis demonstrates hepatomegaly and ascites. B. CT scan of upper level of the liver shows an unusual curvilinear structure (arrow). C-E. Ultrasound performed two weeks after CT scan with patient’s deterioration of liver function. Transverse sonogram (C) reveals a cord-like obliteration of right hepatic vein (arrows). D. Color Doppler sonogram show aliasing indicating stenosis (arrows) at the origin of middle/left hepatic veins. E. Color Doppler sonogram caudal to D demonstrates intrahepatic veno-venous collateral flow (arrow) from right- to middle hepatic vein which corresponds to the curvilinear structure on B.

Fig. 8: Portovenous phase CT images demonstrates an abscess in segment IV/V of the liver with thrombosis of the middle hepatic vein (arrow) and regional hypoattenuation.

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Fig. 9: A and B. Large hydatid cyst within the right lobe of the liver primarily within segment VIII. The cyst is splaying and compressing the middle and right hepatic veins as well as the IVC. The liver has a heterogenous appearance in the right lobe of the liver secondary to congestion. The clue to hepatic venous outflow obstruction are the systemic collateral vessels. Red arrow shows the prominent azygos and hemiazygos veins. C-E. Chronic compensated Budd-Chiari secondary to the hydatid cyst. Post hydatid cyst
deroofing demonstrates a residual collection in the surgical bed in the superior aspect of the liver extending to the diaphragm. There is hypertrophy of the left lobe of the liver with relative atrophy of the right lobe and heterogenous parenchymal enhancement. The middle hepatic vein (short blue arrow) and right hepatic vein are thrombosed with an intrahepatic collateral vessel in the right lobe of the liver (long blue arrow). The IVC is also irregular with a reduction in luminal calibre suggestive of chronic non-occlusive thrombosis within the IVC.

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Fig. 10: Post transplant hepatic venous congestion. The patient with a living donor right lobe graft presented with persistent elevation of serum alkaline phosphatase and bilirubin. A and B. CT scan at post transplantation day 6 shows mild hypoattenuation of middle hepatic vein tributaries (arrows) on arterial phase (A), which becomes hypoattenuating (*) with adjacent hyperattenuation (arrows) on portal venous phase (B). C. On ultrasound at post transplantation day 14, the hypoattenuating area on CT is echogenic (*) which showed atrophy on follow-up scans (not shown).

**Fig. 11:** Status post left lobe liver transplantation with a congested parenchymal enhancement pattern secondary to IVC stenosis at the superior level of the anastomosis (blue arrow).

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**Fig. 12:** Hepatic venous outflow obstruction secondary to membranous obstruction of the IVC. The liver is enlarged and shows peripheral irregular and linear hypoattenuating densities. Multiple intrahepatic collaterals are seen (blue and red arrows); the most
prominent one between the right and middle HV (blue arrow). There is a large right inferior accessory hepatic vein draining into the IVC (green arrow). Extensive extrahepatic collateral vessels are demonstrated. There are dilated paraspinal systemic collaterals with a large azygos and hemiazygos system (orange arrow). Large inferior phrenic-pericardiophrenic collateral vein, along the diaphragmatic and cardiac margins (purple arrow), connecting to a branch of the left hepatic vein.

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**Fig. 13:** Same patient as Fig. 12. Post stent insertion from the right HV to the IVC.

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Fig. 14: Same patient as Fig. 12. The hepatic veins are patent. Intrahepatic collaterals are seen. IVC and RHV are connected with a stent that shows increased velocity and narrowing.

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Fig. 15: Same patient as Fig. 12. After IVC stenting, the liver perfusion returns to normal.
Fig. 16: Chronic hepatic venous outflow obstruction due to membranous obstruction of inferior vena cava (IVC) showing intrahepatic and extrahepatic superficial and deep collateral vessels. A. Sagital CT image shows segmental obliteration of hepatic IVC (circle). B-E. Intrahepatic collateral veins and an inferior accessory hepatic vein. There are multiple extrahepatic collateral vessels including left renal-hemiazygos pathway and superficial collaterals of the abdominal wall. F. Coronal CT demonstrates striking superficial collaterals in the abdominal wall including superior and inferior epigastric veins.

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Fig. 17: There is hepatomegaly. Note the enlarged caudate lobe (*). The hepatic veins are not visualized and the IVC is slit-like and compressed by the enlarged liver. The liver has a heterogeneous appearance with diffuse hypoattenuation in its periphery. There is an arterial enhancing lesion which remains hyperdense in the subsequent images with no washout consistent with a regenerating nodule. Large amount of ascites is seen.

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**Fig. 18:** Same as patient in Fig. 17. MR images demonstrate central liver hypertrophy and peripheral liver hypoperfusion with associated atrophy. The regenerating nodule (blue arrows) is T1 hyperintense and T2 hypointense. It demonstrates arterial enhancement with no washout on the delayed phase images. There are intrahepatic and extrahepatic collateral vessels (green arrows demonstrating the lumbar azygos collateral vessels). Intrahepatic venous collaterals in the caudate lobe lead to the IVC (red arrow).

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**Fig. 19:** Contrast enhanced US: Hypervascular nodule in segment V of the liver which remains hypervascular on the five minute images with no washout.

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**Fig. 20:** Chronic hepatic venous outflow obstruction. The liver is enlarged and diffusely heterogeneous. The IVC is diffusely narrowed due to compression by the enlarged liver and caudate lobe. The hepatic veins are attenuated in keeping with chronic thrombosis. Numerous arterial enhancing lesions with no washout on the delayed phase images are consistent with regenerating nodules.

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Fig. 21: Same patient as Fig. 20. Background innumerable regenerating nodules from hepatic venous outflow obstruction and portal hypertension. There is a confluent T1 hypointense and T2 hyperintense area in the right lobe of the liver consistent with venous ischemia (*). A regenerative nodule is located within the area of ischemia.

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**Fig. 22:** MRI images with Gd-EOB-DTPA demonstrates multiple hyperintense nodules consistent with regenerative nodules.

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Conclusion

The recognition of typical imaging patterns related to hepatic venous outflow obstruction can lead to a timely, accurate diagnosis and appropriate patient management.
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