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## Single Case

# Partial Hepatectomy with Middle Hepatic Vein Reconstruction Using a Left Inferior Vena Cava Graft

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## Keywords

Duplicated inferior vena cava · Hepatic vein · Left inferior vena cava · Reconstruction

## Abstract

Duplicated inferior vena cava (IVC) is a rare congenital anomaly. We describe the utility of a new graft from the left IVC in a patient with duplicated IVC for reconstructing the middle hepatic vein (MHV) after partial hepatectomy with MHV resection. A 67-year-old woman with hepatitis C was found to have a liver tumor. Magnetic resonance imaging confirmed that the tumor, which was attached to the MHV, was hepatocellular carcinoma. Central bisectionectomy (S4, S5, and S8 resection) could not be tolerated because of poor liver function and a low future liver remnant volume. Therefore, partial hepatectomy with MHV resection was performed. The left IVC was harvested as a venous graft and was substituted for the resected MHV. She recovered uneventfully and was discharged on postoperative day 12. To the best of our knowledge, this is the first report of using the left IVC as a venous graft. The left IVC is a good candidate graft for the MHV or for portal vein reconstruction because of its length, diameter, and easy harvesting (it did not require an extra incision) in a patient with duplicated IVC.

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## Introduction

For hepatic malignancies located at the cranial part of the liver and that are close to or invade major hepatic veins, partial hepatectomy with major hepatic vein resection and subsequent reconstruction using an interposing graft is sometimes the only curative option in patients with poor liver function. Numerous graft materials have been described for reconstructing the main hepatic veins or portal vein, including the greater saphenous vein [1], internal iliac vein [2], external iliac vein [3], superficial femoral vein [4], left renal vein (LRV) [5], internal jugular vein [6], ovarian vein [7], and prosthetic vessels [8]. Here, we describe the use of a graft from the left inferior vena cava (IVC) in a patient with duplicated IVC for reconstructing the middle hepatic vein (MHV) after partial hepatectomy with MHV resection.

## Case Presentation

A 67-year-old woman with hepatitis C was found to have a liver tumor located in segment 8 during follow-up computed tomography (CT) for pyogenic spondylitis. She also had a past medical history of cirrhosis due to hepatitis C infection and diabetes mellitus. Laboratory examination showed normal levels of carcinoembryonic antigen, carbohydrate antigen 19-9, and  $\alpha$ -fetoprotein but elevated protein induced by vitamin K antagonist-II at a level of 106 mAU/mL. Other laboratory studies showed the following: total bilirubin 0.6 mg/dL, albumin 3.2 g/dL, prothrombin time 13.7 s, aspartate aminotransferase 28 IU/L, alanine aminotransferase 22 IU/L, blood urea nitrogen 16 mg/dL, and creatinine 0.54 mg/dL. The Child-Pugh score was grade A (6 points), and the indocyanine green retention rate at 15 min was 16.6%. A diagnosis of hepatocellular carcinoma (HCC) located in segment 8 was indicated by CT (Fig. 1a, b), magnetic resonance imaging (Fig. 1c), and ultrasonography. The tumor was attached to the MHV. CT scans also showed multiple varices (Fig. 1d). MHV resection was necessary to obtain sufficient surgical margins. Central bisectionectomy (S4, S5, and S8 resection) was suggested but could not be tolerated because of her poor liver function and low future liver remnant volume, which preoperatively was only 56% by CT volumetry. Therefore, we decided to perform partial hepatectomy with MHV resection. Preoperative CT scans revealed the existence of duplicated IVC (Fig. 2), so we chose to use the left IVC as the graft for reconstructing the MHV.

The surgery started with an inverted L-shaped incision. Intraoperative ultrasonography confirmed a 3.5-cm tumor that was touching the MHV. After mobilization of the right lobe, the liver parenchyma was transected, preserving the right hepatic vein and right anterior glissonian pedicle. A 3-cm portion of the MHV was resected around the tumor to obtain sufficient surgical margins. Immediately before resecting the MHV, we harvested the left IVC for use as the graft. After incising the retroperitoneum beside the Treitz ligament, the LRV, which had ramified from the IVC, was detected. The left IVC, which had ramified 3 cm peripherally from the origin of the LRV, was then isolated and harvested for 5 cm from the confluence of the LRV. The cut ends of the left IVC were closed with 4-0 polypropylene running sutures. The venous graft was anastomosed first to the proximal end of the MHV and then to the distal end using 6-0 polypropylene (Fig. 3). A good Doppler flow through the graft was confirmed after the reconstruction. The operation required 394 min, and the estimated blood loss was 1,894 mL.

Macroscopic evaluation showed a 35-mm bile-stained tumor (Fig. 4a). Histologic examination revealed moderately differentiated HCC without direct invasion of the MHV and a

tumor-free surgical margin (Fig. 4b). The tumor was classified as stage II (T2N0M0) according to the TNM staging system for HCC. The patient recovered uneventfully and was discharged on postoperative day 12.

The patency of the reconstructed MHV was confirmed postoperatively by ultrasonography and dynamic CT (Fig. 5). Laboratory examination 2 years after surgery showed normal levels of total bilirubin (0.6 mg/dL), albumin (4.0 g/dL), aspartate aminotransferase (24 IU/L), alanine aminotransferase (24 IU/L), prothrombin time of 13.5 s, blood urea nitrogen (15 mg/dL), and creatinine (0.46 mg/dL).

New lesions were found in the left lobe of the liver 4 months after surgery and in the right lobe 26 months after surgery. Both lesions were treated using transabdominal catheter embolization.

## Discussion

Major hepatectomy is generally required for hepatic malignancies located in the cranial part of the liver, including segment 8, which is close to, or invading, a major hepatic vein. In patients with cirrhosis or chemotherapy-associated liver injury, however, major hepatectomy cannot be performed because of insufficient remnant liver volume. To achieve curative resection for such cases, partial hepatectomy with segmental removal of the infiltrated vein is a helpful option to preserve sufficient function of the remnant liver. Our patient had hepatitis C infection and cirrhosis with a high indocyanine green retention rate at 15 min. Therefore, we avoided performing central bisectionectomy and, instead, chose partial hepatectomy with resection of the MHV.

The need for reconstruction of major hepatic veins is controversial. The presence of intrahepatic communication of venous branches of the liver [9] and arteriportal shunting [10] are suggested to recover from venous congestion even when a major hepatic vein is sacrificed. By contrast, Wu et al. [2] reported that hepatic vein reconstruction is desirable when the volume of the congestive area of liver remnant exceeds 20% of the future remnant liver volume as it could avoid venous congestion, which might lead to subsequent liver failure and death. In our case, the volume of the congested area after MHV resection was 248 mL (22.7% of the future residual liver volume). Thus, we decided to reconstruct the MHV.

Direct anastomosis is usually attempted to reconstruct the hepatic vein. The indication for direct anastomosis is resection of a 2- to 3-cm segment of hepatic vein in noncirrhotic liver, which is more elastic and mobile than cirrhotic liver [11]. When >3 cm of the hepatic vein is resected, we have to consider using a graft. For venous reconstruction, numerous graft materials have been suggested. For example, a LRV graft is obtained quickly and easily without an additional skin incision, but the length of the graft is limited to 3–4 cm, and it is sometimes associated with impaired renal function in poor-risk patients [12]. The greater saphenous vein, superficial femoral vein, and ovarian vein provide longer grafts, but an extra excision is needed to harvest them, and they are usually small, which means they can only be used as interposition grafts. The external iliac vein graft and internal jugular vein graft have sufficient length and usually match the size of the MHV, but an additional skin incision is necessary for harvesting. In addition, edema of the leg occurs after harvesting the external iliac vein. Although with prosthetic vessels the length and size can be adjusted, the risk of infection is relatively high following liver resection, and postoperative antiplatelet agents or anticoagulants are usually necessary.

The left IVC in patients with duplicated IVC seems to be a good candidate as an interpositional graft of the MHV in that it has sufficient length and a proper diameter. Furthermore, it can be harvested without an extra skin incision. IVC anomalies are due to abnormal regression or abnormal persistence of various embryonic veins [13]. Duplication is one of the most common IVC anomalies, with an incidence of 0.2–3.0% [14, 15]. It results from persistence of both the left and right supracardinal veins. The most common anatomy of the duplicated IVC is shown in Figure 6. The left iliac vein gives rise to the left IVC, and the right iliac vein separately gives rise to the right IVC, uniting with the right renal vein, which crosses anterior to the aorta and joins the left IVC [16]. The left and right iliac veins usually do not join with one another. Our patient had the same variant.

There are 3 types of IVC duplication based on size discrepancy [17]: type 1, the left, right, and suprarenal IVCs are of the same diameter; type 2, the left and right IVCs have the same diameters, but the suprarenal IVC is larger; type 3, the right IVC is larger than the left IVC, and the size of the left IVC is similar to that of the main hepatic vein. In our patient, whose duplicated IVC was type 3, the diameter of the left IVC was 10 mm at the confluence of the right renal vein, which matches the size of the MHV, which was also 10 mm.

After harvesting the left IVC, the venous blood from the left leg is assumed to drain from the left internal iliac vein, left ovarian vein, superficial epigastric veins, lumbar veins, and deep circumflex iliac vein. By preserving these venous flows, it was possible to harvest up to 11 cm of the left IVC in our patient, which was sufficient. Although the patient was expected to experience left lower leg edema, the left IVC was more central than the common iliac vein or left external iliac vein, which meant that there was more collateral circulation than if these vessels had been harvested. Hence, postoperative left leg edema was less likely than would have occurred if the common or external iliac vein had been harvested. Our patient did not experience edema.

## Conclusions

We reported a case in which HCC was treated using partial hepatectomy with MHV resection, which was reconstructed using a duplicated IVC. To the best of our knowledge, this is the first report in which the left IVC is used as a graft for reconstructing a main hepatic vein or portal vein. Although the duplicated IVC is a rare anomaly, the left IVC is considered a good candidate graft for reconstruction of the main hepatic veins or the portal vein.

## Statement of Ethics

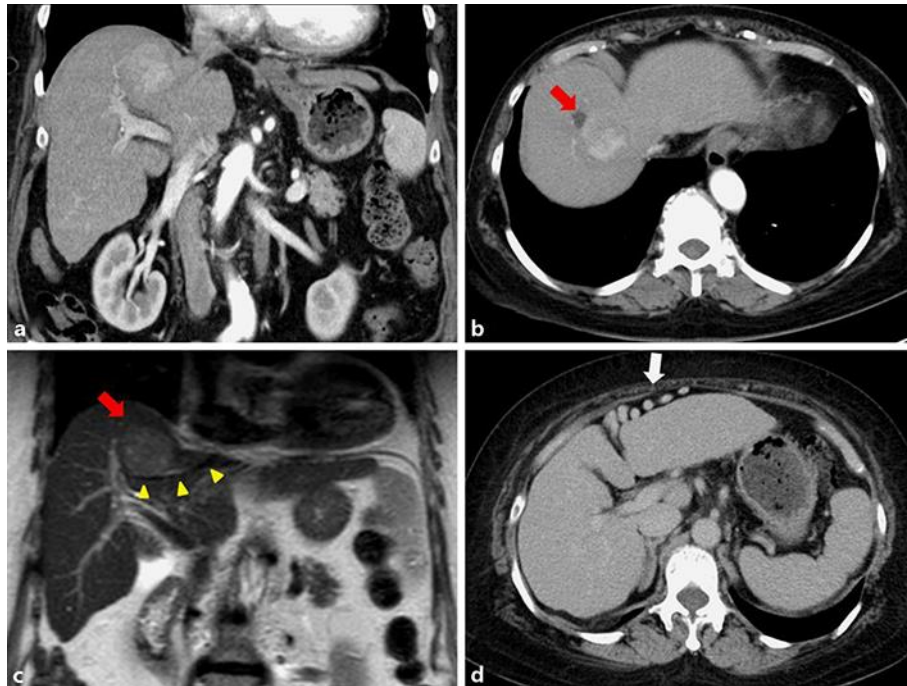
Written informed consent was obtained from the patient for publication of this case report and any accompanying images.

## Disclosure Statement

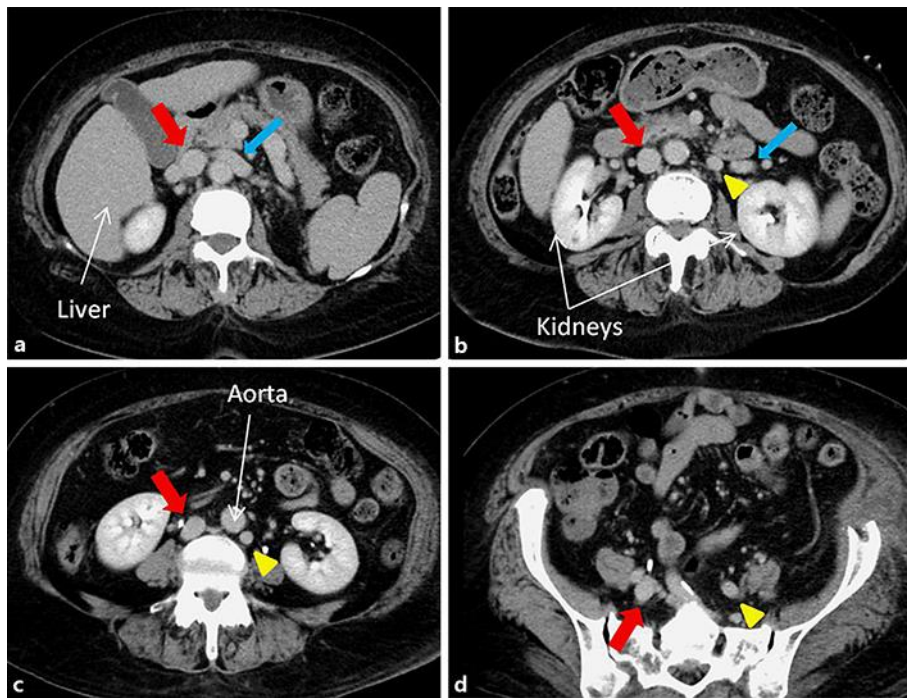
The authors declare that they have no competing interests.

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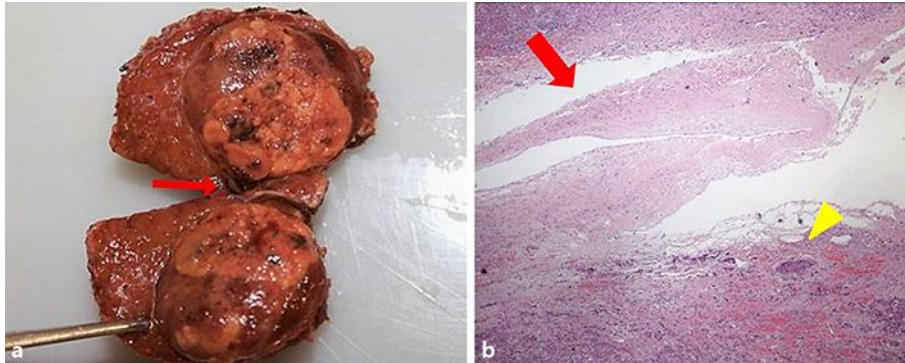
**Fig. 1.** Axial (a) and coronal (b) contrast-enhanced CT images showing an enhanced mass (red arrow) in segment 8 of the liver. c Magnetic resonance imaging showing the tumor (red arrow) as having slightly high intensity on T2-weighted imaging. The tumor adhered to the MHV (yellow arrowheads). d CT scan showing multiple varices (white arrow). CT, computed tomography; MHV, middle hepatic vein;



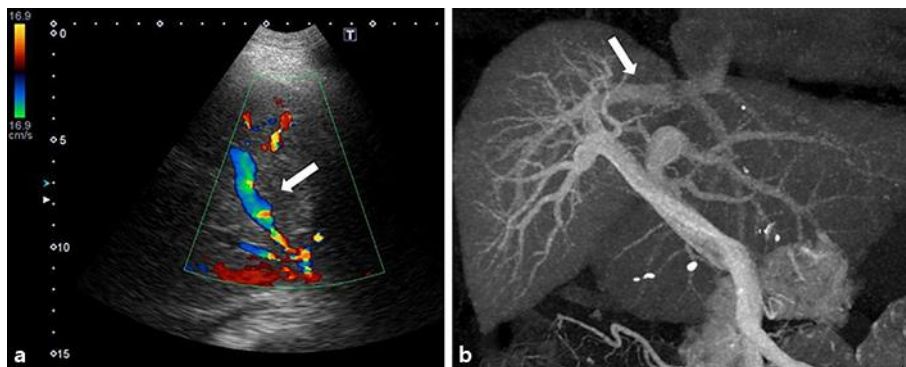
**Fig. 2.** CT images showing a duplicated IVC. **a** Normal IVC (red arrow) and LRV cross anterior to the aorta (blue arrow). **b** Normal position of the IVC (red arrow), smaller left IVC (yellow arrowhead), and LRV (blue arrow). **c** Right IVC (red arrow) and left IVC (yellow arrowhead) below the level of the renal veins. **d** Right IVC (red arrow) and left IVC (yellow arrowhead) at the level of the aortic bifurcation. IVC, inferior vena cava; LRV, left renal vein.



**Fig. 3.** Arrowhead points to the reconstructed middle hepatic vein using the interposing vein graft (the harvested left inferior vena cava).

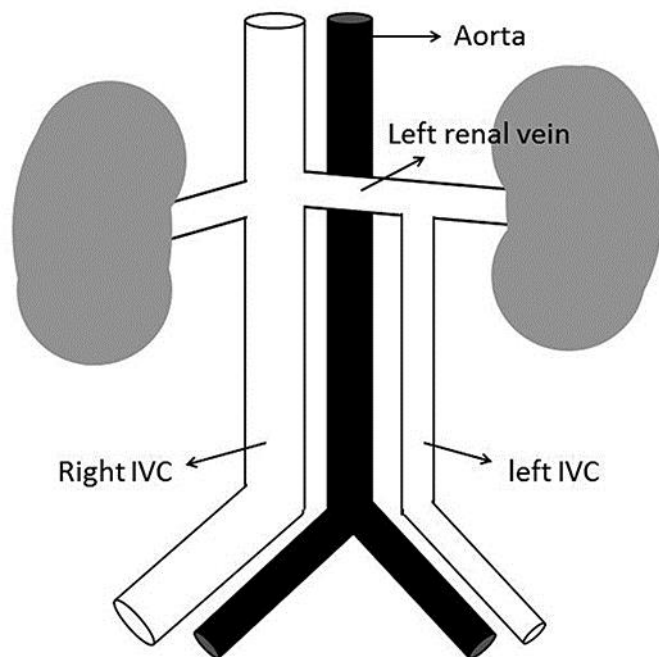


**Fig. 4.** **a** Macroscopic evaluation of the specimen, a 35-mm bile-stained tumor close to the MHV (arrow). **b** The tumor was histologically diagnosed as a moderately differentiated HCC. The MHV (arrow) was not invaded directly. The distance between the tumor (arrowhead) and the MHV was <1 mm. MHV, middle hepatic vein; HCC, hepatocellular carcinoma.



**Fig. 5.** **a** Ultrasonography 1 week postoperatively confirmed the patency of the reconstructed MHV (arrow) (×40). **b** CT angiography showing a patent MHV (arrow) (×40).





**Fig. 6.** Most common anatomy of the duplicated IVC. The left iliac vein gives rise to the left IVC, and the right iliac vein separately gives rise to the right IVC, uniting with the right renal vein, which crosses anterior to the aorta and joins the left IVC.