Diagnosis and Endovascular Treatment of Common Vascular Complications in the Post Liver Transplant Patient: A Pictorial Essay

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ABSTRACT: The role of interventional radiology in the management of patients after liver transplant is ever expanding. Vascular complications after liver transplant are not infrequently encountered, and they are associated with graft loss, high morbidity, and mortality and are a major indication for repeat transplantation. Most vascular complications will develop within 3 months of transplant and should be considered in any patient with an increase in liver function tests. We discuss several of the more commonly seen complications, which include hepatic artery thrombosis and stenosis, as well as stenosis of the portal vein, hepatic veins, and inferior vena cava, and present corresponding case examples and imaging from our own experience.

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Advances in the field of minimally invasive radiologic techniques have increased the importance of interventional radiology in the management of patients after liver transplant. Vascular complications after liver transplant are not infrequently encountered, and they are associated with graft loss, high morbidity, and mortality and are a major indication for repeat transplantation. Most vascular complications will develop within 3 months of transplant and should be considered in any patient with an increase in liver function tests (LFTs). Complications include hepatic artery and portal vein thrombosis and stenosis, as well as stenosis of the portal vein, hepatic veins, and inferior vena cava. In addition, combinations of antiplatelet therapy and anticoagulation are often utilized in conjunction with stent placement. Issues related to post treatment management include the type and duration of anticoagulation to use and when the patient should return for routine follow-up, for which the reader is directed to the dedicated medical literature for details. Multiplanar imaging modalities can be helpful in evaluating the post transplant liver. Doppler ultrasound (DUS) is the most clinically useful imaging modality in the postoperative liver transplant period due to its wide availability, lower cost, and familiarity to most clinicians. Multidetector computed tomographic angiography (MDCTA) also can be a relatively cost-effective and noninvasive technique that can characterize very accurately the hepatic arterial anatomy after transplantation with its excellent spatial resolution and fast scan times, especially for small vessels. Diagnostic accuracy can be further improved with maximum intensity projections (MIP) and volume rendered images. Lastly, digital subtraction angiography (DSA) is the gold standard for assessing patency of the hepatic artery, but it is usually reserved for cases where an interventional therapeutic procedure is necessary because of invasiveness, high cost, and potential complications.
Any alteration of LFTs with an etiology that cannot be explained by diagnostic imaging will require a random liver biopsy to exclude rejection and/or other pathologies. Liver biopsy can be performed by a percutaneous approach, either with ultrasound guidance or blind, or with a transjugular approach.

Depending on the severity of the vascular complication, the patient’s comorbidities, and physiological parameters, endovascular therapies such as balloon angioplasty and/or stenting can be therapeutically employed, as discussed in more detail throughout this work.

**PORTAL VEIN STENOSIS**

While vascular post-transplant complications involving the portal vein are less common than those involving the hepatic artery, portal vein complications can lead to potentially life-threatening sequelae, including graft loss. Portal vein stenosis (PVS) is reported in roughly 3% of postoperative liver transplant patients. Clinical signs of PVS typically include varices, splenomegaly, and ascites, all of which result from portal hypertension.

Patency of the portal vein may be evaluated with DUS and or cross-sectional imaging. Figures 1-4 show images from a case of a 34-year-old female with a history of liver transplant in 1994 due to autoimmune hepatitis and hepatitis, who presented with upper abdominal pain. Imaging evaluation with ultrasound followed by portal angiography was undertaken. Figures 1 and 2 show evaluation of patency.

Karakayali et al examined late onset PVS after living donor transplant in the pediatric population. They found that PVS can be asymptomatic in some cases. Moreover, splenomegaly and low platelet count can be important markers of PVS and early detection using these markers can prevent graft loss.

Percutaneous transhepatic venoplasty is the first-line nonsurgical therapeutic approach for PVS as shown in Figure 3, but the portal vein can also be accessed via a transjugular approach. Multiple studies have examined the success of endovascular treatment in PVS. Shibata et al reported a success rate of 74% with a single session of balloon dilatation; the mean follow-up time was 24 months and 28% of patients suffered recurrent stenosis. In this study, the maximum number of dilation sessions needed to

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**Figure 1.** Sagittal ultrasound image through the proximal main portal vein beyond the anastomosis shows hepatopedal flow and dilated segment up to 3.4 cm. Note the aliasing and turbulent flow at this segment beyond the tight stricture shown in later CT and angiographic images.

**Figure 2.** Coronal (left) and axial (right) IV contrast-enhanced CT images demonstrate the high-grade stenosis (white arrows) of the main portal vein, with marked aneurysmal dilatation of the downstream segment.
resolve the stenosis was three. Ko et al also reported a series of 9 patients who experienced early PVS following liver donor liver transplant. All patients were treated with transhepatic stent placement. At 66 months after placement, 6 of the 9 patients in the study demonstrated adequate stent patency. Notably, 2 post-procedural complications were reported, which included 1 case of intrahepatic pseudaneurysm and 2 cases of hemoperitoneum. Post-procedural patency may be assessed with DUS as shown in Figure 4.

HEPATIC ARTERY THROMBOSIS

Hepatic artery thrombosis (HAT) is the most common vascular complication after orthotopic liver transplantation, with an estimated incidence of between 4% and 11% in adult transplants and between 11% and 26% in the pediatric population. Patients with HAT have a 30% to 50% incidence of eventual liver failure, leading to retransplantation or death. Hence, maintaining hepatic artery patency is likely an important variable in minimizing graft loss and mortality. Clinically, patients will often present with elevated liver enzymes, biliary leak, cholangitis, or other signs of rejection. The first-line diagnostic imaging modality is DUS. A study by Vit et al found the presence of a tardus parvus waveform to be the most reliable individual indicator of hepatic artery stenosis (HAS) or HAT, with a sensitivity of 91% and specificity of 99.1%. Imaging features of hepatic artery thrombosis from underlying stenosis on DUS demonstrating parvus tardus spectral waveforms are seen in Figure 5. If Doppler US and/or CT is suspicious for HAT, the next step is typically an arteriogram to confirm imaging finding. Urgent thrombectomy and revascularization is currently considered the treatment of choice in cases of early diagnosis of HAT. Surgical thrombectomy or retransplantation may also be necessary in patients in which percutaneous techniques fail (Figure 5). In cases of very early diagnosis, selective thrombolytic therapy can be used to try to restore hepatic flow (Figures 5–6).

HEPATIC ARTERY STENOSIS

Hepatic artery stenosis is seen in 5% to 11% of transplants and has up to a 65% chance of developing into HAT within 6 months. Most stenoses occur at or within a few centimeters of the arterial anastomosis. The biliary epithelium is perfused exclusively by the
hepatic artery; as a result, disruption in flow as a result of a stenosis could result in hepatic artery thrombosis, hepatic infarction, biliary ischemia and necrosis, fulminant hepatic failure, sepsis, and bacteremia. HAS is typically diagnosed on DUS. One study by Rinaldi et al reported the sensitivity, specificity, positive predictive value, negative predictive value, and accuracy of DUS in diagnosing HAS to be 100%, 99.5%, 95%, 100%, and 99.5% respectively. These results were similar to two previous studies by Tamsel et al and Platt et al.

Endovascular treatment of HAS can be performed with high technical success, acceptable morbidity, reduced invasiveness when compared to traditional surgical procedures, and similar overall rates of patient survival at 5 years when compared to traditional surgical procedures. The need for repeat intervention is common in our experience. Therefore, periodic follow-up imaging is routine at our institution. Initial use of a stent may improve patency when compared with percutaneous transluminal angioplasty. The not infrequently observed need for reintervention is illustrated in Figure 6 where subsequent session of thrombolysis and angioplasty

Figure 4. Follow-up ultrasound examination demonstrates patency of the main portal vein without residual or recurrent stenosis and without pseudoaneurysm.

Figure 5. A 6-year-old male immediately post orthotopic liver transplant due to propionic acidemia. Doppler ultrasound image obtained on postoperative day 1 demonstrates patent common hepatic artery with normal high resistance arterial waveforms (A). Follow-up Doppler ultrasound obtained on postoperative day 3 demonstrates parvus tardus spectral waveforms and elevated resistive index. The common hepatic and right hepatic arteries were not visualized, collectively raising concern for thrombosis (B). Subsequent digital subtraction image obtained after catheterization of the jump graft with injection to the proximal common hepatic artery demonstrates long irregular segmental stenosis with no definite filling defect seen (C). Injection of papaverine and TPA was performed then repeated on 2 subsequent consecutive days, without success. Hepatic artery thrombosis and long segmental arterial dissection was confirmed intraoperatively. The patient ultimately went on to require retransplantation.
Figure 6. A 56-year-old male status post orthotopic liver transplantation 9 years prior due to hepatitis C infection admitted with hepatic encephalopathy and lower extremity swelling. Sagittal contiguous CT images through the celiac axis from midline (A) to right of midline (B-C) demonstrated abrupt nonopacification of the proximal common hepatic artery near its origin (white arrows). Digital subtraction angiography image in the anterior projection demonstrated complete occlusion of the proximal common hepatic artery due to thrombosis (long white arrow) (D). Note the adjacent periportal collateral vessels (short white arrow). Thrombolysis was performed. Digital subtraction angiography image was obtained after initial thrombolysis session with continuous TPA infusion over 24 hours and showed partial recanalization of the common hepatic artery with persistent irregular areas of narrowing, likely representing residual thrombus (E). After an additional session of thrombolysis, continued improvement was noted, although there are persistent areas of high-grade stenosis involving both the proximal and distal hepatic artery (short arrows) (F). Finally, after balloon dilatation of the proximal stenosis, and balloon dilatation followed by stent placement for the distal stenosis, full patency of the hepatic artery was achieved (G).
were partially successful but only after stent placement achieved full patency. The efficacy of this approach was recently demonstrated in a series by Denys et al, where primary stent patency at 3, 6, and 12 months was 68%, 62%, and 53%, respectively, with a standard deviation of 14% for a confidence interval of 95%. Moreover, secondary stent patency at 3, 6, and 12 months was 84%, 77%, and 60%, respectively, with a standard deviation of 22%. The authors noted that only 4 of the 13 total patients in the series had developed restenosis at 1 year.22 Therefore, in many cases primary stent placement has become an increasingly attractive option at our institution vs balloon angioplasty alone.

**INFERIOR VENA CAVA STENOSIS**

Inferior vena cava stenosis (IVCS) is a rare post-transplant complication seen in approximately 1% of patients, most commonly at the superior anastomosis of the IVC.5 Clinical manifestations of IVCS include refractory ascites which may be accompanied by a pleural effusion and/or associated with renal insufficiency, lower extremity edema, and abnormal liver enzymes.5 Transluminal angioplasty with a transfemoral approach is the treatment of choice for this complication.5,26 Venoplasty is performed with large balloon catheters due to the wide diameter of the IVC as demonstrated in Figure 7, and sequential dilatations may be necessary for long-term patency. Stenoses not responsive to angioplasty are typically treated with a metallic stent.

**HEPATIC VEIN STENOSIS**

Figure 7. A 56-year-old female with history of liver transplantation due to hepatitis C presented with recurrent ascites. Initial ultrasound image was notable only for mild turbulence within the intrahepatic and suprahepatic inferior vena cava (A). Axial, coronal, and sagittal contrast enhanced CT images through the suprahepatic inferior vena cava all demonstrate a subtle stenosis at the level of the piggyback anastomosis (arrows) (B-D). Digital subtraction angiography image obtained at the time of initial venocavogram demonstrates a high grade stricture at the level of the proximal IVC piggyback anastomosis (black arrow) (E). The stricture extended to the level of the hepatic vein origins (not well seen). The measured gradient across the stenosis was 12mmHg. Additional sequential digital subtraction angiography images obtained at a subsequent visit demonstrate significant improvement of the stenosis (black arrows) after venoplasty (F). Follow-up measurement of the gradient was mildly improved at 11 mmHg, thought to be technical in nature in view of the notable angiographic improvement (G).
Hepatic vein stenosis (HVS) is a major post-transplant complication, especially in patients with partial liver graft transplantation producing graft failure with a reported incidence of 1% to 4%. Hepatic vein stenosis leads to hepatic congestion; manifestations include refractory ascites, refractory hydrothorax, and alteration of LFTs. Hepatic vein stenosis is most frequently seen at the site of the anastomosis and is less frequently seen in the hepatic vein itself. In the presence of clinical or radiologic suspicion of HVS, selective catheterization of all hepatic veins is necessary to confirm stenosis and to measure the trans-stenotic pressure gradient. Pressure gradients greater than 3 mmHg between the hepatic vein and the right atrium are considered pathological. For treatment of HVS, percutaneous interventions have adequate clinical and technical success rates. The initial treatment of choice is transjugular or transfemoral angioplasty or metallic stent placement. For example, in our case of hepatic venous stenosis, a 2-year-old who had previously undergone retransplantation benefited from a dramatic reduction of the gradient from 15 mmHg to 4 mmHg, which was achieved with venoplasty (Figure 8). Multiple interventions may be required for long-term sustained patency, including the use of endovascular stent placement.

**CONCLUSION**

Collectively, post-liver transplant vascular complications are not uncommon and require vigilant imaging and clinical follow-up to diagnose in a timely fashion. Interventional radiologists play a critical role in the endovascular and percutaneous treatment of many complications, which often do not require operative intervention to correct. Interventions include advanced imaging (angiography/venography) and pressure measurements to confirm hemodynamic significances of an abnormality, catheter-directed thrombolysis, angioplasty or venoplasty, and if required endovascular stent placement. These interventions are highly efficacious as well. Multidisciplinary collaboration and knowledge of the expected pertinent imaging findings of these treatable complications is essential, particularly in certain cases where endovascular means of treatment fail.

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Figure 8D-G. The left hepatic vein was selected with a glide wire and reverse curve catheter (D). Hepatic venogram demonstrated sluggish flow of contrast toward the anastomosis with no opacification of the IVC (E). This was followed by venoplasty with up to a 5 mm x 80 mm Power Cross balloon catheter (Covidien) (F). Waist in the balloon confirmed the stenosis (black arrow). Final venogram showed continued stenosis but improved flow into the IVC (white arrow) (G).

Figure 8H-I. Over the next month, Doppler ultrasound demonstrated persistent elevation of velocity across the stricture however clinically the patient improved.


