Vascular Complications Following Liver Transplantation

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ABSTRACT

Vascular complications (stenosis or thrombosis of the hepatic artery, portal vein or hepatic vein) are a relatively common occurrence following liver transplantation. Routine screening with ultrasound is critical to early detection of these complications. Careful application of standard interventional techniques (diagnostic catheter angiography, balloon angioplasty with selective stenting) may be used to confirm the ultrasound findings, treat the underlying lesions, and contribute to long-term graft survival.

KEYWORDS: Liver transplantation, balloon angioplasty, hepatic artery, portal vein, hepatic vein

Objectives: Upon completion of this article, the reader should be able to (1) understand the imaging evaluation for patients with liver transplants, (2) understand the vascular anatomy of liver transplants, and (3) understand the role and limitations of catheter-based interventions in treating vascular complications following liver transplantation.

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Advances in surgical technique and immunosuppressive therapy have led to excellent results for orthotopic liver transplantation in both adults and children. Despite these advances, vascular complications remain a significant problem. Although hepatic arterial thrombosis and stenosis are the most common complications, portal venous, hepatic venous, and inferior vena cava (IVC) lesions do occur. Hepatic arterial lesions are reported in 4–25% of patients.¹ Risk factors for developing hepatic arterial complications include pediatric age group, donor arterial variants requiring multiple anastomoses, and anastomosis to the recipient abdominal aorta.²

The patient's presentation in part depends on the site and acuity of the lesion. Many lesions are identified

on routine post-transplantation ultrasonography before they are clinically apparent. Arterial lesions may be asymptomatic or arise with varying degrees of graft dysfunction, biliary stenosis or leak, or frank hepatic necrosis. Portal venous lesions may be asymptomatic or arise with ascites or variceal bleeding. Hepatic vein or IVC lesions may also be asymptomatic or arise with hepatic dysfunction, ascites, or lower extremity edema.

DIAGNOSTIC EVALUATION

Although multiple modalities have been applied to imaging liver transplants, including catheter angiography, computed tomography, and magnetic resonance imaging, ultrasonography remains the first-line screening

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test to evaluate the transplant vasculature. Ultrasound imaging combined with Doppler evaluation of flow allows selection of patients who might benefit from direct catheter angiography. The ultrasound examination is also an inexpensive, noninvasive method for following the results of a percutaneous intervention.

Prior to performing catheter angiography, review of the operative record is critical to understand how the transplantation was performed. This includes the site of the vascular anastomoses and how much of the donor liver was used.

Most commonly, the hepatic arterial anastomosis is performed end to end between the donor and recipient hepatic arteries. If the recipient hepatic artery is not suitable (anatomic variants or celiac stenosis), a conduit is created from the infrarenal aorta to the hepatic artery using donor iliac artery.^{3,4} Less commonly, the supraceliac aorta, the splenic artery, or the inferior epigastric artery may be used as the anastomotic site.⁵⁻⁷ Knowledge of the surgical approach allows the angiogram to be tailored to the individual patient. Performing a focused angiogram with as little iodinated contrast material as possible is especially critical in this population of patients, in whom associated renal dysfunction is common.

Patients with hepatic artery to hepatic artery anastomoses should be evaluated beginning with a selective celiac arteriogram (Fig. 1). The only role for aortography in these patients would be a lateral view if there was concern about celiac stenosis. Multiple oblique projections are frequently necessary to image the anastomosis clearly. At least one series should be performed into the venous phase to image the portal anastomosis.

For patients with an aorta to hepatic artery conduit, the evaluation should begin with an aortogram.

Figure 1 Normal celiac arteriogram demonstrating a widely patent arterial anastomosis. Note that both the donor and recipient gastroduodenal arteries have been ligated.

Multiple projections may be necessary to demonstrate the aortic anastomosis (Fig. 2A and B). Selective injections into the conduit may better demonstrate the distal anastomosis (Fig. 2C). A clear knowledge of the surgical anatomy allows one to make the diagnosis of hepatic artery occlusion confidently (Fig. 3).

The portal vein anastomosis is usually performed end to end between the donor and recipient portal veins. Occasionally, a thrombectomy of the recipient portal vein is required at the time of transplantation, or a graft may be required between the recipient superior mesenteric vein and the donor portal vein.⁴ On indirect (arterial) portography the anastomosis is frequently difficult to identify unless a stenosis is present.

There are two commonly used techniques to reconstruct the hepatic venous drainage. The earlier technique had the donor IVC removed along with the liver. The donor IVC was then interposed into the recipient IVC with two end-to-end anastomoses. The junction between the donor hepatic veins and IVC was left untouched. Stenosis may develop at either caval anastomosis. The more current technique leaves the recipient IVC intact. As part of the recipient hepatectomy, the hepatic vein origins are dissected free and transected, leaving a cuff of hepatic vein. The suprahepatic donor IVC is anastomosed to the hepatic vein cuff end to end.³ The donor infrahepatic IVC is ligated. With this technique the problems usually involve only the hepatic vein origin and not the recipient IVC (Fig. 4A and B). These patients are most easily evaluated from the jugular venous approach. In addition to the venography, pressure measurements across the anastomosis are critical.

Renal insufficiency is a common comorbidity in this population of patients. Creative combinations of low-osmolar iodinated contrast material, gadolinium, and carbon dioxide allow the diagnostic and interventional procedures to be performed with minimal risk to the kidneys.

HEPATIC ARTERY STENOSIS

The accepted treatment for transplant hepatic artery stenosis is balloon angioplasty, with stenting reserved for recurrent stenosis or treatment of severe dissections following PTA. The reason for selective use of stenting is that it may limit future surgical options to revascularize the transplant.

The technique for transplant hepatic artery percutaneous transluminal angioplasty (PTA) is similar to those used in renal artery PTA. Systemic anticoagulation with intravenous heparin is employed. Intra-arterial nitroglycerin to prevent arterial spasm may be important in these patients (Fig. 5).⁸

Although the early reports of transplant hepatic artery PTA employed 5F balloon catheters, the currently

Figure 2 Anteroposterior (A) and left anterior oblique (B) aortograms demonstrate the infrarenal aorta to hepatic artery conduit. The widely patent origin is seen well only on the oblique view. A selective injection (C) into the conduit better depicts the stenosis at the distal anastomosis.

available low-profile, 0.018- and 0.014-inch balloon-guidewire systems have greatly simplified these procedures. After the diagnostic arteriogram has identified a suitable lesion, a 6F guide catheter or sheath can be positioned in the celiac axis or the aortohepatic artery conduit. This allows injection of contrast material around the wire and balloon catheter to assist in balloon positioning and monitoring results. If necessary, the

same access may be used for stent placement. Because of the direct course, this is frequently easier in patients with an aortohepatic artery conduit, but with appropriately shaped guide catheters it may be performed in patients with hepatic artery to hepatic artery anastomoses (Figs. 6 and 7).

In this procedure, unlike PTA of native arteries, oversizing of the balloon should be done with caution. It

Figure 3 Selective injections into the aortohepatic conduit (A) and the common hepatic artery (B) from a different patient demonstrate thrombosis of the hepatic artery. Knowledge of the surgical anatomy is critical in these patients to make the diagnosis of hepatic artery thrombosis correctly.

has been our anecdotal experience that transplant hepatic arteries are more fragile and likely to rupture than native, atherosclerotic arteries (Fig. 8).

Follow-up is best done using Doppler ultrasonography. A baseline examination is obtained shortly after

PTA, and then changes in the waveforms and flow velocities can be easily detected over time.

Unfortunately there are no large published series in the literature evaluating balloon angioplasty in the treatment of transplant hepatic artery stenosis. It is clear

Figure 4 Selective injection into the left hepatic vein in a patient with a piggy-back hepatic vein anastomosis (A). Contrast material (CO_2 in this case) refluxes into all the major transplant hepatic vein branches because of an anastomotic stenosis (not well seen in this projection). This projection does give an overall view of the relationship of the hepatic veins to the recipient inferior vena cava (IVC). Selective injection into the right hepatic vein from another patient (B) demonstrates reflux into the ligated donor IVC stump. This should not be confused with a thrombosed hepatic vein branch.

Figure 5 Selective hepatic arteriograms before (A) and after (B) guidewire manipulation across the anastomotic stenosis. Note the diffuse vasospasm throughout the entire liver. This was only partially broken with intra-arterial nitroglycerin. At the time of repeated intervention 2 months later, intra-arterial nitroglycerin was given prophylactically before a wire was advanced across with anastomosis and no vasospasm was encountered.

that the selective revascularization of the liver, whether by surgical revision or endovascular technique, has a beneficial impact on graft function and survival.^{9,10} Orons et al reported a series of 21 transplant hepatic arteries treated with balloon angioplasty.¹ They achieved technical success in 17 of 21 grafts (81%). Four of these 17 cases went on to require retransplantation, and all

four patients in whom the PTA was unsuccessful required retransplantation.

There have been limited reports in the literature of the use of stents to treat transplant hepatic artery stenosis. These have all been very small, nonrandomized series, so it is difficult to draw significant conclusions.^{11,12} From a technical point of view, stenting

Figure 6 Hepatic arteriogram demonstrating a stenosis at the anastomosis between the donor and recipient hepatic arteries (A). The lesion was crossed with a 0.018-inch wire and dilated with a 4-mm balloon (B). Follow-up angiogram (C) shows a satisfactory PTA result.

Figure 7 Hepatic arteriogram obtained by injecting the aortohepatic artery conduit identifies a stenosis at the distal anastomosis (A). After a guide catheter was placed into the proximal portion of the conduit (B), the lesion was crossed and dilated. In this case a 6F bright-tip sheath was used as a guide. Follow-up injection through the guide catheter (C).

the transplant hepatic artery is simple to perform using the 0.014- and 0.018-inch guidewire-balloon-stent systems. The limitations to stenting include restenosis and the impact on surgical reconstruction if needed. Until better pharmacologic treatments for intimal hyperplasia are developed, stenting for transplant hepatic artery stenosis will continue to face the same limitations as PTA and stenting in other vascular beds. We have limited our use of stenting to nonsurgical candidates with recurrent hepatic artery stenosis or to treat severe post-PTA dissections (Fig. 9).

Catheter-directed thrombolytic therapy has been applied to a limited number of patients with hepatic artery thrombosis (Fig. 10). In the reported cases, PTA

or stents were used to treat the underlying stenosis that caused the thrombosis. The potential benefit of nonsurgical revascularization must be weighed against the risk of significant hemorrhage in a recently operated patient.

PORTAL VEIN STENOSIS

Although portal vein lesion can be imaged using indirect (arterial) portography, direct injection of the portal vein allows much better assessment of the lesion (Fig. 11). This is most easily done by the transhepatic approach, although the transjugular approach may be employed. Although either approach allows interventions to be

Figure 8 Initial hepatic arteriogram obtained by injecting the aortohepatic artery conduit demonstrates a recurrent stenosis at the distal anastomosis (A). There had been two prior dilatations of this lesion. Follow-up run after PTA using a 4-mm balloon (B) shows active extravasation from the ruptured hepatic artery. The balloon was reinflated to control the hemorrhage and the artery repaired operatively.

performed, the transhepatic approach, usually from the right side, allows better control and more direct “pushability” to cross difficult, tight lesions. Many patients with portal vein stenosis have significant ascites. Paracentesis may be performed before the procedure, or a stiff sheath may be used to bridge the gap between the

abdominal wall and the liver during the procedure. After the procedure, the transhepatic track is occluded with coils or Gelfoam.

As in the hepatic artery, balloon angioplasty has been the main endoluminal therapy for portal vein stenosis. Stenting has been reserved for stenoses resistant

Figure 9 Recurrent stenosis (one prior PTA) at the distal anastomosis of a aortohepatic artery conduit (A). Follow-up angiogram after placement of a balloon-expandable stent across the anastomosis (B).

Figure 10 Typical stenosis at the distal anastomosis of an aortohepatic artery conduit (A). Follow-up run after PTA with a 3-mm balloon demonstrates a dissection in the donor hepatic artery (B). Additional run obtained 5 minutes later shows extension of the dissection (C). The flap was tacked down with a balloon-expandable stent (D) with a good technical and functional result. Follow-up angiogram 8 months later, obtained because of an abnormal ultrasound study, shows some intimal hyperplasia within the stent (E). Liver function remained normal.

Figure 11 Arterial portogram of a 3-year-old patient, obtained by injecting the superior mesenteric artery (SMA) (A), identifies a portal vein stenosis with large left upper quadrant varices. Direct portogram obtained from the transhepatic approach better demonstrates the stenosis (B). Follow-up venogram after PTA shows resolution of the stenosis (C).

Figure 12 Transhepatic portogram shows near-complete obstruction at the portal anastomosis (A). Immediate elastic recoil following PTA (not shown) was treated by placing a balloon-expandable stent across the anastomosis (B).

Figure 13 This 12-year-old patient had a portal vein stenosis treated with balloon-expandable stents at age 18 months. Transhepatic portogram shows that the stents have separated (A) and are now too small for the portal vein. Multiple collaterals drain around the stents (B). No intervention was thought to be possible.

to dilatation (elastic recoil) or recurrent lesions (Fig. 12). We have generally used balloon-expandable stents in this setting. They can be placed with precision, and they can be easily dilated larger if the initial result is unsatisfactory. Adjunct thrombolytic therapy, either mechanical or pharmacologic, may be required to achieve satisfactory portal vein flow.^{13,14}

Stents should be used with caution in the younger pediatric population. The stents do not grow with the child, and a result that may be satisfactory in a young child may be too narrow as the child grows. Options for revision at a later date may be limited (Fig. 13).

Published results have been limited to small, uncontrolled series or case reports. Despite this, portal vein PTA and stenting appear to be a viable treatment for post-transplantation portal vein stenosis. Success rates in excess of 70% have been reported.^{15,16}

INFERIOR VENA CAVA/HEPATIC VEIN STENOSIS

As mentioned previously, knowledge of the surgical anatomy is critical in treating lesions involving the venous drainage of a liver transplant. For patients with caval interposition anastomoses, either the femoral or jugular approach may be used. In patients with a "piggy-back" anastomosis the jugular approach gives more direct access to the hepatic veins. The ability to perform liver biopsies is an advantage of the jugular approach in both groups of patients.

IVC lesions are easily treated with balloon angioplasty; however, recurrent lesions are common. Because of the high recurrence rate, primary stenting has been

suggested as the treatment of choice for IVC lesions. Gianturco Z stents (Cook Inc, Bloomington, IL) are ideal in this setting.¹⁷ Not only do they come in sufficiently large diameters but also they have large spaces between the stent struts, minimizing obstruction to inflow from side branches such as the hepatic and renal veins (Fig. 14).

Stenoses involving the origins of the hepatic veins after a piggy-back anastomosis are more difficult to treat. Anastomotic stenosis may be easily dilated from the jugular or femoral approach (Fig. 15). Recurrence related to elastic recoil is common.¹⁸ Recurrent lesions are best treated with stent placement. To achieve a stable stent position, it may be necessary to extend the stent from the largest of the hepatic vein branches across the anastomosis with the IVC, crossing the origins of other hepatic vein branches (Fig. 16). As little stent as possible should extend into the IVC.

Occasionally, one may encounter a patient in whom the venous anastomosis is so tight that it cannot be easily catheterized from the IVC. If this occurs, a hepatic vein branch may be reached from the transhepatic approach and the lesion crossed in an antegrade direction. The lesion may be treated from the transhepatic track, or the transhepatic wire may be snared from the IVC and the lesion treated from the jugular approach.

MISCELLANEOUS PROCEDURES

On occasion other vascular interventions including TIPS, embolizations, and transjugular biopsies may be necessary in this population. These patients undergo

Figure 14 Inferior venacavagram using gadolinium as contrast agent shows a tight stenosis of the intrahepatic IVC (A). Follow-up run after PTA with an 18-mm balloon shows a patent but narrowed IVC with good flow into the right atrium (B). Cavagram in another patient following Gianturco stent placement demonstrates a widely patent IVC (C). Note the large spaces between the stent struts, which minimize obstruction to inflow from side branches such as the hepatic veins.

frequent percutaneous biopsies, and hepatic artery pseudoaneurysm or arterial-portal fistulas may be the result. Treatment is the same as in a native liver. It is critical to occlude the involved hepatic artery branch both proximal and distal to the lesion to prevent reconstitution of the bleeding site by intrahepatic collaterals.

SUMMARY

Doppler ultrasonography is critical in surveillance, early detection (de novo and recurrent lesions), and directing appropriate adjunct imaging studies as needed prior to definitive management. Knowledge of the surgical technique utilized is essential in endovascular therapy planning. Interventional radiology plays a critical role in

Figure 15 Left hepatic venogram in a patient with a piggy-back anastomosis. Note the reflux of contrast material into the right hepatic vein due to the anastomotic stenosis (A). This would have been more easily done from a jugular puncture, but the presence of an implanted central venous catheter precluded this approach. Venogram after PTA (B) of the anastomosis shows resolution of the stenosis. Reflux into the right hepatic vein was no longer seen.

Figure 16 Right hepatic venogram from the same patient as in Fig. 4B shows placement of a balloon-expandable stent to treat the anastomotic stenosis. Despite the stent crossing the origins of the left and middle hepatic veins, the patient's symptoms (ascites) resolved quickly after stent placement.

managing vascular complications following liver transplantation. By applying lessons learned in other vascular beds, graft salvage can be achieved with minimal morbidity.

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