From the Southern Association for Vascular Surgery

Primary stent placement for hepatic artery stenosis after liver transplantation

Linda Le, MD, William Terral, MD, Nicolas Zea, MD, Hernan A. Bazan, MD, Taylor A. Smith, MD, George E. Loss, MD, Edward Bluth, MD, and **W. Charles Sternbergh III, MD,** *New Orleans, La*

Objective: **Significant hepatic artery stenosis (HAS) after orthotopic liver transplantation (OLT) can lead to thrombosis, with subsequent liver failure in 30% of patients. Although operative intervention or retransplantation has been the traditional solution, endovascular therapy has emerged as a less invasive treatment strategy. Prior smaller studies have been conflicting in the relative efficacy of percutaneous transluminal angioplasty (PTA) vs primary stent placement for HAS.**
Methods: **This was a single-center retrospective review of all endovascular interventions for HAS after OLT during a 54-month period (August 2009-December 2013). Patients with ultrasound imaging with evidence of severe HAS (peak systolic velocity >400-450 cm/s, resistive index <0.5) underwent endovascular treatment with primary stent placement or PTA. Outcomes calculated were technical success, primary and primary assisted patency rates, reinterventions, and complications.**
Results: **Sixty-two interventions for HAS were performed in 42 patients with a mean follow-up of 19.1 ± 15.2 months. During the study period, 654 OLTs were performed. Of 61 patients diagnosed with HAS, 42 underwent an endovascular intervention. The rate of endovascularly treated HAS was 6.4% (42 of 654). Primary technical success was achieved in 95% (59 of 62) of the interventions. Initial treatment was with PTA alone in 17 or primary stent in 25. Primary patency rates after initial stent placement were 87%, 76.5%, 78%, and 78% at 1, 6, 12, and 24 months, respectively, compared with initial PTA rates of 64.7%, 53.3%, 40%, and 0% ($P = .19$). There were 20 reinterventions in 14 patients (eight stents, six PTAs). The time to the initial reintervention was 51 days in patients with PTA alone vs 105.8 days for those with an initial stent ($P = .16$). Overall primary assisted patency was 93% at 24 months. Major complications were one arterial rupture and two hepatic artery dissections. The long-term risk of hepatic artery thrombosis in the entire patient cohort was 3.2%.**
Conclusions: **HAS after OLT can be treated endovascularly with high technical success and excellent primary assisted patency. This series represents the largest reported cohort of endovascular interventions for HAS to date. Initial use of a stent showed a strong trend toward decreasing the need for reintervention. Avoidance of hepatic artery thrombosis is possible in >95% of patients with endovascular treatment and close follow-up. (J Vasc Surg 2015;62:704-9.)**

Hepatic artery stenosis (HAS) occurs in 5% to 11% of orthotopic liver transplants (OLTs) and can lead to hepatic artery thrombosis (HAT).[1-3] HAT carries a 30% to 50% incidence of eventual liver failure and represents >50% of all arterial complications in OLT.[4-9] Developing HAT significantly increases a recipient's morbidity and mortality and may require retransplantation in up to 75% of cases.[10] Close surveillance is essential to identify HAS postoperatively, because if left untreated, HAS has up to a 65% chance of progressing to HAT ≤6 months.[11] Zhao et al[12] showed prolonged patient survival of 17 to 30 months in patients who received treatment for HAS compared with patients undergoing expectant management.

From the Department of Surgery, Section of Vascular and Endovascular Surgery, Ochsner Clinic.
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Correspondence: W. Charles Sternbergh III, MD, Ochsner Clinic, 1514 Jefferson Hwy, New Orleans, LA 70121 (e-mail: csternbergh@ochsner.org).
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Traditional approaches for treating HAS and HAT have been open surgical arterial revascularization or retransplantation. However, in the era of minimally invasive techniques, endovascular therapy has evolved as an efficacious and durable alternative. At our institution, early surveillance with hepatic ultrasound imaging and a comprehensive team approach between transplant and vascular surgeons have led to an aggressive strategy in treating severe HAS in OLT recipients.

We previously reported our early results of endovascular therapy for HAS after OLT.[13] In the largest reported series to date, we review our midterm outcomes of angioplasty and stenting in the treatment of HAS. The aim of the study was to identify whether angioplasty alone vs primary stenting is the optimal endovascular management for HAS to prevent HAT in OLTs.

METHODS

This is a retrospective review of all endovascular interventions performed for HAS at a single tertiary care hospital between August 1, 2009, and December 31, 2013. The Institutional Review Board approved this retrospective review study, and informed consent was waived.

As previously published from our institution, criteria for intervention were defined by ultrasound parameters consisting of a main hepatic resistive index (RI) <0.5, a

peak systolic velocity (PSV) >400 to 450 cm/s, and tardus parvus waveforms. Ultrasound findings with all three criteria suggested a >70% stenosis. Recurrent stenosis was defined as worsening of ultrasound parameters to prestent RI and PSV as well as return of tardus parvus waveforms.[14] Most patients with a diagnosis of significant HAS subsequently underwent a computed tomography angiography of the abdomen to confirm the ultrasound results, pinpoint any aberrant anatomy or relative tortuosity, and assist with case planning (ie, femoral vs brachial access).

A detailed description of procedural technique was published earlier with our initial experience of endovascular intervention for HAS.[13] In brief, femoral or brachial access was selected depending on the orientation of the celiac artery, with a femoral approach used in most patients. An acutely angled takeoff of the celiac artery favors a brachial approach, whereas a celiac artery coming off the aorta at a perpendicular angle can be selected via the femoral approach. A multipurpose long sheath or guide was used for additional support, and various types of catheters were used to select the celiac artery. A 0.014-inch wire was used to cross the lesion in most cases. Low-profile coronary angioplasty balloons (2.0- to 5.0-mm diameter × 15- to 30-mm length) were used to predilate the lesion and in cases of stent placement.

As we gained more experience, we have shifted toward primary stenting when possible. Coronary balloon-expandable stents in lengths of 15 mm to 30 mm and diameters from 2.0 mm to 5.0 mm were generally preferred over peripheral self-expanding stents due to their better trackability and precision of deployment because most of the hepatic arteries are tortuous and stenotic lesions were quite focal (Fig 1). In cases of recurrent stenosis or smaller-caliber vessel diameters, a drug-eluting coronary stent was chosen for presumed better patency. Drug-eluting stents were not used in patients who had a size mismatch in proximal and distal landing zones. In a small number of patients, both hepatic arteries were successfully stented using the "buddy wire" technique (Fig 2).

Patients were prescribed dual-antiplatelet therapy for 3 to 6 months. Patients underwent hepatic ultrasound imaging 1 week postintervention, then at 6 weeks, at 3, 6, and 12 months, and annually thereafter. If the procedure was performed on an inpatient, a hepatic duplex study was obtained the following day.

Outcomes analyzed were technical success, complications, and all-cause mortality. Patency rates and time to reintervention were compared between initial percutaneous transluminal angioplasty (PTA) vs initial stent placement. Initial technical success was defined as <30% residual stenosis of the treated hepatic artery by visual estimation of the completion angiogram. Neither intravascular ultrasound nor pressure gradients were used in this series.

The primary patency rate was defined as the time from the initial intervention to any procedure to maintain hepatic artery patency, first occurrence of HAT, or reaching a censored event (retransplant, death, lost to follow-up, or end of study period). Primary assisted patency was defined as the time from the initial intervention until HAT or reaching a censored event and included preemptive reinterventions to maintain patency.

Statistics. Continuous data are presented as a mean with interquartile range. Primary patency with angioplasty alone compared with initial stent and assisted primary patency was analyzed using Kaplan-Meier curve log analysis (GraphPad Prism Software Inc, La Jolla, Calif). Reintervention rates and preintervention vs postintervention mean hepatic artery PSV and RI were compared using a two-tailed *t*-test.

RESULTS

During the study period, 654 OLTs were performed. Of 61 patients diagnosed with HAS 42 underwent an endovascular intervention and 18 were treated conservatively. Indications for conservative management were underlying bacterial or viral infection, concurrent rejection, or HAS that did not meet the duplex criteria for severe stenosis. Patients were treated with aspirin and underwent serial bimonthly ultrasound assessments. One patient underwent an open revision on postoperative day 1 for HAT.

During the 54-month study period, 42 patients underwent 62 endovascular interventions for hepatic artery occlusive disease, of which 61 were performed for HAS and one was performed for HAT. From August 2009 through December 2013, 654 OLTs were performed, giving a 6.4% (42 of 654) incidence of patients treated endovascularly for hepatic artery occlusive disease. Four patients in our cohort had already undergone a second transplant due to HAT and initial orthotopic liver graft failure before our intervention.

The mean time to the initial intervention after OLT was 82.2 ± 56.3 days (range, 12-241 days), demonstrating that most of the interventions were performed fairly early after OLT. Six were performed ≤30 days after OLT, and overall, 27 patients required intervention within the first 3 months. Patients were a mean age of 50.9 ± 11.3 years (range, 15-67 years), and 74% (31 of 42) were male. Mean follow-up in this series was 19.1 ± 15.2 months (range, 1-55 months).

Technical success. Technical success was accomplished in 95% (59 of 62) of cases. There were 42 initial interventions and 20 reinterventions for recurrent stenosis. Of the initial interventions, 60% (25 of 42) consisted of an initial stent. Five drug-eluting stents were placed during an initial intervention, and four were placed during a reintervention. There were 17 initial angioplasty procedures. One initial procedure was for HAT and was successfully treated with thrombolysis and stent placement.

Patency. Primary patency rates after initial stent placement at 1, 6, 12, and 24 months were 87%, 76.5%, 78%, and 78%, respectively, compared with initial PTA rates of 64.7%, 53.3%, 40%, and 0% ($P = .19$; Fig 3). Primary patency rates for the entire cohort were 77.5%, 65.6%, 63.6%, and 46.6% at 1, 6,12, and 24 months, respectively. Overall primary assisted patency rates were 95%, 94%, 95%, and 93% at 1, 6, 12, and 24 months, respectively (Fig 4).

Ultrasound findings. Preintervention ultrasound imaging revealed a mean main hepatic artery PSV of