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The Role of Interventional Radiology in the Multidisciplinary Management of Biliary Complications After Liver Transplantation

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Interventional radiology is a key component of the multidisciplinary team that is required for a successful liver transplant program, as it provides safe, effective, and minimally invasive management of transplant-related complications. Biliary complications remain highly prevalent among transplant recipients, and radiologic techniques can improve graft and patient survival in this population. Such techniques can serve as definitive, first-line therapies in some cases and as adjuncts to multidisciplinary approaches in others. This article reviews vascular and nonvascular radiologic techniques for managing transplant-related biliary complications.
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Introduction

Biliary complications remain a significant contributor to premature graft loss and can occur in up to one-third of patients who undergo liver transplantation.[1-4] Markedly lower rates of such complications are seen after orthotopic transplants than after reduced-size liver transplants and after adult liver transplants when compared with pediatric liver transplants. The prognosis and choice of treatment depend on the type and timing of the complication after transplant. Minimally invasive methods are standard first-line options to manage most biliary complications, not only as definitive treatments but also as stepping stones to or components of strategies that combine interventional radiology (IR) techniques, endoscopic techniques, and open surgical techniques. The morbidity and mortality associated with surgical options vary with clinical condition, type of complication, and number of previous abdominal surgical procedures, but for appropriate candidates and indications, such options may be preferred to minimize treatment time and maximize success rates. However, careful application of IR and endoscopic techniques and the addition of technological advances such as covered stents may continue to reduce the need for open surgical treatment.

Diagnosis and Treatment Modalities

Detection and surveillance of biliary complications have evolved toward noninvasive modalities such as Doppler ultrasound (US), computed tomography (CT), and magnetic resonance (MR) cholangiopancreatography (MRCP). For transplant recipients, endoscopic retrograde cholangiopancreatography (ERCP) is typically performed with the intent to both diagnose and treat strictures and leaks.[5] ERCP is usually successful for choledochocholedochostomy biliary reconstructions, but for many transplant recipients, a Roux-en-Y hepaticojejunostomy (RYHJ) proves too tortuous or lengthy for the endoscopic approach. Percutaneous transhepatic cholangiography (PTC) and percutaneous transhepatic biliary drainage (PTBD) are second-line options for most indications and are reserved for cases in which ERCP fails or is infeasible for clinical or anatomical reasons. That said, imaging detection of biliary obstruction in liver transplant recipients could be difficult because of the reduced compliance of the liver parenchyma associated with chronic graft-versus-host disease, which may prevent biliary dilatation in the setting of obstruction. In such patients, as well as in

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patients with biliary leakage, the absence of biliary dilatation can necessitate PTC and PTBD for the initial diagnosis as well as for treatment.

Vascular-Related Biliary Complications

Collateral circulation is compromised during liver transplantation, and consequently, the biliary system relies heavily on hepatic arterial supply for sustained viability.[6] Consequently, the donor bile ducts are at an increased risk of biliary ischemia. This risk is higher for split-liver than for whole-liver grafts.[7] Ischemic complications may result from hepatic artery thrombosis (HAT) or stenosis (HAS) but can also occur in the presence of a grossly intact hepatic artery (HA).[8] Sequelae include biliary strictures, occlusions, leaks, fistulas, and hepatic abscesses. Although ischemic strictures can affect the entire biliary system, the intrahepatic blood supply relies exclusively on the patency of the HA and is particularly susceptible to HAT or HAS. When diffuse intrahepatic biliary strictures result from ischemia, options for minimally invasive duct decompression may be limited or nonexistent, as, in some cases, placement of drainage catheters may obstruct diseased biliary radicles and worsen the clinical picture. HA compromise occurs in 2%-8% of liver transplant recipients[9-11] and is commonly managed surgically. Consequently, HA percutaneous transarterial angioplasty (PTA) and HA thrombolysis after liver transplantation are described in only short series and case reports. However, published cases describing the clinical success of endovascular revascularization suggest that this strategy may be underutilized.

HA Stenosis

HAS often presents with a more insidious onset than HAT does, usually resulting in ischemic biliary strictures without frank necrosis. Patients often present with constitutional symptoms and laboratory evidence of ductal compromise and obstruction such as elevations of serum levels of gamma-glutamyl transferase, alkaline phosphatase, and bilirubin; a relative absence of alternative explanations for those elevations; and ultimately, imaging evidence of HAS. Not all cases of HAS require endovascular reconstruction. Appropriate clinical indications and risks should be considered alongside imaging findings. Detailed noninvasive vascular imaging with US, CT angiography, and MR angiography is critical to verify the location and nature of the arterial obstruction and to plan appropriate therapy. For the main HA and arterial anastomosis, US offers real-time interrogation of the HA during respiratory variation to distinguish cases of kinking or torsion from cases involving stenoses intrinsic to the vessel wall, such as surgical strictures at the anastomosis and clamp-related injury. CT angiography and MR angiography offer the advantage of 3-dimensional images and the detection of more distal, branch-point stenoses.

All members of the multidisciplinary transplant team should be involved in planning and coordination before HA PTA is performed, and expectations should be communicated to the patient or appropriate representative, particularly regarding the potential need for delayed or emergent surgical reconstruction or even retransplantation in case of failed or complicated PTA. Techniques required for HA PTA vary based on the imaging findings described earlier and may include concurrent thrombolysis in cases of partial thrombosis or thrombotic complications; double-balloon technique in cases of branch-point stenosis; microwires and microballoons in cases of small vessel stenosis (Fig. 1); and stents in cases of kinks, torsions, and refractory stenoses. During the procedure, heparinization before wire traversal of the stenosis is standard. In our experience and in the published literature,[11,12] stenoses involving the arterial anastomosis, the extrahepatic HA, and the right and left intrahepatic HAs are all amenable to PTA, with excellent angiographic and clinical results. HAS of the main HA and anastomosis are particularly amenable to stent placement. Rostambeigi et al[12] performed a meta-analysis of 263 liver transplants with HAS in 257 patients. PTA was performed in 147 patients, and stent placement was performed in 116. Follow-up was 1 month to 4.5 years. For PTA and stent placement, technical success rates were 89% and 98%, complication rates were 16% and 19%, arterial patency rates were 76% and 68%, reintervention rates were 22% and 25%, and retransplantation rates were 20% and 24%, respectively. Similarly, Hamby et al[11] reviewed 35 HA interventions in 23 patients and observed a technical success rate of 97%. Primary patency rates at 1, 3, and 6 months for 10 patients undergoing PTA were 70%, 60%, and 50%, respectively, as compared with 92%, 85%, and 69%, respectively, for 13 stented patients. After PTA, patients should be observed and treated with anticoagulation overnight under the care of a dedicated transplant hepatology team, and serial hepatology panels should be performed to monitor progress and to assess for evidence of acute arterial compromise.

HA Thrombosis

Clinical implications of HAT can range from acute graft failure to compromise of long-term graft survival. Interestingly, some studies have reported graft survival rates of up to 50% in patients with untreated cases of HAT that present late (after 1 month).[10,13] In cases of early (<30 days after transplantation) HAT, graft loss is virtually guaranteed without early intervention. Revascularization within 1 week has been shown to preserve graft survival and prevent the associated extensive, life-threatening biliary complications associated with HAT that include biliary necrosis, bilomas, biliary casts, abscesses, leaks, and fistulas. For early HAT, Scarinci et al[10] reviewed the significance of the timing of surgical reconstruction and reported rates of graft survival of 81%, 62%, and 0% when reconstruction was performed within 1, 2, and 4 weeks, respectively. Until recently, surgery has been considered

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