

WJG 20th Anniversary Special Issues (7): Liver transplant**Interventional radiology in living donor liver transplant**

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Abstract

The shortage of deceased donor liver grafts led to the use of living donor liver transplant (LDLT). Patients who un-

dergo LDLT have a higher risk of complications than those who undergo deceased donor liver transplantation (LT). Interventional radiology has acquired a key role in every LT program by treating the majority of vascular and non-vascular post-transplant complications, improving graft and patient survival and avoiding, in the majority of cases, surgical revision and/or re-transplant. The aim of this paper is to review indications, diagnostic modalities, technical considerations, achievements and potential complications of interventional radiology procedures after LDLT.

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Key words: Portal vein; Hepatic artery; Hepatic vein; Bile duct; Living donor liver transplantation; Liver transplant

Core tip: The aim of this paper is to review indications, diagnostic modalities, technical considerations, achievements and potential complications of interventional radiology procedures after living donor liver transplant.

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INTRODUCTION

Living donor liver transplant (LDLT) is an optimal solution for urgent demands for liver grafts^[1]. However, 25 (27.1%) living donors presented 1 or more episodes of complication in the post-operative period^[2]. Stringent criteria of donor selection criteria and peri-operative care were implemented following one of the first reported

case of living donor death in 2002. In the recipient, vascular and/or biliary complications and infections may lead to graft dysfunction without appropriate management. Advances in the field of percutaneous, radiological, minimally invasive techniques have increased the importance of interventional radiology in the management of patients after LT^[3]. This article describes how interventional radiology could be applied in the management of postoperative vascular and biliary complications in recipients after LDLT by reviewing our experience and other protocols present in literature.

DIAGNOSIS OF GRAFT DISEASE

At our institution, postoperative Doppler ultrasound (DUS) to assess vascular patency and biliary complications is routinely performed on liver transplant patients. DUS is performed on a daily basis during the immediate postoperative period. At outpatient follow-up, regular color DUS is performed routinely every three months. Any alteration of liver function tests not explained by diagnostic imaging, requires a liver biopsy to exclude rejection and/or other pathologies. Computed tomography angiography and magnetic resonance angiography are reserved for supporting sonography (US) findings or when US findings are equivocal. Confirmation and common therapeutic interventions for all vascular or non-vascular complications are done by interventional radiology.

HEPATIC ARTERY COMPLICATIONS

The incidence of hepatic artery (HA) complications is around 4%-16%^[4]. Complications include HA stenosis, occlusion, thrombosis, bleeding, aneurysm, and steal syndrome. Usually, these complications are caused by surgery and trauma, and most often they occur near the site of anastomosis during the perioperative period. Resection and further surgery to HA anastomosis is potentially an optimal way to solve HA complications intraoperatively and at an early stage after liver transplant. Endovascular intervention can easily be selected for diagnosis, then treatment can be started immediately. Intervention is thus a reasonable means allowing for both early detection and early treatment of HA thrombosis^[5,6]. Miraglia *et al*^[7] reported a technique, from a transfemoral approach, with a 5F Cobra 2 or SOS catheter. A coaxial microcatheter is then advanced through the stenosis and the trans-stenotic pressure gradient measured. If a significant pressure gradient is present (> 10 mmHg) then an angioplasty is performed. Before angioplasty, 0.2 mg of nitroglycerine and 2000 UI of heparin are infused into the hepatic artery to reduce the risk of spasm or thrombosis. A 6F guiding catheter is advanced and a balloon catheter advanced over a 0.018 inch or 0.014 inch stiff wire. The diameter of the balloon used varies according to the diameter of the hepatic artery, ranging from 3 to 6 mm. Procedural success is determined by reduction or absence of the stenosis in a final arteriogram with significant reduction of the transstenotic pressure gradient. If a good patency is

not restored, a metallic stent is deployed. There is ongoing discussion regarding the best therapeutic option(s) for HA complications, because both endovascular intervention and open surgery have advantages and disadvantages. It is generally accepted that endovascular interventions are less invasive than open surgery. There were significant differences in the mean length of the operation for the first treatment of HA complications (open surgery, 428 min *vs* endovascular intervention, 160 min, $P = 0.01$) and in the mean value of the post-treatment aspartate aminotransferase/alanine aminotransferase (open surgery/endovascular intervention, $P = 0.04/0.05$)^[8]. However, a higher recurrent stenosis rate in endovascular intervention (60%) than open surgery (37.5%) was reported^[8]. Percutaneous transluminal angioplasty has also been reported to be an effective treatment of HA stenosis after living donor LT, with a success rate of 94% and a complication rate of 6%, with possible HA stenosis recurrent in 33% of patients^[8,9]. These complications included arterial dissection and bleeding.

PORTAL VEIN COMPLICATIONS

Intraoperative portal vein intervention

After reperfusion, if insufficient portal flow was detected by Doppler ultrasound, a direct portogram was performed and stent placement was prepared as an alternative procedure when surgical intervention failed. Intraoperative portal vein (PV) stent placement during liver transplant is a good substitute for surgical adjustment in patients with PV abnormalities. We report two cases in which this procedure was used to guide intraoperative PV stent placement through an inferior mesenteric vein approach and with use of the stump of the segment 4 PV in pediatric living donor liver transplant recipients^[10].

Chronic PV abnormalities are less common and only occur in 2%-13% of transplant recipients^[11,12]. Early diagnosis of any PV complication is essential for the prevention of late PV complication-related graft loss. A jet flow phenomenon of portal flow and post-stenotic dilatation of the PV are often found in patients with severe PV stenosis. Splenomegaly and ascites in some patients may also be clues suggestive of portal vein complications. PV angioplasty/stenting is conventionally performed through the percutaneous trans-hepatic approach, however, this can also be performed through trans-splenic approaches. Ko *et al*^[13] reported a series of patients following living donor LT with early occurrence of PV stenosis that were treated with transhepatic primary stent placement. In our practice, a percutaneous transhepatic/transsplenic puncture of the intrahepatic PV was performed using a 21-gauge Chiba needle (Cook, Bloomington, IN) under ultrasonographic and fluoroscopic guidance. Using Seldinger technique, a 0.018-inch wire was advanced into the main PV. The needle was changed to a 4-French coaxial dilator and a 7-French sheath (Terumo, Tokyo, Japan) over a 0.035-inch angled hydrophilic guide wire (Terumo, Tokyo, Japan). An initial contrast study to serve as a "road map" was performed. The guide wire was

manipulated to advance beyond the point of occlusion or stenosis. A 0.018-inch or 0.035-inch guide wire and a 4-French J curve catheter (Terumo, Tokyo, Japan) were used to traverse the PV occlusion or stenosis. Guide wire manipulation was carried out according to the "road map" and "feel"; as the guide wire was advanced, repeat contrast studies were obtained when necessary. In stenosis patients, a main PV venography and the pressure gradient across the stenosis were obtained. In total occlusion patients, a combination of hydrophilic guide wires with straight, angled and "J" tips and different sizes (0.018-inch or 0.035-inch) with supporting catheters (straight or angled) were often necessary to successfully pass the occluded segments. Once the correct plane was entered, rapid progress without perforation could be obtained with development of a loop or extended J at end of a guide wire during manipulation. A wall stent (7-10 mm with viable length; Boston Scientific, Natick, MA) was placed to bypass the stenotic or occluded portion. Balloon angioplasty following stent placement was performed if necessary. For the percutaneous transsplenic approach ($n = 8$), the success rate was 75% (6/8). For the percutaneous transhepatic approach ($n = 10$), in the three patients who received a right lobe graft, the success rate was 100% but in seven patients who received a left lobe graft, the success rate was only 57%. Hemoperitoneum and hemothorax are common complications in percutaneous transhepatic PV angioplasty and stenting. Early diagnosis and treatment are essential to maximize the use of stent placement and achieve good success rates^[14].

HV COMPLICATIONS

Hepatic vein complications, inducing outflow insufficiency, is a major postoperative complication of LT, especially in patients with partial liver graft transplants. This produces graft failure with a reported incidence of 1%-4%^[15-17]. A smaller recipient-to-donor body weight ratio and the use of reduced grafts were statistically significant risk factors in pediatric patients^[18]. Hepatic congestion can cause refractory ascites, refractory hydrothorax and alteration of liver function tests. If a clinical reports and/or images suggest HVs may be present, selective catheterization of all the HVs is mandatory to confirm the stenosis and measure the trans-stenotic pressure gradient. A pressure gradient greater than 3 mmHg between the HV and right atrium has been reported to be pathological^[18]. Patients with an earlier recurrence of HV complications had a poorer outcome. The primary percutaneous transhepatic approach for HV stenosis treatment may be considered^[18] when the transjugular or the transfemoral approach fails. In general, balloon dilatation is considered the preferred treatment choice and metallic stent placement is reserved for persistent HV complications not responsive to multiple angioplasties. Stent placement should be carefully considered because of the absence of data on the long term patency of the stents and stent-related complications. Anti-coagulation

agent must be given at least 6 mo. In our experience, long term patency of the stents is 100% (3/3) in our center.

BILIARY COMPLICATIONS

Biliary complications include biliary strictures, bile leakage, biliary stones and bilomas. Strictures are one of the most common complications following liver transplant, representing an important cause of morbidity and mortality in transplant recipients. The reported incidence of biliary stricture is 5% to 15% following deceased donor liver transplantations and 28% to 32% following living donor liver transplantations^[19]. Patients with multiple biliary reconstructions have a higher incidence of biliary complications^[20]. Initial evaluation should include liver US with Doppler evaluation. However, due to the high rate of false-negative results, a negative test cannot exclude the presence of biliary complications. Magnetic resonance cholangiopancreatography, which has a sensitivity and specificity close to 90% in establishing the diagnosis of biliary strictures^[21-23] is considered by all to be the gold standard, not only in establishing the diagnosis, but also in allowing therapeutic intervention in the same setting^[24,25]. The treatments for bile duct stenosis after transplant include surgery, endoscopic interventional treatment, and percutaneous intervention. Different liver transplant centers tend to have different opinions regarding which treatment is the best^[26-30]. At present, the preferred endoscopic approach is repeated aggressive dilation of the stricture and insertion of multiple plastic stents, particularly anastomotic stricture. Percutaneous and surgical modalities are now reserved for patients in whom endoscopic treatment fails and for those with multiple inaccessible intrahepatic strictures or Roux-en-Y anastomoses. The success rate of endoscopy is more closely relevant to the technician's skill level, than is the success rate of percutaneous intervention. Sherman reported that about 4% endoscopic operations result in complications or morbidity and 2% in mortality^[28].

In conclusion, Patients who undergo LDLT have a higher risk of complications than those who undergo deceased donor LT. The landscape related to vascular or non-vascular complications after LDLT has changed rapidly in the past 2 decades. The conventional management of these conditions in the past was mainly surgical. Since the introduction of minimally invasive treatments, surgery has given up its position as first-choice treatment for liver transplant complications. Advances in the field of percutaneous, radiological, minimally invasive techniques have increased the importance of interventional radiology in the management of patients after LDLT. Interventional radiology procedures could improve graft and patient survival and avoid, in the majority of cases, surgical revision and/or retransplant. By selecting reasonable devices and methods, we believe that interventional treatment can be the first choice for treatment of LDLT complications.

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