Successful Interventional Therapy for Portal Vein Stenosis after Ex Vivo Liver Resection and Autotransplantation in End-Stage Hepatic Alveolar Echinococcosis with Cavernous Transformation

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Background: End-stage hepatic alveolar echinococcosis (AE) can result in cavernous transformation of the portal vein (CTPV) due to extensive invasion of the portal vein. Ex vivo liver resection and autotransplantation (ELRA) is a new treatment option for patients with end-stage hepatic AE combined with CTPV. ELRA can achieve radical resection of HAE lesions and vascular reconstruction, and also effectively controls bleeding, particularly in cases involving multiple tortuous PV collaterals. Unfortunately, postoperative complications related to the portal vein can impede liver blood flow, thereby increasing the risk of portal hypertension and eventual failure of the transplanted liver if not promptly treated through appropriate medical interventions.

Case Report: We report the case of a 31-year-old woman who underwent ELRA for end-stage hepatic AE combined with CTPV, and early postoperative portal vein anastomotic stenosis occurred. Stenting of the portal vein was performed after clarification of the stenotic segment by portal venography, followed by anticoagulation therapy and close ultrasound follow-up. After the operation, the patient's portal vein anastomosis widened and the blood flow into the liver returned to normal, avoiding graft liver failure. At 3-year follow-up, the portal vein stent was patient and no serious portal vein complications such as thrombosis had occurred.

Conclusions: ELRA provides a new therapeutic approach for patients with HAE combined with CTPV, and intraoperative portal vein reconstruction is one of the key procedures. For CTPV patients with early postoperative portal vein stenosis, interventional therapy (IVR) offers fresh perspectives and avoids acute liver failure caused by liver hypoperfusion.

Keywords: Cavernous Transformation of Portal Vein • Portal Vein Radiology, Interventional Liver Transplantation

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Introduction

Hepatic alveolar echinococcosis (HAE) is a lethal infectious disease caused by the larval stage of *Echinococcus multilocularis* (*E. multilocularis*), commonly known as the fox tapeworm. The area endemic for alveolar echinococcosis (AE) is restricted to the Northern Hemisphere, including the central part of Western Europe, parts of the Near East, Russia, the Central Asian Republics, China, Northern Japan, and Alaska [1]. Among the 18,235 estimated new AE cases per year globally, 91% occur in China, with prevalence of 3% in humans in some areas. Mortality in untreated or inadequately treated AE patients is 90% within 10-15 years of diagnosis [2].

This disease primarily affects the liver and is characterized by tumor-like growths that can infiltrate nearby blood vessels and bile ducts, with the potential to spread to other organs like the brain or lungs through the bloodstream or lymphatic system [3,4]. The primary approach to managing HAE is surgical intervention, particularly radical hepatectomy, due to its potential for complete cure. However, most patients do not experience positive results after this procedure, mainly because they have advanced disease and extensive invasion of critical intrahepatic vascular structures, making conventional radical hepatectomy challenging [5]. Ex vivo liver resection and autotransplantation (ELRA) present an innovative approach for treating individuals afflicted with end-stage hepatic alveolar echinococcosis, a complex condition that is difficult to manage using traditional radical resection techniques. The process of intraoperative revascularization is a major obstacle in ELRA surgeries, with particular emphasis placed on reconstruction of the portal vein due to its pivotal role in determining the overall outcome and success of the procedure [6,7]. However, like LDLT and DCD liver transplantation, ELRA has some potential to cause portal vein complications, such as severe stenosis or thrombosis. These complications can ultimately lead to a decrease in blood flow to the liver, which in turn can result in portal hypertension and even graft failure if left untreated [8]. For CTPV patients undergoing ELRA treatment, monitoring portal vein blood flow during the perioperative period is imperative for prompt detection and diagnosis of portal vein complications, thereby playing a pivotal role in optimizing therapeutic outcomes. Especially during the operation, intraoperative ultrasound should be performed immediately after the completion of portal vein anastomosis, and ultrasound examination should be performed continuously for 7 days after the operation for early detection and timely and effective treatment. Minimally invasive interventional radiology techniques, such as percutaneous transhepatic balloon dilatation and stent placement, are commonly employed for treating portal vein stenosis after liver transplantation due to their lower risk of complications and higher success rates [9]. A patient with end-stage HAE and CTPV at our institution developed severe portal anastomosis stenosis after ELRA, necessitating portal stenting guided by portal venography, resulting in a significant improvement in portal anastomosis lumen width and increased liver blood flow, leading to a favorable postoperative outcome.

Case Report

The patient, a 31-year-old woman, has resided in a pastoral area and had prolonged exposure to canines and domesticated livestock. Upon admission to the hospital, she presented with generalized jaundice of the skin and sclera, accompanied by anorexia and malaise, without evident abdominal pain or distension. She denied any history of smoking, alcohol abuse, food allergies, or medication use. There was no significant past medical history or family medical history reported. Physical examination revealed splenomegaly (spleen palpable 2 cm below the costal margin), with no other remarkable findings. The results of liver function tests showed elevated levels of total bilirubin (116.80 μmol/L) and direct bilirubin (65.55 μmol/L), as well as increased levels of ALT (53.70 U/L) and AST (36.64 U/L), with decreased levels of albumin (24.00 g/L). Coagulation function tests revealed prolonged prothrombin time (>36.8 s) and activated partial thromboplastin time (52 s). After admission, the patient underwent abdominal computed tomography angiography (CTA), magnetic resonance imaging (MRI), and other relevant diagnostic procedures, which definitively established the diagnosis of hepatic AE combined with secondary CTPV and obstructive jaundice (preoperative and postoperative CT images of the patient are shown in Figure 1). Due to the extensive involvement of the first and second hepatic portals, the medical team decided to perform percutaneous transhepatic choledochal drainage (PTCD) to alleviate the jaundice and preserve hepatic function.

On the 24th day after admission, the patient’s overall condition exhibited significant improvement compared to baseline. Owing to severe invasion of the first and second hepatic portals, development of multiple curved collateral circulations in the first hepatic area, heightened risk of bleeding, challenges associated with in vivo resection, and marked proliferation of liver tissue in the left outer lobe on the healthy side of the patient, we opted for ELRA. The patient underwent a Mercedes-Benz incision. Intraoperative examination revealed significant invasion of liver segments I and IV-VIII, as well as the middle and right hepatic veins, inferior vena cava, right branch of the proper hepatic artery, the main portal vein, and its right branch. The procedure involved meticulous dissection to separate the hepatic structures, followed by complete liver resection. Subsequently, the inferior vena cava was replaced with an artificial vessel and the portal vein was anastomosed with this synthetic vessel. This created a portal-inferior vena cava blood flow to temporarily restore circulation. Simultaneously, the resected liver was promptly perfused in HTK fluid at a
temperature range of 0-4°C on a sterile table. The patient’s hepatic ligament was suitably trimmed to restore the integrity of the hepatic vein and inferior vena cava. While careful dissection preserved the integrity of the left and main portal veins during repair procedures. End-to-end anastomosis was performed to connect the repaired retrohepatic inferior vena cava with the autologous inferior vena cava. The left branch of the repaired portal vein was anastomosed end-to-end with the main trunk of the autologous portal vein (ultrasonography performed after reconstruction indicated an internal diameter of the hepatic portal sectoral vein of 0.7 cm, with an average flow rate of approximately 20.9 cm/s). The operation lasted a total of 22 hours, with an anhepatic period of 8 hours 8 minutes. During the surgery, a total of 5200 ml of blood was transfused, which included 9 units of red blood cell suspension, 1700 ml of autologous blood, and 1700 ml of devirulent plasma. After the surgery, the patient was transferred to the Intensive Care Unit (ICU) for close monitoring and life support. Cefoperazone sulbactam was administered as a prophylactic measure against infection, and on the 3rd postoperative day it was switched to imipenem due to coagulation abnormalities.

Figure 1. Preoperative and postoperative CT images of patients. (A) Lesion of hepatic AE. (B) The right branch of the portal vein was invaded by the AE lesion and portal vein occlusion has resulted in cavernous degeneration of the portal vein (the red arrow points to CTPV). (C) Vascular reconstruction in the portal vein phase.
On the 4th postoperative day, significant edema was observed in the patient’s lower limbs, along with notable increases in abdominal and pleural effusions. Symptomatic treatments, including human albumin supplementation and diuresis, were initiated. The bedside ultrasound results on the 5th postoperative day indicated severe stenosis of the portal Anastomosis, with an internal diameter of the Anastomosis measuring 0.4 cm and a maximum flow rate of approximately 307.9 cm/s. The intrahepatic segment of the portal vein had an internal diameter of about 1.2 cm and a maximum flow rate of around 37.9 cm/s, while the extrahepatic segment showed an internal diameter of roughly 0.8 cm with a maximum flow rate of about 45.6 cm/s.

To prevent acute liver failure due to inadequate hepatic perfusion, urgent interventional radiotherapy (IVR) was performed under local anesthesia in the Emergency Department. Further examination revealed that the left branch of the portal vein had a smooth wall and unobstructed flow, while the right branch could not be seen. Additionally, the left branch of the portal vein did not have any blockages but had inadequate blood flow, in contrast to the complete absence of the right branch in the imaging. After diagnosing portal vein stenosis, a self-expanding vascular stent measuring 14×40 mm was successfully implanted to correct the problem. The main objective of this intervention was to restore proper blood circulation and prevent any potential complications that could lead to acute liver failure in the future. Following further imaging, it was confirmed that the stent had been correctly positioned, leading to a significant improvement in the blood flow within the left branch of the portal vein. Subsequently, the catheter was repositioned to the puncture channel, and 6 spring coils measuring 3×3 mm were used for embolization to prevent any potential hemorrhage after the procedure. To minimize the risk of postoperative thrombosis, a daily dose of 40 mg of low-molecular-weight heparin sodium was administered starting from the third day after the ELRA procedure. The dosage was then increased to 80 mg per day for 7 days following placement of the portal stent to prevent any thrombosis within the stent itself. The alterations in portal anastomotic diameter and blood flow velocity before and after interventional therapy are depicted in Figure 2.

Two days after portal vein stenting, bedside ultrasound was utilized for dynamic monitoring of the blood flow in the portal vein and hepatic artery. The findings revealed that the internal diameter of the portal vein anastomosis measured 0.7 cm, with a maximum flow rate of 39.9 cm/s; while the internal diameter of the intrahepatic segment of the portal vein was 1.2 cm, with a maximum flow rate of 23.6 cm/s; and the internal diameter of the external hepatic segment of the portal vein was recorded as 0.8 cm with a maximum flow rate measuring at 35.1 cm/s. Figure 3 shows a comparison of portal vein diameters before and after stent placement. Subsequent to the postoperative period, the patient was discharged from the hospital with notable improvement following the administration of anti-inflammatory and symptomatic treatments, which included thoracic and abdominal fluid puncture and drainage.

Seven months after undergoing ELRA surgery, she was admitted to our medical facility exhibiting a notable accumulation of ascites, abdominal swelling, lower-extremity edema, and various other symptoms. Diagnostic imaging, such as CT scans, revealed stenosis in the inferior vena cava and Budd-Chiari syndrome. After balloon dilatation of the inferior vena cava performed under local anesthesia, she was discharged from the hospital with relief from symptoms. The effectiveness of portal vein stenting was closely monitored for 3 years, during which there was consistent maintenance of normal blood flow in the portal vein without any significant thrombosis. This comprehensive follow-up period allowed for assessment of long-term success of the treatment and the patient’s health. The patient’s clinical course from diagnosis to IVR and follow-up is shown in Figure 4.
Discussion

Portal vein stenosis and portal vein thrombosis can result in hemodynamic alterations within the portal vein system, thereby impacting postoperative liver transplantation function. Portal vein complications following transplantation are rare, with stenosis and thrombosis occurring in less than 3% of cases [10]. Timely diagnosis of these complications is crucial to prevent post-transplantation loss of liver function. Untreated portal vein stenosis can progress to secondary portal vein thrombosis, ultimately leading to portal vein occlusion or cavernous transformation of the portal vein, extensive ascites, splenomegaly, gastrointestinal bleeding, and anemia, posing a significant threat to survival of the transplanted liver and the patient [11,12].

Portal vein stenosis following liver transplantation predominantly occurs at the anastomosis, primarily attributed to the anastomotic technique, mismatch in portal vein diameters at both ends of the anastomosis, types of vascular grafts utilized for portal vein reconstruction, torsion of the transplanted liver’s portal vein, and hematoma compression at the anastomosis site [13]. In our reported case, there was no evidence of portal vein torsion or hematoma compression; ultrasound examination only revealed stenosis at the portal anastomosis and abdominal fluid. We posit that early-onset portal vein stenosis in this patient was chiefly due to disparities in anastomotic portal vein diameter. Subsequent evaluation during surgery led to a decision to perform end-to-end anastomosis between the left and main portal veins. The narrowing of the anastomotic lumen might have resulted from wall overlap folding during anastomosis owing to differences in anastomotic portal vein diameter. Furthermore, certain intraoperative factors may contribute to damage of blood vessels at the site of anastomosis. Meticulous vascular surgical techniques can substantially mitigate post-liver transplantation occurrences of portal vein stenosis, distortion, and thrombosis [14].

The diagnosis of early portal vein stenosis following liver transplantation primarily relies on ultrasound examination [15,16]. In our reported case, severe portal vein anastomosis stenosis occurred during the early stage of ELRA. Due to the hepatic artery blood flow compensation, there was no apparent
deterioration in liver function. Bedside ultrasound examination of the transplanted liver led to timely detection and treatment of portal vein anastomosis stenosis.

In 1990, Olcott et al first reported the successful application of portal vein reconstruction and stent placement for treating portal vein anastomotic stenosis following liver transplantation [17]. Subsequently, this interventional technique has gained increasing popularity due to its minimally invasive nature, high surgical success rate, low complication rate, and rapid recovery [18]. It is gradually supplanting surgical treatments and emerging as the preferred method for managing portal vein system complications after liver transplantation [19]. There is no definitive consensus regarding the optimal treatment for post-liver transplant portal vein stenosis, whether it be balloon dilation of the portal vein or placement of portal vein stents [20]. Table 1 summarizes selected studies reporting portal vein stent placement for treatment of portal vein stenosis after liver transplantation. These studies have reported clinical success rates of 76-100% and long-term patency rates of 68-100% [19,21-27]. Funaki et al reported a 50% recurrence rate of stenosis within an average of 6.3 months following balloon dilation, whereas all patients who underwent stent placement maintained patency during a follow-up period of 47 months [21]. In a long-term follow-up study by Kim et al, 87%, 82%, and 68% patency rates were observed at 1, 5, and 10 years, respectively, after balloon dilation, with a consistent patency rate of 100% following stent placement [25]. According to Kyaw et al, initial stent placement is recommended for patients who experience vascular recoil during balloon angioplasty or require repeated interventions. Contrary to early considerations, recent studies tend to support initial stent placement over simple balloon angioplasty due to improved technical success rates and shorter initial patency times [26]. Some researchers posit that the early complications of portal vein stenosis after liver transplantation can be directly treated with portal vein stenting instead of balloon dilatation to reduce the risk of anastomotic rupture [28,29]. For the same reason, to prevent anastomotic rupture and bleeding during balloon dilation in patients, we opted for direct portal vein stenting. Considering that CT PV has been addressed in ELRA surgery, portal vein puncture and stenting are relatively straightforward. Following stent implantation, the diameter of the portal vein anastomosis significantly increased, blood flow velocity improved markedly, and hepatic blood flow returned to normal levels in the patient, thereby averting post-transplant liver failure.

In the postoperative follow-up, stenosis of the inferior vena cava with Budd–Chiari syndrome was observed 7 months after ELRA. It is hypothesized that inadequate and irregular anticoagulant therapy resulted in thrombosis of the inferior vena cava. However, angiography confirmed a simple occlusion of the superior and inferior vena cava, possibly caused by liver torsion following hyperplasia of the transplanted liver. Consequently, balloon dilation of the occluded segment of the inferior vena cava was performed simultaneously via the jugular vein and femoral vein, leading to significant improvement in venous return.

However, the evidence supporting interventional treatment for post-ELRA portal vein stenosis is currently limited by a paucity of retrospective studies and case reports, as well as variability in outcomes across individual centers. Furthermore, the optimal selection between balloon angioplasty and stenting remains ambiguous due to insufficient understanding of long-term outcomes, complication rates, and constraints associated with endovascular interventions. Both treatments present specific advantages and disadvantages that necessitate careful consideration.

**Figure 4.** Flow chart of the patient’s clinical course from diagnosis to IVR and follow-up.
In conclusion, for patients with end-stage hepatic AE combined with secondary CTPV treated with ELRA, ultrasonography can detect portal vein stenosis complications at an early stage, and if portal vein stenosis complications occur postoperatively, interventional radiology techniques can control the condition, thereby improving the survival rate of the transplanted liver and prolonging the survival of patients. Moreover, most patients can avoid surgical repair and subsequent liver transplantation. By selecting appropriate equipment and methods, we believe that interventional therapy in liver transplantation will become increasingly important in the future.

Conclusions

Patients with end-stage hepatic AE combined with CTPV who undergo ELRA treatment can benefit from early detection of portal vein stenosis complications through ultrasonography. If complications occur postoperatively, interventional radiology techniques can control the condition, thereby improving the survival rate of the transplanted liver and prolonging the survival of patients. Moreover, most patients can avoid surgical repair and subsequent liver transplantation. By selecting appropriate equipment and methods, we believe that interventional therapy in liver transplantation will become increasingly important in the future.

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References: