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Balloon-Occlusion Technique for Managing Portal Vein Hemorrhage in Liver Transplantation

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Background: Portal vein thrombosis (PVT) is relatively common among candidates for liver transplantation and can present significant intraoperative challenges. Depending on the extent of PVT, thromboendovenectomy (TEV), portal bypass, or systemic inflow may be required to restore portal inflow. While TEV is the most commonly used approach to restore anatomic portal inflow, portal vein injury and life-threatening hemorrhage are risks with this technique.

Case Report: We present a salvage technique for managing portal vein injury during TEV using intraluminal balloon occlusion of the portal vein during portal vein repair and reconstruction. This alternative mode of bleeding control optimizes exposure to the retropancreatic space and avoids direct application of vascular clamps that can cause further injury to the vessel and surrounding tissue.

Conclusion: Careful preoperative planning and anticipation of potential problems are essential for safe and effective management of complex PVT intraoperatively. The balloon-occlusion technique can facilitate safe and efficient repair of a portal vein injury during TEV for liver transplantation.

Keywords: *Endovascular procedures, liver transplantation, portal vein, reconstructive surgical procedures, venous thrombosis*

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INTRODUCTION

Portal vein thrombosis (PVT) represents a significant technical challenge in liver transplantation and for many years was considered a relative contraindication. While advances in surgical techniques, axial imaging, and alternative inflow reconstruction options have made liver transplantation possible in transplant candidates with PVT, it remains a significant risk factor for inferior long-term patient and graft survival.[1-3] Patients with known PVT should be carefully considered for selection for liver transplantation, and an operative plan for inflow reconstruction should be developed to ensure that appropriate resources are available.

Management of PVT has been greatly enhanced by improvements in the quality of axial imaging and ultrasonography that allow for thorough characterization of the extent of the thrombus prior to transplantation. For a patient with a known PVT who is maintained on the wait list for transplantation, surveillance imaging may be helpful to assess for progression of PVT and the potential impact on a strategy for reconstruction. The Yerdel classification system for PVT is based on partial or complete obstruction of the lumen and extension into the splenic vein or superior mesenteric vein (SMV).[4] The approach to surgical management and portal vein reconstruction is dictated by the grade of PVT. Partially occlusive PVT limited to the main portal vein (grade 1) can almost always be successfully managed with a simple balloon-catheter thrombectomy and standard end-to-end anatomic reconstruction of the portal vein. Complete PVT with extension into the splenic or mesenteric veins is often not amenable to the thrombectomy approach and may require alternative inflow from collaterals,[5-7] systemic circulation,[8,9] cavoportal hemitransposition,[10,11] or multivisceral transplantation.[12]

Thromboendovenectomy (TEV) is the preferred first-line approach for managing PVT with complete occlusion limited to the main portal vein or with limited extension into the splenic vein or SMV. The complexity of TEV is affected by the extent and chronicity of the thrombus, presence of calcifications within the thrombus, adhesions and fibrosis from chronic inflammation, collateral vessel formation and varices, and the quality of the portal vein tissue for reconstruction. The TEV often involves instrumentation in the retropancreatic portion of the portal vein where exposure can be limited if not prohibitive. In cases with multiple complicating factors, TEV should be carefully considered with alternatives for portal vein inflow from the SMV, dominant collaterals, or left renal vein. The preferred

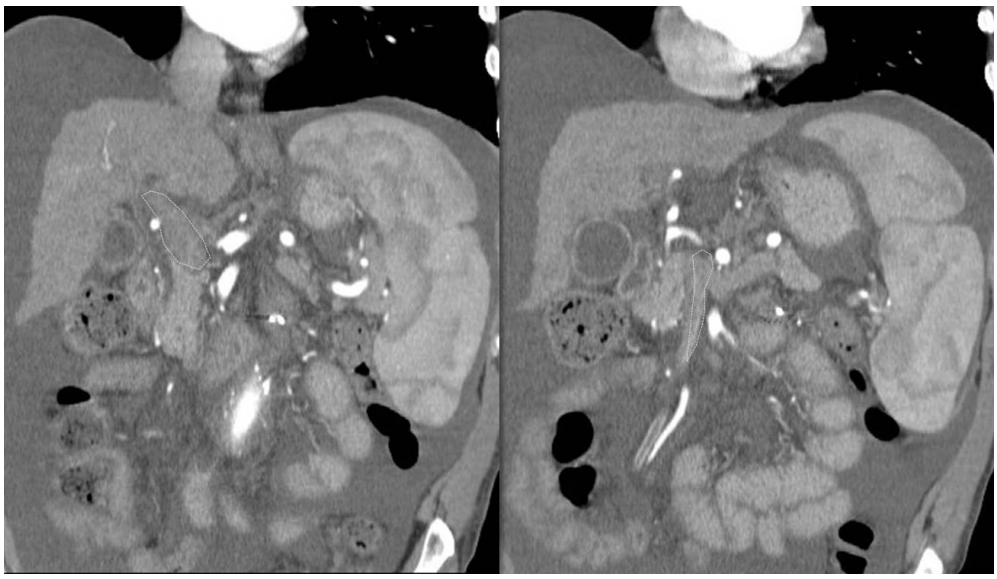

Figure 1. Portal vein thrombosis with extension to the confluence of the superior mesenteric vein and the splenic vein (select coronal reconstructions from computed tomography scan with intravascular contrast).

approach may be dictated by the surgeon's experience or institutional practice. At our center, TEV is the preferred initial approach for grade 2 PVT and, in select cases, for PVT with partial extension to the SMV or splenic vein. While this approach is often successful at restoring anatomic portal vein inflow, potential risks are injury to the portal vein and life-threatening hemorrhage. We present an approach for managing this complication to optimize control of bleeding, efficient repair, and reconstruction of portal inflow.

CASE REPORT

A 55-year-old male status post lung transplant who now had end-stage liver disease secondary to cystic fibrosis and advanced chronic kidney disease secondary to chronic calcineurin inhibitor toxicity presented for combined liver/kidney transplant. His surgical history was also notable for a prior subtotal colectomy and cholecystectomy. His physiologic MELD (Model for End-Stage Liver Disease) score was 25 with moderate ascites and grade 1 esophageal varices. During the patient's transplantation workup, complete PVT was noted on ultrasound without suggestion of cavernous transformation. On triple-phase computed tomography (CT) scan, the PVT was noted to extend to the level of the splenic and SMV confluence, with limited partially occlusive extension into a short segment of the SMV (Figure 1). The preoperative plan was to attempt TEV to restore portal flow and to prepare a venous conduit from the donor iliac vein in case a bypass from the SMV would be required. After extensive discussion of the risks and benefits of liver/kidney transplantation, including the additional risks associated with PVT, the patient consented to proceed.

Operative Technique

The patient was taken to the operating room for a combined liver/kidney transplantation using the bicaval technique standard at our institution. The hepatectomy dissection was completed without significant bleeding, and the vena cava was left in continuity and unclamped while the portal thrombectomy was performed. Dense adhesions from the prior colectomy were noted in the lower abdomen with a moderate degree of varices from portal hypertension. Dissection of the mesentery for access to the SMV was prohibitive, making TEV the best approach to restore portal inflow. Vascular clamps were placed proximally and distally, and the portal vein was transected high in the hilum. Dense, chronic thrombus was meticulously dissected circumferentially with eversion of the vein wall down to the level of the proximal clamp at the level of the pancreas. The vein wall was thin and attenuated, and the peripancreatic tissue was dense and fibrotic from chronic inflammation. The dissected portion of the thrombus was secured with a Kelly clamp. After appropriate communication with the anesthesia team, the proximal portal vein clamp was released, and the Kelly clamp was carefully advanced into the retropancreatic portion of the portal vein. Portal flow was restored after extraction of the thrombus. After replacing the proximal portal vein clamp, profuse bleeding was noted at an avulsion in the portal vein behind the clamp at the level of the pancreas. Attempts at primary repair were unsuccessful because of limited exposure, bleeding, and the friable vein wall. The hemorrhage was controlled with finger compression of the retropancreatic portal vein to allow for resuscitation and preparation for definitive repair.

Balloon-Occlusion Technique

At the start of the operation during back-table preparations of the liver, a segment of donor iliac vein was prepared in anticipation of a possible need for a portal vein bypass. After testing for leaks, a 4 French Fogarty balloon occlusion catheter was advanced through the conduit and placed on the operative field (Figure 2). Alternatively, others have described the use of a Foley urinary catheter in place of a vascular occlusion catheter.[13] Typically after thrombectomy, the patent lumen of the portal vein is relatively small and easily occluded by a vascular occlusion catheter that allows for more precise control and reduces the risk of further injury

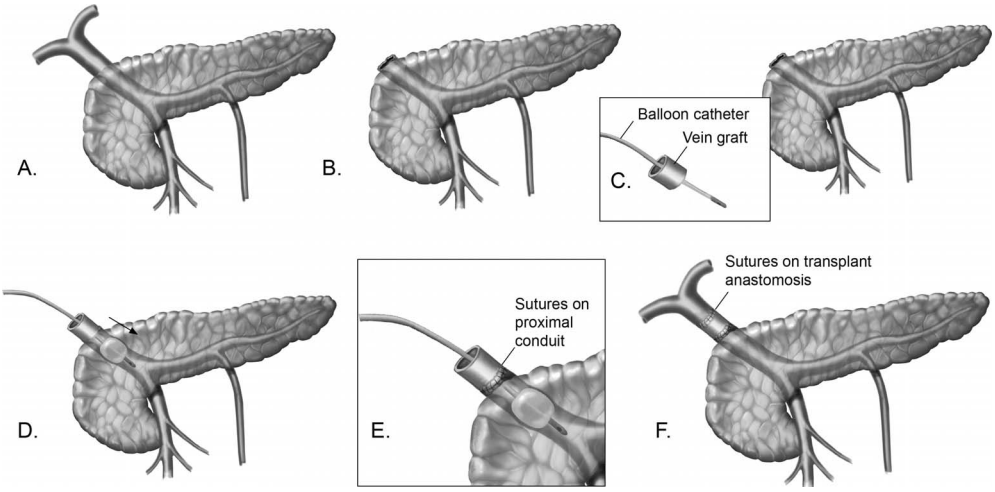

Figure 2. Balloon-occlusion technique for portal vein repair and reconstruction. A. Normal anatomy demonstrating the confluence of the splenic and superior mesenteric veins posterior to the pancreas. B. Transection of the recipient portal vein at the level of the pancreas. C. Preparation of the balloon-occlusion catheter with iliac vein conduit. D. Position of occlusion balloon within the portal vein. E. Anastomosis of the vein conduit to the recipient portal vein. F. Anastomosis of the portal vein on the donor liver to the portal vein conduit.

to the vessel with the application of conventional vascular clamps. After adequate resuscitation and in communication with the anesthesia team, manual occlusion of the portal vein was partially released, and the Fogarty catheter was advanced several centimeters into the portal vein lumen. The balloon was inflated to resistance, and manual compression was released. With occlusion of the portal vein lumen, bleeding was controlled to achieve excellent exposure of the portal vein orifice. A tear in the posterior aspect of the portal vein was identified and carefully repaired with 6-0 PROLENE suture (Ethicon US, LLC). The portal vein was almost completely avulsed at the level of the fibrotic tissue surrounding the pancreas. The vascular conduit was advanced along the catheter and sutured to the portal vein, incorporating surrounding fibrotic tissue to buttress the anastomosis. The distal end of the conduit was occluded, and the balloon was deflated to test inflow and assess bleeding. After confirming adequate hemostasis, the Fogarty catheter was removed, and a vascular clamp was placed at the end of the conduit. The remainder of the transplant was uneventful with standard reconstruction of the portal vein to the recipient portal vein conduit. Because of the risk of bleeding associated with the complex dissection, heparin anticoagulation was not used in the immediate postoperative period. On the second postoperative day, the patient was started on 325 mg aspirin in accordance with our standard posttransplant protocol.

After more than 2 years of follow-up, the patient is alive with a functioning graft, and his most recent imaging demonstrated a patent portal vein without recurrent PVT. The renal allograft recovered from a short period of delayed graft function, and the patient was still off hemodialysis at his most recent follow-up.

DISCUSSION

Successful management of PVT in liver transplantation requires a wide complement of technical skills and reconstruction techniques. Preoperative assessment and planning are essential to ensure preparedness in the operating room. Many centers use a multidisciplinary conference with expert radiologists and surgeons to assess the extent of PVT and determine operative strategy and candidacy for liver transplantation. For patients maintained for several months on the wait list, routine surveillance may be necessary to determine the progression or development of PVT. To date, the evidence is mixed and the practice is variable with respect to the use of anticoagulation to prevent PVT extension and promote recanalization, but anticoagulation therapy does not significantly impact the approach to surgical management.

Portal vein injury is a known potential complication during liver transplantation, especially with TEV. Controlling hemorrhage and repairing injury to the vein can be challenging. The balloon-occlusion technique is an important tool for managing this life-threatening complication when it occurs. Conventional vascular control with clamps is often ineffective because of limited exposure and an attenuated vessel wall that is susceptible to injury. The balloon catheter occlusion allows for control of inflow without traumatizing the vessel and affords unencumbered exposure for repair and reconstruction. The use of a conduit offers several advantages compared to direct anastomosis to the donor portal vein. First, the conduit can be sutured to the recipient portal vein free of tension and with optimal exposure to ensure a quality anastomosis. Second, with distal control of the conduit, the integrity of the proximal anastomosis and any vein repairs can be assessed with the balloon catheter in place to control potential bleeding and allow for additional repairs. Finally, the conduit creates a straightforward setup for the portal vein anastomosis, limiting prolongation of warm ischemia during implantation.

CONCLUSION

Although rarely used, the balloon catheter occlusion can be a potentially life-saving technique after portal vein injury. Emerging endovascular treatment of PVT prior to transplan-

tation may provide an additional option in the future, avoiding the potential complications of TEV. At present, PVT remains a significant technical challenge that requires a thoughtful approach to operative management prior to transplantation to ensure appropriate resources are available at the time of transplant.

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