How I do it: Utilization of the remnant umbilical vein for restoration of embryological liver vascular supply following iatrogenic embolization of the bilateral portal vein branches

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Problem
Portal vein embolization (PVE) is increasingly used to produce appreciable liver hyperplasia and enable a pathway to curative operation in patients with otherwise borderline hepatic parenchymal mass [1]. With improvements in radiologic and interventional techniques, some large studies report using PVE in up to 63% of patients with metastatic liver disease [2]. In the context of perihilar cholangiocarcinoma, portal vein resection decreases perioperative mortality from 16% to 2% secondary to a decrease in the liver failure rate from 19% to 4% [3]. Response to PVE can also be helpful for prognostication, with one study showing that patients with a kinetic growth rate of greater than 2.66% per week do not experience post-operative liver failure [4].

While the rate of minor complications (fever, bile leak, pain or nausea) can occur in up to 12% of patients, major complications such as haemorrhage or thrombus propagation are exceedingly rare (<1%) [5]. In two patients of a series of 188 undergoing PVE, inadvertent embolization of the contralateral portal vein was
described [6]. Reconstruction for extensive bilateral occlusion of the portal vein has not been described previously, and mortality secondary to fulminant liver failure was thought inevitable.

**Solution**

In this paper, we describe a novel reconstructive method for restoring blood flow to the liver, by utilizing the remnant umbilical vein, following the inadvertent embolization of the left portal vein for liver malignancy. Utilization of this vessel does not require the additional dissection or exposure of other body regions and avoids highly morbid complications associated with prosthetic material. Furthermore, it enables the restoration of blood flow to the liver in the context of extensive bilateral occlusion of the portal vein, a solution to this fatal problem that has not been previously described.

**Surgical Technique**

The indication for PVE was cholangiocarcinoma at the confluence of the right anterior, right posterior and left intra-hepatic ducts, with an estimated functional liver remnant of 23% following extended right hepatectomy. At the time of the right portal vein embolization, imaging showed near occlusive and extensive propagation of embolization material into the left portal vein. The patient was taken to theatre immediately, and surgical care was performed in the operating room utilizing anaesthetic care according to our institutional protocol. A midline laparotomy was performed, the ligamentum teres was identified, and the obliterated umbilical vein was exposed via dissection. Recanalization of the obliterated umbilical vein was achieved with successive dilation from 1mm to 5mm until backflow was obtained (see Figure 1). The distal umbilical vein was then anastomosed in a side-to-side fashion utilizing 6-0 interrupted prolene to the extrahepatic portal vein (see Figure 2). Finally, the proximal portal vein was transected with a vascular stapler, ensuring all portal blood flow to the liver was via the remnant umbilical vein (see Figure 3).

**Results**

A nonocclusive thrombus was identified on the second post-operative day, and the patient returned to theatre for an open thrombectomy utilizing size 4 and 5 thrombectomy catheters. Clopidogrel and heparin were utilized in the immediate post-operative period, and re-occlusion did not occur. The patient maintained normal synthetic liver function (albumin, international normalized ratios) throughout their post-operative course. There was no evidence of metastatic disease at the time of staging laparoscopy, cytology was negative and PET scan showed no disease. However, at the time of the relook laparotomy, scarring between loops of small bowel was biopsied which unfortunately confirmed metastatic adenocarcinoma on histopathological review. The patient remains well at 6 months and was managed with metallic biliary stent and referral to oncology for consideration of chemotherapy.

**Discussion**

Bilateral portal vein occlusion due to the migration of embolic material is a rare but devastating complication of portal vein embolization, and no previous work has described a solution to this problem [6]. A single study describes the utilization of the remnant umbilical vein for access for thrombectomy and thrombolysis of the main portal vein in the case of thrombosis following PVE [7].

Other reconstructive models for the portal vein have been described utilizing interposition grafts (autologous, donor or synthetic) [8]. Portal vein reconstruction is utilized in pancreaticoduodenectomy [9] and living-related liver transplantations associated with size mismatch [10]. Novel solutions include using an interposition graft of the superficial femoral vein, internal jugular vein [8], gonadal or inferior mesenteric vein or synthetic PTFE [8]. Complications of interposition grafts include thrombosis, stenosis and rarely fatal rupture [9]. The use of the umbilical vein for the reconstruction of the middle hepatic vein [11] in living related liver transplantation and saphenofemoral bypass surgery has been described previously [12].

In the context of an extensive bilateral portal vein occlusion, however, options for anastomotic sites and reconstruction are limited. Utilization of the embryological bridge between the remnant umbilical vein and the left hepatic vein [13] is a novel solution for restoring hepatic blood flow and preventing fulminant
ischemic liver failure. Given the proximity of this remnant vein to the operative field, the restoration of the embryologic pathway remains an elegant means to prevent death from ischemic hepatopathy. We hope other surgeons reading this work will consider using this novel solution to improve survival and quality of life in patients with malignant liver disease.

**References**


**Figures**

Figure 1. Remnant umbilical vein post dissection and dilation with re-established back bleeding.
Figure 2. Side-to-side anastomosis of the umbilical vein with the extrahepatic portal vein (marked with a blue loop)
Figure 3. Anastomosis of remnant umbilical vein and portal vein following transection of the distal extra-hepatic portal vein