Hepatobiliary & Pancreatic Diseases International xxx (xxxx) xxx

Contents lists available at ScienceDirect

Hepatobiliary & Pancreatic Diseases International

journal homepage: www.elsevier.com/locate/hbpd

Original Article/Liver

# Meso-Rex bypass for the management of extrahepatic portal vein obstruction in adults (with video)

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ARTICLE INFO

*Article history:*
Received 26 January 2021
Accepted 2 August 2021
Available online xxx

*Keywords:*
Meso-Rex bypass
Extrahepatic portal vein obstruction
Extrahepatic portal hypertension
Portal vein thrombosis
Surgical procedure

ABSTRACT

*Background:* Extrahepatic portal vein obstruction (EHPVO) results in severe portal hypertension (PHT) leading to severely compromised quality of life. Often, pharmacological and endoscopic management are unable to solve this problem. Restoring hepatic portal flow using meso-Rex bypass (MRB) may solve it. This procedure, uncommon in adult patients, is considered the treatment of choice for EHPVO in children.
*Methods:* From 1997 to 2018, 8 male and 6 female adults, with a median age of 51 years (range 22–66) underwent MRB procedure for EHPVO at the University Hospitals Saint-Luc in Brussels, Belgium. Symptoms of PHT were life altering in all but one patient and consisted of repetitive gastro-intestinal bleedings, sepsis due to portal biliopathy, and/or severe abdominal discomfort. The surgical technique consisted in interposition of a free venous graft or of a prosthetic graft between the superior mesenteric vein and the Rex recess of the left portal vein.
*Results:* Median operative time was 500 min (range 300–730). Median follow-up duration was 22 months (range 2–169). One patient died due to hemorrhagic shock following percutaneous transluminal intervention for early graft thrombosis. Major morbidity, defined as Clavien-Dindo score ≥ III, was 35.7% (5/14). Shunt patency at last follow-up was 64.3% (9/14): 85.7% (6/7) of pure venous grafts and only 42.9% (3/7) of prosthetic graft. Symptom relief was achieved in 85.7% (12/14) who became asymptomatic after MRB.
*Conclusions:* Adult EHPVO represents a difficult clinical condition that leads to severely compromised quality of life and possible life-threatening complications. In such patients, MRB represents the only and last resort to restore physiological portal vein flow. Although successful in a majority of patients, this procedure is associated with major morbidity and mortality and should be done in tertiary centers experienced with vascular liver surgery to get the best results.


## Introduction

Extrahepatic portal vein obstruction (EHPVO) is a vascular disorder of the liver, defined by obstruction of the extrahepatic portal vein regardless of intra-hepatic portal branches, splenic or superior mesenteric veins. Portal vein obstruction associated with chronic liver disease or neoplasia is a separate entity [1]. EHPVO is the second cause of portal hypertension (PHT) in the Western countries after cirrhosis [2]. EHPVO is usually diagnosed by demonstrating a portal cavernoma at ultrasonography in the absence of cirrhosis or chronic liver disease [3]. Knowledge concerning prevalence and incidence of EHPVO is limited due to its infrequency and tremendous variation in epidemiologic studies [4].

In children, EHPVO is supposedly attributed to fibrosis and phlebo-sclerosis following infection, such as omphalitis or umbilical vein phlebitis caused by cannulation. Congenital anomalies or thrombophilia rarely account for pediatric EHPVO. Yet, in the majority of children, the etiology remains mostly unclear [1].

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https://doi.org/10.1016/j.hbpd.2021.08.003
1499-3872/

Please cite this article as: M. Brichard, S. Iesari, J. Lerut et al., Meso-Rex bypass for the management of extrahepatic portal vein obstruction in adults (with video), Hepatobiliary & Pancreatic Diseases International, https://doi.org/10.1016/j.hbpd.2021.08.003

The meso-Rex bypass (MRB) is considered the treatment of choice in the management of pediatric EHPVO [1,5]. This procedure restores physiological portal flow by decompressing the splanchnic venous system via the superior mesenteric vein (SMV) into the left branch of the portal vein (LPV) using autologous vein graft, typically the left internal jugular vein. The technique was originally described in 1992 by de Ville de Goyet for the treatment of EHPVO after liver transplantation and has since been successfully used to treat non-transplant recipients with thrombosis due to other etiologies [5–7].

In adults, however, underlying hypercoagulable and prothrombotic states are commonly reported as the main etiological factors, with either acquired myeloproliferative neoplasms or inherited systemic thrombophilia. Latent myeloproliferative disorders at the time of diagnosis frequently evolve into overt myeloproliferative neoplasms over time [2]. Local precipitating factors of EHPVO include intra-abdominal inflammation, abdominal infection, abdominal surgery or trauma history. A significant number of cases present with multiple risk factors [8].

In adult EHPVO, beta-blockers, endoscopic management, and interventional radiological management remain the first line treatment for gastrointestinal bleeding related to PHT [4,8]. However, results are ephemeral since the underlying cause of PHT remains unresolved. Consequently, the quality of life is typically compromised by multiple hospitalizations, iron-deficiency anemia and need for multiple transfusions [9,10]. This contrasts with the "surgery first" approach in pediatric EHPVO.

Given the possible coexistence with thrombophilia, extensive investigation of prothrombotic disorders is recommended in adult EHPVO, and adequate treatment of the underlying causes should ensue [11]. The Baveno VI consensus and current guidelines support indefinite anticoagulation in patients with EHPVO, according to the underlying prothrombotic risks [3,4]. Since the major complication of EHPVO is gastrointestinal bleeding, this approach raises the question of the benefit-risk ratio of anticoagulation in patients prone both to thrombosis from thrombophilia and to bleeding from PHT. While anticoagulation in these patients appears not to increase incidence and severity of bleeding, prospective and properly powered studies are still needed [4,8].

We report a single-center experience about 14 adults with EHPVO who underwent MRB, aiming to explore and define feasibility and outcomes of the procedure.

## Methods

This retrospective observational study of case series included 13 patients with symptomatic EHPVO and one patient with asymptomatic EHPVO who underwent MRB between March 1997 and November 2018 at the University Hospitals Saint-Luc in Brussels, Belgium (Table 1). This study was approved by the local ethics committee (CEHF 2020/22JUL/374).

Median age at the time of surgery was 51 years (range 22–66). There were 8 male and 6 female patients. Median body mass index was 22.7 kg/m$^2$ (range 14.2–39.5). All but one patient showed symptomatic EHPVO with severe abdominal discomfort due to ascites, splenomegaly and hypersplenism (8 patients), life-threatening refractory gastrointestinal bleeding (13 patients), portal biliopathy responsible for bacterial and fungal sepsis (3 patients), or a combination of those. One patient presenting asymptomatic EHPVO early after liver transplantation underwent preemptive MRB in an effort to preserve the liver graft function.

The etiologies of EHPVO were previous hepatic surgery-orthotopic liver transplant (3 patients), pancreatic surgery (4 patients), inflammatory intra-abdominal conditions (3 patients), inherited or acquired prothrombotic disorders (4 patients), abdominal trauma (1 patient), or a combination of these. In one case of idiopathic EHPVO, no cause was found.

Out of the three patients with a history of liver transplantation, two presented with chronic EHPVO and portal cavernoma straightaway. Prior Doppler ultrasound screening showed physiological portal vein flow. The third patient showed early acute EHPVO one month after surgery. An attempt of portal vein revascularization by interventional radiology failed before considering surgery. All other patients presented with chronic EHPVO, defined as EHPVO present for more than 28 days from the beginning of symptoms and/or presence of portal cavernoma [12].

The median delay between EHPVO diagnosis and surgical management was 18 months (range 4–147), and was based on symptom tolerance.

The preoperative work-up consisted of hepatic vein catheterization and transvenous liver biopsy to exclude an underlying liver disease, which is a formal contraindication to MRB. Liver biopsy showed non fibrotic, non steatotic liver tissue in all patients. The patency of LPV and SMV was assessed through computed tomography angiography and percutaneous portography. In all cases the patency of the intrahepatic portal veins was confirmed (Fig. 1).

The management algorithm for EHPVO in force in our institution is shown in Fig. 2.

The surgical procedure was performed as described by de Ville de Goyet in 1992, modified if needed, depending on patient's anatomy (Fig. 3) [7]. First, the Rex recess was accessed between segments III and IV, within the umbilical fissure, in direct continuation of the round ligament. If present, the hepatic parenchymal bridge between segment III and IV was opened. The LPV was isolated with selective ligation of the small branches to segments III and IV and clamping of bigger branches with suture ties (Blalock-type clamping). LPV dissection stopped when the branching for segment II and the left portal trunk were identified, allowing an exposure of 3 to 4 cm in length for the future anastomosis. Next, the SMV was accessed in the mesenteric root and a transmesocolic tunnel through the transverse mesocolon was made. Third, depending on availability and the anatomical intraoperative findings, either a free autologous graft was procured, or venous allograft or synthetic graft was prepared on a case-by-case basis. Patient's anatomy and surgical history steered the choice. We used an autologous vein in three patients and a cadaveric iliac vein in four cases. The autologous conduit was the left internal jugular vein in two cases, and the right femoral vein in one case. In seven patients, we needed a polytetrafluoroethylene (PTFE) graft (GORE-TEX®, Gore, Flagstaff, AZ, US) to overcome the gap length between LPV and SMV. In the first three cases, a synthetic graft alone was used. In the last four cases, a composite graft was used consisting of a prosthetic graft prolonged in both ends with a patch of allo- or autologous vein, to buffer vascular resistance between the fragile varicose vein and the stiff synthetic graft (Fig. 4). Finally, the bypass anastomoses were performed. An anterior venotomy was performed on the SMV after lateral clamping and an end-to-side anastomosis was performed in two running half-sutures using non-absorbable monofilament. The graft was then placed through the transmesocolic tunnel. Attention must be paid to avoid any torsion, kinking or twisting of the bypass. After lateral clamping of LPV, a vertical venotomy was made on the ventral aspect of the Rex recess, and the proximal end-to-side anastomosis was then performed as above (Video S1, which demonstrated complete MRB technique using cryopreserved cadaveric iliac vein). Patency and adequacy of the bypass were double-checked by intraoperative ultrasound and direct measure of portal pressure.

Postoperative anticoagulation consisted of low molecular weight heparin for six weeks, or vitamin K antagonists for three to six months, or directly acting oral anticoagulants, or acetylsalicylic acid only (Table 2).

**Table 1**
Patients characteristics.

| Patient | Age (yr) | Sex | BMI (kg/m$^2$) | Etiology | Time since initial surgery (mon) | Symptoms | Time between diagnosis and surgery (mon) |
|---|---|---|---|---|---|---|---|
| 1 | 40 | M | 29.6 | Idiopathic | - | Biliopathy, splenomegaly | 17 |
| 2 | 56 | M | 19.3 | Orthotopic liver transplantation | 48 | Biliopathy, splenomegaly | 27 |
| 3 | 24 | M | 16.4 | Orthotopic liver transplantation | 10 | - | 5 |
| 4 | 33 | F | 22.9 | Heterozygous *F-II* mutation | - | Hematemesis, melena, splenomegaly | 141 |
| 5 | 54 | M | 24.8 | Cephalic duodeno-pancreatectomy | 1 | Ascites, melena | 6 |
| 6 | 64 | F | 15.9 | Chronic calcifying pancreatitis, pancreatico-duodenal derivation | 372 | Hematemesis, melena | 10 |
| 7 | 65 | M | 22.4 | Chronic calcifying pancreatitis, *JAK2* mutation (1%) | - | Ascites, melena | 147 |
| 8 | 59 | F | 23.1 | Orthotopic liver transplantation | 1 | Ascites, splenomegaly, undernutrition | 18 |
| 9 | 39 | M | 20.6 | Total pancreatectomy (with portal vein reconstruction) | 6 | Hematemesis, melena | 4 |
| 10 | 22 | M | 20.7 | Liver trauma (AAST grade IV) (with portal vein suture) | 1 | Splenomegaly | 14 |
| 11 | 48 | F | 39.5 | *F-V Leyden* mutation, oral contraception | - | Biliopathy | 43 |
| 12 | 66 | F | 33.7 | Ulcerative colitis | - | Melena | 71 |
| 13 | 33 | M | 23.0 | *AT-III* mutation | - | Melena, hematemesis, splenomegaly | 129 |
| 14 | 65 | F | 14.2 | Cephalic duodeno-pancreatectomy (with portal vein reconstruction) | 39 | Hematemesis, melena | 10 |

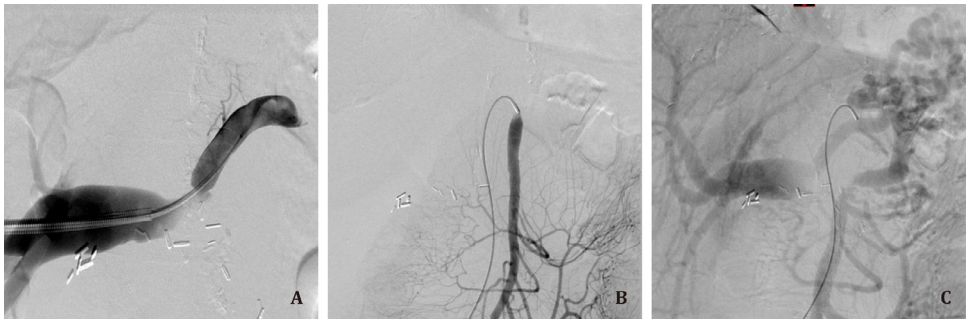


**Fig. 1.** Preoperative work-up confirming intrahepatic portal veins and superior mesenteric vein patency. **A:** Percutaneous intrahepatic portography confirming left portal vein patency. Percutaneous angiography with opacification of superior mesenteric artery (**B**), confirming superior mesenteric vein patency after splanchnic circulation (**C**).

Patients were followed up after surgery using Doppler ultrasonography and computed tomography angiography (Fig. 5).

## Results

Patients' characteristics are summarized in Table 2. The median operative time was 500 min (range 300–730) with no intraoperative mortality. Surgery was usually well tolerated, with a median stay in intensive care unit (ICU) of 1 day (range 1–4) and a median length of stay in hospital of 11 days (range 6–41).

Five patients (35.7%) suffered from major postoperative morbidity (Clavien-Dindo $\geq$ III) [13]. One patient died on postoperative day (POD) 3. He presented early occlusion of the bypass, treated by percutaneous ballooning and stenting. Immediately after the radiological procedure, the patient developed massive bleeding and multiorgan failure, due to a hepatic artery lesion, and subsequently died despite resuscitation attempt. One patient with obstructive lung disease needed readmission to ICU for severe pneumopathy. One patient showed early thrombosis of the MRB at routine Doppler ultrasonography on POD 7, successfully treated by percutaneous transhepatic revascularization with thrombectomy and stenting using stent graft by interventional radiology (Fig. 6). The bypass was still patent at the last follow-up. One patient underwent explorative laparotomy on POD 23, after signs of persistent infection and imaging of intra-abdominal infected hematoma. After wash-up and drainage of the abdominal cavity, the postoperative course was simple. One patient was readmitted on POD 8 for intestinal obstruction managed by surgical adhesiolysis. One patient was readmitted on POD 36 for sepsis of abdominal origin. He had history of local infection after endoscopic sclerotherapy for oesophageal varices six months prior to his MRB procedure, treated by antibiotics. During the MRB procedure, the infected site was debrided and cleaned and a composite synthetic-venous graft was implanted. At readmission, this graft was shown to be infected, and was successfully treated with negative pressure wound therapy. The bypass was still patent at the last follow-up.

The postoperative evolution of all patients is displayed in Table 3. After a median follow-up of 22 months (range 2–169), graft thrombosis occurred in 5/7 (71.4%) PTFE grafts vs. 1/7 (14.3%) biological conduits (Fisher's $P = 0.103$). Bypass occlusion occurred after a median of 15 months (range 2–169). In one patient, a successful percutaneous stenting of MRB was done for shunt stenosis

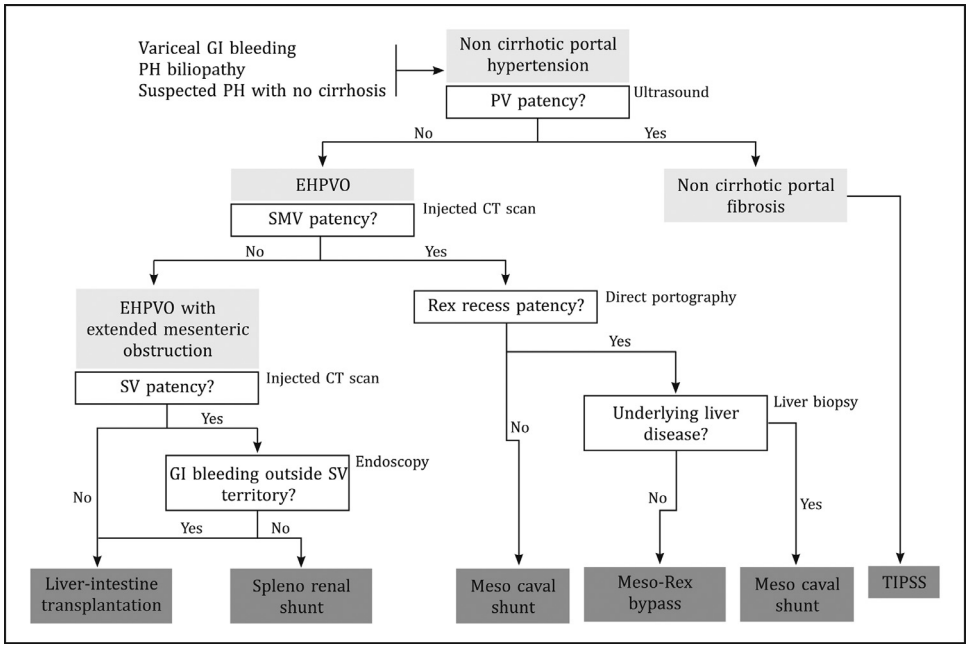


**Fig. 2.** Chronic EHPVO management flow chart. We consider for surgery patients with chronic EHPVO, *i.e.* diagnosed more than 28 days after the beginning of symptoms or cavernomatous transformation of the portal vein, or with acute EHPVO after failed percutaneous revascularization. Our standard surgical treatment consists in the surgical derivation described in the methods section. In case of contraindications to meso-Rex bypass, *i.e.* the presence of an underlying liver disease or an occlusion of LPV or SMV, patients undergo portosystemic shunt with either meso-caval or spleno-renal shunt, depending on pre- and intra-operative findings. EHPVO: extrahepatic portal vein obstruction; GI: gastro-intestinal; PH: portal hypertension; PV: portal vein; SMV: superior mesenteric vein; SV: splenic vein; TIPSS: trans-jugular intrahepatic portosystemic shunt; LPV: left branch of the portal vein.

**Table 2**
Perioperative data.

| Patient | Graft type | Operative time (min) | Length of ICU stay (d) | Length of hospital stay (d) | Clavien-Dindo classification (grade) | Complications | Anticoagulation regimen (duration) | 30-day readmission | Mortality |
|---|---|---|---|---|---|---|---|---|---|
| 1 | PTFE | 480 | 1 | 20 | III | Shunt obstruction requiring PTI (POD7) | VKA (6 mon), persantine (3 years), ASA | - | - |
| 2 | PTFE | 540 | - | 18 | II | Pneumopathy (POD3), clostridium colitis (POD7) | VKA (3 mon) | - | - |
| 3 | PTFE | 315 | - | 6 | III | - | VKA (3 mon), ASA | Surgery for intestinal obstruction (POD 8) | - |
| 4 | IJV | 300 | 1 | 9 | 0 | - | Persantine | - | - |
| 5 | IJV | 390 | 1 | 8 | I | - | ASA | - | - |
| 6 | IJV + PTFE | 510 | 1 | 17 | IV | Pneumopathy | LMWH (6 weeks), ASA | - | - |
| 7 | PTFE + CV | NF | 3 | 24 | 0 | - | LMWH (6 weeks), ASA | Sepsis (POD 36) | - |
| 8 | IJV + PTFE + CV | 500 | 4 | - | V | Shunt obstruction requiring PTI (POD 3), hemoperitoneum and hemorrhagic shock following RHA injury during PTI (POD 3) | LMWH | - | POD 3 |
| 9 | CV | 450 | 1 | 41 | III | Hemoperitoneum requiring surgery, no active bleeding found (POD 23) | - | - | - |
| 10 | PTFE + IJV | 540 | 1 | 6 | 0 | - | LMWH (6 weeks), ASA | - | - |
| 11 | CV | 515 | 1 | 9 | I | Sepsis (POD 2) | DOAC (prior to surgery) | - | - |
| 12 | CV | 620 | 3 | 11 | I | Pneumopathy | ASA | - | - |
| 13 | FV | 730 | 1 | 15 | I | Ileus | DOAC (prior to surgery) | - | - |
| 14 | CCV | 320 | 1 | 7 | 0 | - | LMWH (6 weeks) | - | - |

CCV: cryopreserved cadaveric iliac vein; CV: cadaveric iliac vein; IJV: internal jugular vein; PTFE: polytetrafluoroethylene; FV: femoral vein; NF: not found; POD: postoperative day; PTI: percutaneous transluminal intervention by interventional radiology; RHA: right hepatic artery; ASA: acetylsalicylic acid; DOAC; direct oral anticoagulant; LMWH: low molecular weight heparin; VKA: vitamin K antagonist.

**Table 3**
Long-term outcome.

| Patient | Follow-up period (mon) | Shunt reintervention | Shunt patency at last follow-up | Hemorrhagic event recurrence |
|---|---|---|---|---|
| 1 | 161 | - | Patent | None |
| 2 | 167 | - | Patent | None |
| 3 | 169 | - | Occluded | None |
| 4 | 149 | - | Patent | None |
| 5 | 25 | - | Patent | None |
| 6 | 22 | PTI failure for shunt stenosis (22 mon), shunt ablation for prosthetic-duodenal fistula (23 mon) | Occluded | None |
| 7 | 47 | Shunt infection treated by VAC therapy (26 mon) | Patent | Once (no origin found, no need for transfusion, no recurrence after) |
| 8 | - | PTI for shunt obstruction (POD 3) | - | - |
| 9 | 15 | PTI for shunt stenosis (3 mon) | Patent | Ulcerative gastro-jejunal anastomosis |
| 10 | 9 | PTI failure (9 mon) | Occluded | None |
| 11 | 2 | - | Occluded | None |
| 12 | 3 | - | Patent | None |
| 13 | 16 | - | Patent | None |
| 14 | 2 | - | Patent | None |

POD: postoperative day; PTI: percutaneous transluminal intervention by interventional radiology; VAC: vacuum-assisted closure.

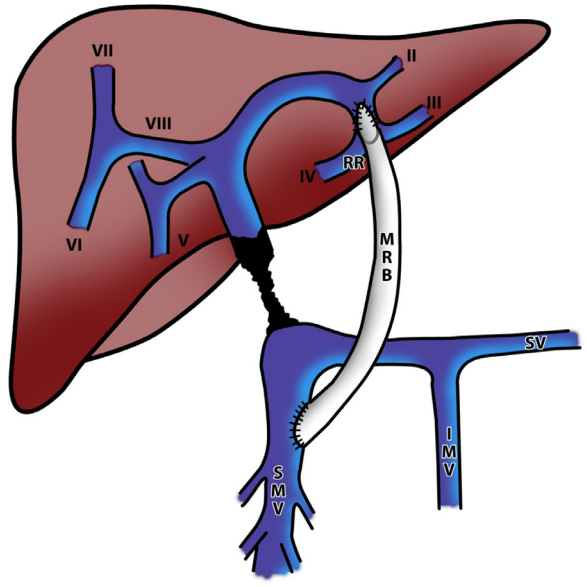


**Fig. 3.** Meso-Rex bypass between the superior mesenteric vein (SMV) and the Rex recess (RR) of the left portal vein. IMV: inferior mesenteric vein; MRB: meso-Rex bypass; RR: Rex recess of the left portal vein; SMV: superior mesenteric vein; SV: splenic vein.

three months after surgery. The bypass was still patent at the last follow-up. Nine out of the 14 MRBs (64.3%) were patent at the last follow-up.

All but two patients showed complete symptoms resolution with disappearance of gastrointestinal bleeding, ascites, and portal biliopathy. One patient presented a single episode of gastrointestinal bleeding two years after surgery. Work up did not identify any source of bleeding, and blood transfusion was not needed. No other episodes have recurred since. The second patient had history of total pancreatectomy and Child reconstruction. He suffered from bleeding from ulceration of the gastro-jejunal anastomosis. No patients showed postoperative encephalopathy.

## Discussion

Though etiologies of EHPVO are different between adults and children, its main consequences remain similar. Portal obstruction leads to PHT with subsequent development of portal cavernomas, portosystemic shunts, oesophageal varices, upper gastrointestinal bleeding, splenomegaly and hypersplenism [14]. Other morbidities include portal biliopathy, minimal hepatic encephalopathy, and eventually, parenchymal extinction [4,10,11].

Although it is unclear whether isolated EHPVO affects survival, which generally depends on the underlying disease, it is clear their quality of life is severely disturbed, mostly due to recurrent gastrointestinal bleeding or sepsis due to biliopathy [4,9–11,15].

Management of adults with EHPVO and preserved liver function remains controversial, and usually consists purely of symptomatic treatment. According to current recommendations, similar principles regarding the use of beta-blocker, endoscopic sclerotherapy or elastic banding in cirrhotic patients are applied in patients with EHPVO-related bleeding [4,8]. However, the natural history between cirrhotic and non-cirrhotic patients is divergent, and the management of EHPVO cannot be simply derived by observations in cirrhotic patients [16].

The indication for long-term anticoagulation in EHPVO patients, in the absence of thrombophilia, remains controversial and is based on expert opinion and retrospective series [3]. While no pharmacological treatment restores a physiological flow in the portal system, gastrointestinal bleeding and biliary sepsis are possibly underrated causes of fatal events and this reality pleads for a surgical approach.

In patients with recurrent bleeding or refractory ascites, transjugular intrahepatic portosystemic shunt (TIPSS) is a derivative technique that is valid for well selected cirrhotic patients but that has not yet been fully evaluated for EHPVO. However, this procedure creates an iatrogenic portosystemic shunt and is associated with multiple complications such as congestive cardiac failure, hepatic encephalopathy and TIPSS infection [17]. The recanalization of the portal vein using contemporary interventional radiology techniques seems promising. It has been recently shown that interventional radiology is successful in up to 50% of cases

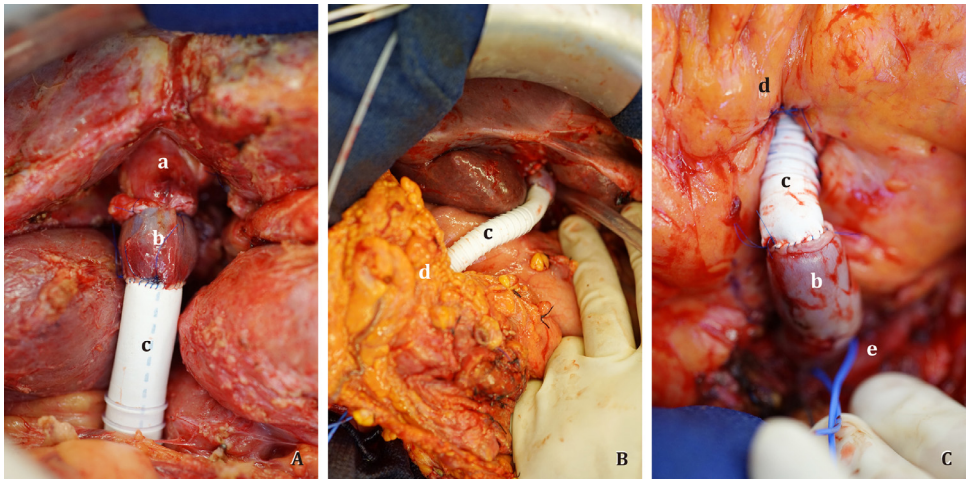


**Fig. 4.** Meso-Rex bypass with composite graft technique. a: Left branch of the portal vein in Rex recess; b: prolongation of the synthetic graft with a patch of autologous internal jugular vein; c: polytetrafluoroethylene (PTFE) conduit; d: trans-mesocolic tunnelization; e: superior mesenteric vein anastomosis.

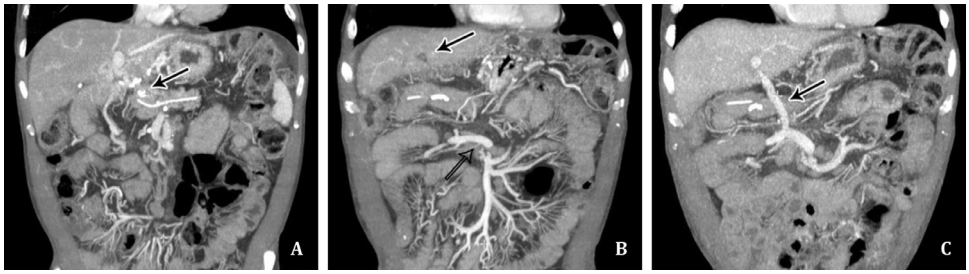


**Fig. 5.** Computed tomography before and after MRB procedure. **A:** Portal cavernoma (plain arrow) as seen before surgery; **B:** Rex recess of the left portal vein (plain arrow) and superior mesenteric vein (hollow arrow) as seen before surgery; **C:** meso-Rex bypass patency (plain arrow) at follow-up 6 months after surgery.

with acute EHPVO before cavernomatous transformation, in terms of portal vein recanalization [12]. Nonetheless, the role of portal vein recanalization in chronic EHPVO is not yet established, especially in long-term fibrotic occlusion [4,8].

Shunt surgery is traditionally reserved to selected patients who present with gastrointestinal bleeding, symptomatic portal biliopathy or severe hypersplenism unresponsive to medical/endoscopic treatments. Historically, surgical options included gastric devascularization, various selective and non-selective non-physiological shunts, and splenectomy.

On the other hand, the MRB procedure restores a physiological portal flow and normal hepatic perfusion. Furthermore, with this technique the dissection of liver hilum and portal cavernoma is avoided. This detail is noteworthy because most patients undergo supramesocolic surgery prior to EHPVO. Nevertheless, this procedure is rather unknown or judged too risky and too difficult by the general surgical community.

In the pediatric population, this paradigm shifted a couple of decades ago, with the advent of the MRB as the definitive treatment for EHPVO [5,18]. In the standard MRB technique in children, the procedure can be done without the use of prosthetic material and the internal jugular vein is used as a conduit between SMV and LPV. Unlike synthetic or allogeneic grafts, autologous conduits which grow with the child do not require prolonged anticoagulation, and have a low risk of secondary stenosis or thrombosis [19].

A number of alternative techniques have already been described in children using venous inflow via inferior mesenteric vein, coronary vein, or splenic vein with or without splenectomy [20–23]. The bypass itself can also be achieved throughout interposition of other conduits, such as autologous femoral vein, saphenous vein, or cadaveric iliac vein [18,21,24]. Some studies have also reported the use of recanalized umbilical vein in the round ligament to perform an end-to-end anastomosis and avoid a challenging end-to-side anastomosis on a hypoplastic portal left branch [25]. However, these conduits are fraught with a higher risk of thrombosis, presumably because of their small diameter, twisty shape, and subsequent risk of kinking [19].

In young adults, some studies have proposed the direct transposition of splanchnic vessels such as the coronary vein or inferior mesenteric vein without the need of a vascular conduit, as an alternative to MRB [22]. The use of recanalized umbilical vein as interposition grafts or vein patch has also been described in multiples hepato-pancreato-biliary procedures, including one modified MRB using the coronary vein [26]. Unfortunately, these approaches are largely impractical in adults because splanchnic vessels are often fragile, compromised by previous surgery, and not long enough.

Previous study has described the autologous saphenous vein as an alternative conduit in MRB to connect SMV and LPV for distances as long as 10 cm [18]. Cadaveric iliac veins are also a viable option. When matched for blood type, cadaveric veins have relatively low immunogenicity and there is no need for immunosuppression [9]. Synthetic grafts have been used when no biological options were available [6,27]. Few studies have evaluated the use of PTFE for portal bypass, which essentially is a separate entity from arterial and venous systemic bypasses. Concerns about the use of PTFE in the portal system are the risk of thrombosis due to low flow, and the risk of infection or fistula due to intra-abdominal location, risks confirmed by some limited evidence in the literature [28]. Despite the reduced sample size, our experience seemingly gravitates toward this hypothesis with 71.4% graft thrombosis in PTFE grafts. Another concern for the use of synthetic PTFE graft in the peritoneal cavity, is the potential erosion of ad-

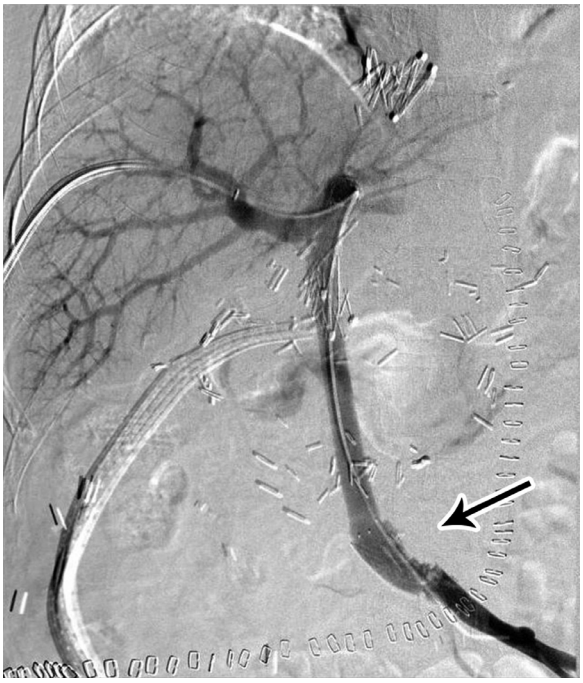

**Fig. 6.** Percutaneous phlebography after thrombectomy and stenting of proximal anastomosis stenosis (plain arrow) at POD7 showing complete portal revascularization.

jacent structures, mostly the duodenum, and the subsequent risk of graft thrombosis, infection, and digestive perforation or obstruction [29]. We observed indeed one case of prosthetic-duodenal fistula requiring shunt ablation 23 months after surgery. Based on our experience, we recommend avoiding synthetic graft altogether and prefer biological graft, *i.e.* autologous or deceased-donor vein.

Despite the lack of evidence regarding anticoagulation therapy after splanchnic vein reconstruction, the latest protocol in our institution included low molecular weight heparin for the early postoperative period, based on the etiopathology of EHPVO and the underlying prothrombotic risk. For patients with confirmed underlying thrombophilia, oral anticoagulation therapy was kept indefinitely.

Although it has been reported that in children long-term meso-Rex graft patency exceeds 90%, postoperative graft stenosis and thrombosis are an issue [30,31]. In this regard, percutaneous interventions, including ballooning and stent placement, have been proven to be effective on long-term venous graft patency and clinical resolution of symptoms in the majority of patients with anastomotic stenosis or thrombosis after MRB [32,33]. In our series, four patients underwent percutaneous intervention, two of whom had the shunt patency been restored. The only fatal event was massive hemorrhage following an arterial lesion caused by the percutaneous intervention.

Only few studies have evaluated the results of MRB for adult EHPVO. The first published adult case underwent MRB in 1995 for EHPVO due to idiopathic chronic pancreatitis. The patient had variceal bleeding and was treated with classical surgical decompression. This patient showed no signs of gastro-intestinal bleeding recurrence with 16-month follow-up [34]. Elnaggar et al. [35] demonstrated that significant liver regeneration was achieved after portal-flow preserving shunts, including MRB, in children and adult with EHPVO. They suggested that current surgical management of EHPVO should restore the hepatopetal portal flow, whenever feasible. Reichman et al. [9] described symptom relief after MRB procedure, in an adult patient experiencing EHPVO after Whipple procedure suffering from recurrent gastrointestinal bleeding.

As EHPVO patients have well-preserved liver function and, usually, less comorbidities, surgery could also be considered in these patients to prevent variceal bleeding, as already reported in the literature [36]. In our series, the vast majority of patients underwent shunt surgery after failure of endoscopic or medical treatment. Unfortunately, prospective study related to MRB for symptomatic adult EHPVO is hardly feasible due to the rarity of this condition. Still, a validation is warranted since long-term morbidity and mortality rates of medically treated EHPVO are unknown and the value of early surgical treatment for asymptomatic patients lingers unestablished.

In conclusion, we describe a series of MRB performed in 14 adults with EHPVO. Our experience shows that this procedure merits further attention of the liver experts community. Despite its surgical complexity, witnessed by major perioperative morbidity, this procedure can definitively relieve complications from PHT. Further refinement of the technique is desirable to improve outcomes. Improved selection criteria and use of venous auto- or allografts are the first steps in this direction. While a prospective comparison of this technique with current pharmacological management is still needed, MRB qualifies as a physiological portosystemic shunt and eliminates major life-altering complications of PHT.

## Acknowledgment

None.

## CRediT author contributions statement

**Martin Brichard:** Data curation, Formal analysis, Writing - original draft. **Samuele Iesari:** Formal analysis, Writing - review & editing. **Jan Lerut:** Writing - review & editing. **Raymond Reding:** Validation, Writing - review & editing. **Pierre Goffette:** Writing - review & editing. **Laurent Coubeau:** Conceptualization, Methodology, Supervision, Validation, Writing - review & editing.

## Funding

None.

## Ethical approval

This study was approved by the Ethics Committee of the University Hospitals Saint-Luc in Brussels (CEHF 2020/22JUL/374).

## Declaration of Competing interest

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

## Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.hbpd.2021.08.003.

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