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Preemptive VAE—An Important Tool for Managing Blood Loss in MVT Candidates With PMT

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Background. Explantation of native viscera in multivisceral transplant candidates, particularly in those with extensive portomesenteric thrombosis (PMT), carries considerable morbidity due to extensive vascularized adhesions. Preemptive visceral angioembolization has been previously described as a technique to minimize excessive blood loss during mobilization of the native viscera but is not well described specifically in patients with extensive PMT. **Methods.** In a series of 5 patients who underwent multivisceral transplant for PMT from June 2015 to November 2018, we performed preoperative superior mesenteric, splenic, and hepatic artery embolization to reduce blood loss during explanation and evaluated the blood loss and blood product utilization, as well as 30-day rates of infectious complications. **Results.** Following preemptive embolization, median total blood loss was 6000 mL (range 800–7000 mL). The median transfusion requirements were as follows: 16 units packed red blood cells (range 2–47), 14 units fresh frozen plasma (range 0–29), 2 units cryoprecipitate (range 1–14), 4 units platelets (range 2–10), and 500 mL cell saver autotransfusion (range 0–1817). In the first 30 postoperative days, 2 out of 5 patients developed positive blood cultures and 3 out of 5 developed complex intra-abdominal infections. Two patients developed severe graft pancreatitis resulting in mycotic aneurysm of the aortic conduit; bleeding from the aneurysm led to 1 patient mortality. **Conclusions.** Preoperative embolization is an effective modality to mitigate exsanguinating blood loss during multivisceral transplant in patients with portomesenteric thrombosis; however, it is unclear if the resultant native organ ischemia during explant carries clinically relevant consequences.

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INTRODUCTION

Abdominal organ explantation in multivisceral transplant (MVT) candidates is technically demanding and carries high morbidity. In patients with portomesenteric

thrombosis (PMT) and severe portal hypertension, collateralization results in highly vascularized adhesions and consequently high-volume blood loss during explanation of the native viscera. Visceral arterial embolization (VAE) has previously been described as an approach to reduce blood loss during dissection^{1–3}; however, few patients in prior case series had the pernicious combination of cirrhosis with extensive PMT and hostile abdomen.^{1–3}

In our experience, we have observed that a subset of MVT patients with PMT, high-MELD, and surgical adhesive disease have high-operative morbidity, given that both bleeding and scarring preclude rapid explantation of the native viscera. In 1 early case, a patient with cirrhosis, extensive PMT, severe portal hypertension, and multiple prior abdominal surgeries suffered profound blood loss (>19 L) during MVT (patient 6 in this series). Since then, our center considers elective VAE on an individual basis for MVT patients. Herein, we describe our selection criteria and outcomes within a series of 5 high-MELD PMT patients with concurrent extensive adhesive disease who underwent VAE.

MATERIALS AND METHODS

Between June 2015 and November 2018, 5 MVT candidates with complete portomesenteric thrombosis were identified who underwent VAE before or during transplant. One additional

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patient with extensive PMT who underwent MVT in 2013 *without* VAE was also included as a comparator (patient 6). Clinical characteristics, intraoperative variables (explant time, cold ischemia time [CIT], warm ischemia time, transfusion data, laboratory values), and outcome variables (graft survival, patient survival, and infectious complications) were collected retrospectively. This study was approved by the Institutional Review Board at Duke University Medical Center USA.

Embolization

All embolization procedures were performed by interventional radiologists after induction of anesthesia in a hybrid operating room. In brief, access was obtained via the right common femoral artery, and a microcatheter was used to access the splenic artery, common hepatic artery, gastroduodenal artery, and inferior pancreaticoduodenal artery to perform embolization. The superior mesenteric artery (SMA) was routinely cannulated with a 5 French 40 cm curved sheath to improve accessibility and to enable the potential for placement of a vascular plug (Amplatzer, St. Jude Medical, Santa Clara, CA). The choice of embolic material was at the discretion of the interventional radiologist; however, in 4 cases, the goal was for proximal occlusion of the target arteries, and, therefore, coils and vascular plugs were utilized, sometimes reinforced with liquid embolic or gelatin sponge particles. Embolization was performed until stasis of flow above the coils and plug was demonstrated angiographically.

Immunosuppression

All patients received induction therapy with rabbit antithymocyte globulin 1.5 mg/kg (ideal body weight) rounded to the nearest 25 mg, which was started in operating room and then continued every 24 hours for 4 days for a total dose of 6 mg/kg. The dose was adjusted for renal function and platelet count as needed during the first week after transplantation until therapeutic tacrolimus (FK) levels were achieved. They also received 500 mg of methylprednisolone intravenous intraoperatively. Postoperatively all patients were maintained on triple immunosuppression with tacrolimus (FK trough goal 15–20 ng/dL for the first month), mycophenolate mofetil, and steroid taper.

Perioperative Antimicrobials

The recipients received courses of Piperacillin-Tazobactam (4/0.5 g every 8 h) and fluconazole (400 mg once a day) for 14 days, starting with first dose at induction. Additional antimicrobial regimen was modified as needed based on preoperative plans, the estimated risk of infection, and prior sensitivities; Depending on the donor (D) and recipient (R) CMV status, all patients received postoperative CMV prophylaxis with gancyclovir or valgancyclovir for 6 months (D+/R–, D+/R+) or acyclovir for 3 months (D–/R–). *Pneumocystis jirovecii* prophylaxis was provided with trimethoprim-sulfamethoxazole (160 mg/800 mg 3 times a week) or pentamidine (150–300 mg inhaled once every 30 d) for 1 y, and thrush prophylaxis was provided with clotrimazole (1 troche twice a day) for 3 months starting after day 14. No gut decontamination was used for donor or recipient.

Statistical Analysis

All continuous variables are reported as number (n) (%) or the median with range.

RESULTS

Five patients underwent VAE during multivisceral transplantation for the indication of portomesenteric thrombosis. Patient 6 did not undergo VAE. The recipient and donor demographics are shown in Table 1. Among the 5 VAE recipients, the median recipient age was 44 (40–55) years; 60% were men. The median MELD score at the time of transplant was 26 (21–37). Four patients underwent a planned presurgery embolization. One patient had intraoperative embolization after initial attempts at explantation of the native viscera were met with heavy bleeding. The visceral arteries embolized included SMA (5/5), splenic artery (5/5), common hepatic artery (3/5), celiac axis (1/5), gastroduodenal artery (1/5), and inferior pancreaticoduodenal artery (1/5) (Table 2). Intraoperatively, we found good demarcation between the embolized and nonembolized bowel and there was no suspected complication or evidence of embolization material migration in any case.

Intraoperative data are shown in Table 3. For the VAE recipients, median total blood loss was 6000 (800–7000) mL and median transfusion requirements were as follows: 16 units packed red blood cells (range 2–47), 14 units fresh frozen plasma (range 0–29), 2 units cryoprecipitate (range 1–14), 4 units platelets (range 2–10), and 500 mL cell saver autotransfusion (range 0–1817, used in only 3/5 patients). Of note, for the sole patient who underwent intraoperative embolization, cell saver was used before embolization when blood loss was heavy and again only following reperfusion. In the other 2 patients, it was used during explantation only during periods of excess blood loss. Comparatively, Patient 6 suffered and estimated blood loss of 19.4 L and required 133 units of blood products during their case.

The overall median time from incision to explant in VAE recipients was 420 (198–490) minutes (including the patient who received intraoperative embolization). In patient 6, the explant time was not recorded; however, the case lasted 690 minutes, and explant of the native viscera was not performed until the very end of the case—in fact, due to the extent of blood loss, GI reconstruction was deferred in this patient due to coagulopathy, and the patient had a temporary tube ileostomy placed and was taken to the ICU with an open abdomen for further resuscitation before establishing GI continuity. Therefore, we estimate the explant time for this patient was between 630 and 690 minutes. To further evaluate the potential impact of visceral ischemia during the explant phase, we examined lactate levels preexplant, postexplant, and at the end of surgery. In VAE patients, the median lactate values were 4.1 (2.1–10.1), 5.8 (3.1–10.6), and 4.2 (2.4–6.3), respectively. By comparison, patient 6 had the highest postexplant lactate (12.3), which had increased and was above the laboratory detection limit of 15 at the conclusion of the case.

The recipient outcomes are shown in Table 4. In the first 30 days, 2/5 VAE patients developed positive blood cultures, and 3/5 developed abdominal infections. In the long term, all 5 VAE MVT recipients and patient 6 developed an infectious complication. Two VAE patients had nontuberculous mycobacterial infections detected at days 5 and 76 posttransplant in abdominal fluid and blood cultures, respectively. Two VAE patients developed severe graft pancreatitis, and both developed mycotic aneurysm of the donor aortic conduits; one of these patients died due to recurrent massive bleeding from

TABLE 1.**Recipient and donor demographics**

	Patient 1	Patient 2	Patient 3	Patient 4	Patient 5	Patient 6 (no VAE)
Recipient						
Age (y)	40	45	55	43	44	48
Sex	F	M	F	M	M	M
MELD	26	24	21	39	27	22
MVT indication	PMT, SBC	PMT, Idiopathic cirrhosis	PMT, HCV cirrhosis	PMT, BCS	Radiation enteritis, SBC, PMT	PMT
ESLD etiology	Sclerosing cholangitis ^a	Idiopathic	HCV	BCS	Radiation-induced biliary stricture	ETOH
Hypercoagulable pretransplant	No	AT-III deficiency, HH	No	JAK2 mutation	No	No
Surgical history	SBR, pancreatic necrosectomy	Ex-lap	Lap RYGB, CCY, C-section, UHR	None	L hepatectomy, SBR, GJ	Partial colectomy for colovesical fistula
Donor						
Age (y)	24	19	20	18	45	21
Sex	F	F	M	M	F	M
Ht(cm)/Wt(kg)/BMI	157/56.2/22.8	157.4/56.2/22.6	176/59/19	175/72/23.5	167.6/69/24.5	188 / 84 / 23.7
Cause of death	Anoxia	Head trauma	CVA	Head trauma	CVA	Head Trauma

^aSecondary to recurrent pancreatitis.

AT-III, antithrombin III; BCS, Budd-Chiari syndrome; BMI, body mass index; CCY, cholecystectomy; CVA, cerebrovascular accident or stroke; ESLD, end-stage liver disease; ETOH, ethyl alcohol; GJ, gastrojejunostomy; HCV, hepatitis C virus; HH, hyper-homocysteinemia; MELD, model for end-stage liver disease; MVT, multivisceral transplant; PMT, portomesenteric thrombosis; RYGB, Roux-en-Y gastric bypass; SBC, secondary biliary cirrhosis; SBR, small bowel resection; UHR, umbilical hernia repair; VAE, visceral artery embolization.

multiple sites along the remaining length of the aortic conduit after a prior excision and primary repair.

DISCUSSION

Multivisceral transplantation describes replacement of >1 abdominal organ during intestinal transplantation. Historically, numerous organ combinations have been described, including grafts containing stomach, pancreas, liver, colon, and kidney. In this series of MVT for patients with PMT, all patients underwent exenteration of upper abdominal viscera including native liver and pancreas, remnant small bowel, most of stomach (variable proximal remnant native gastric pouch), and colon to the level of the sigmoid colon followed by implantation of an en bloc graft containing at least liver, pancreas, and small intestine. Two patients out of 5 received stomach graft, 3 received colon, and 1 patient received kidney in addition to other abdominal organs.

Many patients undergoing intestine transplantation have dense intra-abdominal adhesions due to scarring from multiple previous surgeries or sequela of intra-abdominal infection, which obscure the dissection planes. The presence of PMT or severe portal hypertension predisposes these patients to form extensive collateral vasculature between adjacent viscera, the abdominal wall, and the retroperitoneum. Vascularization of these adhesions leads to abnormally dilated vessels encountered in unexpected places during dissection and makes the explant process tedious and prone to hemorrhage. One strategy previously reported is early dearterialization by clamping of the celiac axis and SMA at the beginning of the surgery to prevent blood loss⁶; however, it is not always feasible to gain rapid access to these vessels during laparotomy due to multiple adhesions and in some a frozen abdomen. In 1 such MVT candidate with PMT with portal hypertension related to cirrhosis at our center, we experienced high-volume blood loss (19L) during the explant phase for requiring massive blood product transfusion.

In 1994, the University of Pittsburgh reported 2 intraoperative patient deaths in patients undergoing attempted MVT due to massive bleeding during dissection of native organs.⁷ The same group described the use of preoperative VAE in 3 multivisceral transplant candidates with IVC and portal vein thrombosis in an attempt to reduce intraoperative hemorrhage and mortality. Despite this, however, the authors describe intraoperative mortality from hemorrhage even with the use of preoperative VAE.¹ Perhaps for this reason, VAE was not adopted as the standard of care for control of intraoperative bleeding for patients with portomesenteric thrombosis.

More recently, Ceulemans et al² reported 3 patients who underwent preoperative VAE with median transfusion requirements of 3 units (2–4) of PRBCs and peaked intraoperative lactate of 6.1 (5.1–7.6) mmol/L. In that series, however, 2 of the 3 recipients had a low MELD scores (MELD = 14, 12, and 32) and none had prior abdominal surgeries. The University of Miami hospital has recently published their experience with preoperative VAE in 3 patients with extensive PMT and MELD scores of 17, 20, and 26.³ Two patients were redo liver transplants and 1 had cryptogenic cirrhosis with a history of bowel resection. They had an explant time of 150–275 minutes and the PRBC requirement ranged from 29 to 97 units. This series reported 1 intraoperative mortality in a patient who developed disseminated intravascular coagulopathy and bleeding needing 97 units red cell transfusion. This particular patient had proximal SMA and celiac trunk embolization; however, on autopsy, the celiac plug was noted to have migrated into the GDA, thereby permitting blood flow to the liver and possibly leading to disseminated intravascular coagulopathy. The team then resorted to distal nonselective end branch embolization for the other 2 patients.

As such, our center first adopted preoperative embolization of the superior mesenteric, splenic, and hepatic arteries in 2015 in select patients to facilitate safe and more efficient explantation of the native viscera. Currently, we consider

TABLE 2.
Procedural data

	Patient 1	Patient 2	Patient 3	Patient 4	Patient 5	Patient 6 (no VAE)
VAE	Preoperative	Preoperative	Intraoperative	Preoperative	Preoperative	None
Vessels embolized	SMA SA GDA IPDA	SMA SA	SMA SA CHACA	SMA SA (incomplete) CHA	SMA SA CHA	None
Extent of embolization	Proximal	Proximal	Proximal	Proximal	Distal/parenchymal	N/a
Embolization material	Coils and plugs	Coils and plugs	Coils with glue	Coils with gel foam	Gelfoam only	N/a
Duration of VAE (min)	123	98	60	121	207	N/a
Organs explanted	Liver Pancreas Stomach (distal) Duodenum Small bowel Ascending colon Transverse colon Descending colon Spleen	Liver Pancreas Stomach (distal) Duodenum Small bowel Ascending colon Transverse colon Descending colon Spleen	Liver Pancreas Stomach (distal) Duodenum Small bowel Ascending colon Transverse colon Spleen	Liver Pancreas Stomach (distal) Duodenum Small bowel Ascending colon Transverse colon Descending colon Spleen	Liver Pancreas Stomach (distal) Duodenum Small bowel Ascending colon Transverse colon Descending colon	Liver Pancreas Stomach (distal) Duodenum Small bowel Spleen
Organs transplanted	Liver Pancreas Duodenum Small bowel	Liver Pancreas Duodenum Small bowel	Liver Pancreas Stomach Duodenum Small bowel Ascending colon Transverse colon, (proximal)	Liver Pancreas Duodenum Small bowel Ascending colon	Liver Pancreas Stomach Duodenum Small bowel Ascending colon	Liver Pancreas Duodenum Small bowel

CHA, common hepatic artery; GDA, gastroduodenal artery; IPDA, inferior pancreaticoduodenal artery; SA, splenic artery; SMA, superior mesenteric artery; VAE, visceral artery embolization.

preemptive VAE in MVT candidates with any of the following attributes:

1. Presence of total portomesenteric/splanchnic thrombosis
2. Anticipated difficult dissection
 - a. Extensive abdominal surgical history or frozen abdomen
 - b. Recurrent pancreatitis
 - c. History of irradiation

Although patients in our series have had generally high-MELD scores (range = 21–39), it is important to note that we do not consider high-MELD alone a criterion for preemptive VAE, given that MELD does not correlate with the degree of portal hypertension. More importantly, however, is that most of our patients had prior abdominal surgeries with extensive dense adhesions. For example, patient 1 had pretransplant recurrent pancreatic necrosis and patient 4 had markedly distorted anatomy due to a hypertrophied caudate secondary to Budd-Chiari syndrome. Despite preemptive VAE, patients in this series sustained substantial blood loss (median 6000 mL) and had high transfusion requirements (median 16 units PRBCs), albeit lower than historical recipients. This is similar to the transfusion requirement in the comparable cohort from Miami³ although due to the complex surgical profile of all our patients, we suspect we had a lengthier explant time (198–490 min).

Two cases from our series highlight the value of preemptive VAE in particular: in the lone patient who underwent intraoperative arterial embolization, there was markedly improved hemodynamic stability, decreased vasopressor requirement, and blood loss immediately following the embolization and during the remainder of the native visceral exenteration. Contrarily, in patient 4, incomplete occlusion of splanchnic arterial flow was noted preoperatively by the radiologist (due to technically

challenging vascular anatomy), and this patient had the largest transfusion requirement of any patient in this series (47 units PRBCs, 29 FFP, 14 cryoprecipitate, 10 platelets).

Despite the potential advantage in preemptive VAE, the approach may not be without consequence. It is possible that

TABLE 3.
Intraoperative data

	Patient 1	Patient 2	Patient 3	Patient 4	Patient 5	Patient 6 (no VAE)
Blood loss (mL)	6000	800	5000	6000	7000	19350
Transfusion						
PRBC	22	2	16	47	16	67
FFP	14	0	16	29	8	51
Cryoprecipitate	2	1	6	14	1	3
Platelets	4	2	3	10	2	12
Cell saver (mL)	0	699	500	1817	0	1080
Explant time (min)	420	315	432	198	490	630–690 ^a
CIT (min)	557	331	310	399	474	>540 ^b
WIT (min)	30	36	34	26	37	N/a
pH						
Preexplant	7.4	7.41	7.38	7.24	7.27	7.36
Postexplant	7.33	7.36	7.31	7.21	7.23	7.09
End of surgery	7.5	7.38	7.49	7.41	7.31	7.35
Lactate						
Preexplant	10.1	2.1	7.1	4.1	3.3	6.7
Postexplant	10.6	3.6	8.9	5.8	3.1	12.3
End of surgery	4.2	3.6	6.3	5	2.4	>15 ^c

^aExact explant time not recorded.

^bExact time not recorded, >9h CIT reported.

^cBeyond detection limit.

CIT, cold ischemia time; FFP, fresh frozen plasma; PRBC, packed red blood cells; VAE, visceral artery embolization; WIT, warm ischemia time.

TABLE 4.**Recipient outcomes—infectious cultures are reported as species (POD reported)**

Infectious cultures	Patient 1	Patient 2	Patient 3	Patient 4	Patient 5	Patient 6 (no VAE)
Blood	None	<i>M. abscessus</i> (76) <i>E. coli</i> (76) <i>S. epidermidis</i> (180)	None	<i>E. cloacae</i> (7)	<i>C. glabrata</i> (7)	None
Peritoneal fluid	<i>E. coli</i> (3) CoNS (16) Diphtheroids (28) <i>C. dubliniensis</i> (3) <i>C. glabrata</i> (26) <i>S. cerevisiae</i> (28) <i>C. albicans</i> (28)	<i>E. coli</i> (76), CoNS (99), <i>S. marcescens</i> (165)	<i>S. hominis</i> (23)		<i>M. fortuitum</i> (5) <i>E. cloacae</i> (26), <i>P. mirabilis</i> (26) <i>E. coli</i> (48) <i>C. glabrata</i> (5)	<i>Enterococcus</i> (31, 75, 166, 175) <i>S. Maltophilia</i> (75) CoNS (75) <i>Candida Kefyr</i> (166, 175)
BAL	None	None	None	None	<i>T. asahii</i> (46)	None
Urine	None	<i>E. coli</i> (70)	None	None	None	None
Other	None	Necrotic wound <i>S. marcescens</i> (182)	None	None	Aspergillus GM Ag + (46)	None
Outcome at 6 mo	Deceased at 1 m	Alive	Alive	Alive	Alive	Alive

BAL, bronchoalveolar lavage; CoNS, coagulase-negative staphylococcus; GM, galactomannan; POD, postoperative day; VAE, visceral artery embolization.

embolization of the abdominal viscera with resulting organ ischemia may worsen lactic acidemia during native visceral exenteration, which could potentially exacerbate hemodynamic instability. While we observed higher postexplant lactate levels in some patients, our series is too small to establish any statistical correlation between the degree of lactic acidosis and intraoperative or postoperative outcomes, but it is reassuring that all but the incomplete embolization patient had good hemodynamic stability.

An additional theoretical consequence of VAE is the risk of bacterial translocation as bowel ischemia progresses during prolonged explantation of native viscera. While long-term infectious complications are nearly universal following multivisceral transplantation,⁸⁻¹³ it is possible that VAE could exacerbate postoperative infection rates. The overall immediate postsurgical (1 mo) infection rates in prior studies range from 57.5% to 63.6%.^{8,13} In a cohort of 184 patients not receiving gut decontamination, Clouse et al¹⁰ reported a 30% rate of intrabdominal abscess formation in the first month, 26% of which were bacterial abscesses and 12% were fungal. They also noted a lower abscess rate in intestine transplant recipients (15%) as compared to modified MVT (38%) and MVT (33%). The 30-day rate of bacterial infection in the same study was 71%, with urinary tract (41%) and bloodstream (32%) being the common sites, followed by pulmonary (17%), wound (11%), and *Clostridium difficile* (4%). Fungal infections occurred in 21% patients with the common sites being the urinary tract (7%), bloodstream (7%), pulmonary (5%), and wound (4%). A study from Georgetown University (n=40) reported a different distribution of infectious complications, with abdomen as most common site of infection (36%), followed by blood (22%), urinary tract (14%), pulmonary (17%), and wound (8%).¹³ In our own series, all 5 patients developed either bacterial or fungal infection within 30 days after transplantation; 2/5 (40%) and 3/5 (60%) patients developed positive blood and peritoneal cultures, respectively. None of the patients had any episode of urinary tract, pulmonary, or wound infection within the first 30 days posttransplant. We also noted some atypical pathogens in this cohort, which included nontuberculous mycobacteria (2), Diphtheroids (1), *Saccharomyces cerevisiae* (1), and *Serratia marcescens* (1). Despite this, it is difficult to implicate VAE alone as causative, given the presence of other

known risk factors for postoperative infections such as CIT,¹⁴ operative time,¹⁵ blood loss,¹⁶ transfusion,¹⁷ and use of cell saver.¹⁸ Larger study cohorts or experimental models would be needed to establish the true impact of VAE specifically on infectious complications.

Another potentially unrelated contributor to our rate of infection was allograft pancreatitis, which developed in patients 1 and 5 (detected intraoperatively during repeat laparotomy on postoperative days 3 and 5, respectively). We suspect the pancreatitis was secondary to prolonged ischemic time in these recipients (587 and 511 min, respectively); however, it is also possible that postreperfusion disseminated intravascular coagulation may have also contributed to this phenomenon. Both of these patients developed infected pancreatic necrosis with multiple organisms, including nontuberculous mycobacterium in 1. In addition, both patients ultimately developed mycotic aneurysms of the donor aortic conduit (Figure 1, patient 1) and suffered intra-abdominal bleeding. This is likely related to the anatomic proximity of the pancreas graft to the arterial inflow of the MVT, which put the donor aorta at risk of enzymatic degradation in the setting of pancreatitis. Although graft pancreatitis is a known complication in pancreas transplantation,^{7,19} these were the first MVT patients at our center to develop this devastating complication. Of these 2 patients in our study, 1 died following massive hemorrhage from the aortic conduit, and the other was salvaged by emergent stent placement through the infected conduit.

There are no formal recommendations to guide the specific vascular targets for preemptive VAE. Prior case series have performed VAE to the entire celiac trunk and SMA for grafts including stomach,^{2,3} while others have utilized embolization to the hepatic, splenic, and superior mesenteric arteries (leaving the left gastric patent) for cases where the native stomach is retained.^{3,4} Regardless of strategy, it is expected that flow will remain beyond the embolic material due to rich collateral supply. For example, despite embolization of the splenic artery, left gastric artery collateral pathways to the short gastric and left gastroepiploic arteries continue to perfuse the splenic hilum. Similarly, despite embolization of the proximal SMA, flow is preserved to the small bowel and right colon via collateral pathways from the inferior mesenteric artery and marginal artery of Drummond. As demonstrated by the



FIGURE 1. Abdominal aortogram in patient 1 demonstrates a small saccular pseudoaneurysm of the donor aortic conduit on postoperative day 28 following multivisceral transplant.

Miami group,³ distal nonselective embolization seems to be a much more reliable method to achieve cessation of blood supply to target organs from both native and collateral vessels. However, it is more time consuming (taking 62 and 160 min) compared with proximal embolization in that series (48 min). Within our cohort, 4/5 patients underwent proximal embolization and we preserved the left gastric in all patients so the native stomach could potentially remain viable for anastomosis. We routinely included the SMA and splenic due to minimal variability in these targets, and the decision to embolize the common hepatic versus its specific branches (including the GDA or IPDA) was made by the radiologist on a case-by-case basis with the surgical team in territories anticipated to cause significant bleeding, noting that CHA embolization may also cause a degree of liver ischemia and thus increase the functional anhepatic time. Our embolization time varied but was generally longer for distal embolization (207 min) compared with proximal embolization (60–123 min).

In general, we believe patients with a chronically occluded portomesenteric system and extensive surgical history represent a special subgroup of MVT patients with an elevated risk of operative blood loss, who likely benefit from visceral embolization. As the number of cases undergoing visceral artery embolization at each individual center is small, a multicenter study would be the way forward to objectively assess the selection criteria balancing the risks and benefits both

intraoperatively and during the early postoperative period. This will allow the development of standard protocols facilitating ongoing assessments of hemodynamic and blood utilization outcomes. Further studies are also needed to evaluate the impact of this risk-benefit decision on abdominal infection rates and other infection-related complications following transplant.

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