MAEDICA – a Journal of Clinical Medicine
2020; 15(3): 381-390
https://doi.org/10.26574/maedica.2020.15.3.381

MÆDICA - a Journal of Clinical Medicine

REVIEW

A Review on Aorta Mesenteric Bypass in Surgical Management of Mesenteric Ischemia: Indications, Techniques and Outcomes

Danilo COCO[a], Silvana LEANZA[b]

[a]Department of General Surgery, Ospedali Riuniti Marche Nord, Pesaro, Italy

[b]Department of General Surgery, Carlo Urbani Hospital, Jesi, Ancona, Italy

ABSTRACT

Mesenteric ischemia (MI) is a rare medical condition which involves insufficient blood supply, inflammatory injury and eventually bowel wall necrosis with high mortality rates. Acute mesenteric ischemia (AMI) and chronic mesenteric ischemia (CMI) are the two major types of mesenteric ischemia. Therapeutic approach of MI includes medical as well as surgical treatment. This review article aims to delineate the abreast knowledge on indications, management through mesenteric bypass surgical technique, and clinical outcomes. Clinical presentation of AMI and CMI varies substantially, depending on the etiology underlying it. The most common symptom of AMI is abdominal pain that is disproportionate to the outcomes of physical exams; whereas CMI normally induces postprandial abdominal pain, commonly epigastric or periumbilical, nausea and weight loss. Recent awareness of AMI management revealed that exploratory laparotomy surgical procedure with careful evaluation of bowel viability played a pivotal role in restoring intestinal oxygenation and avoiding serious complications such as peritonitis and perforation of the gangrene bowels. The management of CMI is mainly surgical, with Aorta/Iliac-SMA bypass and Aorta-Splenic bypass being the currently available options. Due to the high thrombosis levels, only patients whose surgical risk outweighs possible benefits are required for medical care as a single treatment. Furthermore, this review also postulates that aorto mesenteric revascularization procedures for chronic mesenteric ischemia are feasible, but involve careful selection of patients, and they should only be performed by vascular surgeons with extensive experience in laparoscopic vascular surgery at referral centers

Keywords: mesenteric ischemia, AMI, CMI, Aorta/Iliac-SMA bypass, Aorta-Splenic bypass, surgery, surgeons.

Address for correspondence:
Dr. Danilo Coco
Ospedali Riuniti Marche Nord, Pesaro, Italy
Tel.: +393400546021
Email: webcostruction@msn.com

Article received on the 20th of May 2020 and accepted for publication on the 25th of September 2020

INTRODUCTION

Mesenteric ischemia (MI) is a rare medical condition affecting 0.1% of all hospital admissions, with high mortality rates ranging from 24% to 94% (1). It includes insufficient blood supply, inflammatory injury and finally, bowel wall necrosis. The disease can be divvied into acute mesenteric ischemia (AMI) and chronic mesenteric ischemia (CMI). Further subdividing AMI into four categories (2); consequently, AMI can result from arterial embolism, arterial thrombosis, mesenteric venous thrombosis (MVT) and non-occlusive causes (NOMI) such as hypo-perfusion from low cardiac output or mesenteric arterial vasoconstrictions (3). Bowel damage is proportional to the reduction in mesenteric blood flow, which may vary from minimum lesions due to reversible ischemia to transmural injury, accompanied by necrosis which perforation (4).

In more than 95% of cases, CMI is associated with diffusing atherosclerotic disease, with all major mesenteric arteries having stenosis or occlusion. Certain causes include dysplasia from the fibromuscular, vasculitis, arteritis from takayasu, malignancy and radiation. This disorder is often only diagnosed at an advanced stage, due to either a lack of clear signs or its often quiet appearance (5). Persistent, intermittent, non-localized or periumbilic abdominal pain remains the most common symptom (6-8). In CMI patients, postprandial pain, nausea, and weight loss occur (4). Though laboratory studies or plain abdominal films are not indicative, computed tomography (CT) imaging and CT angiography contribute to differential diagnosis and management of AMI. Angiography is also the main criterion for CMI, with high value even in mesenteric duplex ultrasonography (US) and magnetic resonance angiography (MRA) (9-11).

Mesenteric ischemia therapeutic approach consists of both medical and surgical treatment. The most common drugs are papaverine, heparin, warfarin, and thrombolytic (12). Surgical procedures consist of restoring the blood flow with arteriotomy, endarterectomy, or anterograde bypass, while necrotic bowel resection is always applied (13).

There is no consensus on the best method of mesenteric surgical reconstruction for CMI treatment. Controversy remains about the best operative technique and the bypass conduit type selection (14). The type of operation depends on the limit and location of the aortic disease, the surgical risk to the patient, the need for other vascular procedures, and the vascular surgeon's choice and experience. It is also contentious to need to repair only one or two arteries (superior mesenteric artery [SMA] and celiac artery). Multivessel bypass reduces the risk of symptomatic relapse and offers some protection against intestinal infarction in the event of occlusion of a single graft (15).

Mesenteric bypass is a long-time established effective method for treating symptomatic CMI, with excellent primary patency and long-term survival. Although long-term survival is comparable for endovascular therapy and surgical therapy, long-term patency with surgery appears to be superior, with additional interventions required in substantially fewer cases (16-18). Nonetheless, endovascular therapy is therefore more common in most centers than surgical therapy. Factors such as patient preference, reduced significant morbidity, and quicker recovery have motivated most preferences of surgical reconstruction to support endovascular therapy (15, 18). In many patients, mesenteric bypass is performed following failed angioplasty and stent placement.

With this scenario, the present review article aims to delineate the abreast information about signs of mesenteric ischemia, and management by mesenteric bypass surgical procedure, and clinical results to provide an update on existing concepts of surgical management of the disease.

Causes and clinical presentation of mesenteric ischemia

In terms of clinical presentation, AMI and CMI varies substantially, depending on the etiology underlying it (19). The most common symptom of AMI is abdominal pain that is disproportionate to the outcomes of physical exams. Since ischemia is the pathological process, the pain is initially visceral, diffused, non-localized and can be mild to extreme, persistent, often colicky and often unresponsive to opioid analgesics. Some common symptoms include nausea and vomiting, although there may also be diarrhea that leads to constipation. Examination findings are limited and non-specific early in the course of the disease, including minimal abdominal tenderness. If embolic disease is due to ischemia, the pain is extreme and sudden, as occlusion is easily mounted and collateral circulation totally absent (13, 20). On the other hand, since the artery is normally already partially blocked and a collateral supply has been created, AMI due to arterial thrombosis has a much more progressive development of ischemia and infarction, and less serious presentation (21). Signs of peritonitis and septicemia are confronted as the ischemia progresses transmurally (22). Necrosis of the Bowel, septic shock and death are common complications in AMI (Table 1).

Category	Causing factors	Clinical presentations
Occlusive mesenteric	Arterial embolus (50%)	Abdominal pain (95%)
	Cardiac disease	
	Atrial fibrillation	
	Recent myocardial infarction	
	Congestive cardiac failure	Nausea (44%)
	Infective endocarditis	
	Thromboembolism from aorta	
	Digitalis therapy	
	Mesenteric arterial thrombosis	Diarrhea (35%)
	Pre-exiting atherosclerosis lesion	
	Aortic dissection	
	Mesenteric venous thrombosis (5-	
	Antithrombin III deficiency	Vomiting (35%)
	Prothrombotic states	
	Factor V Leiden	
	Protein S deficiency	
	Pregnancy	Low gastrointestinal bleeding
	Protein C deficiency	
	Antiphospholipid antibodies	
	Essential thrombocythemia	
	Oral contraceptive use	Abdominal distention
	Hyperhomocysteinemia	
	Neoplasms	
	Pancreatitis	
	Paroxysmal nocturnal	Fever
	Sepsis	
	Peritonitis and intraabdominal	
	Inflammatory bowel disease	
	Cirrhosis and portal hypertension	Tachycardia
	Diverticulitis, postoperative state	
	Abdominal operations	
	Chronic renal failure	
NOMI (20–30%)	Hemodynamic instability	Tachypnoea
	Hypovolemia, sepsis, shock	
	Use of vasopressors	
	Critically ill patients, renal insufficiency	

TABLE 1. Causing factors and clinical presentation of acute mesenteric ischemia (23)

Chronic mesenteric ischemia usually causes abdominal postprandial pain, generally epigastric or periumbilic, nausea and weight loss. Examination findings include symptoms of malnutrition, clinically excessive discomfort and abdominal bruit (5, 24). Symptomatic CMI is an indication for either open or endovascular revascularization, as patients with untreated symptomatic CMI carry a five-year mortality rate that approaches 100% (25, 26).

Indications for surgery

- Signs of peritonitis on physical exam
- Massive lower GI hemorrhage
- Ongoing signs of abdominal pain, fever, or sepsis
- Symptoms that have persisted for more than 14 to 21 days
- Chronic malabsorption leading to protein-losing colopathy
- Colonoscopic evidence of segmental colitis with frank ulceration
- Presence of an ischemic stricture and abdominal symptoms

Management options of mesenteric ischemia

Despite medical management of AMI, recent awareness has created multidisciplinary management of AMI surgery. The initial aim is to restore intestinal oxygenation and reduce or avoid serious complications such as peritonitis and perforation of the gangrenous bowel. Thus, AMI surgical diagnosis with symptoms of peritonitis primarily includes exploratory laparotomy with careful evaluation of the viability of the bowel (6, 27). It strongly suggests resection of the infarcted intestine. In addition, under Wood Lamp Illumination, intraoperative Doppler US and IV fluorescein infusion and bowel inspection may discern poorly perfused bowel. Necrotic bowel resection plays a crucial role in resuscitation of patients when an attempt at anastomosis remains contentious. A second look operation, along with clinical review and diagnostic imaging is strongly recommended. Intense screening of intestinal revascularization is also carried out (28, 29).

More precisely, an attempt at reperfusion remains vitally necessary in case of embolic AMI (6). Using a balloon-tipped Fogarty catheter for removing the clot, the surgical team will assess the position of the blockage by palpation and proceed to transverse arteriotomy proximal to the occlusion. Embolectomy can be achieved most quickly by exposing the SMA at the transverse mesocolon base. Arteriotomy can be mainly sealed or patched with veins. An alternative approach is bypassing a venous or arterial grafting technique (27, 30, 31). Revascularization is attempted either with antegrade or retrograde aortomesenteric bypass, or with trans-aortic endarterectomy in the event of thrombotic occlusion with absence of gangrenous bowel. In case of spontaneous dissection of SMA, successful percutaneous stent placement has been stated before the onset of intestinal infarction (32-34).

After repair of aortic aneurysm, a significant incidence of AMI has been also recorded. Upon endovascular abdominal aortic reconstruction, the prevalence of clinically visible bowel ischemia is comparable with open surgical approach. Nonetheless, a higher incidence of small bowel ischemia has been observed in patients with endovascular repair and is associated with exceptionally high mortality. In most cases, the direct pathologic evidence and patterns of segmental, skipped, or patchy ischemia suggest that microembolization plays a central role (35, 36).

The management of CMI is chiefly surgical. Because of the high thrombosis levels, only patients whose surgical risk outweighs possible benefits are required for medical care as a single treatment. Furthermore, cautious care such as intestinal rest, avoidance of smoking and administration of vasodilator medicines do not enhance the progression of the disease (49). Medicinal drugs used in CMI include heparin and warfarin to avoid an acute thrombotic/embolic occurrence, intra-arterial papaverine as a vasodilator before surgery to minimize the risk of arterial spasm, and nitrate therapy to provide short-term relief. Given the long malnutrition time, parenteral feeding is required (5, 24).

There are two alternative treatment modalities in patients with CMI: open revascularization (OR) and endovascular revascularization (ER) (37-39). The latter tends to have lower rates of postoperative mortality and morbidity, and shorter length of intensive care unit and hospital stay. Hence, due to its minimally invasive nature, ER has been recommended for high risk surgical candidates or those with low life expectancy (39-41). In ER, a short stump of the patent artery is needed to gain access to the wire. Excessive manipulation of the endovascular system can cause arterial dissection, perforation or embolization. Furthermore, highly calcified or long lesions and mesenteric arteries of small-diameter are often associated with an increased risk of distal embolization and restenosis. However, OR provides symptomatic relief early as well as long-term and substantially lower restenosis levels compared with ER. Thus, most patients should be treated with conventional reconstruction particularly if ER has been tried unsuccessfully beforehand. In summary, although ER had recently gained traction as an alternative therapeutic method, OR is still largely being proposed (39, 42, 43).

Surgical treatment involves transaortic celiac or SMA endarterectomy, antegrade bypass of the

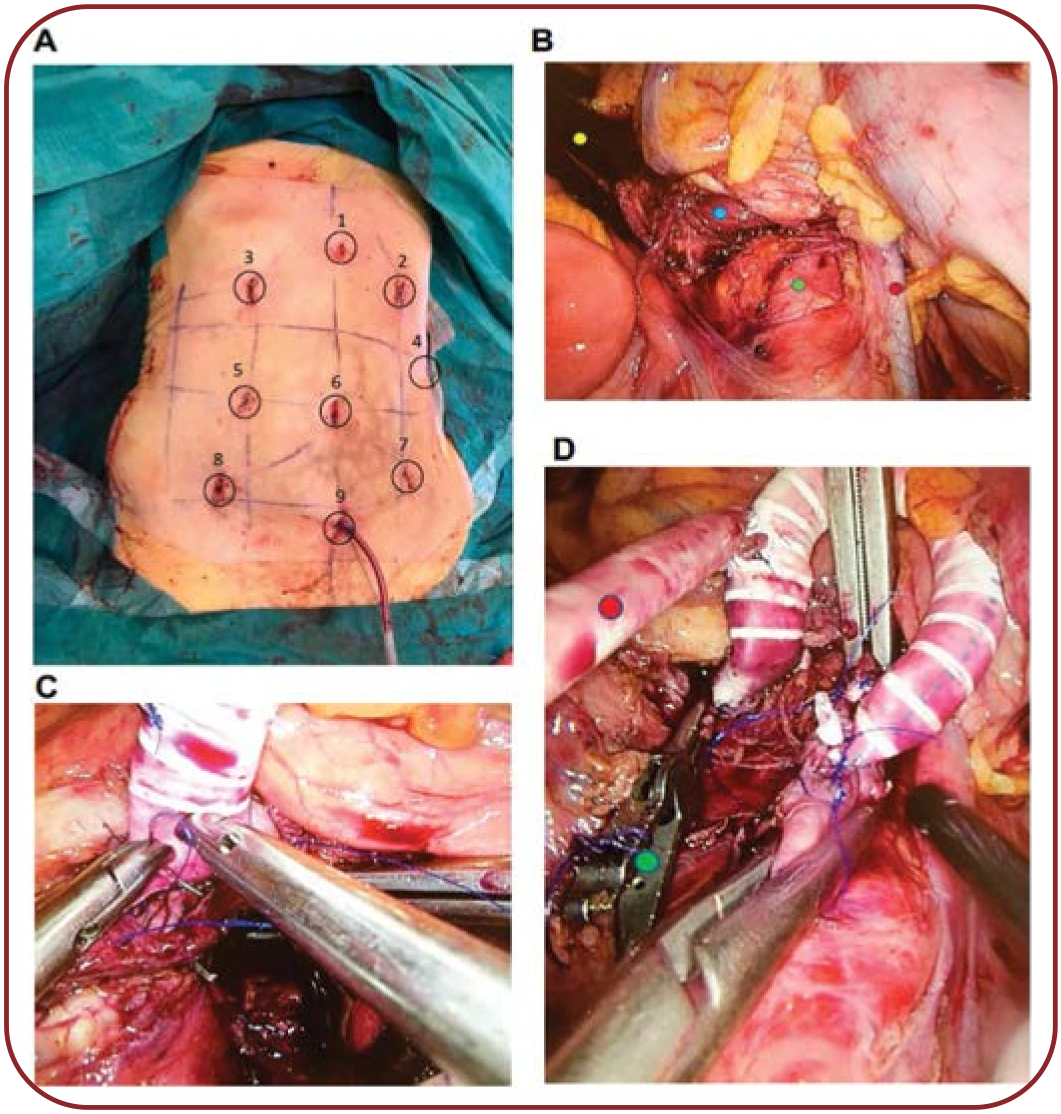

FIGURE 1. Different phases of a laparoscopic retrograde aorto-mesenteric bypass to the superior mesenteric artery. (A): Paramedian vertical lines are midclavicular and anterior axial lines. Upper transverse is subcostal, and lower transverse is the line joining the two anterior superior iliac spines. Trocar position 6 for 30° laparoscope, 1 and 9 for aortic clamps and 4, 5, 7 for working instruments. The rest of the trocar positions for other helping instruments. (B): Partially dissected superior mesenteric artery ( ) and infrarenal aorta ( ). Treitz ligament is divided, and duodenum mobilized distally and held under a retractor ( ). Inferior mesenteric vein ( ). (C): End-to-side anastomosis with superior mesenteric artery. (D): Completed anastomoses on superior mesenteric artery and infrarenal abdominal aorta. Ring enforced expanded polytetrafluoroethylene graft with an end-to-side anastomosed 6 mm graft. Side graft ( ) is being flushed with heparinized NaCl to check the patency of anastomoses before the aortic and superior mesenteric artery clamps are removed. Laparoscopic bulldog artery clamp ( ). Courtesy: Kazmi *et al*, 2020 (44).

supraceliac aorta and retrograde bypass of the infrarenal aorta or common iliac arteries. Bypasses can be achieved with vein or prosthetic material. In highly calcified, thrombotic, occlusive, or dissected lesions, primary stenting is preferred. Little is known about the effect of distal embolization on stent placement. In the presence of a large thrombus burden, an embolic protection device may be considered. However, there is insufficient evidence to prove its efficacy for CMI during ER (37, 38, 42).

Techniques

In patients with CMI, Kazmi *et al* (44) documented the operating techniques and findings of an early encounter with laparoscopic revascularisation. All operations were carried out under general anesthesia. After intubation, all patients received intravenous antibiotic prophylaxis (Cefalotin 2 g), which was repeated every three hours until four doses in total. The patient was positioned supined on a table with the split-legs, and the surgeon stood between the legs. A surgical nurse stood on the surgeon's left side, and an assistant stood on each patient's side. Pneumoperitoneum was accomplished by insufflating carbon dioxide (CO_2) by means of a trocar put under direct peritoneum visualisation. During surgery, a pneumoperitoneum pressure of 12 mm Hg has been maintained. Trocars were positioned, if necessary, in anatomical positions suitable for healthy peritoneal or omental adhesiolysis (Figure 1A). The small intestine pushed slowly into the right side of the abdominal cavity. One or two 10 mm fan retractors (Covidien Endo Retract II Ethicon) were used when required to keep the intestine detached from the surgical field. Abdominal aorta and iliac arteries were approached by opening the peritoneum directly to the surrounding. The infrarenal aorta was dissected free for a duration appropriate for the application of aortic clamps and for the construction of an end-to-side anastomosis (Figure 1B) (44).

Aorto/iliac-SMA bypass

In the area just below the combination of superior and inferior mesenteric veins, SMA had been approached. Treitz ligament was split and duodenum mobilized to free dissect the length of SMA required. Ring-enforced extended polytetrafluoroethylene (ePTFE) 8 mm (Gore-Tex Stretch Vascular Graft) was spatulated at one end and inserted *via* a 12 mm trocar into the abdominal cavity. To achieve anticoagulation, intravenous heparin was administered, and the SMA was clamped distally either with a long vessel loop or with a small laparoscopic bulldog artery clamp. In the case of calcified SMA, a laparoscopic aortic clamp can be used for proximal SMA cross-clamping, which has also helped in keeping the greater omentum and transverse colon, detached from the operation field. Thrombendarterectomy was conducted using a longitudinal arteriotomy. In case of an occluded stent, a partial stent resection (distal portion of the stent) was performed. An end-to-side anastomosis was performed with two hemi-circular 6–0 polypropylene sutures, each approximately 12–15 cm long and with a beforehand tied Teflon pledgets to their ends (Figure 1C); 12 SMA and backflow artery clamps were temporarily removed (44).

Aorto-splenic bypass

Kazmi *et al* reported that, in two cases, the splenic artery was used as the site of distal anastomosis. Figure 2A–D illustrates the position of the trocar and the different phases of the aorto-splenic bypass. The left liver lobe was elevated using the Nathanson liver retractor (Cook Medical). The hepatogastric ligament was excised across the cranial edge of the pancreas to enter the splenic artery. The artery was dissected in length appropriate for cross-clamping, and an end-to-side anastomosis was constructed. A laparoscopic iliac clamp (Carl Storz, Germany) was cautiously passed anterior to the left renal vein along the right side of the aorta and advanced toward the omental bursa, cranially behind the pancreas. Care has been taken to keep the clamp parallel with the aorta; with this clamp, a spatulated 8 mm ring enforced ePTFE graft was grasped and cautiously tunnelled from the omental bursa, dorsal to the pancreas, towards the infrarenal aorta.

The splenic artery was clamped with the laparoscopic aortic clamps or small laparoscopic artery clamps after systemic heparinization. Longitudinal arteriotomy was performed, and 6–0 polypropylene sutures were constructed with an end-to-side anastomosis. The graft was flushed with heparinized NaCl and cross clamped with a

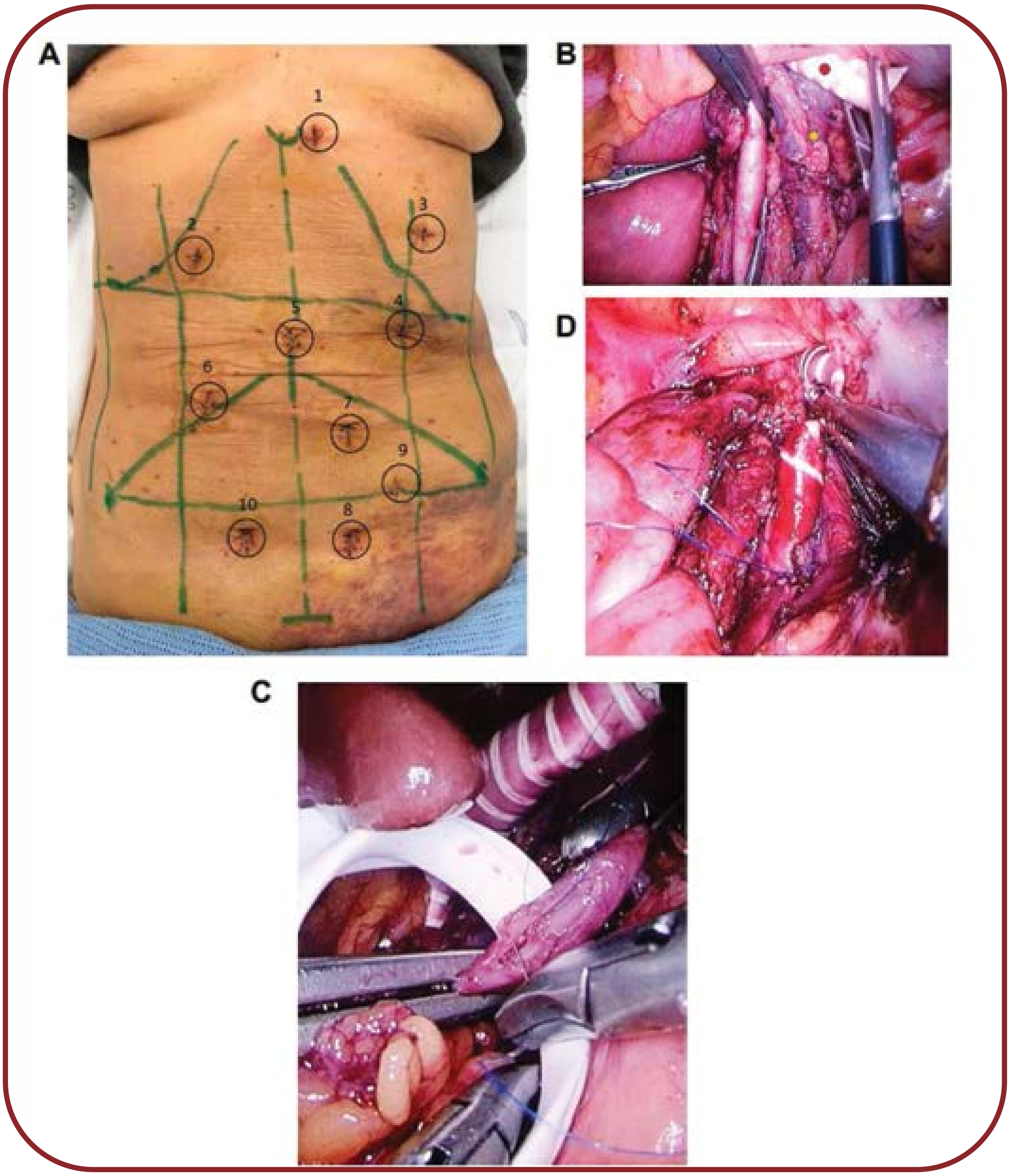

FIGURE 2. (A). Trocar positions for laparoscopic retrograde aorto-splenic bypass. Trocar positions 5 for 30° laparoscope and 1 for Nathanson's liver retractor. Position 2, 4, and 3 for working trocars for splenic artery dissection and anastomosis. Positions 7 and 6 for infrarenal aortic dissection and anastomosis. Other positions are used for helping instruments. (B): Distal end of a tunnelled ring enforced expanded polytetrafluoroethylene graft anterior to the left renal vein ( ). Cross-clamped infrarenal aorta and left gonadal vein ( ). (C): Ring enforced expanded polytetrafluoroethylene graft is being anastomosed end-to-side to a clamped splenic artery. Nathanson's liver retractor is elevating the left liver lobe. (D): Completed end-to-side anastomosis to the infrarenal aorta. Courtesy: Kazmi *et al*, 2020 (44).

laparoscopic aortic clamp until the anastomosis with the aorta was constructed in an end-to-side fashion (Figure 2D). Nathanson liver retractor was removed, and the proximal portion of the graft was covered by the smaller omentum and the left liver lobe. The retroperitoneum had been used to cover all SMA grafts (44).

Clinical outcomes

The results of the retrograde and antegrade mesenteric bypass, as stated in guidelines, have comparable patency (45). Even though one can transect SMA distal to the occlusion and construct an end-to-end anastomosis, all anastomoses were to the SMA in an end-to-side fashion. In their research, Kazmi *et al* indicated that the atherosclerotic plaque stretched over the entire length of Fullen's zone 1 and 2 and combined the source of the lower pancreaticoduodenal artery and middle colic artery. The end-to-side anastomosis was more suitable to preserve these critical branches (44).

Furthermore, Kazmi *et al* experienced free dissection without any technical difficulties of the splenic artery. Lifting the left liver lobe with the Nathanson liver retractor provided excellent access to the hepatogastric ligament and celiac artery tributaries (44). Nevertheless, Bakoyiannis *et al* used a flexible laparoscopic tunneler, placing the graft anterior to the pancreas (46). Kazmi *et al* designed carefully with the aid of CTA and could successfully place the graft in two patients in the retroperitoneum along the aorta (44).

Kazmi *et al* (44) shared their experience of laparoscopic aortic clamps, although bulky, that can be used on the SMA and splenic arteries. Nevertheless, Bulldog clamps with laparoscopic arteries were more fitting and offered functional anastomosis working space. Alternatively, long (30 cm) vascular loops were used for clamping the mesenteric arteries by trocars among two occlusions of early grafting and one stenosis of the graft which resulted in early redo operation. In all three cases, ring enforced ePTFE was directly clamped with the laparoscopic aortic clamp instead of reclamping SMA or splenic artery after flushing the graft with heparinised NaCl. Thrombendarterectomy of the mesenteric artery and the

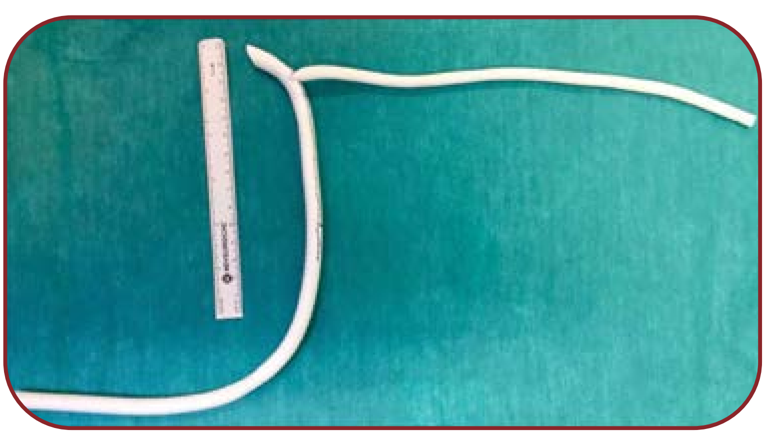

FIGURE 3. A 6 mm expanded polytetrafluoroethylene graft, end-to-side anastomosed to an 8 mm ring enforced expanded polytetrafluoroethylene graft with graduated length markings and spatulated end. Courtesy: Kazmi *et al*, 2020 (44)

graft's cross-clamping period during proximal anastomosis may also have led to the growth of thrombosis in the graft. Although the greater omentum could be used to cover the graft to avoid contact with the intestine, the graft was successfully covered with the retroperitoneum in all patients in this study. Moreover, none of the subjects have developed any graft infections so far (44).

Kazmi *et al* advised some technical improvement due to thrombosis of the graft and stenosis of the grafting. In-vitro, a 6 mm ePTFE graft, was end-to-side anastomosed with the central graft (8 mm) near to the distal (mesenteric) anastomosis site (Figure 3). During the process, this side canal allowed a secure and efficient route to flushing the main graft. If necessary, this side canal can be used for main graft thrombectomy. Through this side graft, one can also perform angiography of completion and if necessary, also stenting of mesenteric arteries. After completion of the bypass, Hem-o-loc polymer clips and a large metal clip were applied near the anastomosis intergraft, and the rest of the 6 mm ePTFE graft was excised and discarded (44). Furthermore, cross-clamping of the graft could be avoided from these modifications after the distal anastomosis is complete (47).

In patients with severe peritoneal adhesions due to earlier abdominal operations, Kazmers *et al* reported one case of conversion due to venous bleeding, and another with left ureter injury (47). It has been estimated that 10 to 37% of patients under elective abdominal surgery would need repeated abdominal surgery (48). In patients with previous multiple abdominal surgeries, the risk of these complications is high even with open surgery (48, 49). Use of preoperative assessment tools such as the Hostile Abdomen Index risk stratification can help select the right patients for laparoscopic procedures (50).

Mocian *et al* described a retrograde aorto-mesenteric bypass with a Gore-Tex 5 mm diameter prosthesis in a 39-year-old female patient who had been diagnosed with partial upper mesenteric artery stenosis via abdominal computed tomography angiography, and had a history of total nephrectomy, chronic kidney failure, and hypertension. Her postoperative evolution was favourable, with no short- and long-term follow up complications. Based on the clinical findings following retrograde aorto-mesenteric bypass with a

5 mm diameter Gore-Tex prosthesis, Mocian *et al* suggested that, in circumstances where the endovascular approach fails or has no indication, such as multiple lesions starting from the origin of the upper mesenteric artery, open surgery should be the indication in chronic mesenteric ischemia (51).

Early experience in the treatment of chronic mesenteric ischemia with laparoscopic revascularization suffered from complications related to the procedure. This is despite long experience with laparoscopic aortic surgery by the operating team (52-54). However, previous experience assisted in anastomosis construction. During the initial experienced with laparoscopic aortic surgery, even a long operating period was observed. Nevertheless, in later experience the operation period for these procedures is not significantly longer (52-54). In summary, the benefits of a minimally invasive procedure such as mesenteric revascularization can only be accomplished by improved patient selection, diligent free dissection technique, avoidance of graft cross-clamping, and mandatory use of ultrasound during surgery or an angiography completion in future research. Only vascular surgeons with expertise in aortic surgery will conduct these advanced laparoscopic procedures in referral centers. ❑

CONCLUSIONS

This review articles outlined that aorto mesenteric revascularization procedures are feasible for chronic mesenteric ischemia but require careful selection of patients. Only vascular surgeons with prior experience in laparoscopic vascular surgery can carry out these procedures in referral centers. ❑

Conflicts of interest: none declared.

Financial support: none declared.

References

1. **Roussel A, Castier Y, Nuzzo A, et al.** Revascularization of acute mesenteric ischemia after creation of a dedicated multidisciplinary center. *J Vasc Surg* 2015;62:1251-1256.
2. **Corcos O, Nuzzo A.** Gastro-intestinal vascular emergencies. *Best Pract Res Clin Gastroenterol* 2013;27:709-725.
3. **Bobadilla JL.** Mesenteric ischemia. *Surg Clin North Am* 2013;93:925-940.
4. **Van den Heijkant TC, Aerts BA, Teijink JA, et al.** Challenges in diagnosing mesenteric ischemia. *World J Gastroenterol* 2013;19:1338-1341.
5. **Pecoraro F, Rancic Z, Lachat M, et al.** Chronic mesenteric ischemia: critical review and guidelines for management. *Ann Vasc Surg* 2013;27:113-122.
6. **Vokurka J, Olejnik J, Jedlicka V, et al.** Acute mesenteric ischemia. *Hepatogastroenterology* 2008;55:1349-1352.
7. **Tadros M, Majumder S, Birk JW.** A review of ischemic colitis: is our clinical recognition and management adequate? *Expert Rev Gastroenterol Hepatol* 2013;7:605-613.
8. **Safioleas MC, Moulakakis KG, Papavassiliou VG, et al.** Acute mesenteric ischaemia, a highly lethal disease with a devastating outcome. *Vasa* 2006;35:106-111.
9. **Palma AB, Caldevilla DB, Parrondo CM.** Mesenteric ischemia: update of new diagnostic techniques for an old disease, and review of radiological signs. *Semergen* 2013;5:279-281.
10. **Seidel SA, Bradshaw LA, Ladipo JK, et al.** Non-invasive detection of ischemic bowel. *J Vasc Surg* 1999;30:309-319.
11. **Zwolak RM.** Can duplex ultrasound replace arteriography in screening for mesenteric ischemia? *Semin Vasc Surg* 1999;12:252-260.
12. **Kozuch PL, Brandt LJ.** Review article: diagnosis and management of mesenteric ischaemia with an emphasis on pharmacotherapy. *Aliment Pharmacol Ther* 2005;21:201-215.
13. **Bingol H, Zeybek N, Cingöz F, et al.** Surgical therapy for acute superior mesenteric artery embolism. *Am J Surg* 2004;188:68-70.
14. **Huber TS, Lee WA, Seeger JM.** Chronic mesenteric ischemia. In: Rutherford RB, ed. *Vascular surgery*. Philadelphia, PA: Elsevier Saunders 2005:1732-1747.
15. **Shanley CJ, Ozaki CK, Zelenock GB.** Bypass grafting for chronic mesenteric ischemia. *Surg Clin North Am* 1997;77:381-395.
16. **Hansen KJ, Deitch JS.** Transaortic mesenteric endarterectomy. *Surg Clin North Am* 1997;77:397-407.
17. **Mell MW, Acher CW, Hoch JR, et al.** Outcomes after endarterectomy for chronic mesenteric ischemia. *J Vasc Surg* 2008;48:1132-1138.
18. **Atkins MD, Kwolek CJ, LaMuraglia GM, et al.** Surgical revascularization versus endovascular therapy for chronic mesenteric ischemia: a comparative experience. *J Vasc Surg* 2007;6:1162-1171.
19. **Chang JB, Stein TA.** Mesenteric ischemia: acute and chronic. *Ann Vasc Surg* 2003;17:323-328.
20. **Schoots IG, Levi MM, Reekers JA, et al.** Thrombolytic therapy for acute superior mesenteric artery occlusion. *J Vasc Interv Radiol* 2005;16:317-329.
21. **Schoots IG, Koffeman GI, Legemate DA, et al.** Systematic review of survival after acute mesenteric ischaemia according to disease aetiology. *Br J Surg* 2004;91:17-27.
22. **Zachariah SK.** Adult necrotizing enterocolitis and non-occlusive mesenteric ischemia. *J Emerg Trauma Shock* 2011;4:430-432.
23. **Memet O, Zhang L, Shen J.** Serological biomarkers for acute mesenteric ischemia. *Annals of Translational Medicine* 2019;16:394.
24. **Char D, Hines G.** Chronic mesenteric ischemia: diagnosis and treatment. *Heart Dis* 2001;3:231-235.
25. **Mendes BC, Oderich GS, Tallarita T, et al.** Superior mesenteric artery stenting using embolic protection device for treatment of acute or chronic mesenteric ischemia. *J Vasc Surg* 2018;4:1071-1078.

26. **Alahdab F, Arwani R, Pasha AK, et al.** A systematic review and meta-analysis of endovascular versus open surgical revascularization for chronic mesenteric ischemia. *J Vasc. Surg* 2018;5:1598-1605.
27. **Park WM, Gloviczki P, Cherry KJ, et al.** Contemporary management of acute mesenteric ischemia: Factors associated with survival. *J Vasc Surg* 2002;35:445-452.
28. **Chang JB, Stein TA.** Mesenteric ischemia: acute and chronic. *Ann Vasc Surg* 2003;17:323-328.
29. **Wain RA, Hines G.** Surgical management of mesenteric occlusive disease: a contemporary review of invasive and minimally invasive techniques. *Cardiol Rev* 2008;16:69-75.
30. **Herbert GS, Steele SR.** Acute and chronic mesenteric ischemia. *Surg Clin North Am* 2007;87:1115-1134.
31. **Kuhelj D, Kavcic P, Popovic P.** Percutaneous mechanical thrombectomy of superior mesenteric artery embolism. *Radiol Oncol* 2013;47:239-243.
32. **Sivamurthy N, Rhodes JM, Lee D, et al.** Endovascular versus open mesenteric revascularization: immediate benefits do not equate with short-term functional outcomes. *J Am Coll Surg* 2006;202:859-867.
33. **Jun KW, Kim MH, Park KM, et al.** Mechanical thrombectomy-assisted thrombolysis for acute symptomatic portal and superior mesenteric venous thrombosis. *Ann Surg Treat Res* 2014;86:334-341.
34. **Luther B, Meyer F, Mamopoulos A, et al.** Options and Limitations in Endovascular Therapy for Acute and Chronic Mesenteric Arterial Occlusions. *Zentralblatt fur Chirurgie* 2015;5:486-492.
35. **Hechtman JF, Lento PA, Scordi-bello I.** Ischemic bowel due to embolization from an isolated mobile thrombus of the ascending aorta: a case report and review of the literature. *J Thromb Thrombolysis* 2011;32:238-241.
36. **Shimamoto T, Komiya T.** Clinical dilemma in the surgical treatment of organ malperfusion caused by acute type A aortic dissection. *Gen Thorac Cardiovasc Surg* 2014;62:398-406.
37. **Oderich GS, Bower TC, Sullivan TM, et al.** Open versus endovascular revascularization for chronic mesenteric ischemia: risk-stratified outcomes. *J Vasc Surg* 2009;49:1472-1479.
38. **Oderich GS, Tallarita T, Gloviczki P, et al.** Mesenteric artery complications during angioplasty and stent placement for atherosclerotic chronic mesenteric ischemia. *J Vasc Surg* 2012;55:1063-1071.
39. **Assar AN, Abilez OJ, Zarins CK.** Outcome of open versus endovascular revascularization for chronic mesenteric ischemia: review of comparative studies. *J Cardiovasc Surg (Torino)* 2009;50:509-514.
40. **Loffroy R, Steinmetz E, Guiu B, et al.** Role for endovascular therapy in chronic mesenteric ischemia. *Can J Gastroenterol* 2009;23:365-373.
41. **Sundermeyer A, Zapenko A, Moysidis T, et al.** Endovascular treatment of chronic mesenteric ischemia. *Interv Med Appl Sci* 2014;6:118-124.
42. **Crafts TD, Jensen AR, Blocher-Smith EC, Markel TA.** Vascular endothelial growth factor: therapeutic possibilities and challenges for the treatment of ischemia. *Cytokine* 2015;71:385-393.
43. **Shirasu T, Hosaka A, Okamoto H, et al.** Bowel necrosis following endovascular revascularization for chronic mesenteric ischemia: a case report and review of the literature. *BMC Gastroenterol* 2013;13:118.
44. **Kazmi SS, Berge ST, Sahba M, et al.** A Short Series of Laparoscopic Mesenteric Bypasses for Chronic Mesenteric Ischemia. *Vasc Health Risk Manag* 2020;16:87.
45. **Bjorck M, Koelemay M, Acosta S, et al.** Management of the disease of mesenteric arteries and veins. Clinical Practice Guidelines of the European Society of Vascular Surgery (ESVS). *Eur J Vasc Endovasc Surg* 2017;53:460-510.
46. **Bakoyiannis C, Cagiannos C, Wasilljew S, et al.** Totaly laparoscopic aortohepatic bypass for aortic debranching during endovascular thoracoabdominal aneurysm repair. *Eur J Vasc Endovasc Surg* 2007;34:173-175.
47. **Kazmers A.** Operative management of chronic mesenteric ischemia. *Ann Vasc Surg* 1998;3:299-308.
48. **Strik C, Stommel MW, Schipper LJ, et al.** Risk factors for future repeat abdominal surgery. *Langenbeck's Archives of Surgery* 2016;6:829-837.
49. **Seetahal S, Obirieze A, Cornwell III EE, et al.** Open abdominal surgery: a risk factor for future laparoscopic surgery? *Am J Surg* 2015;4:623-626.
50. **Goldfarb MA, Protyniak B, Schultheis M.** Hostile abdomen index risk stratification and laparoscopic complications. *JSLS* 2014;18:14-19.
51. **Mocian A, Russu E, Kaller R, Muresan A.** Aorto-mesenteric Bypass for the Treatment of Chronic Mesenteric Ischemia. *Journal of Interdisciplinary Medicine* 2019;2:101-103.
52. **Kazmi SS, Jørgensen JJ, Sundhagen JO, et al.** A comparative cohort study of totally laparoscopic and open aortobifemoral bypass for the treatment of advanced atherosclerosis. *Vasc Health Risk Manag* 2015;11:541.
53. **Krog AH, Sahba M, Pettersen EM, et al.** Cost-utility analysis comparing laparoscopic versus open aortobifemoral bypass surgery. *Vasc Health Risk Manag* 2017;13:217-224.
54. **Sahba M, Krog AH, Pettersen EM, et al.** Cost comparison analysis of laparoscopic versus open aortobifemoral bypass surgery: a randomized controlled trial. *Open Access Journal of Clinical Trials* 2019;11:11.