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TOPIC HIGHLIGHT

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Surgical management of peritonitis secondary to acute superior mesenteric artery occlusion

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Abstract

Diagnosis of acute arterial mesenteric ischemia in the early stages is now possible using modern computed tomography with intravenous contrast enhancement and imaging in the arterial and/or portal phase. Most patients have acute superior mesenteric artery (SMA) occlusion, and a large proportion of these patients will develop peritonitis prior to mesenteric revascularization, and explorative laparotomy will therefore be necessary to evaluate the extent and severity of intestinal ischemia, and to perform bowel resections. The establishment of a hybrid operating room in vascular units in hospitals is most important to be able to perform successful intestinal revascularization. This review outlines current frontline surgical strategies to improve survival and minimize bowel morbidity in patients with peritonitis secondary to acute SMA occlusion. Explorative laparotomy needs to be performed first. Curative treatment is based upon intestinal revascularization followed by bowel resection. If no vascular imaging has been carried out, SMA angiography is performed. In case of embolic occlusion of the SMA, open embolectomy is performed followed by angiography. In case of thrombotic occlusion, the occlusive lesion can be recanalized retrograde from an exposed SMA, the guidewire snared from either the femoral or brachial artery, and stented with standard devices from these access sites. Bowel resections and sometimes gall bladder removal due to transmural infarctions are performed at initial laparotomy, leaving definitive bowel reconstructions to a planned second look laparotomy, according to the principles of damage control surgery. Patients with peritonitis secondary to acute SMA occlusion should be managed by both the general and vascular surgeon, and a hybrid revascularization approach is of utmost importance to improve outcomes.

Key words: Acute mesenteric ischemia; Peritonitis; Explorative laparotomy; Endovascular treatment; Hybrid revascularization; Superior mesenteric artery occlusion

Core tip: Timely diagnosis of acute occlusion of the superior mesenteric artery (SMA) is possible with computed tomography angiography. The establishment of a hybrid operating room is most important to be able to perform explorative laparotomy for evaluation of the extent of mesenteric ischemia and successful intestinal revascularization. In embolic SMA occlusion, open embolectomy is performed followed by angiography. In thrombotic SMA occlusion, the occlusive lesion can be recanalized retrograde from an exposed SMA, the guidewire snared from either the femoral or brachial artery, and stented with standard devices. A necrotic bowel is resected with reconstructions performed at a planned second look laparotomy.

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INTRODUCTION

Recovery following bowel resection for bowel necrosis and peritonitis secondary to mesenteric vessel occlusion was first reported in 1895[1]. Development of peritonitis, followed by explorative laparotomy remained the main pathway to diagnose mesenteric vessel occlusion, and successful therapy was based on pure luck, whether the extent of intestinal infarction was limited and resectable, or not. One century later, the evolution of high-resolution computed tomography (CT) scanners around the clock have had a great impact on early diagnosis of mesenteric vessel occlusion[2], and has been the prerequisite to be able to perform mesenteric revascularization in time to decrease bowel morbidity and increase survival. In current practice, collaboration between the surgeon and vascular surgeon is of great importance. The patient needs to be transported to a vascular center with available hybrid operating room facilities with a high quality, fixed angiographic system, or mobile C arm, where laparotomy and open and endovascular therapy are possible. When applicable, the principles of damage control surgery should follow mesenteric revascularization[3]. This review article aims to outline treatment options and to guide the surgeons prior to or at laparotomy when managing patients with peritonitis secondary to acute superior mesenteric artery (SMA) occlusion.

FREQUENCY OF ACUTE MESENTERIC ISCHEMIA AMONG PATIENTS WITH ACUTE ABDOMEN

The majority, two-thirds, of patients with acute mesenteric ischemia suffers from acute SMA occlusion whereas non-occlusive mesenteric ischemia and mesenteric venous thrombosis is less common[4]. The frequency of acute mesenteric ischemia depends on the patient series studied[5-15] (Table 1). The frequency was reported to be 17.7% among patients undergoing emergency laparotomy[5] and as high as 31% among non-trauma patients managed with damage-control surgery[15].

DIAGNOSIS

Maintaining a high index of suspicion and awareness among physicians evaluating patients who are suffering from acute mesenteric ischemia is not enough to improve outcomes. The typical clinical triad of severe abdominal pain but minimal findings at examination (pain out of proportion), bowel emptying, and presence of a source of embolus in elderly patients with acute embolic SMA occlusion is not a consistent finding. Even though patients with acute thrombotic SMA occlusion often have known cardiovascular disease and a history of undiagnosed attacks of abdominal angina, clinicians find it very hard to diagnose this condition prior to progression towards peritonitis[16]. Unfortunately, there is no plasma marker that is accurate enough as an early diagnostic aid[17]. However, the evolution of available high-resolution CT scanners with rapid reconstructions in the sagittal, coronal and transversal planes has made early diagnosis possible, and increased the proportion of patients that may be considered for mesenteric revascularization[2]. Embolic occlusion appears often as an oval-shaped clot surrounded by contrast in a non-calcified arterial segment located in the middle and distal part of the main stem of the SMA, whereas thrombotic occlusion usually appears as a clot superimposed on a heavily calcified occlusive lesion at the ostium of the SMA.

EVALUATION OF THE EXTENT AND SEVERITY OF MESENTERIC ISCHEMIA

The patients need, if possible, to be transported to a vascular center with an available hybrid operating room. Explorative laparotomy through a midline incision is performed in patients with peritonitis, unless palliative care has been decided, to assess the extent and severity of intestinal ischemia, where color of the intestines, dilatation and peristaltic motion of the bowels, visible pulsations in the mesenteric arcade arteries, and bleeding from cut surfaces are most important in the assessment. The SMA supplies the whole small bowel and the right colon to the mid transverse colon, and the ischemic lesions at laparotomy are usually extensive. Of note, the ischemic lesions occur first in the mucosa and may be extensive, and in a few cases, no signs of ischemia may be visible on the serosa side at early laparotomy. Without treatment, development of a variable length of full bowel wall gangrene will occur. In elderly patients with complete transmural infarction of the small bowel up to the mid transverse colon, palliative care is indicated. In case of bowel perforation, the affected intestinal segment is rapidly resected with staples.

ACUTE REVASCULARIZATION OF THE SMA

Revascularization is preferentially performed prior to bowel surgery. If an explorative diagnostic laparotomy is performed as the first diagnostic step, on table SMA angiography should then be performed. Any previous CT of the abdomen should be scrutinized immediately. If no vascular surgeon is available, resection of obvious bowel necrosis should be performed, the abdomen closed, and the patient transported to a vascular centre. From the national Swedish registry of vascular procedures, SWEDVASC, there has been a steady increase in acute SMA revascularizations for intestinal ischemia since 2004[18], and in 2009, endovascular surgery had surpassed open vascular surgery with 29 endovascular *vs* 24 open vascular revascularizations.

OPEN SMA EMBOLECTOMY

Most patients with embolic SMA occlusion will have a main stem embolus and an extensive intestinal ischemia[4].

Table 1 Frequency of acute mesenteric ischemia in patients with acute abdomen *n* (%)

Patient selection criteria	Population	Study period	Frequency of acute mesenteric ischemia	Ref.
Emergency laparotomy	Atlanta, United States	1996-2001	53 (17.7)	[5]
Suspected peritonitis	Ferrara, Italy	1995-2001	2 (2.1)	[6]
Emergency abdominal surgery and age ⩾ 70 yr	Valladolid, Spain	1986-1995	27 (3.8)	[7]
Forensic autopsy, peritonitis	Malmö, Sweden	1970-1982	6 (4.4)	[8-10]
Acute abdomen and age ⩾ 50 yr	Karlskrona, Sweden	2000-2003	9 (8.9)	[11]
Long-term open abdomen treatment	Malmö, Uppsala, Falun, Gävle	2006-2009	11 (9.9)	[12]
Emergency laparotomy	Eastborne, United Kingdom	2008-2010	3 (3.1)	[13]
Emergency laparotomy and age ⩾ 80 yr	Gillingham, United Kingdom	2005-2010	5 (5.0)	[14]
Damage-control laparotomy and non-trauma patients	Auckland, New Zealand	2008-2010	13 (31.0)	[15]

Open SMA embolectomy is a good treatment option[19]. After laparotomy, exposure of the SMA, transverse arteriotomy, insertion of Fogarty catheter nr 3 downstream and 4 upstream, and balloon embolectomy, is performed. The result should be monitored at least by an ultrasonic transit time flow meter, but angiography of the SMA with antero-posterior and lateral views after femoral artery puncture and catheterization of the origin of the SMA gives better information about the status of the whole vascular tree, and identifies stenosis and dissection at the closure site, residual peripheral embolus in arterial branches not cleared, and venous return to the portal vein. The minority of patients with a peripheral embolic SMA occlusion[4] in one or multiple branches and a limited bowel segment of ischemia may be treated primarily with short bowel resection and primary bowel anastomosis without attempting intestinal revascularization.

HYBRID OR ENDOVASCULAR THERAPEUTIC OPTIONS IN ACUTE THROMBOTIC OCCLUSIONS

Most patients with acute thrombotic SMA occlusion due to thrombosis superimposed on an underlying local occlusive atherosclerotic lesion in the proximal SMA, have extensive intestinal ischemia, which requires revascularization for longer survival[4]. Hybrid (combining open vascular and endovascular surgery) or endovascular approach in acute thrombotic occlusions of the SMA seems advantageous compared with classical open vascular procedures. Endovascular therapy in thrombotic occlusions implies less surgical trauma in these often elderly fragile patients and requires less intensive care resources than the technically more challenging open vascular reconstructions in the emergency setting. It has been learned from experience that there is rarely any indication for revascularization of both the SMA and the celiac trunk, and that SMA revascularization clearly is more important.

ACCESS TO THE SMA

The SMA can be reached *via* the femoral and brachial arterial routes, and after local exposure of the SMA intra-abdominally after laparotomy. Brachial artery access may be preferable in case of a very sharp downward angle between the aorta and the SMA, or if an extensive calcified occlusive lesion in the ostium of the SMA has to be passed with wires, catheters and introducers, to avoid dissection of the SMA. Brachial artery access is preferred when there are occlusive lesions in the aorta below the SMA and/or in the iliac arteries.

RETROGRADE RECANALIZATION AND STENTING OF THE SMA

Laparotomy and exposure of the SMA is performed for retrograde SMA recanalization and stenting[20,21]. This approach offers the ability to inspect the abdominal contents, to have distal control of the SMA, and to avoid bypass surgery in the setting of a necrotic bowel and necessary bowel resections with subsequent risk of infection of the vascular prosthesis.

The SMA is exposed at the junction of the mesocolon and the small bowel mesentery. A puncture is made in the main trunk of the vessel with a micro puncture needle and the occlusion is often easily recanalized with a 0.018 mm guidewire into the aorta. The SMA is clamped distally to avoid distal embolization if a fresh thrombus at the occlusion site is suspected. The proximal SMA lesion is then crossed with a stiff, braided 4 Fr catheter, exchanged for a 260 cm long 0.035-inch hydrophilic guidewire. The wire is snared in the aorta using a snare passed through the brachial or femoral artery and then brought out creating through-and-through access. A small transverse arteriotomy is then performed at the level of the puncture and an over-the-wire Fogarty balloon is passed into the aorta if thrombectomy seems necessary. Thrombectomy is performed over the wire and the SMA inflow evaluated. If thrombectomy is not necessary, no arteriotomy is performed. Occasionally, predilatation with a 3 mm balloon of the hard and occlusive lesion is needed. With slight traction on the wire, a 6-7 Fr introducer, Flexor or Destination, is then placed antegrade in the SMA over the through-and-through wire. A balloon-expandable stent at the calcified ostium is often placed across the lesion, sometimes followed by a distal self-expandable stent extension into the SMA. A balloon-expandable 7-8 mm diameter large stent is chosen as this has better properties than a self-expandable stent

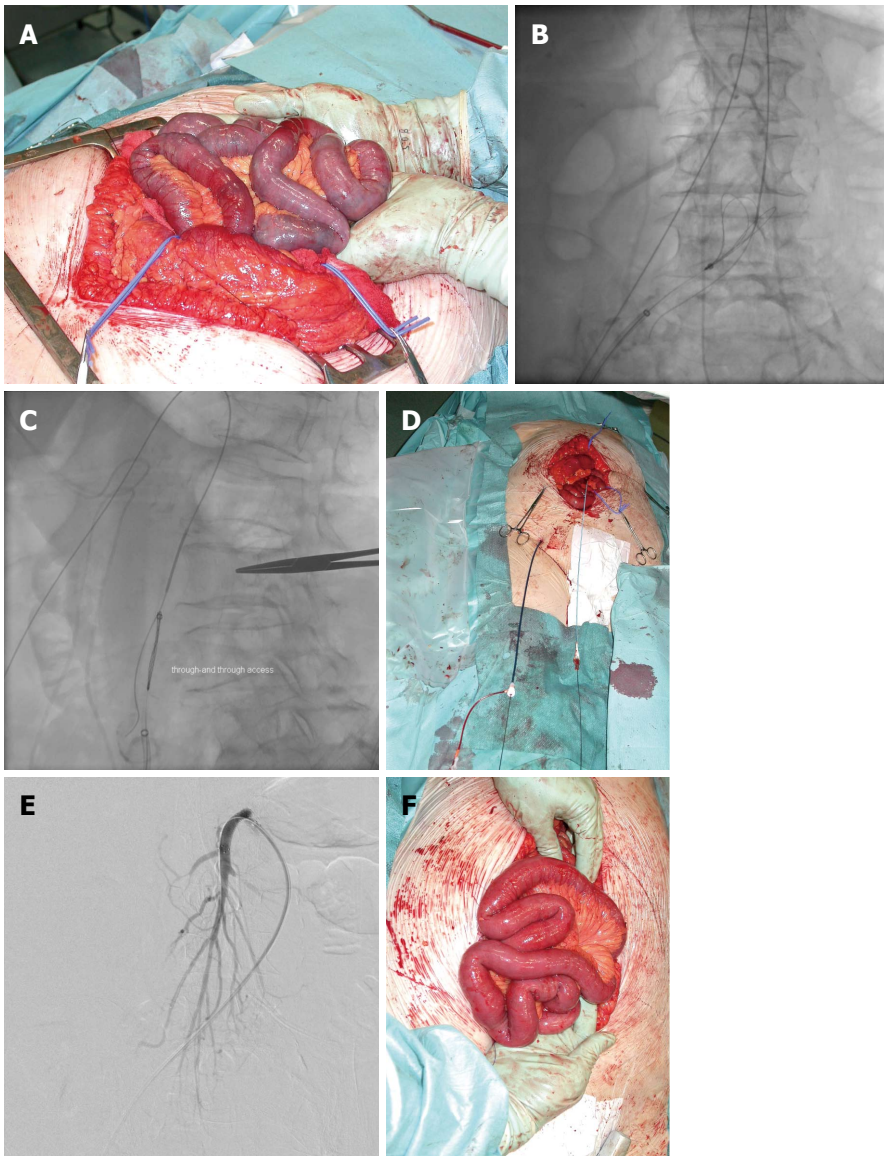

Figure 1 Hybrid approach in a patient with computed tomography verified acute thrombotic occlusion. A: Laparotomy shows extensive small bowel ischemia with appearance of cyanosis, poor peristalsis and slight dilatation of small bowel loops. The superior mesenteric artery (SMA) was exposed followed by retrograde puncture of the SMA, passage of a guidewire across the occlusive lesion, which was first dilated with a 2 mm balloon, followed by passage of a 4 Fr Cobra slip catheter downstream from the infra-renal aorta; B-E: After retrograde puncture in the right common femoral artery, a long introducer and a snare (B) were brought up to catch the guidewire (C) introduced from the SMA, to establish through-and-through access (D) by bringing the guidewire out of the introducer that was inserted in the groin. The introducer was then advanced into the proximal SMA, followed by antegrade stenting with a short balloon expandable stent, then a longer self-expandable stent extension was introduced (E); F: Rapid recovery of normal color of the small bowel loops and peristalsis was noted before closing the abdomen. The patient had an uneventful recovery.

in maintaining a larger stent lumen diameter after stent deployment. However, unfavorable artery angulation and risk of arterial dissection may appear at the distal stent end and the stented arterial segment may therefore be extended with a self-expandable stent into the middle SMA. Results after stenting are controlled by angiography as well as pressure measurements (Figure 1A-F). If there is a residual pressure gradient across the stent (> 12 mmHg), additional percutaneous transluminal angioplasty and/or stenting is performed. The access hole after withdrawal of the through-and-through guidewire in the SMA is treated by manual compression. Antegrade stenting is better than retrograde stenting, since the procedure can be performed in a usual manner with standard devices without exposing the operators to an increased dose of radiation.

ANTEGRADE RECANALIZATION AND STENTING OF THE SMA

After laparotomy, antegrade recanalization and stenting of the SMA can be performed, perhaps in a "hostile abdomen" with extensive intra-abdominal adhesions after several prior operations or after radiotherapy. If femoral artery access fails, an attempt can be made to cross the occlusive ostial SMA lesion from brachial artery access

Table 2 Outcomes after open and endovascular revascularization for acute superior mesenteric artery occlusion *n* (%)

Ref.	Publication year	Population	Study period	Endovascular or hybrid therapy/all cases	Bowel resection	30-d or in-hospital mortality
Schermerhorn *et al*[22]	2009	United States	2000-2006	1857 (35)	2138 (41)	1615 (31)
Block *et al*[18]	2010	Sweden	1999-2006	42 (26)	80 (51)[1]	61 (37)
Arthurs *et al*[23]	2011	Cleveland, OH, United States	1999-2008	56 (80)	60 (80)	29 (41)
Ryer *et al*[24]	2012	Rochester, MI, United States	1990-2010	11 (12)	38 (41)	20 (22)

[1]Incomplete data in six patients.

using a 4 Fr Headhunter catheter. When a stable 0.035 inch guidewire has been placed in the ileocolic artery, an introducer is advanced past the atherosclerotic lesion. Removal of the fresh thrombotic clot may be performed by aspiration, prior to antegrade stenting. One of the most feared complications after antegrade recanalization is a long dissection of the SMA without being able to create a re-entry with the guidewire into the true lumen of the distal SMA. The end result may be worsened ischemia of the intestines, leading to no other option than to perform extensive bowel resection and to leave the patient with short bowel syndrome[21].

OUTCOMES AFTER OPEN AND ENDOVASCULAR REVASCULARIZATION FOR ACUTE SMA OCCLUSION

There are four retrospective studies[18,22-24] reporting outcomes after open vascular and endovascular surgery for acute SMA occlusion (Table 2). Comparison between open and endovascular surgery is dubious due to the existence of many potential confounders, especially disease severity and symptom duration. In comparison with studies reporting on outcomes after emergency bowel surgery only for acute SMA occlusion, bowel morbidity and short-term mortality is clearly reduced after intestinal revascularization. There seems to be lower bowel morbidity and lower mortality after endovascular therapy for acute thrombotic occlusion compared with open vascular surgery[18,22,23]. One important aspect of the endovascular or hybrid approach compared with open vascular surgery, which may influence outcome, is that angiographic monitoring is part of the procedure after endovascular surgery[18], whereas there is room for much improvement in the percentage and quality of monitoring after open vascular surgery.

MEDICAL TREATMENT AFTER ACUTE SMA OCCLUSION

During the critical postoperative period, all patients undergoing revascularization of the SMA and/or bowel resection, are immediately treated with low molecular weight heparin, and a full dose is given to those with embolic occlusion. Patients surviving acute mesenteric vessel occlusion need to be carefully medicated when discharged. In case of thrombotic occlusion, patients need to be medicated against atherosclerosis with an antiplatelet aggregation inhibitor and statins[16]. In the case of embolic occlusion, life-long therapy with a vitamin K antagonist or low molecular weight heparin is indicated. Importantly, most patients with embolic SMA occlusion have synchronous embolism in other vascular territories[4] and need to be protected from new embolic events.

RADIOLOGICAL FOLLOW-UP AFTER STENTING OF THE SMA

Patients with stenting of the SMA need to be followed by either duplex or CT angiography at regular intervals due to the risk of restenosis, need for re-intervention, and the serious consequence of stent occlusion[16]. The small group of patients experiencing acute thrombotic stent occlusion at follow-up was reported to have a mortality rate of 50%[16]. It is suggested that the first imaging can be performed 3 mo postoperatively, followed by imaging examination every 6-12 mo.

DAMAGE CONTROL SURGERY

At laparotomy, necessary bowel resections and organ removal due to obvious transmural and gallbladder necrosis, respectively, are performed, preferably after revascularization of the SMA, according to the principles of damage control surgery[25-27]. The bowel resections are performed with staples, leaving the creation of anastomoses or stomas until the second or third look laparotomy. The abdominal wall can be left unsutured in patients scheduled for planned re-laparotomies. In such cases, a skin only closure or temporary abdominal closure with an abdominal VAC® dressing may be applied when there is severe visceral swelling and risk of intra-abdominal hypertension or abdominal compartment syndrome.

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