Retrograde open mesenteric stenting for acute mesenteric ischemia

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Objective: **Acute mesenteric ischemia (AMI) encompasses the sequels of end-stage untreated chronic mesenteric ischemia and acute mesenteric artery thrombosis. Percutaneous mesenteric artery stenting (PMAS) is the preferred treatment of patients with AMI but is not always feasible. Retrograde open mesenteric stenting (ROMS) is a hybrid technique that combines the advantages of open surgical and endovascular approaches. The literature on the results of this new technique is scarce. The aim of this study was to evaluate the results of ROMS in a consecutive series of patients with AMI.**

Methods: **All patients with emergent mesenteric revascularization for AMI between January 2007 and September 2011 were entered in our prospective registry. Technical success, mortality, patency, clinical success, and complication rate at 30 days and 6 and 12 months were assessed.**

Results: **Sixty-eight patients presented with AMI and 54 underwent PMAS, of which four were unsuccessful and followed by ROMS. Eleven patients were directly treated with ROMS, making a total of 15 patients (10 women and five men; median age, 66 years [interquartile range, 54-73 years]). In all patients, only the superior mesenteric artery was revascularized. In nine of the 15 patients, all three mesenteric arteries were severely stenotic or occluded. Technical success was achieved in 14 patients. At ROMS in two patients, the small bowel was severely ischemic. One of these patients needed a partial bowel resection because of irreversible transmural ischemia. At 30 days, the mortality rate was 20% and the primary patency was 92%. Ten patients underwent unplanned relaparotomy, of whom one needed resection of a large part of the small bowel. At 12 months, the mortality rate was still 20%. The primary patency was 83%. Primary assisted patency was 91%, and secondary patency was 100%. Clinical success at 30 days, 6 months, and 12 months, respectively, was 73%, 67%, and 67%.**

Conclusions: **AMI is still a devastating event. If PMAS is not feasible, ROMS is a reliable alternative and is associated with a relatively low mortality and morbidity rate. (J Vasc Surg 2014;60:726-34.)**

Acute mesenteric ischemia (AMI) encompasses the sequels of end-stage untreated chronic mesenteric ischemia (CMI) and acute mesenteric arterial thrombosis. Transmural bowel ischemia and a full-blown peritonitis will follow without timely restoration of mesenteric blood flow. Over the years, mortality of acute on CMI remained unchanged, between 60% and 90%, despite advances in therapeutic intervention.[1-3] Therefore, the most important factors for improvement of survival are a high index of suspicion, a proper and timely diagnosis of CMI to the onset of AMI, and the immediate restoration of blood flow with minimal collateral damage.

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The preferred option in patients with increased operative risk due to local or systemic risk factors is percutaneous mesenteric artery stenting (PMAS) for CMI.[4] PMAS in case of AMI could also be a bridge to an operative revascularization in a more stable and improved clinical condition. In our experience, PMAS is not possible in nearly 20% of patients with AMI because of extensive aortic wall and mesenteric artery origin atherosclerosis. Furthermore, besides immediate revascularization, patients with AMI often need a laparotomy for inspection and sometimes resection of nonviable bowel. Retrograde open mesenteric stenting (ROMS) of mesenteric arteries is a hybrid technique that combines open surgical and endovascular approaches. This technique has been described in some case reports, but larger series reporting midterm outcome are rare.

In this article, we describe our experience with ROMS in a cohort of 15 patients with AMI.

METHODS

Patients. Our hospital is a nationwide, tertiary referral center for evaluation of patients with suspected CMI and AMI in The Netherlands. Since 1996, all patients with CMI and AMI were prospectively included in our vascular registry. We started with ROMS in 2007. All 68 patients with AMI presenting between January 2007 and September 2011 were included in this report (Fig 1).

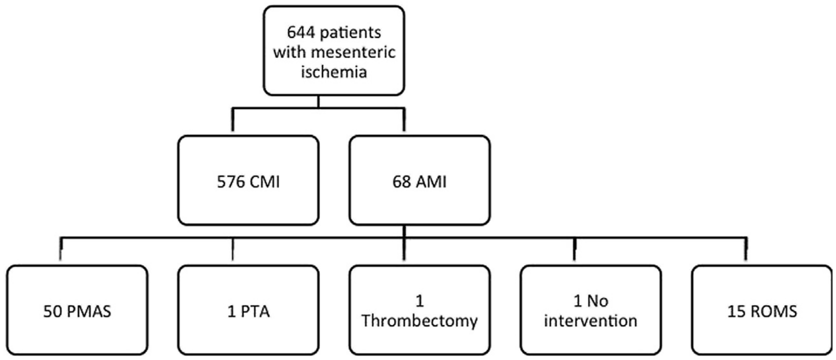

Fig 1. Flow chart of final treatment of patients with suspected chronic mesenteric ischemia (*CMI*) or acute mesenteric ischemia (*AMI*). Initially 54 patients underwent percutaneous mesenteric artery stenting (*PMAS*), but four patients underwent retrograde open mesenteric stenting (*ROMS*) afterward because of the clinical presentation. *PTA,* Percutaneous transluminal angioplasty.

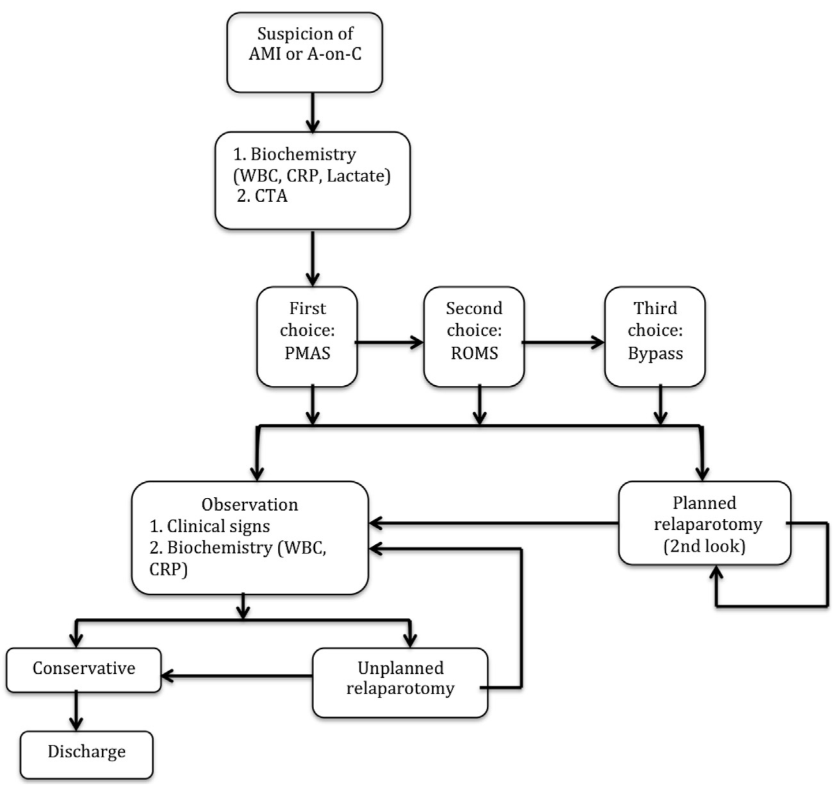

Fig 2. Flow chart of treatment of patients with suspected acute mesenteric ischemia (*AMI*). *A-on-C,* Acute on chronic mesenteric ischemia; *CRP,* C-reactive protein; *CTA,* computed tomography angiography; *PMAS,* percutaneous mesenteric artery stenting; *ROMS,* retrograde open mesenteric stenting; *WBC,* white blood cell count.

The prospectively gathered data were retrospectively analyzed.

All patients thought to have AMI underwent computed tomography angiography (CTA) to confirm significant stenoses or occlusions of the mesenteric arteries and to assess signs of transmural bowel ischemia. PMAS was the preferred option for mesenteric artery revascularization. The decision for an additional urgent laparotomy was based on clear clinical signs of peritonitis. ROMS was the second choice if PMAS was not feasible (Fig 2).

ROMS. A small transverse upper abdominal laparotomy is performed. The superior mesenteric artery (SMA) is exposed and controlled inferior to the transverse colon mesentery. After exposure, the patient is fully heparinized (5000 IU). The SMA is incised distally from the occlusion, a short 0.035-inch wire is introduced,

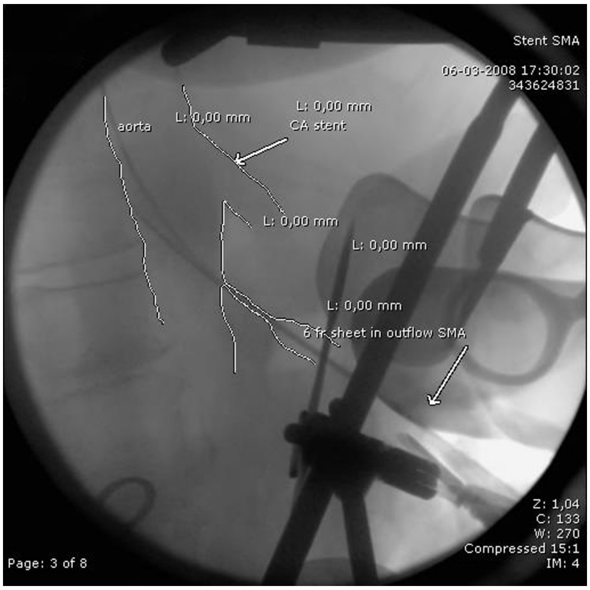

Fig 3. A hand-injected retrograde lateral angiogram. *CA,* Celiac artery; *SMA,* superior mesenteric artery.

and a 6F flexible sheath is placed in a retrograde fashion. Metallic abdominal retractors are removed or replaced when the sheath is in place, and hand-injected retrograde lateral angiography (Fig 3) is performed. Imaging of the re-entry target may be accessed by simultaneous flush aortography with a pigtail catheter introduced by femoral access. A 0.035-inch guidewire (Terumo, Somerset, NJ) is used to cross the lesion transluminally or subluminally. A short 5F PIER (Cordis, Miami, Florida) catheter or an Outback re-entry catheter (Cordis J&J, Waterloo, Belgium) is used to reach the aortic lumen. Calcified lesions usually require predilation. A short 6- or 7-mm balloon-expandable stent (Express; Boston Scientific, Natick, Mass) is placed retrograde in the SMA origin. In case of longer occlusions, the stent is extended with a self-expandable stent (Wallstent; Boston Scientific). The exact performance depends on length and calcification of the lesion. The proximal side of the stent is intended to protrude into the aortic lumen. Completion angiography in both anteroposterior and lateral projections to assess the inflow is performed before the sheath is removed (Fig 4). After sheath removal, the incision in the SMA is closed with Prolene 6-0.

Postoperative treatment and follow-up. All patients received systemic heparin postoperatively (activated partial thromboplastin time between 40 and 60 seconds). Enteral intake was gradually restarted according to a strict protocol adjusted by clinical examination, daily white blood cell (WBC) counts, and C-reactive protein (CRP) measurements. Enteral feeding was disrupted with ongoing abdominal symptoms, severe diarrhea, and increases in WBC counts and CRP levels, compatible with progressive ischemic-reperfusion damage. Patients with clinically or biochemically suspected restenosis or occlusion of the SMA received a contrast-enhanced computed tomography scan. Treatment with dual platelet inhibitors, clopidogrel (for 6 months) and acetylsalicylic acid (as maintenance treatment), was started as soon as the bowel function was restored.

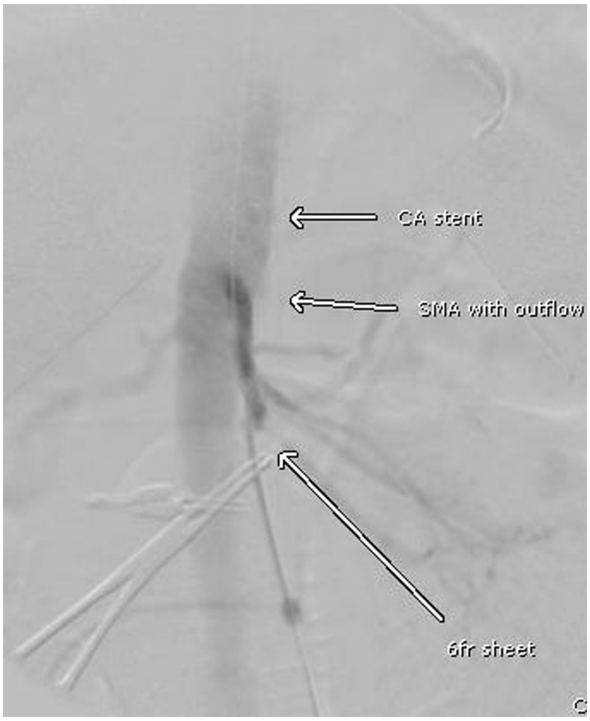

Fig 4. Retrograde completion angiogram after placement of a superior mesenteric artery (*SMA*) self-expandable stent. During the stay of the 6F sheath, there is no flow distally through the SMA. The celiac artery (*CA*) balloon-expandable stent was placed percutaneously.

After discharge, patients underwent mesenteric artery duplex ultrasound evaluation at 3 and 6 months and yearly thereafter.

Definitions. *Technical success* (based on intention to treat) was defined as successful completion of the procedure and <30% residual stenosis at the end of the procedure.[5,6] *Primary patency* was defined as uninterrupted patency with no extra procedures needed.[5,6] *Primary assisted patency* was defined as revision of the revascularization method to prevent impending occlusion or progression of stenosis.[5,6] *Secondary patency* was defined as restored patency after occlusion by thrombectomy, thrombolysis, or transluminal angioplasty or any problems with the stent requiring revision or reconstruction.[5,6] *Clinical success* was defined as relief or improvement of presenting symptoms.[5,6] A *serious adverse event* (SAE) was defined as any clinical event that resulted in death or was life-threatening, produced permanent or significant disability or incapacity, resulted in hospitalization of the patient or prolongation of existing in-patient hospitalization, or required medical or surgical intervention to prevent permanent impairment of function or permanent damage to a body structure.[5,6]

Table I. Preoperative patient characteristics

Case	*Age, years*	*Sex*	*Previous medical history*	*BMI, kg/m²*	*Number of vessels*	*WBC count, × 10⁹/L*	*CRP level, mg/L*	*Imaging*
1	78	M	PAF, contracted kidney, COPD, RA, gout, IC, MI	20.4	2	7.7	10	CT, MRA, duplex ultrasound, DSA
2	59	F	Hematuria, AP, sterilization, resection of ileocecum, PTCA		3	8.6	57	Echocardiography, duple ultrasound, DSA
3	59	M	COPD, peripheral artery bypass, renal failure, PV, aortic bifurcation prosthesis, HT, inguinal hernia correction	19.7	2	7.8	10	CT, DSA, duplex ultrasound, tonometry
4	77	F	COPD, HC, IC	16	1	8.4	10	CT, DSA, duplex ultrasound, gastroscopy, tonometry
5	70	F	HT, HC, peptic ulcer		2	25.2	65	CT, DSA, duplex ultrasound
6	69	M	HT, HC, COPD, MI, aortic bifurcation prosthesis	21	3	6.8	10	CT, duplex ultrasound, tonometry
7	76	F	HT, appendectomy, diverticulosis, peripheral artery stenting	21	3	11.3	68	CT, duplex ultrasound, DSA
8	76	M	CLI, TIA twice, CVA twice, HC, HT, melanoma, DM type 2		3	1.5	83	CT
9	57	F	No	21	3	31.3	49	Echocardiography, CT, DSA
10	64	F	Multiple peptic ulcers	16.48	3	9.6		CT, DSA, tonometry, duplex ultrasound
11	54	F	Resection of ileocecum, bronchitis	16.3	3	16.7	36	CT, DSA
12	55	F	Barrett esophagus, sliding hiatus hernia, *Helicobacter pylori* gastritis, peptic ulcer, IBS, epilepsy, CVA, TIA, HC	20	3	34.4	174	CT, DSA
13	69	M	TIA, HT, peripheral PTA, appendectomy	16.1	3	31.4	305	CT, DSA
14	77	F	HT		2	25.3	312	CT, DSA
15	77	F	HT, DM, triple CABG, AVR, peripheral artery bypass, cholecystectomy		2	23.5		CT

AP, Angina pectoris; *AVR,* aortic valve replacement; *BMI,* body mass index; *CABG,* coronary artery bypass graft; *CLI,* chronic limb ischemia; *COPD,* chronic obstructive pulmonary disease; *CRP,* C-reactive protein; *CT,* computed tomography; *CVA,* cerebrovascular accident; *DM,* diabetes mellitus; *DSA,* digital subtraction angiography; *HC,* hypercholesterolemia; *HT,* hypertension; *IBS,* irritable bowel syndrome; *IC,* intermittent claudication; *MI,* mitral valve insufficiency; *MRA,* magnetic resonance angiography; *PAF,* paroxysmal atrial fibrillation; *PTA,* percutaneous transluminal angioplasty; *PTCA,* percutaneous transluminal coronary angioplasty; *PV,* polycythemia vera; *RA,* rheumatoid arthritis; *TIA,* transient ischemic attack; *WBC,* white blood cell.

Outcome measures. Technical success, mortality, primary and secondary patency, clinical success, and SAE rate at 30 days and 6 and 12 months of ROMS on an intention-to-treat basis were assessed.

RESULTS

Patient characteristics. A total of 644 patients with mesenteric ischemia were included in our vascular registry between January 2007 and September 2011. As shown in Fig 1, 68 patients presented with AMI needing urgent revascularization. In one patient, no treatment was initiated because of the extremely poor health. He died within a couple of days. One patient underwent operative thrombectomy. Fifty-four were treated with PMAS, of which 50 were successful and four failed. The reason for failure in all these four patients was technical impossibility of stent placement. One patient underwent percutaneous transluminal angioplasty alone. Fifteen patients underwent ROMS. In 11 patients, ROMS was the initial treatment; but in four patients, unsuccessful PMAS was the initial treatment, after which ROMS followed.

The characteristics of these 15 patients treated with ROMS are extensively described in Tables I and II. All

Table II. Summary of patient characteristics

Median age, years (IQR)	66 (54-73)
No. (M/F)	15 (5/10)
BMI (IQR)	19.85 (16.2-21)
1-vessel disease	1/15
2-vessel disease	5/15
3-vessel disease	9/15
Cardiac disease	4/15
Carotid disease	3/15
COPD	5/15
Diabetes mellitus	2/15
Hyperlipidemia	5/15
Hypertension	8/15
Renal failure	2/15
WBC count	
Elevated	9/15
Median (IQR)	10 (8-26)
CRP level, mg/L	
Abnormal	9/14
Median (IQR)	57 (10-129)
IC admission, days (IQR)	2 (0-10)
Ward admission, days (IQR)	14 (9-18)
Hospitalization, days (IQR)	19 (15-25)
Follow-up, months (IQR)	33 (5-57)

BMI, Body mass index; *COPD,* chronic obstructive pulmonary disease; *CRP,* C-reactive protein; *IC,* intensive care; *IQR,* interquartile range; *WBC,* white blood cell.

Table III. Perioperative patient outcome

Case	*Technical success*	*Viable bowel at ROMS*	*Resection at ROMS*	*Clinical success*	*Relaparotomy planned (second look)*	*Relaparotomy unplanned*	*SAE*	*Deceased*	*IC stay, days*	*Total in hospital stay, days*
1	Yes	Yes	No	Yes	No	Yes; adhesiolysis	Prolonged ileus	No	13	27
2	Yes	Yes	No	Yes	No	Yes; no abnormalities	Mesenteric hematoma, liver failure, wound infection	No	0	38
3	Yes	Yes	No	Yes	No	No	No	No	0	12
4	No	Yes	No	No	No	No	Rectus abdominis bleeding, coiling superior epigastric artery	No	0	14
5	Yes	Yes	No	Yes	No	Yes; 150 cm of ischemic small bowel resected	Cardiac arrest, mesenteric hematoma	Yes	0	16
6	Yes	Yes	No	Yes	No	Yes; hemostasis	Bleeding-induced tear in the falciform ligament	No	2	19
7	Yes	Yes	No	Yes	No	No	No	No	0	18
8	Yes	Yes	No	Yes	No	No	No	No	0	15
9	Yes	Yes	No	Yes	No	No	Reflux esophagitis, wound infection	No	0	24
10	Yes	Yes	No	Yes	No	Yes; no abnormalities	No	No	9	16
11	Yes	Yes	No	Yes	No	Yes; resection of ischemic ileocecum	Sepsis (central venous line infection)	No	2	21
12	Yes	Yes	No	Yes	No	Yes; no abnormalities	Pneumonia	No	10	24
13	Yes	Yes	No	Yes	No	Yes; no abnormalities	No	No	2	11
14	Yes	No; small bowel	Yes; small bowel	Yes	Yes; no resection	Controlled fistula[a]	Recurrent bowel perforation and abscesses	Yes	26	26
15	Yes	No; small bowel	No[b]	No	Yes; no resection	Ileostomy	Multiorgan failure	Yes	25	25

ROMS, Retrograde open mesenteric stenting; *SAE,* serious adverse event.
[a]Because of a poor condition (severe shock state), the patient was not able to undergo bowel resection. The intra-abdominal problems were treated in a conservative manner.
[b]After ROMS, bowel perfusion improved clearly, and consequently a resection was not performed.

patients suffered acute or acute on CMI due to extended atherosclerosis of the mesenteric vessels. Median age was 66 years (interquartile range [IQR], 54-73 years). Ten patients were female. Body mass index was available in 10 patients; the median was 19.85 kg/m^2 (IQR, 16.2-21 kg/m^2). In nine of the 15 patients, all three mesenteric arteries were severely stenotic or occluded. Preoperative WBC counts were in the normal range in six patients, elevated (>10,000) in eight patients, and decreased (<4000) in one patient. The median WBC count was 10×10^9/L (IQR, 8-26 $\times 10^9$/L). In nine patients, the CRP level was increased. The median CRP level was 57 mg/L (IQR, 10-129 mg/L). The median intensive care stay was 2 days (IQR, 0-10 days), and the mean hospital stay was 19 days (IQR, 15-25 days). The mean follow-up was 33 months (IQR, 5-57 months).

Outcome. Table III extensively describes the periprocedural details and results. Technical success was reached in 14 of 15 patients. A 6-mm balloon-expandable stent was used in all patients with successful ROMS. In all patients, only one vessel, the SMA, was treated. Five patients received more than one stent in the SMA.

In one patient, ROMS was not possible because of the extent of calcification in all the mesenteric vessels and in the aortic wall. The SMA was occluded, but the celiac artery and the inferior mesenteric artery were not severely stenotic. The bowel showed no transmural ischemia. Consequently, we treated this patient conservatively with our strict refeeding protocol. After 12 months, the patient was eating six times daily in small portions without weight loss.

During ROMS, 13 patients had viable bowel. In one patient, the viability of the small bowel was restored after revascularization. In another patient, viability of the small bowel was not regained. A large part of the small bowel was resected, leaving only 90 cm of viable small bowel in situ.

In two patients, a relaparotomy was needed because of suspicion of progression of bowel ischemia. In one patient, an ischemic ileocecum was resected, and in the other patient, 150 cm of ischemic small bowel was resected.

Fig 5. The recanalization of the superior mesenteric artery (SMA) was unintentionally partially extraluminal, with formation of a false aneurysm around the balloon-expandable stent.

Because of progressive multiple organ failure, the last patient deteriorated, which led to a cardiac arrest and death on the sixteenth postoperative day.

At 3 months of follow-up, one patient suffered some postprandial abdominal pain. She had a normal diet, and no weight loss was reported. Duplex ultrasound evaluation of the stent showed no signs of stenosis. We decided on a wait-and-see approach because ROMS had remarkably improved the symptoms. Thirty-nine months after ROMS, the situation of the patient is stable, and no signs of acute or chronic ischemia have been detected.

In one patient with adequate revascularization and abolishment of AMI after 6 months of follow-up, duplex ultrasound and CTA showed that the SMA recanalization was actually partially located unintentionally extraluminally with formation of a false aneurysm around the balloon-expandable stent. We had thus created a "false lumen" or unintended "stent bypass." A covered stent was placed through a left brachial approach within this balloon-expandable stent to preserve SMA vascularization and to prevent further growth of the false aneurysm (Fig 5). The patient had an uneventful course thereafter.

Figs 6 to 8 show Kaplan-Meier curves of the mortality, primary and primary assisted patency, and clinical success. The mortality rate at 30 days and 6 and 12 months of follow-up was three of 15 (20%). In these three patients, the extent of the splanchnic ischemia and reperfusion damage was irreversible despite technically successful ROMS. Primary patency at 30 days was 11 of 12 (92%); at 6 and 12 months, respectively, it was 10 of 12 and 10 of 12 (83% and 83%). Primary assisted patency at 30 days, 6 months, and 12 months, respectively, was 11 of 12 (92%), 10 of 11 (91%), and 10 of 11 (91%). Secondary patency at 30 days, 6 months, and 12 months, respectively, was 11 of 12 (92%). Clinical success at 30 days was 11 of 15 (73%); at 6 and 12 months, it was both 10 of 15 (67%).

Ten patients experienced SAEs in the first 30 days. Details are shown in Table III. Ten patients underwent unplanned relaparotomy, of whom one patient needed resection of a large part of the small bowel. Because of the aggressive use of systemic anticoagulation in four of these patients, additional surgical hemostasis of the dissection area was needed.

Table IV. Review of the literature including present series

Literature	*Patients, No.*	*Mortality*	*Primary patency*	*Follow-up, months*
Wyers et al[8]	6	50%	50%	Mean, 13 ± 7
Sonesson et al[7]	6	—	—	—
Moyes et al[9]	4	25%	—	Range, 6 days-36 months
Stout et al[10]	3	0%	100%	8.4 (range, 1.2-16.6)
Milner et al[11]	1	100%	100%	36
Do et al[12]	1	0%	100%	12
Pisimisis et al[13]	7	—	—	—
Present series	15	20%	92%	33 (range, 5-57)

DISCUSSION

Reports in the literature about ROMS are rare and include up to six patients (Table IV). Sonesson et al[7] were the first to report the use of ROMS in six patients after misalignment of a fenestrated aortic endoprosthesis. Mortality, patency, and complication rates are, unfortunately, not given. Wyers et al[8] described their ROMS technique in six patients with acute mesenteric occlusion. Almost all their patients had ROMS for a failed attempt of PMAS. After a mean follow-up of 13 months, their mortality and patency rates were both 50%. The patients with restenosis in their series were also asymptomatic. Moyes et al[9] described ROMS in four patients with acute mesenteric occlusion. The in-hospital mortality rate was 25%. No information is given about patency and complication rates. The present series of 15 patients added substantially more information on the outcome of ROMS.

We demonstrated that ROMS is a hybrid technique combining the advantages of open surgical and endovascular approaches in case of AMI. It creates the opportunity for an efficient, minimally invasive revascularization and assessment of bowel viability. The population described is severely ill, is cachectic, and has a high mortality risk. Even after revascularization, mortality and morbidity are high.[2,14] PMAS is first-choice therapy, but it is not feasible in 20% of cases. In our experience, most AMI patients are not in an appropriate condition

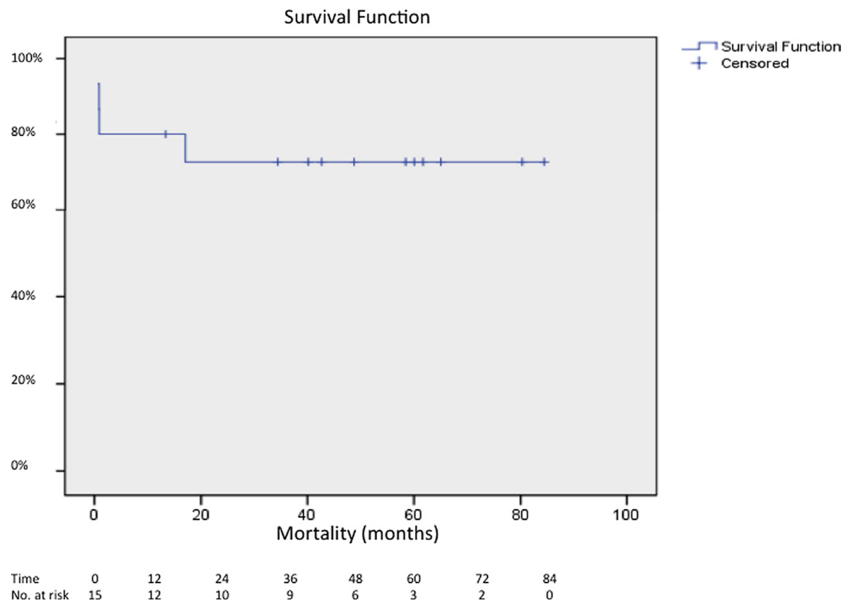

Fig 6. Overall mortality after retrograde open mesenteric stenting (ROMS).

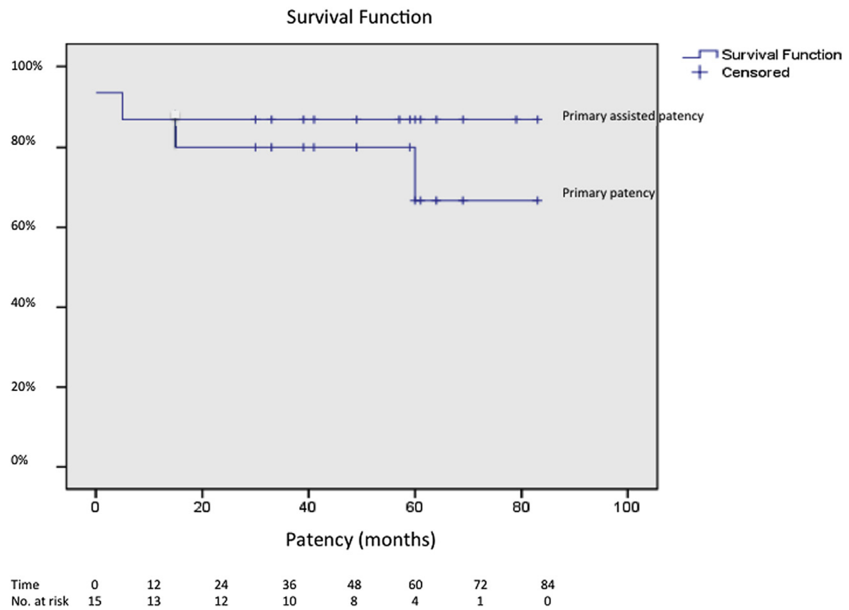

Fig 7. Primary and primary assisted patency of retrograde open mesenteric stenting (ROMS).

to undergo extended bypass surgery. Because of the superior long-term patency, bypass surgery should be reserved for patients in good anabolic condition, with few comorbidities and young age. In all other patients, the low treatment burden and low morbidity make PMAS the preferred choice. Our series of ROMS, the second choice if PMAS is not feasible, shows a high technical success of 93%. With primary, primary assisted, and secondary patency exceeding 90% after 30 days and 83% after 6 and 12 months, our clinical success is 67% after 12 months. The number of SAEs is substantial and was in large part attributed to bleeding complications of the dissection area due to our aggressive anticoagulation therapy. The hospital mortality rate of three of 15 patients was acceptable in these severely ill patients with a failed attempt of PMAS in comparison with the current literature.[1,2] We experienced that our strict refeeding protocol, including daily clinical and hematologic assessment,

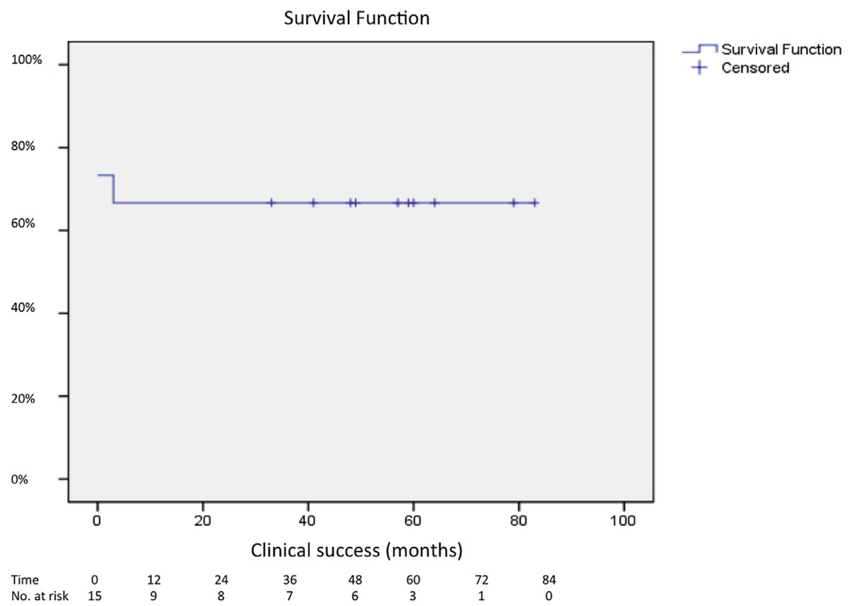

Fig 8. Clinical success after retrograde open mesenteric stenting (ROMS).

diminished the detrimental effects of the ischemia-reperfusion cascade previously seen in these patients.

In retrospect, the one patient in whom ROMS was unsuccessful suffered from one-vessel disease. Although clinical presentation was severe and AMI was suspected, for which ROMS was initiated, the bowel showed no signs of ischemia at ROMS. Afterward, the condition of the patient gradually stabilized when enteral feeding was addressed according to our strict refeeding protocol. In hindsight, this patient did not have AMI but severe one-vessel CMI. In our experience, bowel infarction in one-vessel CMI is rare. This patient died 17 months after ROMS of an exacerbation of chronic obstructive pulmonary disease.

In one patient, ROMS was a bridge to an antegrade autologous aorta-mesenteric bypass. At 16 months of follow-up, the patient had no abdominal symptoms and was gaining weight, but routine duplex ultrasound followed by CTA showed an in-stent stenosis. Because of the improving clinical situation, watchful waiting was the temporary treatment of choice. As the condition of this relatively young patient had improved remarkably, the patient was fit enough to undergo the bypass operation 3 years after ROMS. The patient is doing well, eating without pain, and gaining weight.

At 12 months, our clinical success was 10 of 15 (67%), with a mortality of three of 15 (20%). This is better than described in the current literature on ROMS and is in line with the literature on PMAS. A review in 2002 for surgical treatment of AMI showed a mortality rate of 32% at 30 days and 57% at 12 months and a complication rate of 79%.[2] For PMAS, the mortality rate is 38% at 30 days, with a morbidity rate of 63%.[14] To improve the mortality, morbidity, and clinical success in these mostly fragile patients suffering AMI, we tried to optimize and to individualize treatment, including ROMS and our nine-step bowel rehabilitation scheme. By doing so, we believe we can identify ischemia and reperfusion injury at an earlier stage and are able to act on it in a timely manner and appropriately.

Early detection of AMI is the key to survival. A high index of suspicion after a thorough history and physical examination still serves as the cornerstone.[3,7] Because of its widespread availability, CTA is the modality of choice to confirm the diagnosis of AMI.[8,15] In our series, 14 of 15 patients underwent emergency CTA. One patient underwent only a duplex ultrasound study, followed by digital subtraction angiography instead, because the patient did not need immediate revascularization at initial assessment. Duplex ultrasound was performed first, followed by angiography for antegrade revascularization; only PMAS failed, after which ROMS followed. Because of the good quality of the duplex ultrasound and digital subtraction angiography images, we did not perform additional CTA.

CONCLUSIONS

AMI is still a devastating event. ROMS is associated with a favorable mortality and morbidity rate compared with extensive bypass surgery. ROMS should be the second choice when PMAS has failed.

AUTHOR CONTRIBUTIONS

Conception and design: JB, RG, RM, JK, DG
Analysis and interpretation: JB, RG, RM, MB
Data collection: JB, RG,
Writing the article: JB, RG, RM, JK, DG

Critical revision of the article: JB, RG, RM, JK, DG, MB
Final approval of the article: JB, RG, RM
Statistical analysis: JB, RG, RM, MB
Obtained funding: Not applicable
Overall responsibility: JB

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