

Percutaneous Stenting of the Superior Mesenteric Artery for the Treatment of Chronic Mesenteric Ischemia¹

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Purpose: We wanted to evaluate the effectiveness of stent placement on the superior mesenteric artery as a treatment for chronic mesenteric ischemia.

Materials and Methods: Seven patients (mean age: 55 years, age range: 43 - 66 years) with chronic mesenteric ischemia were enrolled between March 2000 and September 2003. All the patients underwent pre-procedure contrast enhanced computerized tomography to evaluate for occlusion or stenosis of the mesenteric arteries and they then underwent an angiographic procedure. A balloon-expandable metal stent was placed in the superior mesenteric artery, and this was combined with balloon angioplasty and thrombolysis. We evaluated the angiographic and procedural success after the procedures.

Results: Angiographic and procedural success was obtained in 100% of the patients and the clinical symptoms improved in 100% of the patients. The patency at 6-months and 1-year was 85% and 71%, respectively. The mean follow-up period was 12 months (range: 1 - 25 months). During the follow-up period, ischemic symptoms recurred in 2 patients, and restenosis in a stent was confirmed with angiography; one patient was successfully treated by stent placement in the celiac artery and the other patient died due to extensive mesenteric thrombosis.

Conclusion: For the treatment of chronic mesenteric ischemia, percutaneous stent placement on the superior mesenteric artery showed a favorable result and it was an effective alternative to surgery for the high-risk patients.

Index words : Ischemia

Mesenteric artery, superior

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Mesenteric ischemia of an arterial origin is an uncommon condition that's associated with high morbidity and mortality. Acute mesenteric ischemia (AMI) has a reported rate of mortality greater than 50%, and when left untreated, chronic mesenteric ischemia (CMI) eventually leads to death from intestinal infarction or starvation (1).

Surgical revascularization and resection of an infarcted bowel is currently the main treatment for both acute and chronic mesenteric ischemia. Indeed, surgery is the method of choice for AMI, especially if there are indications of a bowel infarction. For cases of CMI, however, immediate stent placement combined with percutaneous transluminal angioplasty (PTA) and/or thrombolysis has been reported to be an effective therapeutic approach. The results from an earlier series of reports on the use of PTA and stenting for CMI showed a technical success rate of 96%, a symptom relief rate of 88%, lower complication rates in the range of 0 - 25% and a low periprocedural mortality rate of 0 - 13% (2 - 8).

The purpose of this study is to present our experience with endovascular treatment of the superior mesenteric arteries (SMA) with using modern stent delivery technology and we also evaluated the efficacy of this procedure as an alternative means of treating CMI.

Materials and Methods

Seven patients (5 males and 2 females, mean age: 55 years, range: 43 - 66 years) with symptomatic CMI were retrospectively enrolled in our hospital between March 2000 and September 2003. The diagnosis of CMI was made according to the clinical symptoms, including postprandial abdominal pain associated with significant weight loss, food phobia, nausea, vomiting or diarrhea that lasted more than 3 months. The diagnosis was initially confirmed by contrast enhanced computed tomography with the findings of significant stenosis with more than a 70% reduction of the luminal diameter. AMI was an exclusion criterion, and this was considered to be an indication for immediate surgery. The definite exclusion criteria were pregnant or lactating women, a patient having a history of prior life-threatening reaction to the contrast agent and those cases with visual angiographic evidence of intraluminal thrombus that was thought to increase the risk of plaque fragmentation and distal embolization. For these cases, the clinical symptoms were abdominal pain ($n=6$) and hematochezia ($n=1$). Seven patients had a previous history of severe heart problems

(4 patients had coronary heart disease and 3 had received a valve replacement).

All the patients underwent pre-procedure contrast enhanced computerized tomography (CT; LightSpeed Plus, GE medical systems, Milwaukee, WI, U.S.A.) to evaluate for occlusion or stenosis of the mesenteric arteries and they all underwent an angiographic procedure, with the intent to treat, on the basis of the prior CT studies and clinical symptoms. We observed four isolated SMA stenoses in four patients and SMA stenosis associated with celiac artery stenosis was observed in three patients. All the inferior mesenteric arteries were patent.

The interventions were performed under local anesthesia that was supplemented with intravenous sedation and analgesia when indicated. The patients were monitored with pulse oximetry and electrocardiography (ECG), and their blood pressure was measured. For thrombotic mesenteric ischemia, urokinase (UK; Yuhan, Seoul, Korea) was infused, as needed, at a dose of 15,000 IU/hr for 24 hours through the SMA with using a 5 Fr infusion catheter (Cook, Bloomington, IN, U.S.A.). A common femoral artery was punctured under local anesthesia. After inserting a long sheath below or above the origin of the targeted mesenteric arteries, angiography of the abdominal aorta and mesenteric arteries was performed. Balloon catheters were used for dilatation and stent placement. The diameter of the balloons was chosen to allow for slight overdilatation of the artery, but the balloon diameter was more than 1mm larger as compared with the corrected diameter of the vessel. Stenting was performed with using a balloon expandable Corinthian stent (Johnson and Johnson interventional system, Warren, NJ, U.S.A.) mounted on the same size balloon, and delivery was performed coaxially through a 7Fr sheath (Johnson and Johnson interventional system).

All the patients underwent heparinization for 1 - 2 days following intervention, and warfarin therapy was administered for a minimum of 6 months thereafter.

All the patients were informed about the potential surgical alternatives and they all gave us their consent to perform a percutaneous procedure for the treatment of CMI.

Angiographic success was defined as a final stenosis diameter of <30% and procedural success was defined as angiographic success without a major complication while at the hospital. Specifically, complications were considered procedure-related if they occurred within 30

days after percutaneous intervention. The complicating events were classified as either major or minor on the basis of the criteria established by the Standards of Practice Committee of the Society of Interventional Radiology (9).

Angiographic CT scanning and angiography were done to assess the patency of the stents between 6 months and 1 year after the procedure, or sooner if there were recurrent symptoms.

Table 1. Summary of the Results of Endovascular Treatment on the Superior Mesenteric Artery

	Sex/Age	Symptoms	Lesion	Stenosis (%)	Urokinase	Stent (mm)	Follow-up (months)	Recurrence	Dead/Alive
1	M/46	Abdominal pain	CA	80	Yes	8 × 40	23	8 months	Alive
			SMA	90		7 × 20			
2	M/58	Hematochezia	CA	90	Yes	6 × 16	25	No	Alive
			SMA	90		6 × 20			
3	M/57	Abdominal pain	SMA	90	No	7 × 17	17	No	Alive
4	F/43	Abdominal pain	CA	100	No	7 × 17	5	No	Alive
			SMA	80		6 × 20			
5	M/48	Abdominal pain	SMA	100	Yes	6 × 16	6	6 months	Dead
6	M/66	Abdominal pain	SMA	70	No	7 × 14	8	No	Alive
7	F/65	Abdominal pain	SMA	80	No	6 × 16	1	No	Alive

M: male; F: female; SMA: superior mesenteric artery; CA: celiac artery

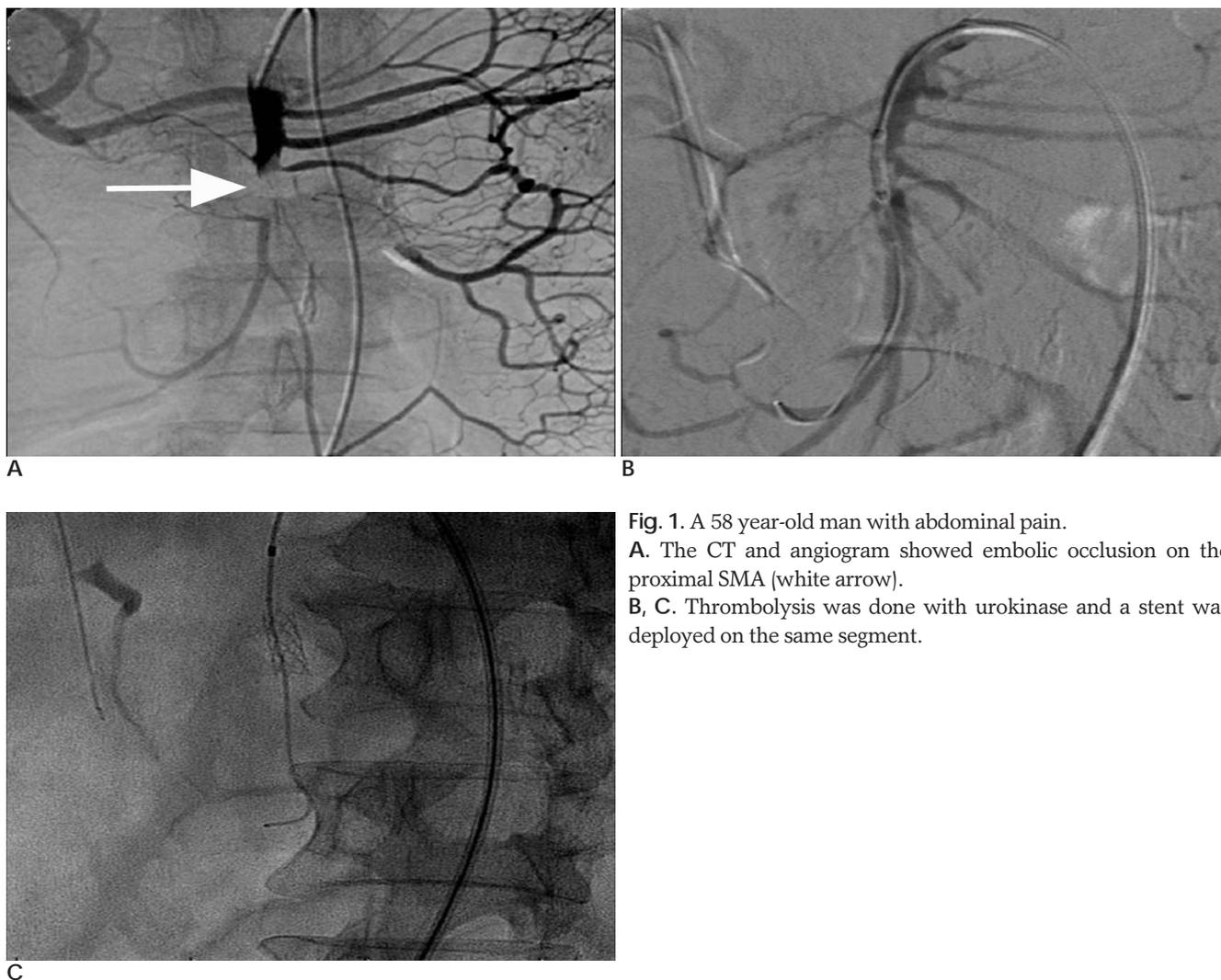


Fig. 1. A 58 year-old man with abdominal pain.
A. The CT and angiogram showed embolic occlusion on the proximal SMA (white arrow).
B, C. Thrombolysis was done with urokinase and a stent was deployed on the same segment.

Results

Angiographic and procedural success was obtained in 100% of the patients (Fig. 1, 2). Likewise, improvement of symptoms occurred in 100% of the patients who had a successful procedure (Table 1). There was no major or minor complication from the procedures.

Seven stents were successfully implanted in the SMA and 3 stents were successfully implanted in the celiac artery. Delivery of a single SMA stent was performed in four patients, and the remaining patients underwent interventions on both the celiac artery and SMA. For treating the thrombotic mesenteric ischemia, UK was infused in the SMA in three patients. The patency rate at 6-months and 1-year was 85% and 71%, respectively.

The mean follow up time was 12 months (range: 1 - 25 months), and 6 of the 7 patients who underwent a successful procedure and left the hospital survived; the sole death was related to recurrent mesenteric ischemia due to extensive thrombosis of the proximal and distal SMA (Fig. 3).

Ischemic symptoms recurred in 2 patients, and stent restenosis was confirmed in them via angiography. One of the two patients died due to recurrence of mesenteric ischemia 6 months after the first procedure. For the second patient, symptoms recurred 8 months after the first procedure, and the patient was successfully treated by placing a stent on the celiac artery instead of restenting the SMA. After restenting, the SMA's patency was maintained for at least 23 months after the secondary procedure.

Discussion

Symptomatic CMI is rarely encountered, and this is probably because of the abundant collateral circulation to the intestines (10). Clinical signs are observed when at least 2 mesenteric arteries are obstructed (8, 11). In one study, 86% of the patients with significant three-vessel arterial disease had mesenteric ischemia or vague abdominal symptoms or they died (12). In approximately 15% to 50% of CMI patients, the initial clinical presentation was acute mesenteric ischemia, which has a mortality rate of 15% to 70% (13, 14).

Surgery has traditionally been the treatment of choice for chronic bowel ischemia; however, the surgical techniques depend on surgeons' habits as well as the anatomical characteristics of the lesions (transaortic endarterectomy, aorto-mesenteric bypass, mesenteric artery re-implantation). In two meta-analysis studies of 335 and 175 patients who underwent open surgery, respectively, Cluzel *et al.* reported a 95% and 96% rate of initial technical success, 6% and 9% procedure-related deaths, 22% and 26% major complications and 80% and 84% primary patency during follow-ups of 24 - 69 months and 36 - 48 months, respectively (15). In an additional study, open surgery revascularization was reported to be an excellent and durable symptomatic cure. Unfortunately, surgical revascularization was associated with perioperative complications in the range of 19% to 54%, with the mortality rates ranging from 0% to 17% (16, 17). The patients who were considered to be at a high surgical risk [an American Society of Anesthesiologists (ASA) score of III-

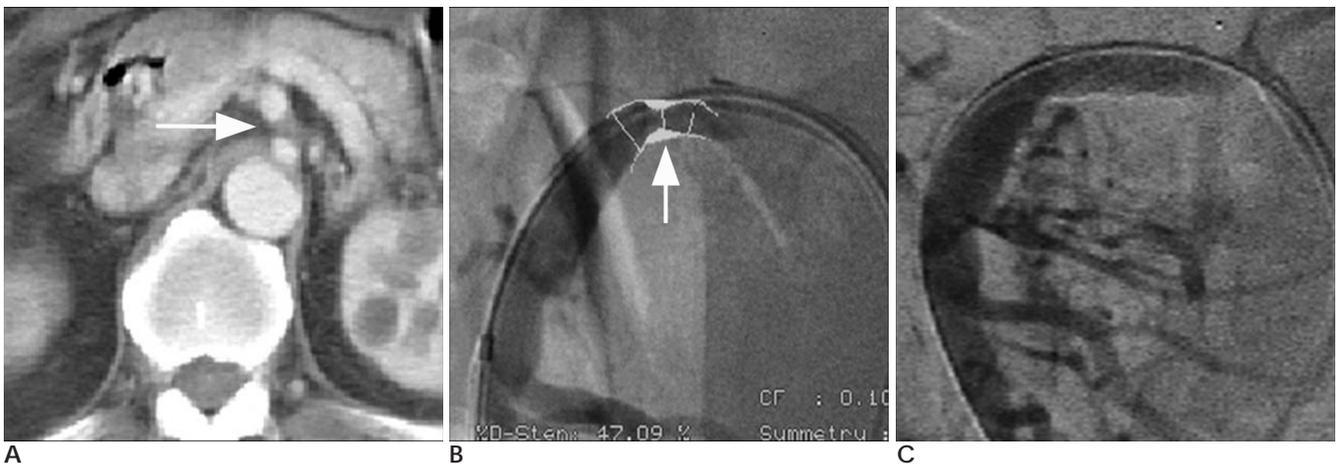


Fig. 2. A 57 year-old man with abdominal pain.
A, B. The CT and angiogram showed segmental stenosis on the proximal SMA due to atherosclerosis (white arrow).
C. Mesenteric blood flow was restored after stent placement.



Fig. 3. A 48 year-old man with abdominal pain.
A. The aortogram showed total occlusion of the SMA and atherosclerotic stenosis of the abdominal aorta.
B. Restoration of mesenteric flow was done after urokinase thrombolysis and stent placement.
C, D. Reocclusion and extensive thrombosis of the SMA was noted on the aortogram and the selective SMA angiogram.
E, F. After thrombolysis with urokinase, persistent thrombosis of the SMA was shown on the follow-up CT.

IV] had a higher high rate of perioperative complications and mortality. The complex anatomy, the technical challenges encountered during open surgical exposure of the paravisceral aorta and the physiological changes have prompted interest in minimally invasive endovascular options for treating CMI.

PTA of the mesenteric artery, as an alternative to surgical transluminal angioplasty and surgical revascularization, was first described in 1980 (18). However, the use of endovascular therapy in mesenteric vascular occlusive artery disease has been limited to only a few series of reports. Immediate stent placement with PTA and/or thrombolysis in CMI has recently been reported to be an effective therapy. These studies have shown that PTA has a high rate of procedural success, with low rates of morbidity and mortality, suggesting that endovascular therapy is an important alternative treat-

ment to surgical revascularization in certain patients (5, 19). In a recent study of 25 patients for whom 26 arteries were treated with primary stenting, technical success was obtained in 96% of the patients and relief was obtained in 88%. There was no procedural mortality, and the only complications were due to the development of a pseudoaneurysm ($n=2$), and renal failure ($n=1$) (2). In particular, Silva et al. reported treating 59 consecutive CMI patients with using stent placement in a total of 79 stenotic mesenteric arteries. Single vessel stenting was performed in 71% of the patients and multivessel stent placement was done in 29% of the patient. Procedural success was obtained in 96% of the patients and symptom relief occurred in 88%. At a mean follow up time of 38 ± 15 months, 79% of the patients were still alive. The primary patency rate at 14 ± 5 months was 71%. Recurrence of ischemic symptoms occurred in 10 pa-

Table 2. Literature Review of Endovascular Treatment of the Mesenteric Arteries in Patients with Chronic Mesenteric Ischemia

Study	No. of patients	Angiographic success(%)	Clinical success(%)	Periprocedural complication(%)	Mortality (%)	Primary Patency(%)	Follow up (months)
Matsumoto (5)	19	79	63	16	0	NA	25
Allen (19)	19	95	79	5	5	NA	79
Maspes (6)	23	90	77	9	0	88	27
Nyman (11)	5	100	80	40	0	40	21
Sheeran (7)	12	92	92	0	8	74	16
Kasirajan(21)	28	100	NA	18	11	73	24
Sharafuddin (2)	25	96	88	10	0	92	15
Chahid(1)	14	88	100	14	0	NA	27
Silva (3)	59	97	88	3	0	71	38
Gabriele(23)	9	100	100	22	0	78	31
Our study	7	100	100	0	14	71	12

NA: Not available

tients. Nine of these 10 patients underwent single-vessel stent placement (3). According to an updated literature review of 213 patients who underwent endovascular treatment for CMI, the mean angiographic success rate was 94%, the clinical success rate was 85% and the primary patency rate was 74%. The complication rate and mortality rate were 14% and 2.4%, respectively (Table 2).

Our results are in accordance with the literature review; the angiographic and procedural success in our study was 100%. Single vessel stenting was performed in 60% of the patients and multivessel stenting was done in 40%. Yet there was no difference of the recurrence rate between these two groups of patients. Further, there was no procedural mortality, and symptom relief occurred for all patients. The patency rate at 6-months and 1-year patency was 85% and 71%, respectively.

Recurrence of ischemic symptoms occurred in 2 patients, and one of these patients died due to recurrent mesenteric ischemia 6 months after the first procedure. Analysis of the patient revealed 100% stenosis in the long segment (length = 3 cm) at the initial diagnosis and recurrent extensive mesenteric thrombosis was noted in spite of thrombolytic treatment and SMA stenting. Brown et al. reported one case of mortality after endovascular treatment for CMI. That patient died 13 months after the stenting due to acute mesenteric ischemia (20). For our second patient who had recurrence of ischemic symptoms, the symptoms recurred 8 months after the primary procedure and the angiography showed severe stenosis of the celiac artery and minimal restenosis of the stented segment in the SMA. So, this patient was successfully treated by placing a stent on the celiac artery. After restenting, patency was main-

tained for 23 months after the secondary procedure.

Kasirajan et al. reported their series of 28 patients who were treated by PTA/Stent and they compared their PTA/Stent results with those of conventional surgical revascularization for the treatment of CMI. The authors reported that the results of PTA/Stent and surgery were similar with respect to the duration of hospitalization, the morbidity, the mortality and the long-term survival. But the PTA/Stent group had a higher rate of recurrent symptoms (21). A retrospective study by Marvin et al. also compared the safety and efficacy of open surgery and endovascular therapy for CMI. There was no difference of the in-hospital major morbidity or mortality, and the incidence of symptomatic or radiographic recurrence. But the endovascular group had a lower primary patency rate and this was associated with the need for earlier reintervention (22).

Because of the relatively low prevalence of mesenteric ischemia, a prospective, randomized clinical trial that compares surgical and endovascular treatment of CMI has not been done. This was a single center study and so it had some limitations due to the small number of patients and the short term follow-up period. Long term follow up with a larger number of patients will be necessary to determine the appropriate role of endovascular treatment for CMI.

For the treatment of CMI, percutaneous stent placement on the SMA showed favorable results and a high rate of effectiveness. Therefore, stent revascularization could be considered as an alternative to surgery for patients with CMI and it is the treatment of choice for patients who are at high risk for surgical complications.

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