# Role of endovascular interventions in treatment of thromboembolic occlusion of superior mesenteric artery

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**Objective**
The aim was to evaluate the efficacy and safety of endovascular management of acute thromboembolic occlusion of superior mesenteric artery (SMA).
**Patients and methods**
Our prospective study was conducted at Vascular Surgery Department, Zagazig University Hospitals, Egypt, and Vascular Surgery and Intervention Radiology Departments, Alnoor Specialist Hospital, Makkah, Saudi Arabia, from March 2015 to September 2019. Eleven cases diagnosed as having thromboembolic occlusion of SMA by computerized tomographic angiography underwent endovascular intervention. Mean age was 54±11 years, and seven patients (63.6%) were males. Abdominal pain and nausea were the commonest symptoms, and none of the patients had acute peritonitis. Median time from start of symptoms to hospital admission was 9 h and from hospital admission to endovascular intervention was 11 h. Etiology was embolic in six (54.5%) patients and thrombotic in five (45.5%) patients. All patients underwent catheter-directed thrombolysis. Median dose of alteplase was 23 mg, and median infusion rate was 0.8 mg/h. Median duration of thrombolysis was 24 h. Two patients underwent balloon dilatation, and one patient underwent balloon dilatation and stenting.
**Results**
Technical success was seen in seven (63.6%) patients, whereas failure of endovascular revascularization in four (36.4%) patients (two of them were thrombotic and died before planned laparotomy and the other two patients were embolic and underwent laparotomy for surgical embolectomy and resection of necrotic bowel segment). Postoperative complications occurred as bleeding in four (36.4%) patients and technical complications in two (18.2%) patients. Three (27.3%) patients died during hospital admission.
**Conclusion**
Endovascular intervention can be an alternative to open surgery for intestinal revascularization for the treatment of early cases of acute SMA occlusion. Computerized tomographic angiography rapid diagnosis, urgent endovascular management, and intensive care and follow-up are the cornerstone for good prognosis.

**Keywords:**
endovascular, occlusion, superior mesenteric artery, treatment

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## Introduction

Acute mesenteric ischemia carries a high mortality risk (60–80%), which is caused by occlusion of one of the major mesenteric vessels or their branches. Thromboembolic lesions usually occur at the superior mesenteric artery (SMA) owing to narrow angle of its take off from aorta. Surgery may increase morbidity and mortality, which are high owing to delayed diagnosis because of unspecific symptoms, lack of reliable signs on examination, and unavailability of a standard management [1].

Recently, endovascular procedures include not only percutaneous transluminal angioplasty (PTA) and stenting but also catheter-directed thrombolysis, vasodilators, and suction embolectomy. Endovascular management offers less invasive techniques for early diagnosed patients, which could restore the arterial supply to the intestine in a shorter time than that done by open surgery [2].

Early revascularization using endovascular techniques has been reported to increase the hospital survival to ~80%, because endovascular techniques decreased the need for abdominal exploration, the length of resected

intestine, and development of complications such as pulmonary and acute renal failure [3].

## Patients and methods

We conducted our prospective study after approval of ethical committee at Vascular Surgery Department, Zagazig University Hospitals, Egypt, and Vascular Surgery and Intervention Radiology Departments, Alnoor specialist Hospital, Makkah, Saudi Arabia, from March 2015 to September 2019. Our patients underwent history taking, physical examination, laboratory investigations, pelviabdominal ultrasound, and abdominal computerized tomographic angiography (CTA).

### Inclusion criteria

The following were the inclusion criteria:

(1) Early presentation of acute abdominal pain less than 24 h.
(2) Patients with CTA showing evidence of thromboembolic occlusion of SMA (main vessel or branch).
(3) Patients with no clinical or radiological proof of intestinal gangrene.

### Exclusion criteria

The following were the exclusion criteria:

(1) Patients with advanced bowel ischemia as presenting with abdominal rigidity, marked abdominal distension, severe hypotension, abdominal free air, or air in the mesenteric veins on CT.
(2) Patients with bleeding disorders or contraindications to thrombolytic agents.
(3) Patients presented with mesenteric venous ischemia.
(4) Patients associated with acute aortic dissection.

All patients or their relatives provided informed consent for undergoing the procedure and agreed to the use of the contrast material.

### Endovascular technique

All the procedures were done under local anesthesia. The access was through the right common femoral artery, which was ultrasound guided, and with a micropuncture set (MAK mini access kit; Merit Medical Systems, Inc., South Jourdan, Utah, USA). Because of using thrombolytic therapy, micropuncture system was preferred to avoid bleeding (as failed puncture with a regular needle would predispose to bleeding). Then a 6 Fr, 45 cm sheath was introduced (Destination Sheath; Terumo, Tokyo, Japan). A 65 cm, 5 Fr, C1 glide Hydrophilic Coated Catheter was used to do SMA angiography (GlideCath; Terumo). Then catheter-directed thrombolysis was done using 4-Fr infusion catheter (Fountain; Merit Medical Systems Inc.) with side holes and infusion length 20 cm. The infusion catheter was connected to infusion pump to deliver 0.6–1 mg/h Alteplase (Actilyse 50 mg vial; Boehringer Ingelheim Pharma GmbH & Co., Biberach/Riss, Germany). The sheath was flushed with 500 U/h heparin. Monitoring the therapeutic effect was achieved with fibrinogen level and partial thromboplastin time. If fibrinogen drops by more than 50% of baseline or drops to less than 150 mg/dl, alteplase infusion was stopped. If partial thromboplastin time prolonged more than 120 s, heparin infusion was stopped.

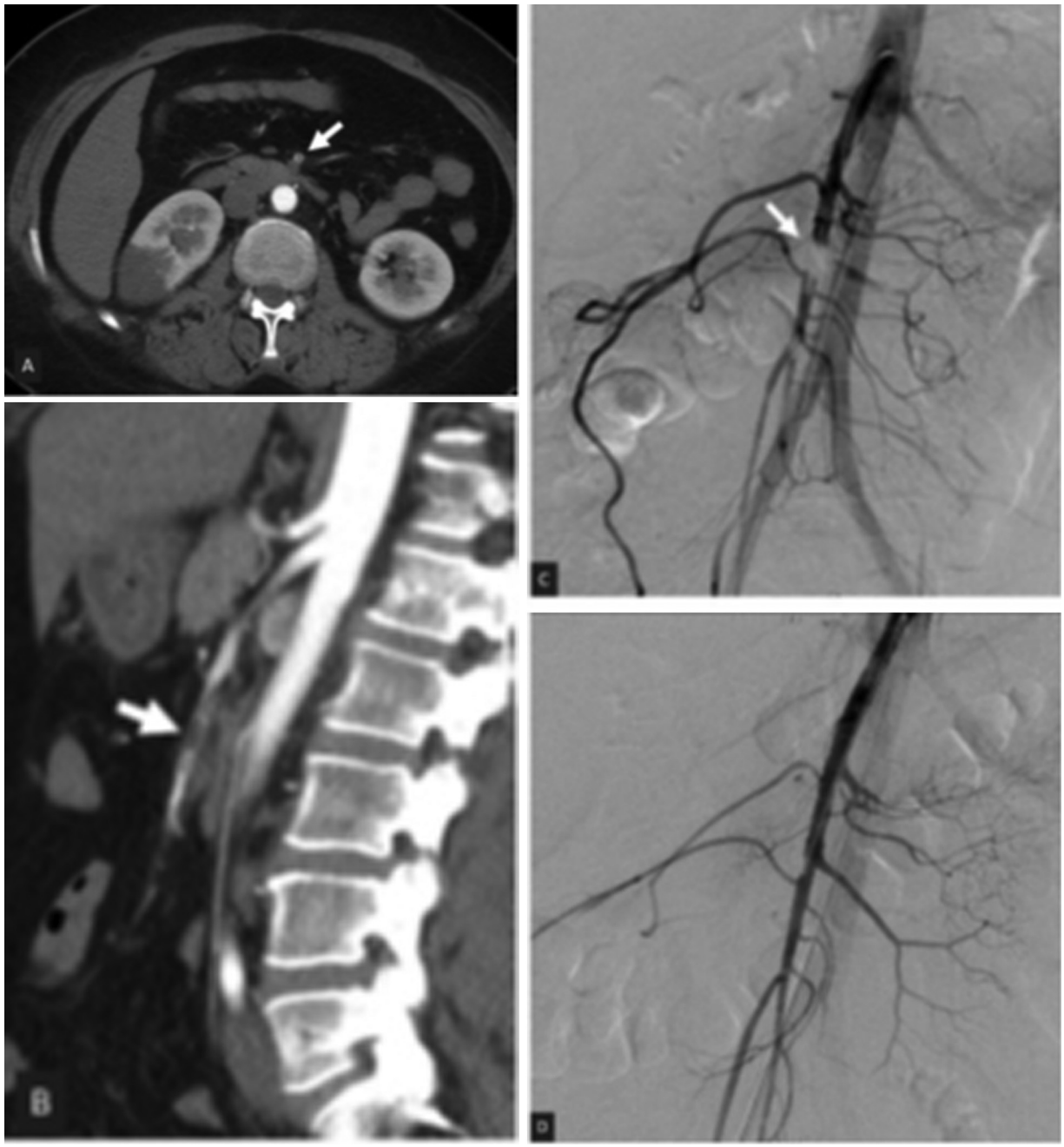
Every 12 h, angiogram was done to assess efficacy of thrombolysis. Complete thrombolysis was achieved in some cases (Fig. 1), and partial thrombolysis was achieved in some cases (Fig. 2). After thrombolysis, treatment of the underlying stenosis, when present, was done (Fig. 3).

Three patients with atherosclerotic changes required balloon angioplasty with 3–4 mm, noncompliant plain balloons (Armada; Abbott Vascular, Santa Clara, California, USA and Advance LP; Cook, Bloomington, Indiana, USA). One patient required stenting (4 mm) due to recoil (Omnilink Elite, Balloon Expandable Stent; Abbott Vascular).

### Postprocedure care

Patients were admitted to the ICU for accurate follow-up of thrombolytic therapy and possibility of complications. Patients underwent bowel rest, intravenous fluid therapy, and nasogastric tube. Abdominal exploration was done if abdominal pain increased or if the case complained of new symptoms or had new signs suggestive of intestinal perforation or gangrene. If intestinal perforation or gangrene was encountered, resection of the affected segment was performed. A second-look abdominal exploration was done if there was worsening of the patient general condition after intestinal resection or if leaving suspicious segment. Therapeutic dose of low-molecular-weight heparin was given. Warfarin was started or regained for cases of atrial fibrillation on disappearance of pain. Cases with significant atherosclerosis or underwent stenting were given antiplatelet therapy (clopidogrel 75 mg/day for 3 months and aspirin 100 mg/day forever).

**Figure 1**



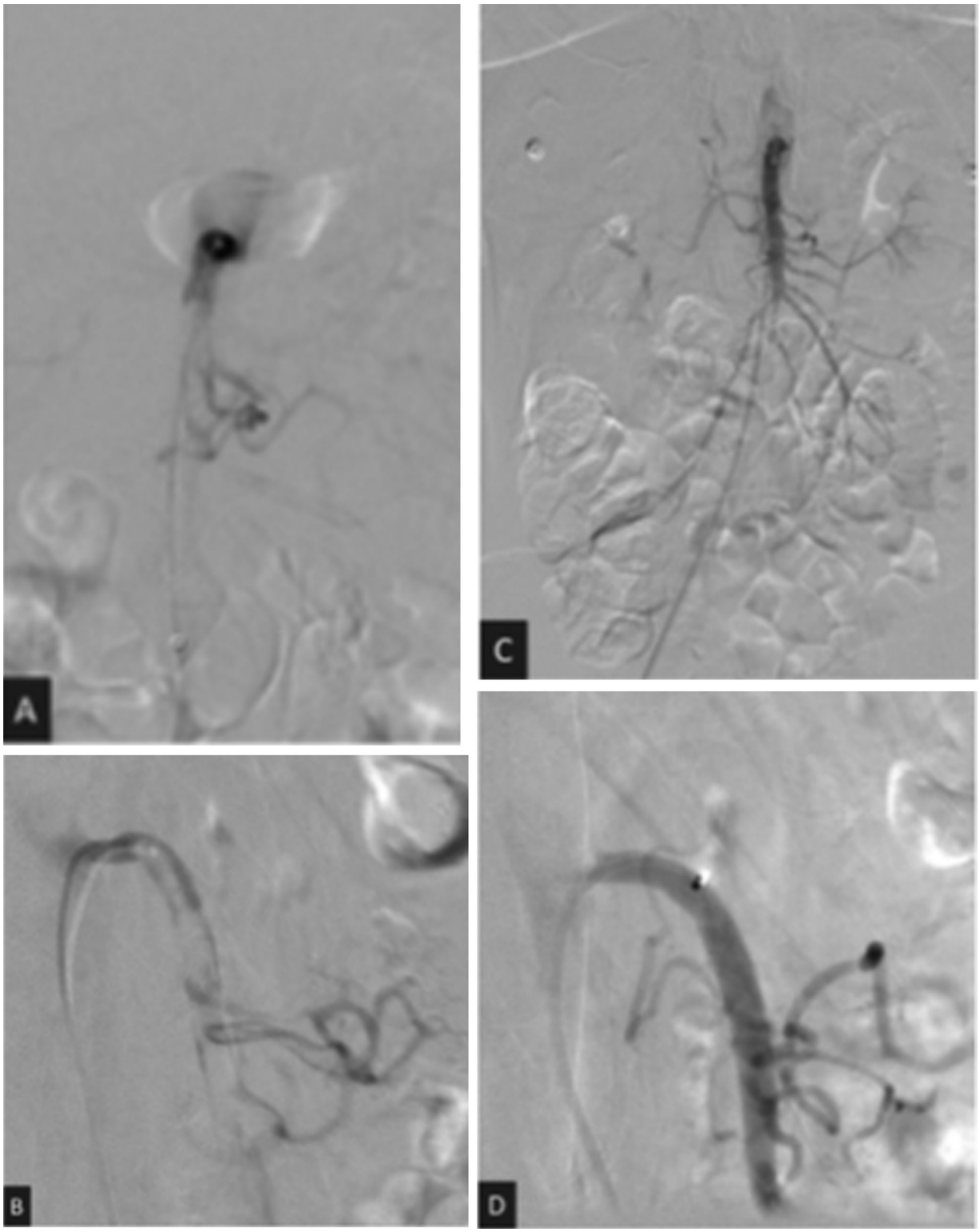
A 49-year-old female, known of atrial fibrillation, presented with acute abdominal pain for few hours. Computerized tomographic angiography was done immediately and showed embolic filling defects within the SMA (arrow in a and b) as well as ischemic changes in right kidney. Selective superior mesenteric artery angiography was done (c). Catheter-directed thrombolysis was done using infusion catheter. Completion angiography after 24 h shows complete restoration of the flow without residual thrombus (d).

## Results

From March 2015 to September 2019, 11 cases came to our emergency department complaining of acute abdominal pain were rapidly diagnosed as acute thromboembolic SMA occlusion by CT abdomen with intravenous contrast. These patients had no clinical or CT evidence of advanced bowel ischemia and were managed by endovascular intervention. The demographic, clinical characteristics, and risk factors are summarized in Table 1. The mean age was 54±11 years (range: 45–71); seven (63.6%) cases were males and four (36.4%) cases were females. Abdominal pain and nausea were the commonest symptoms, and none of the patients had acute peritonitis. The median time from start of symptoms to hospital admission was 9 h (range: 5–24), and the median time from hospital admission to endovascular intervention was 11 h (range: 8–23).

The etiology was embolic occlusion in six (54.5%) patients compared with thrombotic occlusion in five

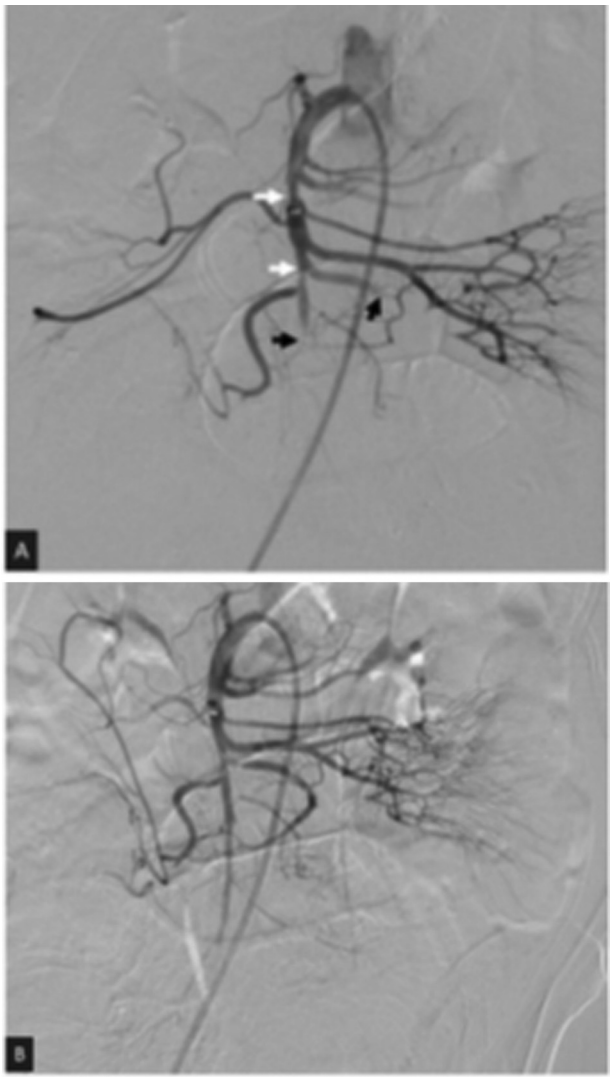
**Figure 2**




A 52-year-old male, known case of atrial fibrillation, presented with acute abdominal pain. Computerized tomographic angiography (not shown) showed extensive thrombosis of the superior mesenteric artery. These findings were confirmed on angiography (a and b). Catheter-directed thrombolysis was done using infusion catheter performed and flow restored. Completion angiography (c and d) shows residual thrombus in the most distal part of the superior mesenteric artery but patient improved.

(45.5%) patients owing to underlying atherosclerosis, with occlusion less than 70% in three (27.3%) patients and occlusion more than 70% in two (18.2%) patients, where one of them had 90% stenosis and the other one had complete occlusion. Of the embolic occlusion which mainly originated from a cardiac source, four (36.4%) patients had main vessel occlusion and two (18.2%) patients had mixed main vessel and branch

**Figure 3**



A 55-year-old diabetic hypertensive male presented with acute abdominal pain. computerized tomographic angiography (not shown) showed atherosclerotic changes with thrombus in the superior mesenteric artery. (a) superior mesenteric artery angiography shows two stenotic segments (white arrows) and abrupt cut-off of some jejunal branches (black arrows); (b) completion angiography after catheter-directed thrombolysis and balloon dilatation was done.

**Table 1 Demographic data and clinical presentation**

| Variables | *N*=11 [*n* (%)] |
|---|---|
| Age (mean±SD) (years) | 54±11 |
| Sex | |
| Male | 7 (63.6) |
| Female | 4 (36.4) |
| Comorbidity | |
| Hypertension | 4 (36.4) |
| Diabetes mellitus | 4 (36.4) |
| Active smoking | 5 (45.5) |
| Hyperlipidemia | 5 (45.5) |
| Peripheral arterial disease | 3 (27.3) |
| Atrial fibrillation | 6 (54.5) |
| Coronary artery disease | 3 (27.3) |
| Duration of symptoms (onset to treatment) | |
| Median (range) (h) | 20 (13–41) |
| Clinical presentation | |
| Abdominal pain | 11 (100) |
| Nausea | 9 (81.8) |
| Emesis | 7 (63.6) |
| Bloody diarrhea | 2 (18.2) |

**Table 2 Angiographic and laboratory findings**

| Variables | *N*=11 [*n* (%)] |
|---|---|
| Type and site of occlusion according to CT angiography | |
| Embolic | 6 (54.5) |
| Main vessel | 4 (36.4) |
| Main vessel and branch | 2 (18.2) |
| Thrombotic | 5(45.5) |
| Main vessel | 3 (27.3) |
| Main vessel and branch | 2 (18.2) |
| Laboratory tests [median (range)] | |
| WBC count ($\times 10^3$/dl) | 14.1 (9.6–18.4) |
| Creatinine (mg/dl) | 1.3 (0.67–2.4) |
| Potassium (mg/dl) | 4.3 (3.4–5.6) |
| pH | 7.34 (7.32–7.45) |
| Lactate (mmol/l) | 2.3 (1.3–4.7) |
| Hb (g/dl) | 9.3 (6.4–13.2) |
| CRP (mg/dl) | 18 (4–42) |

CRP, C-reactive protein; CT, computed tomography; Hb, hemoglobin; WBC, white blood cells.

occlusion. Of the thrombotic occlusions, three (27.3%) patients had main vessel thrombosis and two (18.2%) patients had mixed main vessel and branch thrombosis (Table 2).

All patients underwent catheter-directed thrombolysis using alteplase. The median dose of alteplase was 23 mg (range: 17–36 mg), and the median infusion rate was 0.8 mg/h (range: 0.6–1.0 mg/h). Follow-up angiography was done every 12 h. The median duration of thrombolysis was 24 h (range: 12–36 h). Two patients underwent balloon dilatation of stenotic segments and one patient underwent balloon dilatation and stenting. Endovascular success was defined as complete or partial thrombolysis at completion angiogram and resuming intestinal perfusion without abdominal exploration and the need for embolectomy or bypass. Technical success was achieved in seven (63.6%) patients. Failure of endovascular revascularization occurred in four (36.4%) patients; two of them were thrombotic and died before planned laparotomy [one of them with total thrombotic occlusion died within 24 h of the procedure because of toxemia and the other due to myocardial infarction (MI)], whereas the remaining two (18.2%) patients with SMA main trunk embolic occlusion underwent laparotomy for surgical embolectomy with resection of the necrotic bowel segments. The length of the resected intestine was 40 cm in one

**Table 3 Endovascular management**

| Variables | *N*=17 [*n* (%)] |
|---|---|
| Endovascular success | 7 (63.6) |
| Endovascular failure | 4 (36.4) |
| Type of endovascular therapy | |
| Thrombolysis | 11 (100) |
| Adjunctive PTA | 2 (18.2) |
| Adjunctive PTA and stenting | 1 (9.1) |
| Open revascularization | 2 (18.2) |
| Embolectomy | 2 (18.2) |
| Bypass | 0.0 |

PTA, percutaneous transluminal angioplasty.

**Table 4 Complications**

| Complications | *N*=11 [*n* (%)] |
|---|---|
| Bleeding complications | 4 (36.4) |
| Access site bleeding | 2 (18.2) |
| GIT bleeding | 1 (19.1) |
| Cerebral bleeding | 1 (9.1) |
| Technical complications | 2 (18.2) |
| CFA thrombosis | 1 (9.1) |
| SMA branch perforation | 1 (9.1) |
| Death | 3 (27.3) |
| Toxemia | 1 (9.1) |
| MI | 1 (9.1) |
| Cerebral bleeding | 1 (9.1) |

CFA, common femoral artery; GIT, gastrointestinal tract; MI, myocardial infarction; SMA, superior mesenteric artery.

patient and 120 cm in the other patient who underwent a second-look abdominal exploration after 36 h, but without more intestinal resection, but 1 day later, the patient developed cerebral bleeding and stroke and then died (Table 3).

Postoperative complications occurred as bleeding complications, which occurred in four (36.4%) patients; two (18.2%) patients at the site of the sheath in the femoral artery who were treated conservatively with blood transfusion, another one (9.1%) patient had mild temporary bleeding from the gastrointestinal tract whereas cerebral bleeding and stroke had occurred in one (9.1%) patient, who died 4 days after failed endovascular intervention and open surgical embolectomy and resection of bowel segment and second-look abdominal exploration. Moreover, technical complications in the form of common femoral artery (CFA) thrombosis, mostly owing to nonheparinized sheath, which occurred in one (9.1%) patient, and the patient underwent successful thrombectomy, and guidewire perforation of one of the SMA branches was found in one (9.1%) patient and was managed conservatively. Three patients (27.3%) died: two of them after failed endovascular intervention and before planned laparotomy (one of them due to toxemia and the other due to MI), and one patient died owing to cerebral bleeding after failed endovascular intervention and open embolectomy and resection of necrotic bowel segments and second-look abdominal exploration (Table 4).

### Follow-up

The patients were followed up at the outpatient clinic after 1 week, 2 weeks, 1 month, 2 months, and 6 months for abdominal pain and short bowel syndrome. Patients who experienced abdominal pain underwent abdominal CTA.

## Discussion

Acute mesenteric ischemia carries a high risk of mortality. Untreated sudden decrease in bowel perfusion results in intestinal infarction and fatal septicemia. Rapid diagnosis and management can restore intestinal perfusion and save life of patient. In spite of SMA embolectomy being first done in 1951, SMA thromboendarterectomy in 1958, and aortomesenteric bypass in 1973, the mortality remains very high (60–80%). Endovascular interventions presented minimally invasive approaches for restoring intestinal perfusion [4].

In our study, the number of patients was 11 [seven (63.6%) males, four (36.4%) females], and the mean age was 54±11 years. Embolic occlusion was seen in six (54.5%) patients and thrombotic occlusion in five (45.5%) patients; the most common predisposing factor was atrial fibrillation in six (54.5%) patients, and all patients presented with acute abdominal pain (100%) without any signs of peritonitis or any radiological evidence of advanced intestinal ischemia, and the median time from start of symptoms to hospital admission was 9 h (range: 5–24), and the median time from hospital admission to endovascular intervention was 11 h (range: 8–23). However, in a study done by Björnsson *et al.* [5] for endovascular management of thromboembolic SMA occlusion, the number of patients was 34 [14 (41.1%) males and 20 (58.9%) females], and the median age was 78 years. Embolic occlusion was present in 28 (82.3%) patients and thrombotic occlusion in six (17.7%) patients. Moreover, all patients were presented with acute abdominal pain (100%) and the most common predisposing factor was atrial fibrillation (74%). and the median time from start of symptoms to admission of the patient was 7 h (range: 4–22 h) and from admission to endovascular intervention was 10 h (range: 6–29 h). Moreover, in a study done by

Zhang *et al.* [6], the number of patients was 18 [12 males (66.7%) and six (33.3%) females], and the median age was 60 years. There was embolic occlusion in 15 (83.3%) patients and thrombotic occlusion in three (16.7%) patients, and the most common predisposing factor was atrial fibrillation (50%) followed by hypertension in 33.3%, and the median interval from start of abdominal pain to endovascular intervention was 12 h (range: 4–48). However, in a study done by Block *et al.* [7], the number of patients was 42 [18(42.9%) males and 24 (57.1%) females], and the median age was 77 years. Embolic occlusion was in 12 (28.5%) patients and thrombotic occlusion in 26 (71.5%) patients, and the most common predisposing factor was IHD and hypertension (51%) followed by atrial fibrillation (38%), and the median time from start of abdominal pain to endovascular intervention was 24 h (range 10–72).

In our study, all patients underwent catheter-directed thrombolysis using alteplase. The median dose of alteplase was 23 mg (range: 17–36 mg), and the median rate of infusion was 0.8 mg/h (range: 0.6–1.0 mg/h); the median duration of thrombolysis was 24 h (range: 12–36 h). Adjunctive angioplasty was done in two (18.2%) patients and adjunctive angioplasty and stenting was used in one (9.1%) patient because of recoil. Open surgical embolectomy was done in two (18.2%) patients owing to failure of endovascular revascularization procedures. However, in a study done by Arthurs *et al.* [8], which included 56 patients, 48% of patients underwent catheter-directed thrombolysis using tissue plasminogen activator. The dose was 1.0 mg/h in 63%, 0.5 mg/h in 19%, 0.25 mg/h in 12%, and 2.0 mg/h in 6% of patients. The duration of catheter-directed thrombolysis was 24 h in 58% of patients, 48 h in 36% of patients, and 72 h in 5% of patients. Adjunctive aspiration was performed in 12% of patients, and 33% required adjunctive PTA and stenting. Overall, 11% were treated with aspiration without thrombolysis, and of those patients, 22% were also treated by PTA and stenting. However, in a study done by Jia *et al.* [9], which included 21 patients, only aspiration was needed in seven (33.3%) patients, and adjunctive thrombolysis was done in 14 (66.7%) patients, using urokinase. Prostaglandin E1 (10 mg) was injected intra-arterially in 17 cases. One patient with severe stenosis underwent PTA and stenting.

Our study demonstrated that after the endovascular revascularization of the occluded SMA, seven (63.6%) patients obtained technical success with restoration of intestinal blood flow. Four (36.4%) patients failed and required laparotomy, where two of them died before planned laparotomy (one due to toxemia and the other due to MI) and the other two underwent laparotomy for open embolectomy and resection of segment of intestine (one of them died later owing to cerebral bleeding). Three (27.3%) patients died within 30 days in the hospital.

Over the past years, there are a few reports demonstrating the management of thromboembolic occlusion of superior mesenteric artery (ATOS) through endovascular revascularization. Karkkainen *et al.* [10] showed endovascular treatment of 50 patients with ATOS and achieved technical success in 88% patients, with endovascular therapy related complication rate of 10% and a mortality rate of 36%. Puippe *et al.* [11] reported that after the endovascular revascularization of ATOS, 38.5% of patients obtained technical success with complete restoration of the intestinal vascularity, 38.5% required laparotomy, and 30.8% died within 30 days after procedure in hospital. Chen *et al.* [12] revealed complete recanalization with technical success rate of 75% among patients who received endovascular management of ATOS, with 0% complication rate and postprocedure in-hospital mortality rate of 25%. However, in a study done by Zhang *et al.* [6] for 18 cases who received endovascular therapy, 44.4% achieved complete technical success, 33.3% required laparotomy, and 30-day postprocedure in-hospital mortality was 16.7%. The discrepancy of efficacy did not depend only on the reported treatment but was related also to the interval from onset of symptoms to intervention and the difference in development of endovascular therapy for ATOS between different countries.In our study, complications were in the form of bleeding complications (access site, cerebral, and gastrointestinal tract bleeding) and technical complications (CFA thrombosis and SMA perforation) and were matched with the literature, as mentioned by Lerardi *et al.* [13], who demonstrated that commonest complications mentioned in the literature are acute renal failure, bowel ischemia, myocardial and cerebral infarctions, short bowel syndrome, SMA trauma that can lead to arterial dissection, perforation or atheroembolization, and access-related complications.

## Conclusion

Endovascular intervention can be an alternative to open surgery for intestinal revascularization for the

management of early cases of acute SMA occlusion. CTA rapid diagnosis, urgent endovascular management and intensive care and follow up are the cornerstone for good prognosis.

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Nil.

**Conflicts of interest**
There are no conflicts of interest.

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