Minimally invasive modalities in the management of acute mesenteric ischemia: a prospective case-series study

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Introduction
Acute arterial mesenteric ischemia (AMI) represents a challenging disease regarding diagnosis and treatment; usually the patient is diagnosed at a late stage of the disease that imposes a high risk of mortality, and usually the diagnosis is reached intraoperatively with the full-blown picture of intestinal gangrene.
Aim
The aim was to assess the feasibility and effectiveness of minimally invasive modalities (laparoscopy and endovascular techniques) in the diagnosis and treatment of patients having acute AMI.
Patients and methods
This is a prospective case-series study that was conducted over 11 patients who were diagnosed to have an acute abdomen with suspected acute mesenteric ischemia. They were subjected to an intervention in the form of diagnostic laparoscopy with simultaneous direct mesenteric angiography through a transfemoral approach, this was done for diagnosis and possibly treatment of this condition.
Results
About 18.2% presented within 24 hours from the onset of symptoms, 81.8% presented after 1 day from the onset of symptoms. About 36.4% of patients had a white blood cell count of greater than 15 000/ml, 45.4% had a white blood cell count of greater than 12 000–15 000/ml, while 18.2% of patients had a white blood cell count of less than 12 000/ml. As for D-dimer, it was greater than 2.0 mg/l in 9.1%, greater than 1.0–0.2 mg/l in 63.7%, and 0.5–1.0 mg/l in 27.3%. About 81.8% of patients had thrombosed superior mesenteric artery (SMA), together with intestinal gangrene or devitalized segments of the intestine, they were treated by laparotomy and bowel resection with no intervention regarding the SMA. Two patients (18.2%) had dusky bowel loops with a critical stenosis at the origin of SMA for which stenting was done, with no need for laparotomy.
Conclusion
The use of minimally invasive modalities is an efficient method in definitive diagnosis of patients having AMI, as well as it can be used for treatment. Those minimally invasive techniques offer a low-risk intervention with reduced morbidity, reducing the time needed for diagnosis and treatment, but in order to reach this goal, the patient must present as early as possible in order to intervene while the intestine is still viable.

Keywords:
acute mesenteric ischemia, diagnostic laparoscopy, direct mesenteric angiography

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Introduction

Acute arterial mesenteric ischemia represents a challenging disease regarding diagnosis and treatment; usually the patient is diagnosed at a late stage of the disease that imposes a high risk of mortality, and usually the diagnosis is reached intraoperatively with the full-blown picture of intestinal gangrene. The estimated mortality rate of this pathology is 60–90% [1,2]. There are no definite typical abdominal signs and symptoms; also, there are no accurate laboratory studies, and even a contrast-enhanced computed tomography (CT) may be nonconclusive [3–5]. Nowadays, multislice computed tomography angiography (CTA) is considered the golden standard in diagnosing acute mesenteric ischemia, but still many patients will undergo exploratory laparotomy if CTA is not conclusive [6,7]. In the last few decades, laparoscopy has been introduced as a less invasive alternative for diagnosing acute mesenteric ischemia [8].

On the other hand, revascularization of acute mesenteric ischemia carries a mortality rate of more than 50% [9–11]. Since the first superior mesenteric artery (SMA) embolectomy was carried out in 1951 [12], surgical intervention has been the golden standard for dealing with cases of acute mesenteric ischemia. But lately, endovascular techniques have evolved and have been used with comparable results and complications [13,14].

Patients and methods

This is a prospective case-series study that was conducted over 11 patients presenting to the emergency department with acute abdominal pain from July 2014 to July 2020. Patients' consent and ethical committee approval were obtained. Patients were considered to have acute mesenteric ischemia if they have any of the following: (a) acute sudden-onset abdominal pain may be associated with fever, tachycardia, nausea, vomiting, and/or bleeding per rectum. (b) Signs of peritoneal irritation. (c) Pelviabdominal CT findings suggestive of nonocclusive mesenteric ischemia or nonconclusive CT findings.

We excluded (a) patients with previous abdominal surgical interventions. (b) Vitally unstable patients who will not tolerate pneumoperitoneum. (c) Patients with elevated serum creatinine. (d) Patients suspected to have embolic mesenteric ischemia. (e) Patients suspected to have mesenteric venous occlusion.

All patients underwent diagnostic laparoscopy and intraoperative angiography in the same setting under general endotracheal anesthesia in an operating theater equipped with a C-arm dedicated for vascular interventions.

After patient preparation and draping, a 6 F sheath was inserted into the right common femoral artery through which a hydrophilic 0.035 guidewire was passed till the level of T12. A pig-tail diagnostic 6 F catheter was passed over the wire. Diagnostic angiogram was performed to identify the ostia of the celiac and SMAs. Then the pig-tail catheter was exchanged with a Judkins right 5 F catheter for selective angiography. In case of need of intervention, a 0.035 guidewire is passed through the lesion, then a balloon-mounted stent is passed over the wire and positioned over the lesion and the balloon is inflated, and then completion angiography is performed to ensure patency of the stent.

Concurrently, pneumoperitoneum was established slowly using Hasson's technique keeping the intra-abdominal pressure around 8 mmHg, a 10-mm port was inserted into the periumbilical region through which a telescope was advanced for inspection of the abdominal cavity looking for signs of intestinal ischemia.

The decision of conversion to open laparotomy was taken in the following conditions: (a) gangrene or infarction of the bowel. (b) Intestinal devitalization.

Results

Data were obtained from 11 patients who presented to the emergency department with an acute abdomen, patients were suspected to have acute arterial mesenteric ischemia upon the criteria mentioned previously. All patients underwent diagnostic laparoscopy, and in the same setting, intraoperative selective mesenteric angiography was performed. Demographic data of those patients are shown in Table 1.

Eight (72.7%) patients gave previous history of recurrent abdominal pain related to meals; they described their pain as being afraid to eat.

The presenting symptom for all patients was abdominal pain, but the patients presented at different time intervals from the onset of symptoms. Nine patients (81.8%) presented to us with severe abdominal pain after 24 h from the onset of symptoms, a patient (9.1%) presented earlier within 12 h from the onset of symptoms, while the last one (9.1%) presented within 24 h from the onset of symptoms. Three patients (27.3%) complained also from nausea and vomiting, another patient (9%) had bleeding per rectum.

On examination, seven patients (63.6%) had signs of peritoneal irritation. As for the laboratory investigations, white blood cell count (WBC) was found to be less than 12 000/ml in two (18.2%) patients, greater than 12 000/ml–15 000/ml in five

Table 1 Demographic data

	n (%)
Sex	
Male	9 (81.8)
Female	2 (18.2)
Age (mean±SD)	59.54±7.52
Comorbidities	
Hypertension	11 (100)
Diabetes mellitus	9 (81.8)
Coronary artery disease	7 (63.6)
Stroke	1 (9)

(45.4%) patients, and the last four (36.4%) patients had a WBC count greater than 15 000/ml. D-dimer was found to be 0.5–1.0 mg/l in three patients (27.3%), greater than 1.0–2.0 mg/l in seven patients (63.6%), and greater than 2.0 mg/l in one patient (9.1%).

Laparoscopic findings: six (54.5%) patients had intestinal gangrene, three (27.3%) patients had devitalized bowel loops, and the other two (18.2%) had dusky intestine, as shown in Fig. 1.

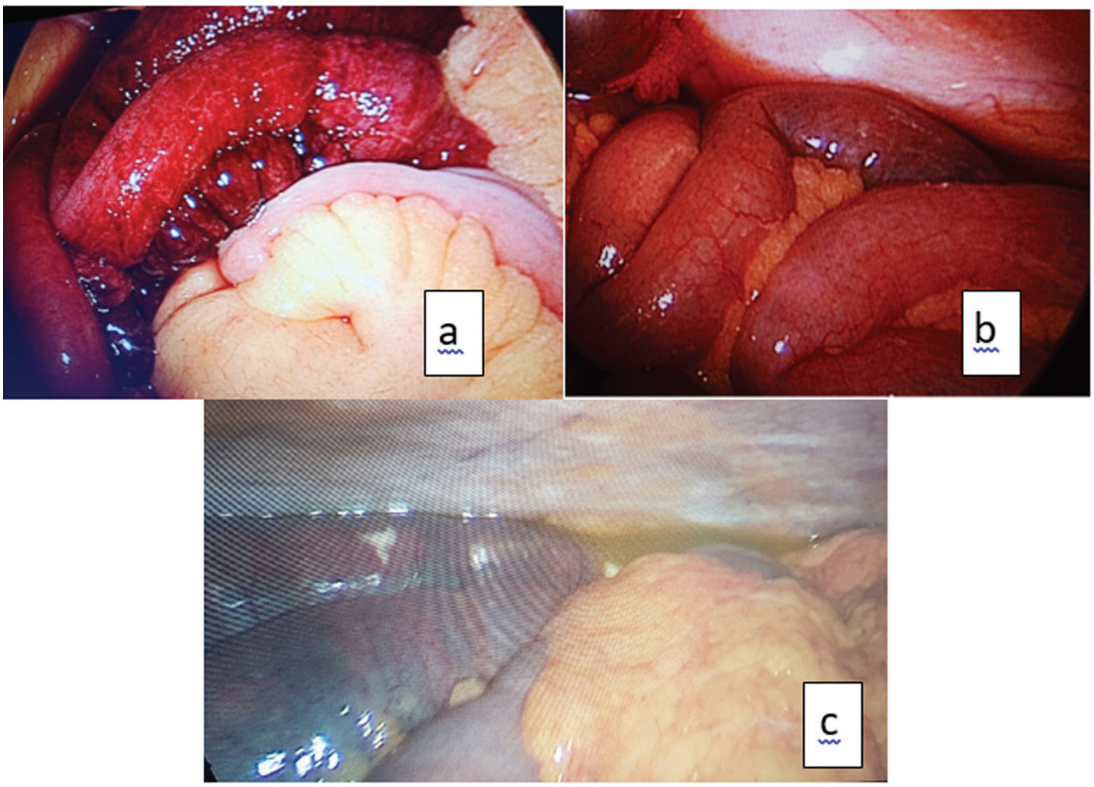
Angiographic findings: nine (81.8%) patients had total thrombosis of the SMA, the other two (18.2%) had a critical stenosis of the SMA.

Table 2 shows the relation between time of presentation, angiographic findings, laparoscopic findings, D-dimer, and WBC count.

After checking the viability of the intestine by laparoscopy in patients having thrombosed superior mesentric artery, it was found that the intestine was either gangernous or devitalized, and those patients were converted to open laparotomy for bowel resection, as shown in Fig. 2.

While the other two patients had dusky bowel but viable, the stenotic segment was treated by stenting

Fig. 1



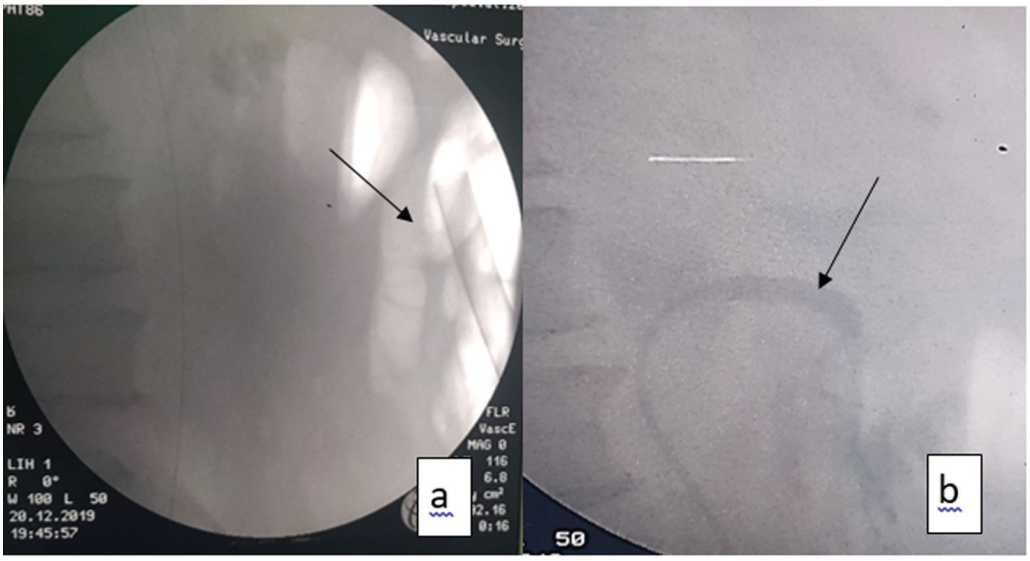
(a) Bowel gangrene; (b) Dusky bowel; (c) Devitalized bowel loops.

Table 2 The relation between time of presentation, angiographic findings, laparoscopic findings, D-dimer, and WBC count

Number of patients	WBC count	D-dimer	Laparoscopic findings	Angiographic finding	Time of presentation
2	10 000–12 000/ml	0.5–1.0 mg/l	Dusky bowel	Critical stenosis of SMA	First 24 h
1	>12 000–15 000/ml	0.5–1.0 mg/l	Gangrenous, devitalized bowel	Total thrombosis of SMA	>24 h
4	>12 000–15 000/ml	>1.0–2.0 mg/l			
3	>15 000/ml	>1.0–2.0 mg/l			
1	>15 000/ml	>2.0 mg/l			

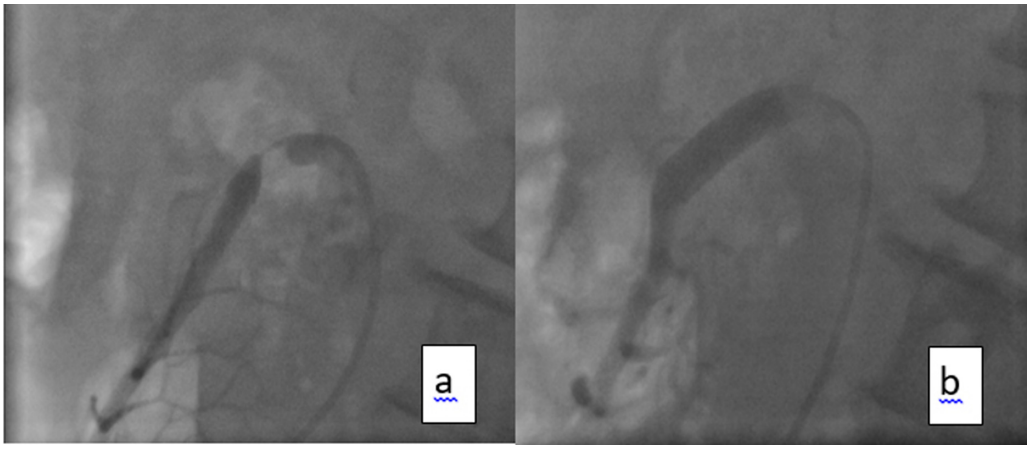
SMA, superior mesenteric artery; WBC, white blood cells.

Fig. 2



(a) The port (arrow) is seen during selective mesentric angiography. (b) Selective angiography of the superior mesentric artery showing patent stump but thrombosed superior mesenteric artery distally.

Fig. 3



(a) Near-total occlusion of the superior mesenteric artery. (b) Stenting of the superior mesenteric artery with restoration of normal flow.

using balloon-mounted stents, and completion angiography showed restoration of luminal continuity of the superior mesentric artery, and laparoscopically the intestine regained its normal appearance, as shown in Fig. 3.

The mean time for the procedure of simultaneous direct mesenteric angiography and diagnostic laparoscopy was 65.46±10.26 min, including the time of intervention (stent application).

Postoperatively, three patients out of nine (33.3%) needed a second-look laparotomy after 48 h; meanwhile, the other six (66.7%) patients showed improved signs and symptoms, which derived us not to intervene again.

The median time for hospital stays for the group who underwent resection of the bowel was 14 days. The in-hospital mortality in this group was one patient (11.1%).

While patients who underwent stenting of the SMA showed improved symptoms, with good tolerance to fluids and solids. The median time for hospital stay was 4.5 days. There was no mortality among this group.

Discussion

Acute mesenteric ischemia is a morbid condition that started to increase in prevalence in the past few years, it is responsible for 1/1000 of hospital admissions [15]. Making the diagnosis at an earlier stage represents a challenge due to the nonspecificity of symptoms [16,17]. In our study, abdominal pain was the presenting symptom in all patients, which nearly matches the results of 96% by Kougias *et al.* [9] Otherwise, diagnosis of acute mesenteric ischemia is very challenging and the delay in diagnosis is associated with more morbidity and mortality. The World Society of Emergency Surgery Guidelines for Acute Mesenteric Ischemia stated that any abdominal pain out of proportion of physical examination is highly suspicious of acute mesenteric ischemia, also it stated that there are no laboratory investigations to identify bowel necrosis [18]. But in our study, we found that increased white blood cell count was related to bowel necrosis as patients who had a count greater than 12 000/ml had bowel necrosis, and conversion to laparotomy and bowel resection was mandatory.

Current literature states that there is no accurate biomarker to diagnose acute mesenteric ischemia [19,20]. Elevated D-dimer reflects ongoing clot formation and endogenous degradation by the fibrinolytic system, an elevated D-dimer greater than 0.9 mg/l means intestinal ischemia, and has an accuracy, sensitivity, and specificity of 79, 60, and 82%, respectively [21]. In our study, patients having an elevated D-dimer greater than 1.0 mg/l had totally thrombosed SMA with intestinal gangrene, except one patient. Bala *et al.* [18] stated that D-dimer may assist in the diagnosis.

Adopting minimally invasive techniques for diagnosis gave us the benefit of reducing the time to reach a definitive diagnosis; we relied upon clinical suspicion to proceed with these techniques as we know that diagnostic delays may be considerably long because the symptoms may be obscure and nonspecific specially in patients with chronic arterial occlusion, also the diagnosis may be missed in CT by the radiologist [22].

Time of presentation was a critical issue. We had 18.2% of patients presenting within 24 hours from the onset of symptoms, those patients had lower white blood cell counts and D-dimer than patients who presented at later stages, and they had a better course of events. The time of presentation, the presence of premonitory symptoms, and no signs of peritonitis represent a good indicator for the success of endovascular techniques [22]. Another study showed more technical success and less mortality rates in patients presenting within 12 h from the onset of symptoms [23]. Our study showed that patients who presented earlier had a better chance for achieving a technical success in the endovascular procedure with no need for bowel resection, while patients with late presentation had bowel necrosis with a totally thrombosed SMA, which gave us no chance to use thrombolysis to regain patency of the SMA.

It is known that excluding bowel necrosis is an essential indicator to use endovascular techniques [23]. We relied upon diagnostic laparoscopy to detect the viability of the intestine, together with intraoperative direct mesenteric angiography, this saved time and reduced hospital stay.

Diagnostic laparoscopy is a useful tool and can reduce the need for laparotomies that have a high morbidity rate of 5–22%, especially in critically ill patients [24]. But diagnostic laparoscopy alone may be misleading, the mucosa of the intestine may be severely ischemic, while the external appearance of the intestine is normal, that is why diagnostic laparoscopy has low sensitivity in early acute mesenteric ischemia. To overcome this problem, some authors used intravenous fluorescein and laparoscopic ultraviolet light [25,26]. In our study, we combined intraoperative direct mesenteric angiography with diagnostic laparoscopy that gave us the advantage of early diagnosis and intervention in some patients. Also, we can use diagnostic laparoscopy for a second look and avoid laparotomy as Tshomba and colleagues did in their series. They also stated that it is safe to use diagnostic laparoscopy in patients having acute mesenteric ischemia and acute aortic dissection [27].

The mortality rate during hospital stay for patients who underwent laparotomy and bowel resection was 11.1%, while there was no mortality among the endovascular group. Arthurs *et al.* [28] reported mortality of 36% in patients treated by endovascular techniques, compared with 50% in patients who underwent open revascularization. In the review by Murphy *et al.* [29], endovascular interventions were associated with lower 30-day mortality rates.

Conclusion

Combining direct mesenteric angiography with diagnostic laparoscopy appears to be an effective technique to diagnose and intervene at the same

time. It is not time-consuming and decreases the morbidity associated with open laparotomy. In order to maximize the benefit from this technique, the patient must present early with no signs of peritonitis.

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Conflicts of interest
There are no conflicts of interest.

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