

# Diagnosis and Treatment of Acute Mesenteric Ischemia: Clinical Analysis for 40 Cases of the Patients

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**Objective:** To explore the methods of diagnosis and treatment of the patients with acute mesenteric ischemia (AMI).

**Material and Method:** The present study took place at Department of General Surgery, Xiangyang Central Hospital of Hubei Province, China between January 2002 and December 2013. The clinical data of 40 cases of AMI were analyzed.

**Results:** Among 40 cases of AMI, 38 had to surgical treatment and two had thrombolysis in superior mesenteric artery (SMA) through interventional radiology. Twenty cases died; thus, overall mortality was 50%. Fifteen cases were subjected to surgical or interventional therapy within 16 hours after onset, and all of them survived. Twenty-five cases were subjected to surgical treatments over 16 hours after onset and five survived. There was significant difference between them ( $t = 3.4$ ,  $p = 0.0009$ ).

**Conclusion:** The key point to improve survival rate of AMI was early diagnosis and treatment. In the process of treatment, more attention should be paid on recovering blood supply of SMA, and the relationship between total excision of necrotic intestine and reservation of functional intestine. The operation should be handled properly to reduce the possibility of short bowel syndrome.

**Keywords:** Superior mesenteric artery, Acute ischemia, Diagnosis, Therapeutics

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Acute mesenteric ischemia (AMI) refers to an abrupt decrease or disappearance of the blood supply to the superior mesenteric artery (SMA) for various reasons such as embolism, thrombosis, or vasospasm. AMI can induce dysfunction of the intestinal muscle, acute ischemia, or necrosis of the intestine, and is the most common type of vascular ileus related to the intestine. AMI is a potentially fatal disease in emergency abdominal surgery and can lead to serious physiological disorders and pathological phenomena. The process of AMI includes a series of comprehensive pathological changes that eventually leads to intestinal necrosis<sup>(1)</sup>. The main pathophysiological changes of AMI are dysfunction of absorption and secretion around the intestine as well as necrosis and abscission of intestinal epithelial cells<sup>(2)</sup>. The ischemia causes the impairment of intestine microcirculation, with the activation of the monocytes, leukocytes, platelets, and endothelium<sup>(3)</sup>. The characteristics listed above can induce circulatory dysfunction due to substantial

aqueous humor entering the enteric cavity, resulting in hypovolemic shock<sup>(4)</sup>. Because of the accumulation of aqueous humor and disorders in the nervous adjustment, the motor function of intestine decreases significantly, while providing a suitable environment for bacterial proliferation<sup>(5)</sup>. Once the intestinal micro-flora changes, bacteria, and bacterial products can enter the circulation through the intestinal wall, causing an imbalance of the water and electrolytes in the internal environment, metabolic acidosis, hypokalemia, dehydration, and infective intoxication from bacterial invasion. All of these lead to multiple organ dysfunction, shock, and eventual failure of the liver, kidneys, respiratory system, circulatory system and other organs<sup>(6)</sup>.

AMI has a relatively low incidence rate of 816/100,000 annually, but it has a high mortality rate of 60 to 80%, according to statistics<sup>(7)</sup>. In recent years, the incidence rate of AMI have been witnessed a gradual increase, which should be taken seriously by general surgeons. During the 80 years since the earliest report of AMI, there have been no significant improvements in the survival rate for AMI<sup>(8)</sup>. This is mainly because of the need for improvement in early diagnosis and timely treatment, while the key for patient survival lies in whether there is timely surgical intervention before necrosis of the small intestine<sup>(9)</sup>.

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The present study collected the clinical data from 40 cases of patients with AMI whom underwent surgery or interventional therapy at Xiangyang Central Hospital affiliated Hubei University of arts and science, Hubei province, China between 2002 and 2013, and aimed to conduct a preliminary discussion on the diagnosis and treatment of AMI.

### Material and Method

Between January 2002 and December 2013, forty consecutive patients with AMI at the Department of General Surgery, Xiangyang Central Hospital of Hubei Province, China, were included in the present study. The Ethics Committee of Xiangyang Central Hospital approved the study. Because this was a retrospective study, there was no need for written consent from subjects. Our inclusion criteria were the patients who were diagnosed with AMI. The exclusion criteria were that the patients had been diagnosed with AMI but did not receive any treatment in the hospital because of any reasons such as transferring to other hospital or abandoning treatment.

### Clinical data

Clinical data of the patients are shown in Table 1. The study population consisted of 18 males and 22 females with ages ranging from 40 to 81 years and an average age of  $59.3 \pm 11.2$  years. Twenty-five patients had a history of rheumatic heart disease and atrial fibrillation during the attack. There were 15 patients with lower extremity atherosclerotic occlusive disease, 10 patients with a history of hypertension and coronary heart disease, and three patients with a left ventricular aneurysm.

All 40 patients suffered from acute and sharp abdominal pain, which was mostly around the navel. Ten patients suffered accompanying abdominal distention, nausea, and vomit; two patients had bloody

stools. On admission, 35 patients showed no apparent signs of peritonitis and two patients had shock symptoms. All patients underwent routine blood test. The white blood cell count was  $12.1 \times 10^9/L$ - $22.3 \times 10^9/L$ , with an average of  $(18.3 \pm 1.5) \times 10^9/L$ , and the red blood cell count was normal. Amylase in the blood and urine was tested in 35 patients, of which 12 showed amylase increases in the blood. Serum enzymes were examined in 20 patients and all showed different degrees of increases in the creatine phosphate kinase (CPK), aspartate transaminase (AST), and lactate dehydrogenase (LDH). Electrocardiogram (ECG) was conducted in all the cases, and 36 patients had abnormal findings, including 25 with atrial fibrillation and 10 with coronary heart disease ST-segment changes or left ventricular hypertension. An erect abdominal radiograph was performed in all patients; 15 patients had no abnormal findings, nine patients found enteric pneumatosis, 16 had two to six small air-fluid levels, and none had enlarged or isolated intestinal loops. Abdominal B-mode ultrasound or color ultrasound was performed in 30 patients, identified 11 with enteric pneumatosis, and six with ascites. Diagnostic peritoneocentesis was performed in 17 patients, and seven had positive findings of reddish bloody fluid. Fourteen patients underwent an abdominal aorta computed tomographic angiography (CTA) test, and all had partial or complete occlusion of the superior mesenteric artery (Fig. 1A, B).

Among all the patients, sixteen were diagnosed with AMI on admission, while the remaining 24 patients were suspected of acute intestinal obstruction, intestinal volvulus, acute pancreatitis, myocardial infarction, acute cholecystitis, or acute gastroenteritis.

### Therapeutic methods

Thirty-eight patients underwent laparotomy surgeries. The time elapsed from disease attack was six to 48 (average of  $16 \pm 6.2$ ) hours. In most of the patients, dark red ascites had been found, in part or widespread of the intestinal necrosis in the abdominal cavity, necrotic area, which consisted mostly of small intestine. The longest stretch of necrosis started about 30 cm away from Treitz ligament and extended to hepatic flexure of transverse colon. All patients had thrombus or embolism in SMA, and 16 of them had thrombosis in superior mesenteric vein (SMV). Fifteen patients underwent SMA embolectomy. In the twelve cases that succeeded, there were good blood spurts at proximal and distal ends of the cut artery.

**Table 1.** Clinical data of the patients

Variable	n	Percent
Age (years), mean $\pm$ SD	$59.3 \pm 11.2$	
Gender, male/female	18/22	45/55
Rheumatic heart disease	25	62.5
Atrial fibrillation	25	62.5
Peripheral arterial disease	15	37.5
Hypertension	10	25.0
Coronary heart disease	10	25.0
Left ventricular aneurysm	3	7.5

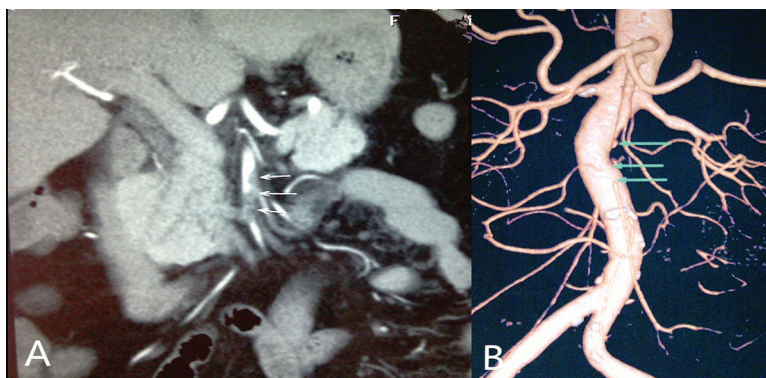
Two cases failed due to widespread SMA sclerosis. One case had good blood return at distal end but poor blood spurt at proximal end. This was due to severe stenosis near the opening of SMA. As a result, abdominal aorta-SMA autogenous saphenous vein bypass was performed to recover blood flow.

Among the aforementioned 13 cases with restored blood supply in the SMA, no significant intestinal necrosis was found in seven cases; therefore, no intestinal resection was performed. Necrotic intestine resection was performed in 31 cases, twenty-two of them underwent necrotic small intestine resection, nine cases underwent small intestine plus right semicolon resection, and the longest resection included all small intestine that was 30 cm distal to Treitz ligament and right semicolon. Laparoscopic examinations were performed in cases that showed partial SMA occlusion in the abdominal aortic CTA before the operation. Three patients had partial intestinal necrosis and were converted to open surgery.

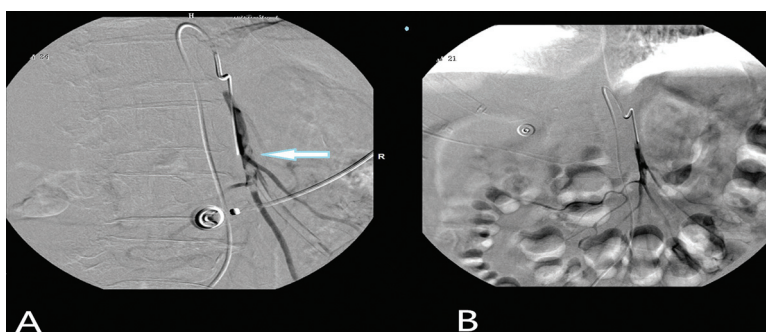
No intestinal necrosis was found in the other two patients and catheter-directed thrombolysis (CDT) was performed. Specifically, after selective SMA digital subtraction angiography (DSA), a micro-catheter was placed in the SMA root (Fig. 2A). Four hundred thousand units of urokinase were continuously infused into the micro-catheter once every eight hours, and 150 mg papaverine/50 ml normal saline were 24-hour non-stop infused via micro-pump. Meanwhile, abdominal signs were under strict observation. The micro-catheter was removed until blood flow in major SMA branches was recovered via angiography after three days (Fig. 2B).

#### Data and statistical analyses

Statistical analyses were performed by using IBM SPSS Statistics 22.0 software. Unpaired student's t-test was used to analyze mean differences between groups. The  $p < 0.05$  was considered as statistically significant.



**Fig. 1** CT angiography of a case with AMI. A 72-years-old female patient with acute mesenteric ischemia (AMI) was diagnosed by CT angiography of superior mesenteric artery (SMA). A was two dimensional and B was three dimensional. The arrows indicated the thrombosis in SMA.



**Fig. 2** Catheter-directed thrombolysis in SMA for a case with AMI. A micro-catheter was placed in the SMA root for the same patient (A), digital subtraction angiography (DSA) of SMA showed the lesion (arrow), catheter-directed thrombolysis (CDT) was carried out. Three days after CDT, the thrombosis in SMA disappeared, and the blood flow in major SMA branches was recovered via angiography (B).

## Results

In this group, twenty patients died, making the overall death rate of 50%. All 15 patients who underwent operation or intervention therapy within 16 hours after the attack survived. Of the other 25 patients who underwent operation at more than 16 hours after the attack, five survived. There were significant differences between the two groups ( $t = 3.4$ ,  $p = 0.0009$ , Table 2). Among the 20 deaths, eight patients died from multiple organ dysfunctions within 72 hours after the operation, nine suffered anastomotic leakage and severe abdominal infection within one week after operation, then eventually died from septic shock, and three patients died from severe short bowel syndrome within one month after the operation. Among surviving patients, three patients suffered from anastomotic leakage. They recovered after jejunostomy and were discharged from the hospital. Two patients suffered short bowel syndrome, but they were able to consume an elemental diet after comprehensive treatments. The eight patients who underwent necrotic small intestine and right semicolon resection died, while the 13 patients that underwent laparotomy and SMA blood supply restoration operations survived. The two patients who underwent SMA CDT survived. Of the seven patients underwent re-operations,

**Table 2.** Treatment effect based on time elapsed

Variable	n	Survival	t-value	p-value
Treatment within 16 hours	15	15		
Treatment besides 16 hours	25	5	3.4	0.0009*

\*  $p = 0.0009$ , compared with treatment within 16 hours group

**Table 3.** Outcomes of the patients

Variable	n	Death	Death rate (%)
Laparotomy	38	20	52.6
SMA CDT	2	0	0.0
MODS	8	8	100.0
Anastomotic leakage	12	9	75.0
Short bowel syndrome	5	3	60.0
Plus right hemicolectomy	8	8	100.0
Restoration of SMA	13	0	0.0
Second time operations	7	4	57.1

SMA CDT = catheter-directed thrombolysis in superior mesenteric artery; MODS = multiple organ dysfunctions  
Plus right hemicolectomy: necrotic small intestine and right semicolon resection, Restoration of SMA: SMA blood supply restoration

included second time necrotic intestinal resection and enterostomy, four died (Table 3).

## Discussion

AMI is a rare, acute abdominal disease. Despite its low incidence rate, AMI lacks specific symptoms and physical signs, making it extremely difficult to diagnose and treat in early stage, therefore, prognosis is poor<sup>(10)</sup>. In the present study, twenty patients died and the overall death rate was 50%, which is slightly lower than the relevant literature and reports<sup>(7)</sup>. AMI is mainly caused by arteriole embolism, acute thrombosis, and acute non-occlusive ischemia<sup>(11)</sup>. Arterial embolism is caused by the detachment of cardiac embolus, including mural thrombus and left ventricular aneurysm produced during valvulopathy or arrhythmia attacks, etc.<sup>(12)</sup>. Of our 40 patients, 25 had a history of valvulopathy and suffered accompanying atrial fibrillation during the attack and one patient suffered left ventricular aneurysm. Therefore, the incidence rate of AMI caused by arterial embolism in the present study was consistent with that in relevant literature and reports<sup>(13)</sup>. The remaining 15 patients had a history of lower extremity atherosclerotic occlusive disease or coronary heart disease, as a result, the diagnosis of acute SMA thrombosis was considered. It was noteworthy that thrombectomy was difficult to perform in these patients due to widespread SMA sclerosis. Moreover, because it took longer for them to have obvious surgical indications, they suffered wider extent of intestinal necrosis and had worse prognosis than arterial embolism patients. Eleven patients in this group eventually died, mainly because of the long period of intestinal ischemia, which led to widespread intestinal necrosis and high incidence of postoperative short bowel syndrome, anastomotic leakage, and multi-organ dysfunction. This suggested that more attention should be paid to the patients with sharp stomachache of unknown reason and concomitant of hypertension, coronary heart disease, peripheral arteriosclerosis, or arteriosclerosis. The diagnosis should be verified as early as possible by abdominal aorta CTA or SMA angiography to initiate treatments before intestinal necrosis. Non-occlusive mesenteric ischemia (NOMI) is a rare disease. Currently, the etiology remains unclear, it is somewhat related to excessively low cardiac output<sup>(14)</sup>. No such case was observed in the present study.

Due to lack of specific symptoms and physical signs, auxiliary examinations are of key importance to



suspected AMI patients. In laboratory examinations, significant increase in the white blood cell count facilitated the diagnosis. The average white blood cell count in the present study was  $(18.3 \pm 1.5) \times 10^9/L$ , however, it was obviously not caused by common infections. We believe that if white blood cell count has significantly increased while there are no significant abdominal physical signs, the diagnosis of AMI should be considered. Some studies have reported that abdominal pain, tenderness, and high white blood cell counts were associated with higher mortality<sup>(15)</sup>. Enzyme measurement is also helpful<sup>(16)</sup>. Serum enzymes were examined in 20 cases, and there were different degrees of increases in CPK, AST, and LDH. Researchers found that dynamic measurements of CPK could be sensitive and specific for the status of AMI; therefore, it may be used for the detection and early diagnosis of many types of intestinal ischemia diseases<sup>(17)</sup>. The opinion was supported by the present study. ECG was performed in all patients, most patients had abnormal findings, including atrial fibrillation, coronary heart disease, ST-segment changes and left ventricular hypertension. We think ECG might be valuable for diagnosing AMI. Erect abdominal plain radiography could provide little information in AMI diagnosis, it was performed in all patients, twenty-five patients had positive findings, but none showed pathognomonic signs. The diagnosis in 14 patients that underwent abdominal aorta CTA had been clarified. Abdominal aorta CTA test is a fast and safe, non-invasive diagnostic method with high diagnosis rate, making it a good choice for AMI-suspected patients<sup>(18)</sup>. Selective SMA angiography, however, remains the gold standard for AMI diagnosis<sup>(19)</sup>. However, we do not consider it as the first choice for diagnosis of AMI, because it is invasive, more time-consuming, costlier, and needs higher technical conditions.

Early diagnosis and treatments are key to improved survival rate<sup>(9)</sup>. In the present study, all 15 patients who underwent an operation within 16 hours after the attack survived. Among the remaining 25 patients who underwent operation more than 16 hours, only five patients survived. There was significant difference between them ( $t = 3.4$ ,  $p = 0.0009$ ). AMI is highly suspected in patients with inconsistent abdominal, physical signs and history of heart diseases, or peripheral vascular diseases. ECG, serum enzyme examination or abdominal aorta CTA should be performed as soon as possible to clarify the diagnosis, as well as laparotomy and laparoscopic examination. Laparoscopy is less invasive and more

acceptable than laparotomy for many patients. Observation of bowel color and peristalsis will help to judge intestinal hemodynamic disorder. In this group, laparoscopic examination was performed in five patients after CTA. Three patients were found partial intestinal necrosis and the procedures were converted to laparotomy, then the embolectomy of SMA was performed and the necrotic small intestine was resected. Eventually, the patients recovered and were discharged from the hospital. The other two cases did not have necrosis of intestine, and then SMA CDT was performed. After three days, follow-up SMA angiography was performed, the major branches of SMA were found patent, and the thrombosis disappeared. Later, the patients recovered and were discharged from the hospital.

For patients with signs of peritonitis, exploratory laparotomy should be immediately performed to eliminate ischemia factors and remove necrotic intestine, despite of unclear diagnosis. When there was no widespread intestinal necrosis, SMA embolectomy should be considered. Autogenous abdominal aorta-SMA saphenous vein bypass could be grafted to restore the SMA blood supply when embolectomy failed and the patients were in good condition. Of the 15 patients in this group undergoing SMA embolectomy, 12 of them were successful. Two of them failed due to widespread SMA sclerosis. One patient had good blood return at distal end but poor blood spurt at proximal end. The blood flow was restored after abdominal aorta-SMA autogenous saphenous vein bypass grafting. After restoring the blood supply, the actual area for resection was determined according to the blood supply restoration of the ischemic intestine. It was key to judge the intestinal activity during operation. It could be performed by observing bowel color, marginal artery pulsing, and hemorrhage at the incision edge. During the operation, the blood supply to the ischemic intestine should be restored as much as possible. Resection of necrotic intestine and the embolic mesentery should be thorough, while the intestine with a normal blood supply should be retained as much as possible<sup>(20)</sup>. In the present study, all nine patients who underwent resection of the necrotic small intestine and right semicolon died. This indicated that the survival rate is closely related to the range of intestinal resection. Therefore, the relationship between necrotic intestine resection and normal intestine retention should be properly handled to lower the incidence of postoperative short bowel syndrome.

SMA CDT was performed on two patients and achieved good results. It provides a new approach for AMI treatment. SMA CDT is applicable for patients that are diagnosed AMI via abdominal aorta CTA and have no abdominal physical signs or necrotic intestine by laparoscopy<sup>(21)</sup>. During the treatments, abdominal signs should be under strict observation and serum enzyme should be monitored. After two to three days, selective SMA angiography should be performed again; catheter should be removed if the restoration of SMA blood supply is confirmed.

In conclusion, although AMI is a severe, acute abdominal disease, it can still be cured. With the improvement in understanding of AMI, the advancements in modernized non-invasive diagnostic methods and minimal invasive treatments, the cure rate of AMI will be improved gradually.

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#### Potential conflicts of interest

None.

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