The Treatment and Outcome of Superior Mesenteric Artery Embolism: a Hospital-based Survey

Ryogo Ito (ryogoito55110@gmail.com)
Toyohashi Municipal Hospital

Taro Aoba
Toyohashi Municipal Hospital

Motol Yoshihara
Nishichita General Hospital

Kazuhiro Hiramatsu
Toyohashi Municipal Hospital

Research Article

Keywords: Superior mesenteric artery embolism, pneumatosis intestinalis, endovascular intervention

Posted Date: January 20th, 2022

DOI: https://doi.org/10.21203/rs.3.rs-1230683/v1

License: © This work is licensed under a Creative Commons Attribution 4.0 International License. Read Full License
Abstract

Objectives: The treatment for superior mesenteric artery (SMA) embolism is controversial because of the low prevalence of this disease. This study aimed to examine the treatment options for SMA embolism.

Methods: We retrospectively reviewed the clinical data of twenty patients with SMA embolisms at the Toyohashi Municipal Hospital from April 2010 to March 2020. Clinical characteristics, findings, treatment and outcomes were evaluated.

Results: The overall median age of the patients was 80 years old. In 16 cases, the obstructed regions of the SMA were proximal to the ileocecal artery (ICA) bifurcation. Nine cases had pneumatosis intestinalis (PI). Two patients underwent surgery, twelve patients received endovascular intervention (EI) and four patients received heparin treatment. Five patients died in the hospital. A comparative study of the outcomes after EI showed that the nonsurvivor group had a significantly higher rate of PI than the survivor group (P = 0.046). The patients that had obstructions proximal to the ICA bifurcation and the presence of PI had a high mortality rate of 60% after EI.

Conclusions: Determining if there is the presence of PI and finding the obstructed region of the SMA are useful for evaluating the appropriate treatment for SMA embolisms.

Introduction

Superior mesenteric artery (SMA) embolisms are a type of acute mesenteric ischemia (AMI) disease and a rare disease among emergency abdominal diseases. The incidence of AMI is 12.9 per 100000 person-years, and the percentage of SMA embolisms among AMIs is 67.2% [1].

SMA embolisms are diseases with a poor prognosis, and the in-hospital mortality rate is 60%-80% [2]. The causes of the increase in mortality are likely due to the difficulty in obtaining an early diagnosis and the development of intestinal necrosis due to the time that passes between the diagnosis and the onset of the disease [2]. Even if surgical treatment can save lives, the development of short bowel syndrome may impair the patient’s quality of life.

Recent studies have reported the efficacy of endovascular intervention (EI) for SMA embolisms [3, 4]. EI can preserve the small intestine and has a good outcome. Several studies have reported that EI was performed for patients with hemodynamic stability and without clinical or radiologic signs of advanced intestinal ischemia [5–7]. However, the indications of EI are controversial. The purpose of this study was to examine the treatment outcomes in SMA embolisms.

Methods

This study was approved by the institutional review board of the Toyohashi Municipal Hospital (approval no. 609) and was conducted according to the principles of the Declaration of Helsinki. Informed consent was obtained in the form of opt-out on the web-site. We performed a retrospective, single-center study of patients with SMA embolisms at the Toyohashi Municipal Hospital from April 2010 to March 2020. We collected the following data: age, sex, history of present illness, comorbidities, physical findings (vital signs and peritoneal irritation sign), CT findings, blood tests, treatments, and outcome.

The following was the treatment policy for SMA embolisms in this hospital. A SMA embolism was diagnosed when the contrast-enhanced CT of patients with acute abdomen revealed SMA defects. Clinicians (surgeons, radiologists, gastroenterologists, etc.) decided on the treatment plan after considering the onset, physical findings, and imaging findings. If extensive intestinal ischemia was suspected, we selected surgical treatment. If not, we selected EI or drug therapy such as heparin. However, best supportive care (BSC) was selected after considering the age, comorbidities, and intentions of the patients or the families.

Statistical analysis

The patients who received EI were divided into two groups based on the outcomes (survivors vs nonsurvivors). Patient demographics, clinical symptoms, physical examinations, CT findings (obstructed region in the SMA (Fig. 1); proximal or distal to the bifurcation of the ileocecal artery (ICA), pneumatosis intestinalis (PI), ascitic fluid), and blood test results were analyzed.

The data are expressed as medians (25th–75th percentiles) for continuous variables or as numbers/percentages for categorical variables. We compared the two groups using Fisher's exact test for categorical variables and the Mann-Whitney U test for numerical variables. P-values of 0.05 or less were considered significant. All statistical analyses were performed with EZR (Saitama Medical Center, Jichi Medical University, Saitama, Japan), which is a graphical user interface for R (The R Foundation for Statistical Computing, Vienna, Austria).

Results

A total of 20 patients with SMA embolisms were included in this study. Patient characteristics, clinical features and outcomes are listed in Table 1. The median age of the patients was 80 years (range 69–100 years), and the female-to-male ratio was 9:11. All patients had comorbidities (11 patients had arrhythmias such as atrial fibrillation). The obstructed regions of the SMA were proximal to the bifurcation of the ICA in 16 cases. Nine cases had PI based on the CT findings. There were 2 cases that underwent surgery, 12 cases who had EI, 4 cases who had heparin treatment and 2 cases who had BSC for the initial treatment. Two surgical cases required small bowel resection and the length of the remnant small bowel was 70 and 100 cm. One patient who underwent EI (case 15) required small bowel resection due to recurrence of SMA embolism on the 17th day after EI, and the remnant small bowel was 200 cm. EI was approached from the femoral artery. One case (Case 7) underwent stent placement and 11 cases underwent mechanical thrombectomy. All 12 patients had
concomitant intra-arterial injection of urokinase. Fifteen patients survived, and five patients died in the hospital. In the survivors, two patients needed parenteral nutrition because of the development of short bowel syndrome (case 9, 15).

| Case | Age | Sex | Shock | Peritoneal irritation sign | Comorbidity | Time to diagnosis (hr) | Obstructed region* | Pneumatosis intestinalis | Treatment | Remnant small intestine (cm) | Nutrition | Hospitalization (day) |
|------|-----|-----|-------|-----------------------------|-------------|------------------------|---------------------|------------------------|-----------|---------------------------|-----------|------------------------|
| 1    | 86  | F   | -     | -                           | DM, CKD (HD), HT | 5                      | Proximal            | -                      | BSC       | -                         | Oral      | 3                      |
| 2    | 95  | F   | -     | -                           | Arrhythmia (PM) | 14                     | Proximal            | -                      | BSC       | -                         | Oral      | 2                      |
| 3    | 92  | F   | -     | -                           | HT           | 4                      | Proximal            | -                      | EI        | -                         | Oral      | 2                      |
| 4    | 80  | M   | -     | -                           | Af, CVD, HT, CKD, LC | 10                    | Proximal            | -                      | EI        | -                         | Oral      | 3                      |
| 5    | 71  | M   | -     | -                           | Af           | 6                      | Proximal            | -                      | EI        | -                         | Oral      | 2                      |
| 6    | 72  | M   | -     | -                           | Af           | 13                     | Proximal            | -                      | EI        | -                         | Oral      | 3                      |
| 7    | 86  | F   | -     | -                           | Af, DM, prostatic cancer | 27                    | Proximal            | -                      | EI        | -                         | Oral      | 42                     |
| 8    | 100 | M   | -     | -                           | HT, IHD      | 4                      | Proximal            | -                      | OPE       | 70                       | Oral      | 26                     |
| 9    | 91  | F   | -     | -                           | Af           | 36                     | Proximal            | -                      | OPE       | 100                      | TPN       | 66                     |
| 10   | 86  | M   | -     | -                           | HT, CVD      | 6                      | Proximal            | -                      | EI        | Oral                     | Oral      | 12                     |
| 11   | 65  | M   | -     | -                           | Af           | 17                     | Proximal            | -                      | EI        | Oral                     | Oral      | 8                      |
| 12   | 72  | M   | -     | -                           | HT           | 5                      | Proximal            | -                      | EI        | Oral                     | Oral      | 19                     |
| 13   | 59  | F   | -     | -                           | DM, HT, CVD  | 5                      | Proximal            | -                      | EI        | Oral                     | Oral      | 30                     |
| 14   | 72  | F   | -     | -                           | HT, IHD      | 10                     | Proximal            | -                      | EI        | Oral                     | Oral      | 38                     |
| 15   | 85  | M   | -     | -                           | HT, CVD, HL  | 4                      | Proximal            | -                      | EI→OPE** | 200                      | PPN       | 53                     |
| 16   | 69  | M   | -     | -                           | Af, HT       | 36                     | Proximal            | -                      | Heparin   | Oral                     | Oral      | 7                      |
| 17   | 70  | M   | -     | -                           | Af, DM       | 4                      | Distal              | -                      | EI        | Oral                     | Oral      | 16                     |
| 18   | 83  | M   | -     | -                           | CKD, VHD, LC | 28                     | Distal              | -                      | Heparin   | Oral                     | Oral      | 24                     |
| 19   | 80  | F   | -     | -                           | Af, HT, DM   | 29                     | Distal              | -                      | Heparin   | Oral                     | Oral      | 7                      |
| 20   | 77  | F   | -     | -                           | Af           | 10                     | Distal              | -                      | Heparin   | Oral                     | Oral      | 11                     |

**Abbreviations:** HT, hypertension; CVD, cerebrovascular disease; Af, atrial fibrillation; CKD, chronic kidney disease; LC, liver cirrhosis; DM, diabetes mellitus; IHD, disease; PM, pacemaker insertion; HD, hemodialysis; VHD, valvular heart disease; HL, hyperlipemia; EI, endovascular intervention; Heparin, heparin medication operation; BSC, best supportive care; TPN, total parenteral nutrition; PPN, peripheral parenteral nutrition; F: female; M: male.

* column indicates whether the obstructed region of the superior mesenteric artery is proximal or distal to the ileocecal artery.

** indicates that operation was performed because of the relapsed SMA embolism on the 17th day after EI.

All three deaths, excluding the patient who received BSC, received EI. They had intestinal necrosis after EI, but did not seek further treatment. To assess the risk factors for mortality in the patients who received EI, we compared the clinical features (age, sex, time to diagnosis, vital signs, peritoneal irritation sign), CT findings (obstructed region in the SMA, PI, ascitic fluid), and blood test results (WBC, Plt, D-dimer, CK, LDH, CRP, lactate) between the survivor group and the nonsurvivor group (Table 2). The rate of PI in the nonsurvivor group was significantly higher than that in the survivor group (100% vs 22.2%, P=0.046).
## Table 2
Comparison of outcomes after endovascular intervention

|                         | Survivor group (n=9) | Non-survivor group (n=3) | P value |
|-------------------------|----------------------|--------------------------|---------|
| Age, year               | 72 [70~85]           | 80 [75.5~86]             | 0.46    |
| Male sex, n (%)         | 6 (66.7)             | 3 (66.7)                 | 1       |
| Time to diagnosis, hr   | 6 [5~13]             | 3 [5~8]                  | 0.71    |
| SBP, mmHg               | 149 [125~197]        | 152 [140~171]            | 0.93    |
| Pulse, bpm              | 74.5 [55~94]         | 98 [86~122]              | 0.066   |
| Shock, n (%)            | 0 (0)                | 1 (33.3)                 | 0.25    |
| Peritoneal irritation, n (%) | 1 (11.1)       | 1 (33.3)                 | 0.46    |
| **CT findings**         |                      |                          |         |
| Proximal obstruction*, n (%) | 8 (88.9)           | 3 (100)                  | 1       |
| Pneumatosis intestinalis, n (%) | 2 (22.2)       | 3 (100)                  | 0.046   |
| Ascitic fluid, n (%)    | 1 (11.1)             | 0 (0)                    | 1       |
| **Blood test**          |                      |                          |         |
| WBC, /µL                | 14220 [13300~16130]  | 14590 [11910~15760]      | 1       |
| Plt, ×10⁴/µL            | 16.2 [13.7~21.8]     | 27.0 [25.5~27.65]        | 0.21    |
| D-dimer, µg/mL          | 3.6 [2.2~6.1]        | 17.55 [13.0~22.1]        | 0.18    |
| CK, IU/L                | 80 [50.0~107.0]      | 111 [90.5~120.5]         | 0.37    |
| LDH, IU/L               | 315 [285~367]        | 349 [348~366.5]          | 0.48    |
| CRP, mg/dL              | 0.87 [0.24~2.06]     | 0.21 [0.18~2.13]         | 0.73    |
| Lactate, mg/dL          | 29.5 [24.5~37]       | 40 [31.5~48]             | 0.41    |

**Note:** Numerical data are indicated as medians. Values in parentheses are percentages, and values in brackets are IQR; first quartile~third quartile

**Abbreviations:** SBP, systolic blood pressure; WBC, white blood cell; Plt, platelet; CK, creatine kinase; LDH, lactate dehydrogenase; CRP, C-reactive protein.

* indicates that the superior mesenteric artery occlusion occurred proximal to the ileocecal artery bifurcation.

All 20 patients were classified into 3 groups according to the obstructed region in the SMA and the existence of PI based on the CT findings; the findings of group A were that the obstructed region was proximal to the ICA bifurcation and that PI was present, the findings of group B were that the obstructed region was proximal to the ICA bifurcation and PI was not present and the findings of group C were that the obstructed region was distal to the ICA bifurcation and PI was not present. Table 3 shows the treatment and outcomes of each group. There were 9 cases in group A (Case1-9 in Table 1). The mortality rate in the cases that received BSC was 100% in group A. No deaths were found among the operated cases, but all the cases had short bowel syndrome. The mortality rate after EI was 60% (3 out of 5 cases), and 3 patients had died within 3 days after starting treatment. These patients needed surgical treatment because of their deteriorated general condition after EI. However, these patients and their families did not wish to receive treatment. There were 7 cases in group B (Case10-16 in Table 1). Six patients received EI, and one patient received heparin therapy. There were no deaths, and one patient had a recurrence of the SMA embolism 17 days after EI. He received a small bowel resection, which resulted in short bowel syndrome. There were 4 cases in group C (Cases 17-20 in Table 1). One patient received EI, and the others received heparin treatment. There were no deaths or recurrence of the SMA embolism.
Table 3

| Group | n   | Occlusion location | PI | Initial treatment, n | Mortality, n (%) |
|-------|-----|-------------------|----|----------------------|-----------------|
| A     | 9   | Proximal          | +  | BSC, 2               | 2 (100)         |
|       |     |                   |    | OPE, 2               | 0 (0)           |
|       |     |                   |    | EI, 5                | 3 (60)          |
| B     | 7   | Proximal          | -  | EI, 6                | 0 (0)           |
|       |     |                   |    | Heparin, 1          | 0 (0)           |
| C     | 4   | Distal            | -  | EI, 1                | 0 (0)           |
|       |     |                   |    | Heparin, 3          | 0 (0)           |

Note: Group A included the patients with a superior mesenteric artery occlusion that was proximal to the ileocecal artery bifurcation and pneumatosis intestinalis, group B included the patients with a superior mesenteric artery occlusion that was proximal to the ileocecal artery bifurcation and no pneumatosis intestinalis and group C included the patients with a superior mesenteric artery occlusion that was distal to the ileocecal artery bifurcation and no pneumatosis intestinalis.

Abbreviations: Proximal, obstruction that is proximal to the ileocecal artery bifurcation; Distal, obstruction that is distal to the ileocecal artery bifurcation; PI, pneumatosis intestinalis; BSC, best supportive care; EI, endovascular intervention; OPE, operation; Heparin, heparin medication.

Discussion

SMA embolism is a rare life-threatening condition, and the in-hospital mortality rate is as high as 60%-80% [2]. Surgical treatment or EI is mainly selected as the treatment for SMA embolisms. Recent studies have shown the efficacy of EI [3, 4]. EI has the advantage of being minimally invasive compared to surgical treatment. Short bowel syndrome and activities of daily living decline after emergency surgery are major problems for elderly patients. In our hospital, 60% (12 cases) received EI, and the success rate was 75% (9 cases). This rate was almost the same as the previously reported success rate of 70-73% in recent reports [7, 8]. A comparative study of the survivor group and the nonsurvivor group after EI showed no difference in the clinical factors or the blood test findings, but the nonsurvivor group had a significantly higher rate of PI based on the CT findings (P = 0.046). It is necessary to consider the absence of PI when considering EI for treatment. The presence of PI on CT scans is an important finding that suggests intestinal necrosis, and if intestinal necrosis has already occurred, the reperfusion of blood flow with EI treatment would have no therapeutic effect.

We classified all cases into 3 groups and examined them regarding the obstructed region in the SMA and for the existence of PI. Group A (obstruction proximal to the bifurcation of the ICA and PI) had a poor prognosis with a mortality rate of 55.6%. There were no surgical deaths, although there was a high possibility of short bowel syndrome. On the other hand, the survival rate after EI was as low as 40%. All of the dead patients died within 3 days after starting EI. It was possible that these patients already had intestinal necrosis. If surgical treatment was chosen as the initial treatment, it might have been lifesaving for these patients. Group B (obstruction proximal to the bifurcation of the ICA and no PI) had a relatively good prognosis. Only one patient required surgery, but it was possible to treat these patients with EI or heparin. We could not evaluate whether EI or heparin medication should be selected for Group B patients because of the small number of cases. However, if the therapeutic response to heparin medication was poor, it could lead to intestinal necrosis. EI treatment may be more useful for Group B patients. Group C (obstruction distal to the bifurcation of the ICA and no PI) had a good prognosis. Only one patient underwent EI, but 3 patients could be treated with heparin therapy. Patients with an obstruction distal to the bifurcation of the ICA have a narrow range of intestinal ischemia, and the blood flow from the marginal artery would remain. Therefore, it takes time to develop intestinal necrosis. We believe that intestinal necrosis can be prevented by anticoagulant therapy with heparin. However, careful follow-up is important because the SMA embolism might worsen or recur.

Based on the above results, we propose a treatment flowchart for SMA embolism, which is shown in Fig. 2. If the CT showed PI, surgical treatment was selected. If not, we would select the treatment based on the region that was obstructed in the SMA. We selected EI for obstructions that were proximal to the bifurcation of the ICA and heparin treatment for obstructions that were distal to the bifurcation of the ICA. This study was a retrospective observational study, and the number of cases was limited. This flowchart is a hypothesis and requires prospective multicenter research. Further studies to evaluate a larger number of patients are needed to examine the treatment strategy and the prognostic factors for SMA embolisms.

Conclusion

We suggest that it is useful to consider the existence of PI and the obstruction region as determined on CT in patients with SMA embolisms. If PI is observed on CT, surgical treatment would be better than EI because of the possibility of intestinal necrosis.

Declarations

Competing interests

The authors have no conflicts of interest to declare.

Ethics approval and consent to participate
This study was approved by the institutional review board of the Toyohashi Municipal Hospital (approval no. 609). Informed consent was obtained in the form of opt-out on the web-site.

Consent for publication

Informed consent was obtained in the form of opt-out on the web-site.

Availability of data and materials

All data generated or analysed during this study are included in this published article and its supplementary information file (Supplementary table 1)

Funding

This study was not funded.

Authors' contributions

RI analyzed and interpreted the patient data regarding the SMA embolism and wrote the manuscript. All authors read and approved the final manuscript.

Acknowledgements

We gratefully acknowledge the work of past and present members of our department.

Declarations of interest

none'.

References

1. Acosta S, Björck M. Modern treatment of acute mesenteric ischaemia. Br J Surg. 2014; 101:e100–8.
2. Yasuhara H. Acute mesenteric ischemia: the challenge of gastroenterology. Surg Today. 2005; 35:185–95.
3. Björck M, Orr N, Endean ED. Debate: whether an endovascular-first strategy is the optimal approach for treating acute mesenteric ischemia. J Vasc Surg. 2015; 62:767–72.
4. Ryer EJ, Kalra M, Oderich GS, Duncan AA, Gloviczki P, Cha S, et al. Revascularization for acute mesenteric ischemia. J Vasc Surg. 2012; 55:1682–9.
5. Björnsson S, Björck M, Block T, Resch T, Acosta S. Thrombolysis for acute occlusion of the superior mesenteric artery. J Vasc Surg. 2011; 54:1734–42.
6. Freitas B, Bausback Y, Schuster J, Ulrich M, Bräunlich S, Schmidt A, et al. Thrombectomy devices in the treatment of acute mesenteric ischemia: initial single-center experience. Ann Vasc Surg. 2018; 51:124–31.
7. Raupach J, Lojik M, Chovanec V, Renc O, Strýček M, Dvořák P, et al. Endovascular management of acute embolic occlusion of the superior mesenteric artery: a 12-year single-centre experience. Cardiovasc Intervent Radiol. 2016; 39:195–203.
8. Puippe GD, Sussertrunk J, Nocito A, Pfiffner R, Glenck M, Pfammatter T. Outcome of endovascular revascularisation in patients with acute obstructive mesenteric ischaemia - a single-centre experience. Vasa. 2015; 44:363–70.

Figures

![Figure 1](image_url)
The obstruction region of superior mesenteric artery embolism

Note: We divided superior mesenteric artery embolisms into two groups focusing on the obstruction region. “Proximal” indicated that the obstruction region was proximal to the bifurcation of the ileocecal artery. “Distal” indicates that the obstruction region was distal to the bifurcation of the ileocecal artery.

Abbreviations: SMA, superior mesenteric artery; MCA, middle colic artery; RCA, right colic artery; ICA, ileocolic artery; JAs, jejunal arteries; IAs, iliac arteries.

Figure 2

Hypothesized treatment flowchart for superior mesenteric artery embolisms

Note: If the patient with a superior mesenteric artery embolism had pneumatosis intestinalis based on the CT findings, surgical treatment was selected. If not, we selected the treatment based on the obstructed region in the superior mesenteric artery. We would be better to select endovascular intervention for obstructions proximal to the bifurcation of the ileocecal artery and heparin treatment for obstructions distal to the bifurcation of the ileocecal artery.

Abbreviations: ICA, ileocolic artery.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- SupplementaryTable1.xlsx