Rare Mesenteric Arterial Diseases: Fibromuscular Dysplasia and Segmental Arterial Mediolysis and Literature Review

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Abstract:
Fibromuscular dysplasia (FMD) and segmental arterial mediolysis (SAM) are noninflammatory, nonatherosclerotic arterial diseases that cause aneurysm, occlusion, and thromboses. These diseases are rarely seen in mesenteric arterial lesions; however, as they can be lethal if appropriate management is not provided, the accumulation of clinical information from cases is essential. We herein report the cases of a 57-year-old man diagnosed with FMD and a 63-year-old man diagnosed with SAM. We conclude that an early diagnosis with imaging modalities and clinical information followed by the appropriate treatment improves the prognosis of these arterial diseases.

Key words: fibromuscular dysplasia, segmental arterial mediolysis, mesenteric lesion, diagnosis

Case Reports

Case 1

A 57-year-old man was admitted to our hospital with a chief complaint of acute-onset severe and continuous sharp epigastric pain with no trigger. The pain gradually reduced, but the abdominal discomfort persisted.

He had a history of untreated hypertension, hyperlipidemia, and diabetes. He had been a smoker for 33 years (1 pack/day). Upon admission to our hospital, he had a blood pressure of 142/98 mmHg, heart rate of 92 beats/min, and temperature of 36.5°C. Laboratory findings showed a mild elevation of the white blood cell count (12,800/μL) and C-reactive protein (7.49 mg/dL), blood sugar (152 mg/dL), lactate dehydrogenase (LDH; 243 IU/L), creatinine kinase (538 IU/L), and hemoglobin A1c (6.5%). Computed tomography (CT) and three-dimensional reconstruction showed arterial stenosis, aneurysmal changes, and partial dissection in the superior mesenteric artery (Fig. 1a-c) as well as stenosis and aneurysmal changes in the branch of the right renal artery (Fig. 1d, e). Magnetic resonance angiography (MRA)
showed stenosis (red arrows) and aneurysmal changes (red arrowheads) in the left vertebral artery (Fig. 1f). Because of his noninflammatory, nonatherosclerotic multiple arterial lesions in the midsized arteries, hypertension, and long history of smoking, we diagnosed him with FMD.

Given the diagnosis of FMD and persistently high blood pressure at 160/90 mmHg, antihypertensive therapy was started with continuous intravenous infusion of nicardipine (2 μg/kg/min) followed by the oral administration of valsartan (40 mg/day) starting on hospital day 7, which successfully brought down the blood pressure to 110/60 mmHg. In addition, to prevent cerebral infarction because of aneurysmal lesions in the left vertebral artery, anticoagulant therapy was also started with continuous intravenous infusion of heparin (10,000 IU/day) on hospital day 11, followed by the oral administration of aspirin (81 mg/day). As the epigastric symptoms disappeared soon after the blood pressure came under control, they were considered to have been due to the progression of stenotic changes with vasoconstriction of mesenteric arterial lesions due to the increase in the blood pressure. With treatment of valsartan (40 mg/day) and aspirin (81 mg/day) for 18 months, no recurrence of the symptoms or other complications have been noted to date.

Case 2

A 63-year-old man was admitted to our hospital with a chief complaint of left-sided abdominal pain that showed slow progression from the day before the admission. He was a nonsmoker and had no history of illness.

Upon admission to our hospital, he had a blood pressure of 129/84 mmHg, heart rate of 75 beats/min, and temperature of 36.9°C. Other than the mild elevation of his white blood cell count (12,090/μL) and LDH (283 IU/L), no abnormal findings were noted. CT and three-dimensional reconstruction showed bleeding in the abdominal cavity and dissecting aneurysm in the celiac artery to the splenic artery (Fig. 2a-c). In addition, the bilateral external iliac arteries showed multiple aneurysmal changes and partial dissection (Fig. 2d-f). Because of noninflammatory, nonatherosclerotic multiple arterial diseases, dissecting aneurysm of the celiac and splenic arteries, and bleeding in the abdominal cavity probably from the arterial lesions, we diagnosed him with SAM.

As the symptoms significantly improved after admission...
with no increase in the bleeding in the abdominal cavity on day 2 or recurrence of the symptoms, and the hematoma decreased significantly on day 7, no emergent intervention or additional medication was started. However, in order to monitor the size of the aneurysmal changes and dissection, scheduled CT was performed every three to six months, and the blood pressure was carefully monitored. No recurrence of the symptoms or other complications has been noted in 16 months of follow-up.

**Discussion**

FMD and SAM are noninflammatory, nonatherosclerotic arterial diseases originally diagnosed based on histological findings; however, with marked advances in imaging modalities, including CT and magnetic resonance imaging, opportunities to diagnose these diseases based on imaging findings and clinical information without a pathological examination are increasing (3).

The clinical and pathological classification of FMD was first reported by Harrison and McCormack in 1971 (4), and recently, data belonging to the first 447 patients from the U.S. Registry for FMD were reported (5). FMD is a rare, medium-sized arterial disease occurring throughout the body with a frequency of 0.02%, predominantly in women (5). In addition, smoking, hormones, HLA-DRw6 polymorphism, and physiologic stimulation have been reported to be risk factors (6). The histologic changes in the arterial muscle replaced by fibroplasia can lead to arterial stenosis, occlusion, aneurysm, and dissection, and such events typically occur in the renal, extracranial, carotid, and vertebral arteries. Therefore, although rare, mesenteric FMD can cause unspecific abdominal pain, diarrhea, nausea, and vomiting (2). Imaging studies, including CT and angiography, reveal the narrowing and aneurysmal changes of the vasculature that lead to a beaded appearance (1). Our Case 1 also had a history of smoking, and CT showed a multiple-beaded aneurysmal appearance and partial dissection of the superior mesenteric and right renal arteries. In addition, MRA showed stenosis and dissection of the left vertebral artery, which is rather typical for FMD. Therapeutic options include antiplatelet, antithrombotic, and antihypertensive therapy (7), and our Case 1 was also successfully treated with these approaches with no recurrence.

SAM was first reported by Slavin and Gonzalez-Vitale in 1976 (8) and is a rare disease, with 50 cases reported to date. SAM is caused by the disruption of the arterial medial layer of a medium- to large-sized artery, and its risk factors include hypoxia, shock, hypertension, circulatory disturbance, and other vasoconstrictor stimuli (2, 8, 9). Because of
| Case No | Ref Age | Gender | Symptoms | Imaging findings | Histological findings | Treatment | Outcome |
|---------|---------|--------|----------|------------------|----------------------|-----------|---------|
| 1       | 50 81 F |        | Syncope  | Hematoma and hepatic artery rupture. Narrowing and aneurysms in celiac, common hepatic, renal artery. Stenosis in celiac artery. | N/A | Endovascular exclusion of the pseudoaneurysm with a balloon-expandable covered stent. Aspirin and clopidogrel. | Improved |
| 2       | 49 60 M |        | Abdominal pain, disturbed consciousness | Dissection in SMA and right vertebral artery. | N/A | Fluid replacement therapy | Improved |
| 3       | 48 54 F |        | Diarrhea, abdominal pain, weight loss | Multiple aneurysms in SMA, celiac, splenic and renal artery. Beaded appearance in both renal arteries. | N/A | TPN, Anticoagulation, open repair of the SMA aneurysms | Improved |
| 4       | 47 61 F |        | Abdominal pain | Multiple aneurysms and stenoses in SMA, IMA and renal artery. | Multiple tears and dissections of the medial layer and fibromuscular thickening | Anticoagulation | Improved |
| 5       | 46 20 F |        | Abdominal pain, hemorrhagic shock | Intramural enteric crisis and mesenteric of the transverse colon. "String of beads" appearance in the jejunal and SMA | N/A | Transcatheter arterial embolization | Improved |
| 6       | 45 52 M |        | Lower abdominal pain | The inferior mesenteric artery is tortuous and stenosed | Nocclusion of the mesocolic, fibrosis of the intima, media of these vessels was normal. | Left hemicolectomy | Improved |
| 7       | 44 19 F |        | Abdominal pain and vomiting | Stenosis of the origin of the SMA and multiple aneurysms involving the proximal SMA. Right renal artery is mild irregularity. | N/A | The aneurysmal segment of the SMA was resected and an aorto-SMA interposition graft with polyester prosthene was performed. | Improved |
| 8       | 43 47 F |        | Nausea, early satiety and upper abdominal pain | Narrowing of the superior mesenteric artery at its origin, with marked hyper trophy of the gastroduodenal artery and pancreaticoduodenal arteries. | N/A | An aorto-superior mesenteric artery and an aorto-hepatic artery bypass. | Improved |
| 9       | 42 47 F |        | Abdominal pain, diarrhea and hypertension | A partial occlusion of the celiac trunk and a total occlusion of the superior mesenteric artery. | Intimal and medial proliferation | Antihypertensive drug | Died |
| 10      | 41 30 M |        | Abdominal pain and hypertension | Dissections of the celiac, SMA, left renal, and external iliac artery. | N/A | β-blocker, Ca blocker, warfarin, and aspirin. Angioplasty for right renal artery. | Improved |
| 11      | 40 44 F |        | Hypertension, abdominal pain, diarrhea and vomiting | SMA stenosis and nonspecific colitis | N/A | Angioplasty | Improved |
| 12      | 39 43 F |        | Hypertension, abdominal pain and headache | Aneurysms in the left renal artery with severe fibromuscular stenosis. The string-of-beads appearance is shown in the right renal artery. Severe stenoses with post-stenotic dilatation is detected in SMA. | Intimal fibroplasia and an increased deposition of fibrous tissue in the vessel wall media. | Aneurysm resection and aortoenteral bypass and percutaneous transluminal angioplasty | Improved |
| 13      | 38 38 M |        | N/A | N/A | N/A | Angioplasty and antihypertensive drugs | Improved |
| 14      | 38 43 F |        | Hypertension and headache | String-of-beads appearance in the right renal artery and SMA. Stenosis and multiple irregularities in the left renal artery. | N/A | N/A | Improved |
| 15      | 37 N/A | N/A | Abdominal pain, distention and constipation | A thick cuff (petal-like) of smooth muscle proliferation with normal intima and media in the mesenteric artery. | N/A | Angioplasty and antihypertensive drugs | Improved |
| 16      | 36 38 M |        | Gastrointestinal bleeding, anemia | Ectasia, bleeding and narrowing in SMA. Ectasia in IMA | Thickening and hyalinization of medium sized vessel walls, with intimal proliferation. | Real resection | Improved |
| 17      | 35 48 F |        | Acute abdominal pain | Occlusion of the SMA and celiac trunk with an enlarged hypertrophic IMA and reinnervation of the distal SMA, common hepatic artery and splenic artery. | Intimal fibroplasia and an increased deposition of fibrous tissue in the vessel wall media | Reimplantation of the SMA | Improved |
| 18      | 34 57 F |        | Acute abdominal pain, weight loss, anorexia, nausea, vomiting and non-blood diarrhea | Long, tubular and narrowing of SMA and celiac artery. | Medial thickening, smooth muscle hyperplasia in SMA and celiac artery | Aorto-celiac and aorto-SMA bypass | Died |
| 19      | 33 48 F |        | Abdominal pain and hemoperitonitis | Multiple small aneurysms in SMA, Celiac and Renal artery (string-of-beads) β-blocker. | N/A | Surgical hemostasis and antihypertensive medications | Improved |
| 20      | 32 43 M |        | No symptoms | Aneurysms of the SMA, hepatic artery, splenic artery, jejunal artery and internal iliac arteries. | Medial fibroplasia is observed in the artery wall | Aneurysm resection and arterial reconstruction | Improved |
| 21      | 31 78 F |        | Hypertension, abdominal pain and hemoperitonitis | Dilated loop of the small bowel and a small amount of fluid in the hemoperitoneum. | Medial and peripheral fibroplasia, forms the characteristic petal-like appearance in SMA. | None | Died |
| 22      | 30 33 M |        | Abdominal pain | String-of-beads appearance in SMA | Thickening of the media due to hypoperfusion in SMA | Real resection | Improved |
| 23      | 23 57 M |        | Acute epigastric pain, neck stiffness | Multiple beaded aneurysmal appearance (stenosis and aneurysms) in SMA and right renal arteries. Stenosis and dissection in left vertebral artery | N/A | TPN, heparin, aspirin, Ca blocker, ACE inhibitor | Improved |

FMD: fibromuscular dysplasia, M: male, F: female, N/A: data not applicable, SMA: superior mesenteric artery, IMA: inferior mesenteric artery, RA: renal artery, CT: computed tomography, TPN: Total parenteral nutrition
### Table 2. Summary of SAM Cases Reported Recently

| Case | Ref | Age | Gender | Symptons | HA | Imaging findings | Treatment | Outcome |
|------|-----|-----|--------|---------|----|------------------|-----------|---------|
| 1    | 75  | 40  | M      | Shock, severe abdominal pain | HA | None | Embolization with coil | Improved |
| 2    | 73  | 60  | M      | Acute abdominal pain | HA | None | Embolization with coil | Improved |
| 3    | 74  | 57  | M      | Hypertension | HA | None | Embolization with coil | Improved |
| 4    | 75  | 58  | M      | Abdominal pain | HA | None | Embolization with coil | Improved |
| 5    | 72  | 32  | M      | Abdominal pain | HA | None | Embolization with coil | Improved |
| 6    | 70  | 49  | F      | Shock, severe abdominal pain | HA | None | Embolization with coil | Improved |
| 7    | 71  | 36  | M      | Abdominal pain | HA | None | Embolization with coil | Improved |
| 8    | 71  | 40  | M      | Abdominal pain | HA | None | Embolization with coil | Improved |
| 9    | 66  | 60  | M      | Hypertension, severe abdominal pain | HA | None | Embolization with coil | Improved |
| 10   | 68  | 36  | M      | Abdominal pain | HA | None | Embolization with coil | Improved |
| 11   | 64  | 56  | M      | Abdominal pain | HA | None | Embolization with coil | Improved |
| 12   | 65  | 20  | M      | Abdominal pain | HA | None | Embolization with coil | Improved |
| 13   | 62  | 51  | M      | None | HA | None | Embolization with coil | Improved |
| 14   | 64  | 51  | M      | Uncontrollable bleeding | HA | None | Embolization with coil | Improved |
| 15   | 60  | 70  | M      | Hypertension | HA | None | Embolization with coil | Improved |
| 16   | 66  | 64  | F      | Hypertension, severe abdominal pain | HA | None | Embolization with coil | Improved |
| 17   | 66  | 64  | F      | Abdominal pain | HA | None | Embolization with coil | Improved |
| 18   | 64  | 51  | M      | Abdominal pain | HA | None | Embolization with coil | Improved |
| 19   | 60  | 70  | M      | Abdominal pain | HA | None | Embolization with coil | Improved |
| 20   | 9   | 20  | F      | Acute, abdominal pain | HA | None | Embolization with coil | Improved |
| 21   | 59  | 60  | M      | Abdominal pain, diarrhea | HA | None | Embolization with coil | Improved |
| 22   | 58  | 57  | M      | Abdominal pain, shock | HA | None | Embolization with coil | Improved |
| 23   | 56  | 76  | F      | Abdominal pain, diarrhea | HA | None | Embolization with coil | Improved |
| 24   | 56  | 76  | F      | Abdominal pain, shock | HA | None | Embolization with coil | Improved |
| 25   | 55  | 49  | M      | Abdominal pain, shock | HA | None | Embolization with coil | Improved |
| 26   | 54  | 52  | M      | Sudden death | HA | None | Embolization with coil | Improved |
| 27   | 53  | 35  | F      | Abdominal pain, shock, hemorrhage | HA | None | Embolization with coil | Improved |
| 28   | 52  | 78  | M      | Abdominal pain, shock | HA | None | Embolization with coil | Improved |
| 29   | 51  | 60  | M      | Abdominal pain, shock | HA | None | Embolization with coil | Improved |
| 30   | 51  | 60  | M      | Abdominal pain, shock | HA | None | Embolization with coil | Improved |

**SAM**: segmental arterial mediolysis; **M**: male; **F**: female; **N/A**: data not applicable; **SMCA**: superior mesenteric artery; **HA**: hemorrhage artery; **CT**: computed tomography; **MCA**: middle cerebral artery; **VA**: vertebral artery; **TPN**: Total parenteral nutrition
the involvement of larger arteries than FMD, the rupture of an aneurysm in these arteries can be life-threatening. Histologically, vacuolization and lysis of the outer arterial media can be seen (8), which can lead to aneurysm, dissection, occlusion, and stenosis. Mesenteric SAM in the splenic, celiac, hepatic, and mesenteric arteries can cause abdominal symptoms, including nonspecific abdominal and flank pain, diarrhea, nausea, and back pain caused by aneurysm and dissection (2, 9, 10). CT and MRA have shown aneurysms, dissection, occlusion, and stenosis. Therapeutic options include antihypertensive therapy (11), embolization, bypass, and resection of the injured arteries. Patients presenting acutely with intraabdominal hemorrhaging are treated with emergent catheter angiography, endovascular intervention, or surgical treatment (12). Our Case 2 also suffered from abdominal pain, which had been caused by the minor rupture of a small aneurysm in the branch of the celiac or splenic artery; however, as the symptoms improved smoothly and the aneurysm was located on the main trunk of the celiac artery, no emergent intervention was performed. Fortunately, no recurrence has been seen to date; however, a careful follow-up of the aneurysm by imaging has been performed once every three to six months. In addition to our Case 2, Cases 12 and 13 improved with conservative therapy, although hemoperitoneum was found in abdominal cavity (Table 2). These three cases showed no progression of hemoperitoneum and no extravasation upon admission, so these signs may be markers supporting the selection of conservative treatment.

Due to difficulty in collecting tissue samples from the arteries in these areas, the importance of imaging studies is increasing, and although some similarities in the radiologic and histologic diagnoses have been reported for FMD and SAM, the two diseases show different clinical profiles in terms of the age of onset, gender, distribution of the affected arteries, imaging, symptoms, and treatment. It is therefore possible to diagnose these diseases clinically and suggest appropriate therapeutic options (Table 1, 2). For example, FMD affects middle-aged women, whereas there is no predilection for age or gender for SAM (3, 5, 13, 14). In addition, while FMD often shows stenosis and aneurysms in medium-sized arteries, including the renal, extracranial, carotid, and vertebral arteries (12), SAM shows changes in larger arteries, such as the celiac and mesenteric arteries (13), leading to a higher risk of arterial rupture and hemorrhaging from the weakened arterial wall in these larger arteries (15).

To improve our understanding of these diseases, we recently reviewed the reported cases of FMD and SAM in the gastroenterologic regions (3, 9, 11, 15-29) and reported the characteristics of imaging studies. For a further understanding of the clinical characteristics, we updated the information, focusing on cases reported within the past 20 years, since imaging modalities have shown significant advances in this time period (30-78). Based on the obtained information, CT revealed stenosis and aneurysmal changes in 33 cases (77%) of FMD and aneurysm, dissection, occlusion, and stenosis in 28 cases (88%) of SAM. In addition, hemorrhaging or hematoma was seen in 15 cases (47%) of SAM. Our cases also showed a similar pattern to the previously reported cases. Regarding the therapeutic options, open surgery was performed in 56%, endovascular intervention in 23%, antihypertensive therapy in 19%, and anticoagulation therapy in 11.6% for FMD. In contrast, open surgery was performed in 41%, endovascular intervention in 42%, antihypertensive therapy in 6.3%, and anticoagulation therapy in 6.3% for SAM (including Case 2). These data clearly demonstrate that early imaging studies and appropriate decision-making are essential for successful management.

Interestingly, 13 cases of FMD (30%) and 19 cases of SAM (59%), mainly recent cases, have been diagnosed without histological examinations and administered appropriate therapies, indicating that the accumulation of the information and results of imaging studies encouraged physicians to be suspicious of and diagnose the cases.

In conclusion, FMD and SAM are rare, and no standard diagnostic criteria or therapeutic methodologies have yet been established. The accumulation of similar cases and the summary of the clinical characteristics of the reported cases are important. In this report, we described two representative recent cases and summarized the findings of cases reported recently in order to improve the understanding and knowledge of these diseases. Further cases and the accumulation of clinical information will help physicians diagnose and treat such cases and facilitate the development of diagnostic criteria and standard therapeutic options.

Written informed consent was obtained from the patient for publication of this case report and accompanying images.

The study was reviewed and approved by the Institutional Review Board of Niigata University.

The authors state that they have no Conflict of Interest (COI).

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