Gastrointestinal Intervention

journal homepage: www.gi-intervention.org

Review Article

Segmental arterial mediolysis: Literature review focused on radiologic findings and management

Seung Yeon Noh, Ji Hoon Shin,* Hyun-Ki Yoon, Gi-Young Ko, Kyu-Bo Sung

ABSTRACT

Segmental arterial mediolysis (SAM) is a rare disease which can have catastrophic consequences due to massive hemorrhage or dissecting hematomas. The pathophysiology of this disease is not well-known, and the symptoms vary according to the organs involved. In many patients the diagnosis is based on the clinical and radiologic features rather than the pathologic confirmation. The catheter-based endovascular technique can be an interventional treatment option for SAM, as well as surgical management.

Copyright © 2016, Society of Gastrointestinal Intervention. All rights reserved.

Keywords: Aneurysm; Embolization, therapeutic; Therapeutics; Vasculitis

Introduction

Segmental arterial mediolysis (SAM) is a rare arterial disease that presents with massive hemorrhage in various parts of the body, including the abdominal cavity, retroperitoneum, heart or the brain.^{1–5} It is nonatherosclerotic, noninflammatory vascular disease involving large- to medium-sized arteries and occasionally adjacent veins.^{6–8} It affects the media of arteries, thus leading to smooth-muscle-cell vacuolar degeneration.^{9,10}

SAM is one of the disease entities that may be difficult to diagnose and the exact incidence of the disease is unknown. This can be attributed to the nonspecific clinical presentations including subclinical presentations, multiple organ involvement, common radiologic findings with other types of vasculitis such as fibromuscular dysplasia (FMD) and lack of routine angiography performed for patients with abdominal pain.^{1,9,11,12} The increased awareness of SAM led to its increased reporting and the technical advances in computed tomography (CT) and magnetic resonance (MR) imaging enabled an early diagnosis before clinical presentation. In this article, we reviewed the radiologic considerations, clinical features, diagnosis and management of SAM.

Pathologic Consideration

Although SAM was first reported in 1976 by Slavin and Gonzalez-Vitale,¹³ the pathologic findings were then not well-recognized. According to current studies, lysis of the medial layer of the muscular arterial wall, caused by disruption of the smooth muscle cell membrane, is the primary pathologic finding.^{9,11} This seems to be a dynamic process with a temporal sequence of damage in the media, and thus injuring and stimulating a robust reparative response in the muscular arteries.^{6,10} Slavin^{1,6} suggested both the initial injurious phase and the subsequent reparative phase. In the initial phase, vacuolar degeneration is seen in the medial layer, and in the reparative phase, proliferation of granulation tissue filling and expansion of arterial wall defects, which subsequently forms plaques, can be observed.^{1,6,12}

These pathologic findings are related to the pathogenesis of the disease. Repeated vasoconstrictive stimuli causing degeneration of smooth muscle cells in the media seems to be the key pathogenesis.¹⁰ Exposure to α -1 adrenergic receptor agonists or β -2 receptor agonists causing release of norepinephrine from the peripheral nervous system, is also thought to be the possible cause of SAM. The recent animal study by Slavin and Yaeger¹⁴ supports this theory in which the exogenous ractopamine, the β -adrenergic receptor agonist, injected into dogs leads to

Department of Radiology and Research Institute of Radiology, Asan Medical Center, University of Ulsan College of Medicine, Seoul, Korea

Received July 17, 2015; Revised September 8, 2015; Accepted September 19, 2015

* Corresponding author. Department of Radiology and Research Institute of Radiology, Asan Medical Center, University of Ulsan College of Medicine, 88 Olympic-ro 43-gil, Songpa-gu, Seoul 05505, Korea.

E-mail address: jhshin@amc.seoul.kr (J.H. Shin).

pISSN 2213-1795 eISSN 2213-1809 <http://dx.doi.org/10.18528/gii150012>

© This is an open-access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (<http://creativecommons.org/licenses/by-nc/3.0>) which permits unrestricted noncommercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

SAM.^{6,10,14} Considering this hypothesis, the use of norepinephrine antagonists for the treatment of SAM can be a possible option, although it is as yet untested.⁶

Clinical Features

SAM was originally reported to affect middle-aged and older adults; however, more recently, this disease has been seen in all age groups, and with a slight male predominance (male:female ratio of 1.5:1).^{1,10,11,15} Cerebral arterial involvement is reported to be more common in younger patients.³

The symptoms vary according to the involved organ as SAM can affect almost every part of the body. As the most commonly involved site is the celiac trunk, and which we will discuss later, the most common symptom of SAM is abdominal pain, accounting for approximately 66% of the reported symptoms.¹¹ Hemoperitoneum and hypovolemic shock occur in less than 1/3 of the patients.¹⁰

End-organ damage, including bowel ischemia, hematuria, and neurologic deficits, have also been reported.¹⁰ And according to the systematic review by Shenouda et al.,¹¹ six of their 85 patients were incidentally found without specific symptoms. Asymptomatic patients are being more frequently diagnosed with SAM due to the increasing use of CT and MR for other abdominal symptoms. In symptomatic patients, varying symptoms and involved sites can be obscure and, therefore, make the early and exact diagnosis of the disease more difficult.

Radiologic Findings

Because the pathologic diagnosis is not available in many patients with SAM, the radiologic findings have a critical role in the diagnosis of this disease. The most commonly involved sites are the celiac artery and its branches, including the splenic artery, which account for 70% to 80% of the cases.^{10,11,16} Renal arteries are the most commonly affected non-visceral arteries, and which account for seven to 24% of the cases.^{10,11,16}

Six types of angiographic findings were suggested by Slavin.^{1,6}

They are arterial dilatation, single aneurysm, multiple aneurysms, dissecting hematomas, arterial stenosis, and arterial occlusions. Lysis of media of the arterial wall can be seen as arterial dilatation or aneurysm on angiography (Fig. 1A, 2B).¹ It can involve multiple areas with an intervening, intact arterial segment, and causing the typical "string of beads" appearance (Fig. 3, 4).¹¹ Dissecting aneurysms can be seen when transmural mediolysis results in "arterial gaps".¹¹ Unlike mycotic aneurysms, arterial dilatation and aneurysm formation rarely involve the branching sites.¹⁰ There may be multiple aneurysms in one-third of the cases.¹⁷ Isolated peripheral arterial dissection unrelated to the aorta is characteristic of SAM.^{11,17-19} Arterial stenosis and occlusions result from luminal narrowing caused by reparative granulation tissue forming plaques.^{1,20,21}

A dedicated CT or MR angiogram can reveal the characteristic arterial abnormalities of SAM, as previously described, as well as ancillary findings of intra-abdominal hematoma (Fig. 1B, 2A, 4A), active bleeding (Fig. 4A), bowel ischemia, and renal and splenic infarcts. CT and MR angiograms can be used for follow-up of patients with SAM.

Diagnosis

Although the diagnosis of SAM requires pathologic confirmation, in many cases the diagnosis is based on the clinical and radiologic features.^{9,15} There is a lack of consensus regarding the noninvasive diagnostic criteria for the diagnosis of SAM.¹⁸ An institutional guideline for diagnosing SAM has been suggested by Kalva et al.,¹⁸ and which was based on the clinical features, laboratory values, and imaging findings as well as the exclusion of other vascular disorders.

As mentioned above, the radiologic diagnosis is confounded by a variety of vasculopathies that have similar imaging findings; however, it can be diagnosed after excluding other similar diseases. According to the institutional guidelines suggested by Kalva et al.,¹⁸ the absence of a congenital predisposition for dissections, e.g., Ehlers-Danlos syndrome, Marfan syndrome, the absence of a more plausible diagnosis such as FMD or collagen vascular dis-

Fig. 1. The 79-year-old male patient underwent anterior resection with left lateral sectionectomy of the liver for sigmoid colon cancer with liver metastasis. On post-operative day 11, he presented with melena with hemoglobin drop. (A) On conventional angiography, there was aneurysmal change (arrow) of the mid-colic artery near the splenic flexure. (B) On the computed tomography scan, there is a large hematoma seen in the lesser sac with a suspected aneurysm (arrow) in the mid-colic artery. (C) The distal and proximal portions were embolized with microcoils and glue (n-butyl cyanoacrylate, 1:2 mixture with lipiodol), respectively. And the final superior mesenteric artery angiogram shows complete isolation of the lesion.

Fig. 2. The 71-year-old male patient with a history of immunoglobulin A nephropathy presented with general edema, nausea, and vomiting. His vital signs were unstable and his hemoglobin had dropped. (A) Computed tomography scan shows mesenteric hematoma (asterisk) with a dissecting aneurysm (arrow) in the jejunal branch of the superior mesenteric artery (SMA). (B) The SMA and selective small-bowel branch angiograms show ectatic change with a dissecting aneurysm (arrow) of the jejunal branch. (C) Glue (n-butyl cyanoacrylate, 1:2 mixture with lipiodol) was used to embolize the proximal and distal parts, as well as the aneurysm, itself. (D) The final SMA and common hepatic artery angiograms show complete embolization of the aneurysm as well as the proximal/distal parts.

Fig. 3. A 78-year-old female patient presented to the Emergency Department due to abdominal pain and massive hematochezia for six days. (A) The initial computed tomography scan shows a fusiform dilatation (arrow) of the long segmental jejunal branch of the superior mesenteric artery (SMA) and with a surrounding fluid collection. (B) On the SMA angiogram there was fusiform dilatation with luminal irregularity (arrow) in a branch of the proximal jejunal artery. As there was no evidence of active bleeding, embolization was not done considering the patient's age and the risk of bowel infarction. The patient underwent full recovery with conservative management.

order, the absence of associated contiguous aortic dissection or atherosclerosis, and the absence of inflammatory markers can be included in the diagnostic criteria.¹⁸

The differential diagnosis of SAM includes: 1) Systemic vasculitis, such as polyarteritis nodosa, Takayasu's arteritis, and Behcet's syndrome; 2) Mycotic aneurysms; 3) Collagen vascular diseases such as Ehlers-Danlos syndrome; and 4) Degenerative vasculopathies such as cystic adventitial artery disease or cystic medial necrosis. The characteristic clinical features can help to

distinguish systemic vasculitis, collagen vascular diseases, and degenerative vasculopathies. Increased acute-phase reactants and specific auto-antibodies present in many types of vasculitis are not seen in SAM. Mycotic aneurysms more commonly involve arterial bifurcation.

One important disease, which was previously considered to be related to SAM, is FMD. Previously, SAM was thought to be a variant or a precursor of FMD.^{1,3,17,22} The morphologic appearance of FMD resembles that of the reparative phase of SAM.^{1,6,8} How-

Fig. 4. A 77-year-old male patient with a history of pulmonary thromboembolism presented with sudden onset of right upper-quadrant pain. He has been on anti-coagulation with warfarin. (A) The initial computed tomography scan shows a large hematoma at the right side of the ascending mesocolon and omentum. There is also an extravasation (arrow) of contrast media from the right colic artery. (B) Superior mesenteric artery angiogram shows multifocal ectatic and stenotic change (arrows) of the right colic, transverse colic, and ileal branches. There was also active bleeding from the right colic artery. (C) The back door was occluded using five microcoils as well as the n-butyl cyanoacrylate (1:2) proximally. After the embolization, the patient complained of persistent abdominal pain, and a physical exam demonstrated abdominal tenderness. Therefore, explorative laparotomy was planned, and right hemicolectomy was performed.

ever, a recent study shows that FMD is not solely caused by SAM but represents a group of arterial disorders with diverse etiologies.⁶ FMD typically occurs in young females and has a predisposition for the renal arteries.⁷ The clinical presentation also differs in the two diseases, i.e., SAM presents with profuse bleeding from abdominal intestinal arteries, while FMD presents with ischemic changes causing hypertension derived from renal artery alterations.⁶

Management

In the past, the mortality rate of SAM was known to approach nearly 50%.^{11,19} According to the recent study by Shenouda et al.,¹¹ it is now estimated to be 26%, and which is attributed to the advanced techniques used for the early diagnosis of symptomatic and asymptomatic patients and as well as for their treatment. The management of SAM hinges on its clinical presentation, the vessels involved, and the presence of end-organ ischemia.

Although some studies have shown successful conservative management of SAM patients, the majority of these patients require an interventional procedure.^{9,11,23} Since the first successful management of SAM using coil embolization was reported in 2000, minimally invasive techniques, especially catheter-based endovascular techniques, are coming into the spotlight.²¹ With the proper selection of patients and the continuous advancement of endovascular devices, catheter-based endovascular treatment can be a successful option for the treatment of SAM (Fig. 1C, 2C, 2D), as well as open surgical procedures.

Surgery is reserved for the management of occlusive symptoms, such as bowel ischemia, and for vascular lesions which cannot be accessed endovascularly. In angiographically inaccessible cases, endovascular management can be used to ameliorate the situation using balloon occlusion before surgical intervention.¹⁰

Conclusion

SAM is a rare arterial disease caused by degeneration of medial, smooth-muscle cells, and which can bring about catastrophic

massive hemorrhage in various parts of the body.⁶ Because the pathologic diagnosis is not available in many patients with SAM, the radiologic findings have a critical role in the diagnosis of this disease. Minimally invasive techniques, especially catheter-based endovascular techniques, can be a successful option in certain patients, as well as use of the conventional, open surgical approach.

Conflicts of Interest

No potential conflict of interest relevant to this article was reported.

References

- Slavin RE. Segmental arterial mediolysis: course, sequelae, prognosis, and pathologic-radiologic correlation. *Cardiovasc Pathol.* 2009;18:352-60.
- Gruenewald P. Necrosis in the coronary arteries of newborn infants. *Am Heart J.* 1949;38:889-97.
- Basso MC, Flores PC, de Azevedo Marques A, de Souza GL, D'Elboux Guimarães Brescia M, Campos CR, et al. Bilateral extensive cerebral infarction and mesenteric ischemia associated with segmental arterial mediolysis in two young women. *Pathol Int.* 2005;55:632-8.
- de Sa DJ. Coronary arterial lesions and myocardial necrosis in stillbirths and infants. *Arch Dis Child.* 1979;54:918-30.
- Eifinger F, Fries J, Bald R, Körber F, Kribs A, Roth B. Segmental arterial mediolysis in a preterm. *J Perinatol.* 2004;24:461-4.
- Slavin RE. Segmental arterial mediolysis: a clinical-pathologic review, its role in fibromuscular dysplasia and description and differential diagnosis of the masquerader-muscular artery cystic necrosis. *World J Cardiovasc Dis.* 2013;3:64-81.
- Baker-LePain JC, Stone DH, Mattis AN, Nakamura MC, Fye KH. Clinical diagnosis of segmental arterial mediolysis: differentiation from vasculitis and other mimics. *Arthritis Care Res (Hoboken).* 2010;62:1655-60.
- Slavin RE, Inada K. Segmental arterial mediolysis with accompanying venous angiopathy: a clinical pathologic review, report of 3 new cases, and comments on the role of endothelin-1 in its pathogenesis. *Int J Surg Pathol.* 2007;15:121-34.
- Michael M, Widmer U, Wildermuth S, Barghorn A, Duewiel S, Pfammatter T. Segmental arterial mediolysis: CTA findings at presentation and follow-up. *AJR Am J Roentgenol.* 2006;187:1463-9.
- Pillai AK, Iqbal SI, Liu RW, Rachamreddy N, Kalva SP. Segmental arterial mediolysis. *Cardiovasc Intervent Radiol.* 2014;37:604-12.
- Shenouda M, Riga C, Naji Y, Renton S. Segmental arterial mediolysis: a systematic review of 85 cases. *Ann Vasc Surg.* 2014;28:269-77.
- Marshall L, O'Rourke T, McCann A, Finch R, Strong R. Spontaneous intrahepatic haemorrhage: two cases of segmental arterial mediolysis. *ANZ J Surg.* 2015;85:49-52.
- Slavin RE, Gonzalez-Vitale JC. Segmental mediolytic arteritis: a clinical pathologic

- study. *Lab Invest.* 1976;35:23-9.
14. Slavin RE, Yaeger MJ. Segmental arterial mediolysis—an iatrogenic vascular disorder induced by ractopamine. *Cardiovasc Pathol.* 2012;21:334-8.
 15. Filippone EJ, Foy A, Galanis T, Pokuah M, Newman E, Lallas CD, et al. Segmental arterial mediolysis: report of 2 cases and review of the literature. *Am J Kidney Dis.* 2011;58:981-7.
 16. Tameo MN, Dougherty MJ, Calligaro KD. Spontaneous dissection with rupture of the superior mesenteric artery from segmental arterial mediolysis. *J Vasc Surg.* 2011;53:1107-12.
 17. Lie JT. Segmental mediolytic arteritis. Not an arteritis but a variant of arterial fibromuscular dysplasia. *Arch Pathol Lab Med.* 1992;116:238-41.
 18. Kalva SP, Somarouthu B, Jaff MR, Wicky S. Segmental arterial mediolysis: clinical and imaging features at presentation and during follow-up. *J Vasc Interv Radiol.* 2011;22:1380-7.
 19. Sakano T, Morita K, Imaki M, Ueno H. Segmental arterial mediolysis studied by repeated angiography. *Br J Radiol.* 1997;70:656-8.
 20. Chao CP. Segmental arterial mediolysis. *Semin Intervent Radiol.* 2009;26:224-32.
 21. Davran R, Cinar C, Parildar M, Oran I. Radiological findings and endovascular management of three cases with segmental arterial mediolysis. *Cardiovasc Interv Radiol.* 2010;33:601-6.
 22. Tabassum A, Sasani S, Majid AJ, Henderson C, Merrett ND. Segmental arterial mediolysis of left gastric artery: a case report and review of pathology. *BMC Clin Pathol.* 2013;13:26.
 23. Agarwal S, Stephen E, Selvaraj D, Mathur K, Keshava S, Chandy ST. Visceral ischemia: could it be segmental arterial mediolysis. *Indian J Gastroenterol.* 2009;28:72-3.