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ORIGINAL ARTICLE

Value of Multi-detector CT in Detection of Isolated Spontaneous Superior Mesenteric Artery Dissection

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Objective To investigate the role of multi-detector computed tomography (CT) in the diagnosis and classification of isolated spontaneous superior mesenteric artery dissection (ISSMAD).

Methods From July 2012 to December 2016, 30 consecutive patients with ISSMAD underwent CT scan at least two times. We retrospectively summarized the clinical characteristics and CT findings of them. The stenosis ratio of true lumen was compared between the patients without bowel ischemia and ones with bowel ischemia.

Results There were 5 cases of type I ISSMAD, 14 cases of type II, 1 case of type III, 7 cases of type IV and 3 cases of type V. Intestinal ischemia occurred in 5 patients. The stenosis ratio of true lumen in the patients without bowel ischemia was lower than that with bowel ischemia (45.6% vs. 76.0%, $t=-14.5$, $P=0.000$). Five patients with intestinal ischemia underwent superior mesenteric artery stenting and others received conservative therapy. The abdominal pain was alleviated for all the patients after treatment. Follow-up was complete in 30 cases. Follow-up CT angiography of superior mesenteric artery showed dissection remodeling in 12 patients.

Conclusion Multi-detector CT is a valuable method in diagnosis and classification of ISSMAD and monitoring the changes of dissection.

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I SOLATED spontaneous superior mesenteric artery dissection (ISSMAD) without aortic involvement represents a rare condition. However, with the development of the multi-detector computed

tomography (CT) imaging technology and application in the abdominal scanning, increasing ISSMAD has been identified.¹⁻³ As far as the therapeutic strategy of ISSMAD, no consensus has been reached. The therapeutic options include conservative, endovascular intervention, and open surgery. The arterial dissection is a potential life threatening condition and may be in dire need of urgent surgery

once intestinal ischemia or arterial rupture occurs. Here we retrospectively summarized computed tomography angiography (CTA) findings of 30 cases with ISSMAD and investigated the type and remodeling of the dissection.

PATIENTS AND METHODS

Patients

From July 2012 to December 2016, 30 ISSMAD patients received treatment in our hospital. The cohort of patients did not have any previous endovascular procedures. The diagnosis of ISSMAD was made according to the CT imaging findings, such as an intimal flap or thrombosis in the false lumen.⁴ Those patients with superior mesenteric arterial dissection complicated by aortic dissection were excluded.

The clinical characteristics including patients' age, gender, symptoms, risk factors such as hypertension, hyperlipidemia, smoking, diabetes, arteriosclerosis, treatment options, outcomes, follow-up time were retrospectively recorded. For asymptomatic ISSMAD, patients were observed without any treatment and followed up at 1 month, 6 months and annually thereafter. For symptomatic ISSMAD, the patients were admitted to the hospital and managed conservatively with bowel rest, fluid supplementation, blood pressure control, anticoagulation, and nutritional support. When the conservative treatment failed, the patients were given endovascular intervention treatment or surgical treatment. The follow-up interval between two CT scans was the same for asymptomatic patients. All patients were followed up with CT scan to assess the dissection remodeling.

Multi-detector CT imaging

CTA was performed on a 256-slice CT scanner (Brilliance iCT, Philipsmedical System, Holland). Scanning parameters were as follows: 100 kV, auto mAs, pitch 0.914, slice collimation 128×0.6 mm, thickness 0.6 mm. Each patient received 80 ml contrast media (Omnipaque 350 mgI/ml, GE Healthcare, Pewaukee, WI, USA) intravenously at a rate of 4 ml/s.

For vessels reconstructing, axial image data were transferred to an Advanced Workstation for post-processing [Extended Brilliance Workspace (EBW)]. The superior mesenteric artery (SMA) was reformatted with Volume Render (VR), maximum intensity projection (MIP), multi-planar reconstruction (MPR) and curved planar reconstruction (CPR).

Measurements

Imaging characteristics including entry site location

(distance to the SMA curvature), angle between the SMA and abdominal aorta, morphologic classification of the dissection, the residual true lumen diameter, stenosis ratio of the lumen [(adjacent normal SMA diameter–true lumen diameter)/adjacent normal SMA diameter×100%], and dissection length were analyzed and measured. Stenosis degree was divided into 3 categories: mild stenosis (<50%); moderate stenosis (50%-75%); severe stenosis (>75%). We classified the ISSMAD according to Sakamoto types⁵ and modified morphologic classification⁴ (Fig. 1). Type I, patent false lumen with entry and re-entry; type II, "cul-de-sac" shaped false lumen without re-entry; type III, thrombosed false lumen with an ulcer-like projection (ULP); type IV, completely thrombosed false lumen without an ULP; type V, dissection aneurysm. The dissection aneurysm of SMA is defined as an increase in diameter of more than 50% compared with the adjacent normal SMA size. Intestinal ischemia was also observed. The features of intestinal ischemia on CT images are poor enhancement of the intestinal wall, edema of the mesentery, and gas in the mesenteric blood vessels in the advanced cases.

The remodeling of dissection was evaluated on CTA scan: (1) no change, (2) complete remodeling, (3) partial remodeling, and (4) progression to total occlusion. Complete remodeling means false lumen disappears and true lumen is completely recanalized. Partial remodeling means false lumen size reduces and true lumen is partially recanalized. Progression means true lumen size is more stenotic.

Figure 1. ISSMAD classification according to Sakamoto types and modified morphologic classification.

ISSMAD: isolated spontaneous superior mesenteric artery dissection.

Statistical analysis

Statistical analysis was conducted using *t* test with the SPSS software (15.0 version; SPSS Inc., Chicago, IL, USA). The continuous variables were expressed as mean±SD, and categorical variables were expressed as percentage. *P* values of <0.05 were considered statistically significant.

RESULTS

Patients' characteristics

The study included 25 male and 5 female gender, with a

mean age of 53.5 ± 7.7 (ranging from 27 to 76) years old. Regarding background factors, 14 (46.7%) patients had hypertension, 20 (66.7%) had history of smoking, 5 (16.7%) had hyperlipidemia, and 1 (3.3%) had diabetes. Abdominal aortic atherosclerosis was detected in 15 (50.0%) patients. No other relevant comorbidities such as vasculitis, trauma, and Marfan's syndrome were found. Sudden abdominal pain and discomfort occurred in 26 (86.7%) patients. ISSMAD were accidentally detected when CT scan was performed to diagnose other diseases in 4 patients.

CT appearances

The angle between SMA and abdominal aorta was 67.9 ± 21.1 degree. The beginning of SMA dissection was proximal to SMA curvature in 19 patients, and the mean distance to SMA curvature was 11.6 ± 4.8 mm. The beginning of SMA dissection was distal to SMA curvature in 11 patients, and the mean distance to SMA curvature was 16.5 ± 4.5 mm. The mean dissection length was 51.9 ± 25.5 (ranging from 5 to 90) mm.

Five (16.7%) patients were divided as type I ISSMAD (Fig. 2A), 14 (46.7%) patients as type II (Fig. 2B), 1 (3.3%) patient as type III, 7 (23.3%) patients as type IV (Fig. 2C) and 3 (10.0%) patients as type V (Fig. 2D).

The normal lumen diameter was 67.4 ± 11.7 (ranging from 46 to 89) mm, the residual true lumen diameter was 33.2 ± 15.2 (ranging from 0 to 66) mm, and the mean stenosis ratio of the lumen was $50.9\% \pm 20.3\%$. Bowel ischemia was present in 5 (16.7%) patients whose stenosis ratio of true lumen was more than 75% (2 with type II and 3 with type IV). For 25 patients without bowel ischemia, 13 (43.3%) were with mild stenosis and 12 (40.0%) with

moderate stenosis. The stenosis ratio of true lumen in the patients without bowel ischemia (45.6%) was significantly lower than that in the patients with bowel ischemia (76.0%, $t = -14.5$, $P = 0.000$).

Treatment

Only routine observation was performed in four asymptomatic patients. Twenty-six patients received conservative treatment initially, including control of hypertension, bowel rest, fluid supplementation, and anticoagulation. Abdominal pain relieved in twenty-one patients. Five patients with bowel ischemia underwent SMA stenting because of no relief of abdominal pain after conservative treatment. Their symptoms disappeared and all the patients were discharged from the hospital.

Follow-up

All patients were followed up for 25.5 ± 20.6 month, ranging from 1 to 46 months. And 15 cases were followed up more than 12 months, 9 cases more than 6 months and 6 cases less than 6 months. No abdominal pain has recurred. Out of the 25 patients with conservative treatment, CT scans showed complete remodeling in 4 patients (follow-up time 1-21 months) (Figs. 3, 4), partial remodeling in 5 patients (follow-up time 3-30 months), progression in 3 patients (follow-up time 1-3 months) including 1 whose SMA progressed to total occlusion. But the 3 patients with angiographic progression to total occlusion had no symptoms due to collateral vessel formation. CT scan revealed no obvious change in 13 patients with conservative treatment (follow-up time 1-46 months). For 5 patients with endovascular stents treatment, follow-up CT showed partial remodeling (Fig. 5).

Figure 2. A. A 53-year-old male patient. Sagittal maximum intensity projection image shows type I ISSMAD. His abdominal pain had continued for 1 week. B. A 50-year-old male patient. Coronal maximum intensity projection image shows type II ISSMAD. His abdominal pain had continued for 9 days. C. A 53-year-old male patient with type IV ISSMAD. Sagittal maximum intensity projection image shows completely thrombosed false lumen without an ulcer-like projection. His abdominal pain had continued for 10 hours. D. A 43-year-old male patient. Volume rendering image shows type V, dissection aneurysm. His abdominal pain had continued for 1 day.

Figure 3. A 44-year-old male patient, whose abdominal pain had continued for a day, underwent CT scan. Sagittal maximum intensity projection image shows type IV ISSMAD (A). Sagittal maximum intensity projection image shows complete remodeling after one month of treatment (B).

Figure 4. A 52-year-old male patient, whose abdominal pain had continued for a day, underwent MD scan. Oblique volume rendering image shows type IV ISSMAD (A). Oblique volume rendering image shows thrombosis in the false lumen completely absorbed after one month of conservative treatment (B).

Figure 5. Sagittal (A) and coronal maximum intensity projection images (B) show type II ISSMAD with ischemia in a 50-year-old female patient. The stenosis ratio of true lumen was more than 75%. She underwent superior mesenteric artery stenting because abdominal pain was not alleviated after conservative treatment for 3 days. Sagittal maximum intensity projection image shows the stent is patent after follow-up of 29 months (C).

DISCUSSION

ISSMAD without aortic involvement is a rare vascular disease that has been increasingly identified due to image technology advancement.⁶⁻⁹ Although there were some reports on the role of multi-detector CT in the diagnosis of ISSMAD, the number of cases was limited, and few was more than 20. The case number of the present study was relatively large, and there were 30 cases included. Moreover, we not only emphasized the value of multi-detector CT in the diagnosis and classification of ISSMAD, but also concentrated on the morphologic changes of the dissection after treatment at the indicated time of follow-up.

The underlying cause of ISSMAD has not been clarified. It may be the result of interaction between internal and external factors. The internal factors include cystic media necrosis, fibromuscular dysplasia, atherosclerosis, and disease of elastic tissue.¹⁰ Park *et al*¹¹ suggested hemodynamic force induced by convex curvature was another etiology. In our study, we found ISSMAD located within 20 mm proximally and distally to SMA curvature, which is consistent with previous study.¹² SMA curvature is the area where hemodynamic force changes. SMA curvature is exposed to shearing force because this area forms the border zone between the fixed retropancreatic portion and the more distal mobile mesenteric portion, analogous to what was seen at the ligamentum arteriosum during rapid deceleration injury such as aortic dissection.¹³ In our study, ISSMAD was more prevalent in male gender (83.3%) and cigarette smoker (66.7%), which is consistent with previous reports.^{5, 14-15} In addition, 50.0% ISSMAD patients were with atherosclerosis and 46.7% ones with systemic hypertension. So, we suppose that there might be correlation between ISSMAD and atherosclerosis, hypertension.

As a substitute for angiography, CTA has been shown to be useful for diagnosis of ISSMAD. Intimal flap, rupture, entry site and re-entry site, true lumen and false lumen, thrombosis in the lumen, dissection length, stenosis degree of true lumen, intestinal ischemia can be identified on multi-detector CT images. The advantage of VR is visualizing the relationship between the true lumen and false lumen of ISSMAD. MPR can present the intimal flap, rupture, entry site, re-entry site, true lumen and false lumen, dissection length, stenosis of true lumen, and angle between SMA and abdominal aorta. The angle measurement is helpful for the clinicians to implant SMA stents for the patients with bowel ischemia. Lumen severe stenosis is also associated with bowl ischemia. Min *et al*¹⁶ regarded that bowl ischemia would occur when the lumen stenosis

was more than 75%. In our study, bowel ischemia was present in 5 patients whose stenosis ratio of true lumen was more than 75%, and their abdominal pain was alleviated after treatment with SMA stenting. CTA can also be used to evaluate the dissection changes during follow-up: (1) no change, (2) complete remodeling, (3) partial remodeling, and (4) progression to total occlusion. CTA revealed the majority of SMA dissection showed no change or remodeling. Progression to total occlusion in 1 patient was observed. However, the patient was asymptomatic, which might be due to collateral flow development. The collateral vessels from the celiac trunk, inferior mesenteric artery, and marginal artery and arch of Rioloan, as well as mesenteric ischemia have been demonstrated on CTA images.¹⁷

The optimal treatment for ISSMAD has not been established. At present, the main option includes conservative, endovascular intervention and surgical treatment. Conservative treatment has been considered to be sufficient for the patients without complicated lesions.¹⁸⁻¹⁹ Endovascular or surgical treatment should be performed in cases after failure of conservative treatment, presenting persistent abdominal symptoms, and intestinal ischemia and rupture of the artery.²⁰⁻²¹ In our study, most patients accepted conservative treatment and obtained a favorable outcome except 5 who underwent endovascular intervention. The true lumen stenosis degree was more than 75% and bowel ischemia occurred in these 5 patients. Therefore, intestinal necrosis resulting from the severe ischemia should be prevented in the management of this rare condition.

The study has some limitations. First, both number of the enrolled cases and the patients treated with SMA stenting were small, which might lead to statistical analysis bias.

In conclusion, ISSMAD usually occurs in the middle aged and old male smoker with hypertension and atherosclerosis. MDCT can be used in the diagnosis, classification of ISSMAD, as well as detection of the dissection changes during follow-up.

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