

Multidetector computed tomography in the diagnosis of spontaneous isolated superior mesenteric artery dissection: changes in diameter on nonenhanced scan and stent treatment follow-up

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Abstract

Objective: This study was performed to assess the changes in diameter of the superior mesenteric artery (SMA) in patients with spontaneous isolated SMA dissection (SISMAD) on nonenhanced multidetector computed tomography (MDCT) and determine the clinical value of follow-up MDCT after endovascular stent placement (ESP).

Methods: The diameters of the SMA and superior mesenteric vein (SMV) as measured on nonenhanced MDCT were compared between 20 patients with SISMAD and 20 control subjects. ESP was performed in 14 patients with SISMAD, and follow-up MDCT was performed after ESP.

Results: The mean diameter of the SMA in the SISMAD group and control group was 11.69 ± 1.26 and 7.10 ± 0.97 mm, respectively, with a statistically significant difference. The SMA

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diameters were even larger than the SMV diameters. Follow-up MDCT showed stent patency in 13 patients and occlusion in 1 patient.

Conclusions: An enlarged diameter of the SMA on nonenhanced MDCT is an important finding for diagnosis of SISMA, and MDCT is a valuable follow-up method after ESP for SISMA.

Keywords

Superior mesenteric artery, dissection, multidetector computed tomography, endovascular stent placement, superior mesenteric vein, diameter

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Introduction

Spontaneous isolated superior mesenteric artery dissection (SISMA) without associated aortic dissection is clinically rare but has been reported increasingly more often in recent years with the wide application of multidetector computed tomography (MDCT). Previous studies on the diagnosis and treatment strategies of SISMA were mainly based on enhanced MDCT scans.¹⁻⁶ However, a nonenhanced MDCT scan is usually used as an initial etiological screening method for abdominal disorders. Although no consensus on the optimal management of SISMA has been established, endovascular stent placement (ESP) is recognized as an effective treatment method for symptomatic patients. In this study, we examined the significance of changes in the diameter of the superior mesenteric artery (SMA) in the diagnosis of SISMA on nonenhanced MDCT scans and assessed the value of follow-up MDCT after ESP.

Materials and methods

Patient data

Patients who had been diagnosed with SISMA in our department from May 2013 to June 2018 were included in this

study. All patients who underwent ESP were followed up by MDCT at 3, 6, and 12 months after the procedure. Patients with concomitant aortic dissection, recent upper abdominal surgery, or SMA catheterization were excluded. No patients enrolled in the study had a recent history of blunt abdominal trauma. An equal number of patients who had undergone abdominal MDCT for the purpose of physical examination were randomly selected as a control group, and those with gastrointestinal symptoms or arterial sclerosis were excluded. The Institutional Review Board of the Ethics Committee of Peking University Shenzhen Hospital approved this retrospective study and waived the requirement for informed consent.

MDCT protocol

The MDCT images were obtained using a GE Discovery CT750 HD CT system (GE Healthcare, Milwaukee, WI, USA). The contrast medium was 300 mg I/mL of non-ionic iodinated contrast medium (Iohexol), which was injected into the cubital vein at a rate of 4 to 5 mL/s through an 18-G intravenous catheter using an automatic injector (MEDRAD Stellant; Bayer HealthCare, Whippany, NJ, USA) at a dose of 1.5 mL/kg body weight. The beam

collimation was 64×0.625 mm, and the helical pitch was 0.984. Images were obtained from the diaphragmatic top level to either the lower border of the pubic symphysis (most patients) or to the lower border of the right kidney. Arterial phase scans were obtained using real-time monitoring of CT values by placing the region of interest at the level of the descending aorta. The starting time of the arterial phase scan was 3 s after the Hounsfield unit measurement of the region of interest reached 100 HU, and the portal venous phase scan was started 55 to 65 s after the contrast medium was injected. Multiplanar reconstruction or curved planar reformation, volume rendering, and maximum intensity projection were used according to the clinical needs.

SISMAD evaluation and data measurement

SISMAD was diagnosed by characteristic CT findings, including a false lumen (with or without thrombosis), intramural hematoma, dissecting aneurysm, and intimal flap;^{6,7} the morphological classification was based on the method described by Li et al.⁶ The length of the dissection and site of origin were evaluated on initial multiplanar reconstruction sagittal imaging. The original axial nonenhanced images were used to measure the diameters of the SMA and superior mesenteric vein (SMV) in both the SISMAD and control groups at the level of the uncinate process of the pancreas, and the measurements were repeated twice and averaged. The diameter of the SMA was compared with that of the SMV in the SISMAD group and with the diameter of the SMA in the control group, and the diameter of the SMV was compared between the SISMAD and control groups.

Statistical analysis

Continuous variables are presented as mean \pm standard deviation, and t-tests were used to analyze the data. All statistical analyses were performed using the statistical software SPSS version 20.0 (IBM Corp., Armonk, NY, USA). A p value of <0.05 was considered to indicate a statistically significant difference.

Results

Study population

Twenty patients with SISMAD were included in the study (18 men, 2 women; mean age, 52.3 years; range, 42–77 years). Seventeen patients had a history of abdominal pain, and three patients were asymptomatic. Fourteen patients underwent ESP with a bare stent (Medtronic, Dublin, Ireland), and six patients were treated conservatively by blood pressure control, bowel rest, and nutritional support with or without anticoagulation agents. The control group also comprised 20 patients (17 men, 3 women; mean age, 48.2 years; range, 35–76 years). The mean age was not significantly different between the two groups.

Data measurement and statistics

Seventeen patients underwent a standard scan protocol of nonenhanced, arterial phase, and portal venous phase scans. The other three patients with acute abdominal pain showed no abnormalities in the initial emergency nonenhanced scan, because of aggravated symptoms, thus, an additional enhanced scan was performed the next day. Images were obtained from the diaphragmatic top level to the lower border of the pubic symphysis in 17 patients and to the lower border of the right kidney in 3 patients. The mean length of the dissections was 75 mm (range, 38–152 mm) with a mean entry site distance of 20 mm (range,

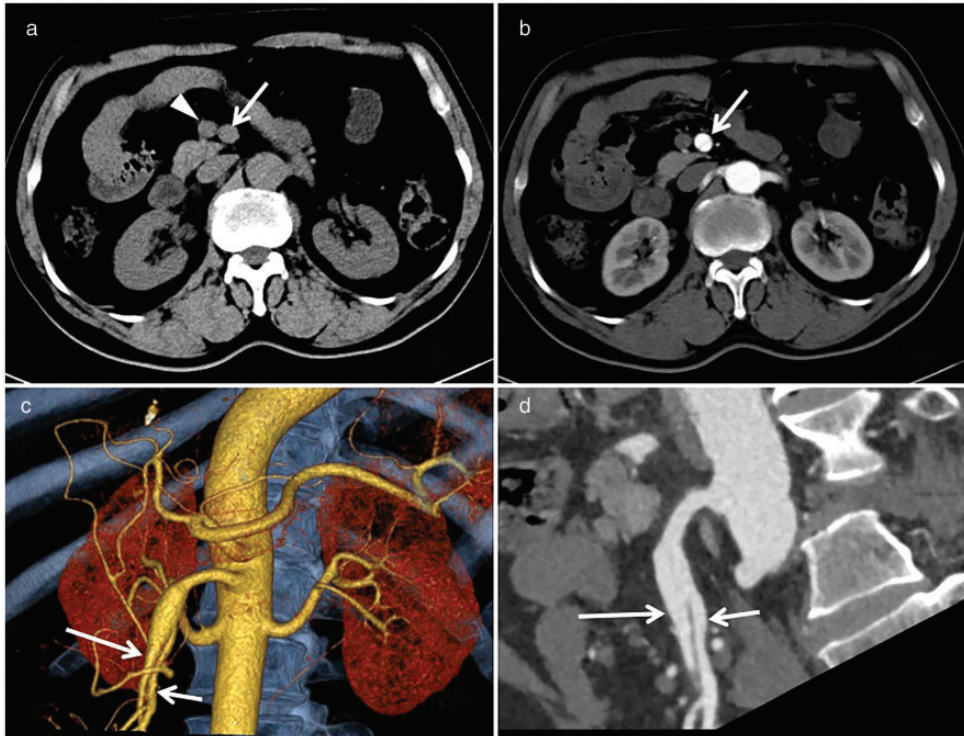


Figure 1. Asymptomatic spontaneous isolated superior mesenteric artery dissection was incidentally detected in a 38-year-old man on upper abdominal multidetector computed tomography. a. Nonenhanced axial image at the level of the uncinate process of the pancreas shows that the diameter of the superior mesenteric artery (arrow) is slightly larger than that of the superior mesenteric vein (arrowhead). b. Arterial phase axial image reveals the false lumen, true lumen, and linear low-density intimal flap (arrow). c, d. Volume rendering and maximum intensity projection show the false lumen (long arrow) and patent true lumen (short arrow).

11–37 mm) from the orifice of the SMA. All dissections involved the convex curvature of the SMA and extended below the inferior margin of the uncinate process of the pancreas (Figures 1 and 2(a)–(d)). The diameter of the SMA in the SISMA group was 11.69 ± 1.26 mm, which was significantly larger than that in the control group ($t=11.617$, $p=0.000$) (Table 1), and the diameter of the SMA was even larger than that of the SMV in the SISMA group (Figures 1(a) and 2(a)), although without a significant difference ($t=1.563$) (Table 1). The diameter of the SMV was not significantly different between the

SISMA and control groups ($t=0.383$) (Table 1), but the diameter of the SMA was significantly smaller than that of the SMV in the control group ($t=9.612$, $p=0.000$) (Table 1, Figure 3).

ESP and follow-up

ESP was performed in 14 patients with severe abdominal pain. Categorization of the types of SISMA revealed seven patients with type IIb, three with type IIIb, one with type IVb, one with type IVc, and two with type V. The treatment process involved placement of a self-expandable

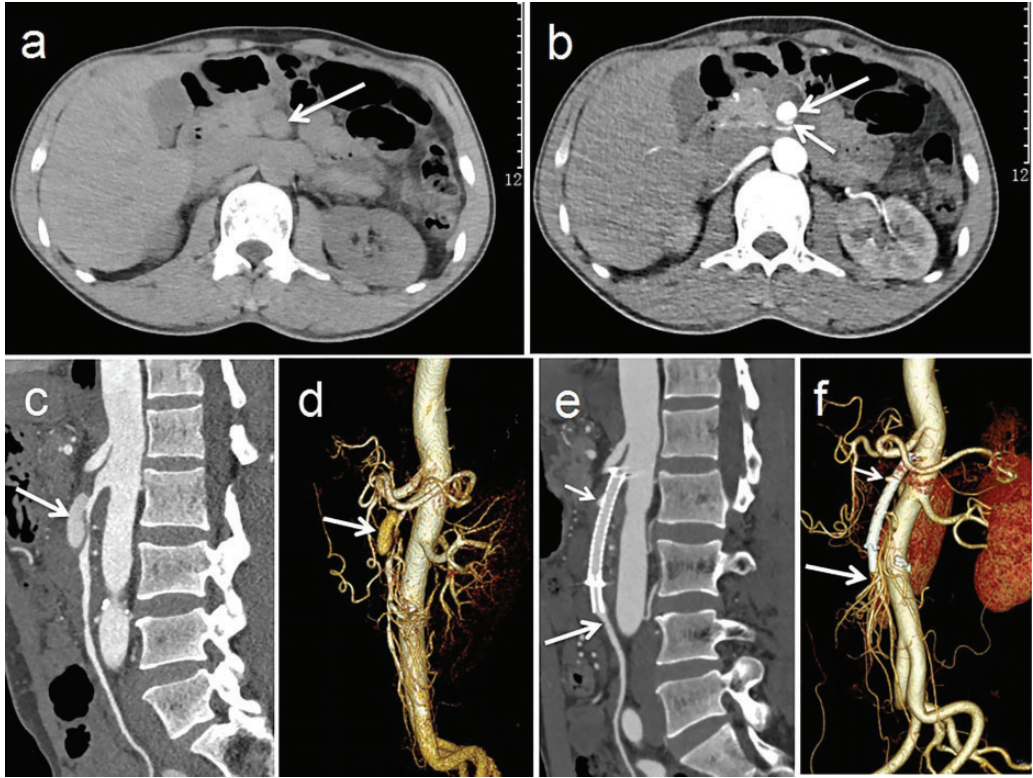


Figure 2. A 52-year-old man with abdominal pain. (a) Nonenhanced axial multidetector computed tomography (MDCT) image at the level of the uncinate process of the pancreas shows an obviously enlarged diameter of the superior mesenteric artery (arrow). (b) Arterial phase axial image shows aneurysm development of the false lumen (long arrow) and high compression of the true lumen and intimal flap (short arrow). (c, d) MDCT [maximum intensity projection (MIP) and volume rendering (VR)] images show the “cul-de-sac”-shaped false lumen (arrow) and severe stenosis of the true lumen. (e, f) MIP and VR reveal the patency of the stent (long arrow) and a tiny nipple-like residual false lumen (short arrow) at the 3-month follow-up.

bare stent via the right common femoral artery approach and antiplatelet therapy for 3 months postoperatively. Follow-up MDCT showed successful outcomes with patent stents in 13 patients and a failed outcome with an occlusive stent in 1 patient. No procedural complications were associated with ESP. Five patients with successful outcomes still retained a residual false lumen (RFL) at the 3-month follow-up (Figures 2(e) and (f), 4(a) and (b)), and the RFL had disappeared completely at the 12-month follow-up (Figure 4(c) and (d)).

Morphologically, the RFL appeared as a nipple-like or cystic-like sac. The collateral arteries were well constructed in the patient with ESP treatment failure at the 6-month follow-up (Figure 5).

Discussion

SISMAD is a clinically rare disease that can be detected as an incidental finding but may also cause drastic complications, such as bowel infarction and severe hemorrhage.^{8,9} The development of advanced imaging

Table 1. Comparison of the diameters of the SMA and SMV between and within the SISMAD and control groups.

Diameter	Groups		t	p-value
	SISMAD ^a	Control ^b		
SMA (mm)	11.69 ± 1.26	7.10 ± 0.97	11.617	0.000
SMV (mm)	10.77 ± 1.59	10.55 ± 1.32	0.383	0.704

Data are presented as mean ± standard deviation.

SMA, superior mesenteric artery; SMV, superior mesenteric vein; SISMAD, spontaneous isolated superior mesenteric artery dissection.

^aComparison of the diameter of the SMA with that of the SMV in the SISMAD group ($t = 1.563$, $p = 0.146$).

^bComparison of the diameter of the SMA with that of the SMV in the control group ($t = 9.612$, $p = 0.000$).



Figure 3. Nonenhanced axial multidetector computed tomography image shows that the normal diameter of the superior mesenteric artery (short arrow) is smaller than that of the superior mesenteric vein (long arrow) at the level of the uncinate process of the pancreas.

technology, particularly abdominal MDCT, appears to have increased the detection of SISMAD; however, the definitive diagnosis is dependent on contrast-enhanced scans to differentiate the false and true lumens.²⁻⁷ The value of nonenhanced scans in the diagnosis of SISMAD is generally believed to be limited. However, nonenhanced MDCT is an initial clinical screening modality for abdominal pain or other abdominal disorders in daily practice, especially for patients who present on an emergency basis or patients with a contraindication to the use of iodine contrast

agents. Under such circumstances, radiologists or clinicians tend to focus on the imaging findings of solid organs (such as the liver, pancreas, spleen, and kidney), the biliary tract system, or the gastrointestinal tract, and morphological variations of the SMA may be neglected. In fact, in the present study, initial emergency non-enhanced scans performed in three patients with acute abdominal pain with an increased SMA diameter failed to detect the abnormalities, and an additional contrast-enhanced scan the next day finally revealed SISMAD. The diameter of the SMA did not change in these three patients between the first plain CT and the second contrast-enhanced CT. The diameter of the SMA was larger in the SISMAD group than control group, and it was even larger than the diameter of the SMV. These results suggest that it is important to focus on the changes in diameter of the SMA on non-enhanced abdominal MDCT scans. The diameter of the SMV is typically larger than that of the SMA, and our statistical analysis produced results consistent with this. The diameter of the SMA was smaller than that of the SMV, and the difference was significant in the control group; however, the diameter of the SMV was similar between the SISMAD group and control group. Therefore, we recommend using

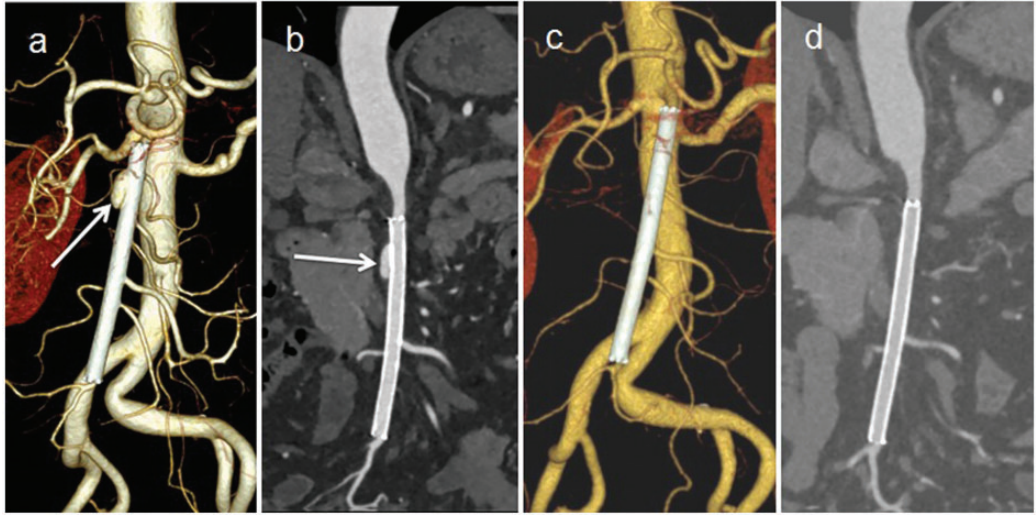


Figure 4. A 48-year-old man with spontaneous isolated superior mesenteric artery dissection who underwent successful endovascular stent placement. (a, b) Volume rendering (VR) and curved planar reformation (CPR) indicate a patent stent and a cystic-like residual false lumen (RFL) (arrow) at the 3-month follow-up. (c, d) VR and CPR show that the RFL had disappeared completely at the 12-month follow-up.

the diameter of the SMV as a reference value to judge the enlargement of the SMA on a nonenhanced scan. If the diameter of the SMA is similar to or larger than that of the SMV, then a diagnosis of SISMAD should be considered, and further contrast-enhanced scans should be performed to confirm the diagnosis. For patients with contraindication to the use of iodine contrast agents, contrast-enhanced magnetic resonance imaging can assist in the diagnosis of SISMAD.^{9,10} Although the patients in the SISMAD group showed an enlarged diameter of the SMA on nonenhanced scans, the SMA actually consists of a true lumen, a false lumen, and an intimal flap that are clearly shown on contrast-enhanced scans. The diameter of the SMA may also be enlarged in patients with aneurysms, but it is relatively limited in scope and spherical in shape, which is obviously different from SISMAD.

The SMA is more susceptible to shearing stress at 15 to 30 mm from the ostium because of its relationship to the pancreas.^{7,11} The median distance from the SMA

ostium to the beginning of the dissection was 20 mm in our study, which is consistent with the above hypothesis. The mean length of the dissections was 75 mm, and all involved the convex curvature of the SMA and extended to the inferior margin level of the uncinate process of the pancreas. Therefore, we measured the diameters of the SMA and SMV at the level of the uncinate process of the pancreas, where the SMA and SMV travel in a vertical orientation, and the measured data were closely representative of the true size of the vessel.

The treatment options for SISMAD include expectant management, anticoagulation, open surgery, and endovascular intervention; however, the optimal initial treatment remains controversial.^{9,12–15} Early endovascular intervention before the onset of fatal complications of bowel ischemia or arterial rupture is recommended.¹⁵ ESP can be performed with good results and may be the preferred treatment in patients with symptomatic SISMAD.^{9,16–19} In addition to describing the characteristics



Figure 5. A 51-year-old man with spontaneous isolated superior mesenteric artery dissection who underwent failed endovascular stent placement. Volume rendering displays the occlusive stent (long arrow) and patency of the ileal artery (arrowhead) and collateral arteries (short arrow) at the 6-month follow-up.

of SISMAD for guiding selective therapy algorithms, MDCT can also provide important information for evaluating the prognosis after ESP.^{6,7,15,19} In our study, the 3-month follow-up MDCT showed that 92.86% (13/14) of patients who had undergone ESP had patent stents and satisfactory reperfusion of the SMA, and 38.46% (5/13) of them still had an RFL, which presented as a prominent nipple- or sac-like contrast filling outside of the stent and then disappeared completely at the 12-month follow-up. Although RFLs have different causes, their morphologic findings are similar to those of a type III endoleak after endovascular aortic aneurysm repair; such an endoleak is caused by mechanical failure of the stent graft (a leak through a defect in the graft) and is characterized by persistent blood flow within the aneurysm sac following the aneurysm repair.^{20,21} If the RFL continues to expand, further interventional procedures or surgical intervention is necessary. For patients with ESP treatment

failure, MDCT can be used to evaluate the active status of the intestinal structures and show the condition of the collateral vessels, offering reliable information for further treatment plans.

This study had two main limitations. First, because this was a retrospective study, the images were not obtained in a standard region, and three patients received only an upper abdominal scan instead of a full abdominal scan. Second, although the diameter of the SMA was abnormal in the patients with SISMAD, the density of the SMA and its surrounding fat should have also been abnormal; however, we did not observe such changes in this study.

In conclusion, although the definitive diagnosis of SISMAD depends on contrast-enhanced imaging, the enlarged diameter of the SMA on nonenhanced MDCT is an important finding that indicates the possibility of SISMAD. In addition to confirming the diagnosis of SISMAD, MDCT is also a valuable follow-up method after ESP treatment of SISMAD, and it can provide evidence for evaluating the status of the SMA blood flow, the RFL, and the collateral vessels after ESP.

Research ethics and patient consent

The Institutional Review Board of the Ethics Committee of Peking University Shenzhen Hospital approved this retrospective study and waived the requirement for informed consent.

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Declaration of conflicting interest

The authors declare that there is no conflict of interest.

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