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Outcomes and radiographic findings of symptomatic isolated mesenteric artery dissection with conservative management

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Abstract

Objectives: The aim of this study was to evaluate the computed tomography follow-up outcomes and radiographic findings of symptomatic isolated mesenteric artery dissection (IMAD) after conservative management.

Methods: In this retrospective study, 130 consecutive patients with symptomatic IMAD from three institutions were enrolled from January 2011 to December 2019. The general epidemiological data, clinical manifestations, first-episode symptoms, imaging findings, and treatment strategy selection were analyzed from the medical records.

Results: Among 130 patients diagnosed with symptomatic IMAD, positive remodeling of the SMA was achieved in 75.38% (98/130), and negative remodeling of the SMA was achieved in 24.62% (32/130). In the positive remodeling group, complete remodeling was achieved 39.23% (51/130) (type I 6 patients, type IIa 10 patients, type IIb 35 patients), in which type IIb was the most ($p = 0.004$). Moreover, of the 32 patients in whom negative remodeling of the SMA was achieved, significant differences were observed between the type IIa with respect to dissecting aneurysm formation ($p = 0.04$).Of the seven factors analyzed with a logistic regression model identified three factors significantly associated with negative remodeling: length of dissection (Waldχ^2 13.331; OR 6.945; 95% CI 2.762–10.498; $p = 0.014$), true lumen residual diameter (TLRD) (Waldχ^2 9.626; OR 7.85; 95% CI 1.892–19.063; $p = 0.022$), and branch involvement (Waldχ2 11.812; OR 7.247; 95% CI 1.245–14.830; $p = 0.011$).

Conclusion: The prognosis of most symptomatic IMAD has a tendency to positive remodeling after conservative management, in which the initial type IIb classification is common. In contrast, risk factors for negative remodeling were type IIa, length of dissection, TLRD, and branch involvement. Patients with these morphological characteristics may not benefit from conservative management.

Keywords

Superior mesenteric artery, dissection, computed tomography, treatment

Introduction

Unlike secondary mesenteric artery dissection, isolated mesenteric artery dissection (IMAD) is not associated with aortic dissection, which is very rare. Recently, its identification has been increasing with the advanced imaging technology.[1,2] The etiology remains largely unknown, several risk factors include hypertension, smoking, atherosclerosis, vasculitis, dysplasia of myofibrillae fibers, arterial cystic degeneration, medial degeneration, pregnancy, connective tissue disease, autoimmune diseases, etc.[3]

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In clinical settings, the initial manifestation of symptomatic IMAD is usually acute abdominal pain, which has potentially catastrophic pathology with variable and unpredictable outcomes.[4] In addition, a few patients are asymptomatic, with IMAD detected as an incidental finding on imaging studies for other complaints. Currently, conservative management with or without antithrombotic agents is sufficient according to European Society for Vascular Surgery guidelines,[5] because it generally has a benign course. In cases of emergent presentation, invasive therapy (endovascular interventions and surgical procedures) is warranted. However, the prognosis of IMAD with conservative management has not yet been fully explored.

This study retrospectively analyzed the clinical data to propose the radiologic courses and factors related vascular remodeling based on conservative management.

Methods

Patients

The present retrospective study was approved by the institutional review board, and the requirement for written informed consent was waived. Initially, 156 consecutive patients from three institutions were enrolled in the study from January 2011 to December 2019. IMAD was diagnosed with one of the following signs in the superior mesenteric artery (SMA) on the computed tomography (CT) scan: (1) double lumen can be detected in SMA, in which contrast material is filled; (2) crescent-shaped area along the wall of the SMA with higher attenuation than blood, showing no contrast enhancement after intravenous administration of contrast material.[6] Invasive intervention therapy was initially performed in 26 patients (19 patients underwent endovascular intervention and 7 patients underwent surgical procedures) due to worsening of abdominal pain, or development of signs of peritonitis. Of these patients were excluded because they initially received invasive treatment. Finally, the remaining 130 symptomatic patients underwent conservative management as first line treatment and comprised the study population, in which was successful in 98 (75.38%, 98/130) patients and failed in 32 (24.62%, 32/130) patients (Figure 1). Failure of conservative management was defined as the persistence or aggravation of symptoms and signs, increasing size of aneurysmal dilation, or appearance of peritonitis after conservative management.[7] The general epidemiological data, clinical manifestations, first-episode symptoms, imaging findings, and treatment strategy selection were obtained from the medical records.

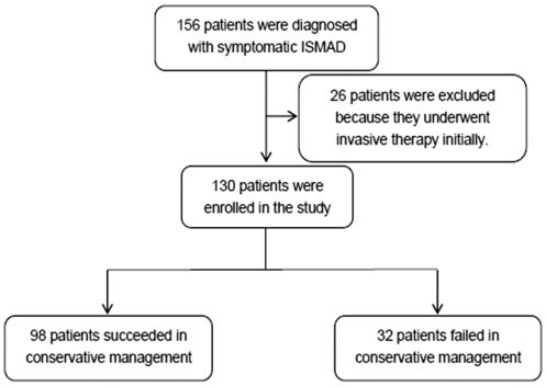

Figure 1. Study flowchart.

Image analysis

Two experienced radiologists and two vascular surgeons reviewed all CT examinations and reached consensus. IMAD was classified based on the Yun classification as follows: type I, patent true and false lumen revealing entry and re-entry sites (entry and re-entry tear visible, patent false lumen), type IIa (only entry tear visible, patent false lumen), type IIb (thrombosis of false lumen, patent true lumen), and type III (occlusion of true and false lumen).[8] IMAD changes on CT scan were assessed and compared with the initial findings. Morphological characteristics were analyzed including location of laceration (distance between the ostium of the SMA and the origin of the dissection), length of dissection, TLRD (true lumen residual diameter, true lumen size compared with the adjacent normal SMA size);[9] branch involvement, signs in favor of the small bowel ischemia (wall thickening, thinning of the intestinal wall, abnormal contrast enhancement of bowel wall, intramural hematoma, pneumatosis, perforation, and peritonitis),[10] obliteration of the true lumen, and aneurysm dissection formation (at least 50% larger than the adjacent normal mesenteric artery diameter).[11] The disease prognosis was categorized into positive or negative remodeling through the analysis of initial and follow-up CT scans. Positive remodeling was defined as the following: (1) complete remodeling (the false lumen has disappeared due to thrombus absorbed; and the true lumen morphology and hemodynamics were restored to achieve functional repair completely),[12] (2) positive morphological changes (a change from type I, IIa to IIb, or a type IIb false lumen with no change), and (3) TLRD improvement (TLRD was an improvement than initial). Negative remodeling was defined as the following: (1) dissecting aneurysm formation, (2) negative morphological changes (a change from type IIb to IIa, I, III, or a type IIa, I false lumen with no change),

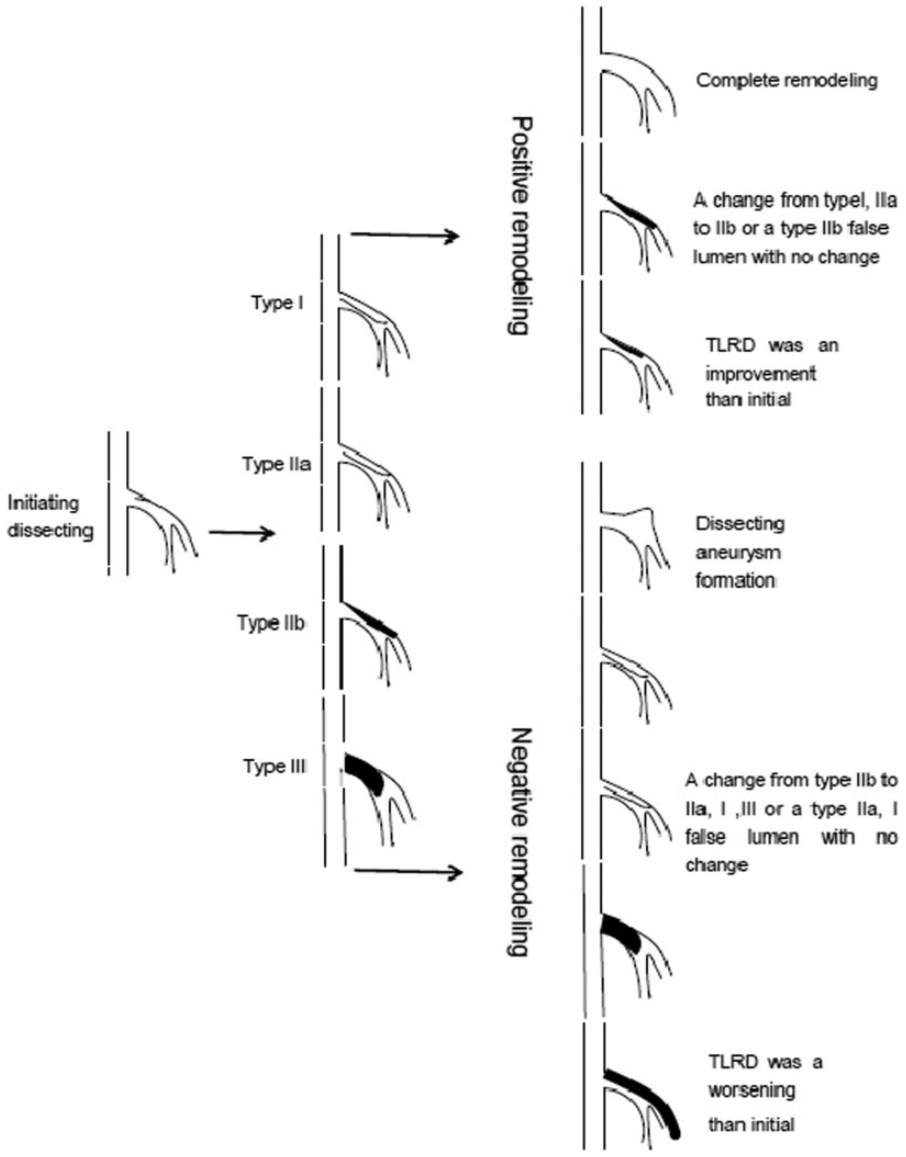

Figure 2. Prognostic trends between symptomatic ISMAD types during a time interval.
TLRD: true lumen residual diameter.

and (3) TLRD worsening (TLRD was a worsening than initial) (Figure 2).

Therapeutic schemes

For symptomatic IMAD patients, conservative management consisted of fasting, gastrointestinal decompression, analgesia, spasmolysis, parenteral nutrition, and maintained hypertension(the systolic blood pressure and diastolic blood pressure should be 130–140 mmHg and 70–80 mmHg, respectively). Anticoagulant regimen: during hospitalization, low molecular weight heparin sodium at a dose of 100 IU/kg, subcutaneous injection, every 12 h; after discharge, oral warfarin, international normalized ratio controlled at 2.0–3.0, or oral rivaroxaban at a dose of 15 mg/day for a time period of 15 days. Antiplatelet regimen: during hospitalization, oral aspirin at a dosage of 100 mg/day, and oral clopidogrel at a dosage of 75 mg/day; after discharge, oral aspirin at a dosage of 100 mg/day, for a time period $\geq$ 12 months; oral clopidogrel 75 mg/day, for a time period $\geq$ 6 months. However, conservative management failed were considered candidates for invasive therapy as the second-line treatment. Invasive therapy of symptomatic IMAD has been recommended for patients with consistent symptoms over a period of 7 days despite conservative treatment; these patients were considered suitable candidates for endovascular intervention in this study.

Follow-up

Patients without recurrent pain were followed up by contrast-enhanced CT scans at 3 months, 6 months, and 12 months after discharge and annually thereafter. For the patients who underwent invasive therapy, clinical follow-up was scheduled every 6 months after discharged. More frequent evaluations were performed when needed. Those whose symptoms indicated worsening 85 lesions underwent imaging evaluations immediately.

Statistical analyses

All statistical analyses were performed using SPSS 22.0 software (SPSS Inc., Chicago, IL, USA). Continuous variables are presented as the medians and ranges in the cases of nonparametric distributions, and comparisons were made using the *Mann-Whitney test*. Continuous variables are presented as the means and standard deviations in cases of parametric distributions, and comparisons were made using the independent t-test. Categorical variables were compared with the *chi-square test* or *Fisher's exact test,* and they are reported as frequencies and percentages. Potential associations between symptomatic IMAD negative remodeling and patient gender, age, follow-up duration, location of laceration, length of dissection, TLRD, and branch involvement were assessed using univariable logistic regression analysis. Results are presented as odds ratios (OR) and 95% confidence intervals (CI). A p value <0.05 was considered statistically significant for all analyses.

Results

Patients

From January 2011 to December 2019, 130 patients diagnosed with symptomatic IMAD were collected in this study; in all of these patients, 118 (90.8%, 118/130) patients were men. Of these, the median age was 53 years old (ranging from 26 to 76). Risk factors are associated with symptomatic IMAD include tobacco smoking 62 (47.7%, 62/130), hypertension 58 (44.62%, 58/130), renal cyst 36 (27.69%, 36/130), and hyperlipidemia 21 (16.15%, 21/130). Among the 130 patients, 119 (91.54%, 119/130) had abdominal pain as the initial symptom accompanied by nausea and vomiting (61, 46.92%). Of these patients, 22.31% (29/130) had type I IMAD, 26.92% (35/130) had type IIa, 50.77% (66/130) had type IIb, and no patients had type III. Approximately 78% of patients were type II lesions, which are basically consistent with the results in the previous literature.[13] Branch involvement and intestinal ischemia were seen in 28.46% (37/130) and 8.46% (11/130), respectively. In addition, the mean distance between the ostium of the SMA and the origin of the dissection was 18.9 ± 11.5 mm. The mean length of dissection was 51.84 ± 23.42 mm, and the TLRD was $36.4 \pm 15.8\%$. The clinical features and imaging findings of the patients are summarized in Table 1.

Table 1. Characteristics of study patients.

General conditions	Total (n=130)
median age, y (min, max)	53 (26,76)
male	118(90.77)
Risk factors	
smoking history	62(47.69)
hypertension	58(44.62)
renal cyst	36(27.69)
hyperlipidemi	21(16.15)
Symptoms	
abdominal pain	119(91.54)
lower back pain	11(8.46)
chest pain	4(3.08)
abdominal distension	21(16.15)
hematochezia	14(10.77)
nausea and Vomiting	61(46.92)
Initial imaging finding	
radiologic type	
type I	29(22.31)
type IIa	35(26.92)
type IIb	66(50.77)
type III	0
location of laceration(mm)	18.9±11.5
length of dissection(mm)	51.84±23.42
TLRD(%)	36.4±15.8
branch involvement	37(28.46)
intestinal ischemia	11(8.46)

Note—Values are n (%).
Location of the laceration: the mean distance between the ostium of the SMA and the origin of the dissection.
Length of dissection: the average length of the dissection.
True lumen residual diameter (TLRD): true lumen size compared with the adjacent normal SMA size.
Intestinal ischemia: wall thickening, thinning of the intestinal wall, abnormal contrast enhancement of bowel wall, intramural hematoma, pneumatosis, perforation, and peritonitis.

Clinical outcomes

Of the 130 patients, 32 (24.62%, 32/130) patients underwent invasive therapy after conservative management failure, in which bare stent implantation was performed in 18 (13.85%, 18/130) patients; stenting combined with coiling was performed in 6 (4.62%, 6/130) patients; coil embolization was performed in 3 (2.31%, 3/130) patients; and endovascular thrombolysis was performed in 4 (3.08%, 4/130) patients as second-line treatment due to failure of conservative management. One patient with indications of

peritonitis, emergency surgery, and small intestine resection was performed. The remaining 98 (75.38%, 98/130) patients underwent successful conservative management and were included in this study.

Clinical follow-up

During the 26.5 months (range, 6–72 months) of follow-up, positive remodeling of the SMA was achieved in 75.38% (98/130), and negative remodeling of the SMA was achieved in 24.62% (32/130) based on the follow-up contrast-enhanced CT scan. In the positive remodeling group, complete remodeling of the SMA was achieved 39.23% (51/130) (type I 6 patients, type IIa 10 patients, and type IIb 35 patients), in which type IIb according to the initial type of IMAD were more likely to translate into complete remodeling ($p = 0.004$) (Figure 3). Moreover, positive morphological changes and TLRD improvement accounted for 22.31% (29/130) and 13.85% (18/130), respectively. Of the 32 patients in whom negative remodeling of the SMA was achieved, 8 patients(6.15%, 8/130) converted into dissecting aneurysm (Figure 4), 12 patients (9.23%, 12/130) converted into negative morphological changes, 12 patients (9.23%, 12/130) converted into TLRD worsening (Figure 5). Significant differences were observed between the type IIa with respect to dissecting aneurysm formation ($p = 0.04$) (Table 2).

Factors associated with symptomatic IMAD negative remodeling

Of the seven factors analyzed with a logistic regression model identified three factors significantly associated with negative remodeling: length of dissection (Waldχ^2 13.331; OR 6.945; 95% CI 2.762–10.498; $p = 0.014$), TLRD (Waldχ^2 9.626; OR 7.85; 95% CI 1.892–19.063; $p = 0.022$), and branch involvement (Waldχ^2 11.812; OR 7.247; 95% CI 1.245–14.830; $p = 0.011$). The remaining factors, such as gender, age, follow-up duration, and location of the laceration, were not associated with symptomatic IMAD negative remodeling (Table 3).

Discussion

IMAD was formerly regarded as a rare vascular lesion. Document of symptomatic IMAD has been reported increasingly, which mainly in Asia (China, Korea, and Japan). The clinical manifestation, imaging classification, and management strategy of symptomatic IMAD have been explored in more detail gradually. However, the prognostic trend based on conservative management

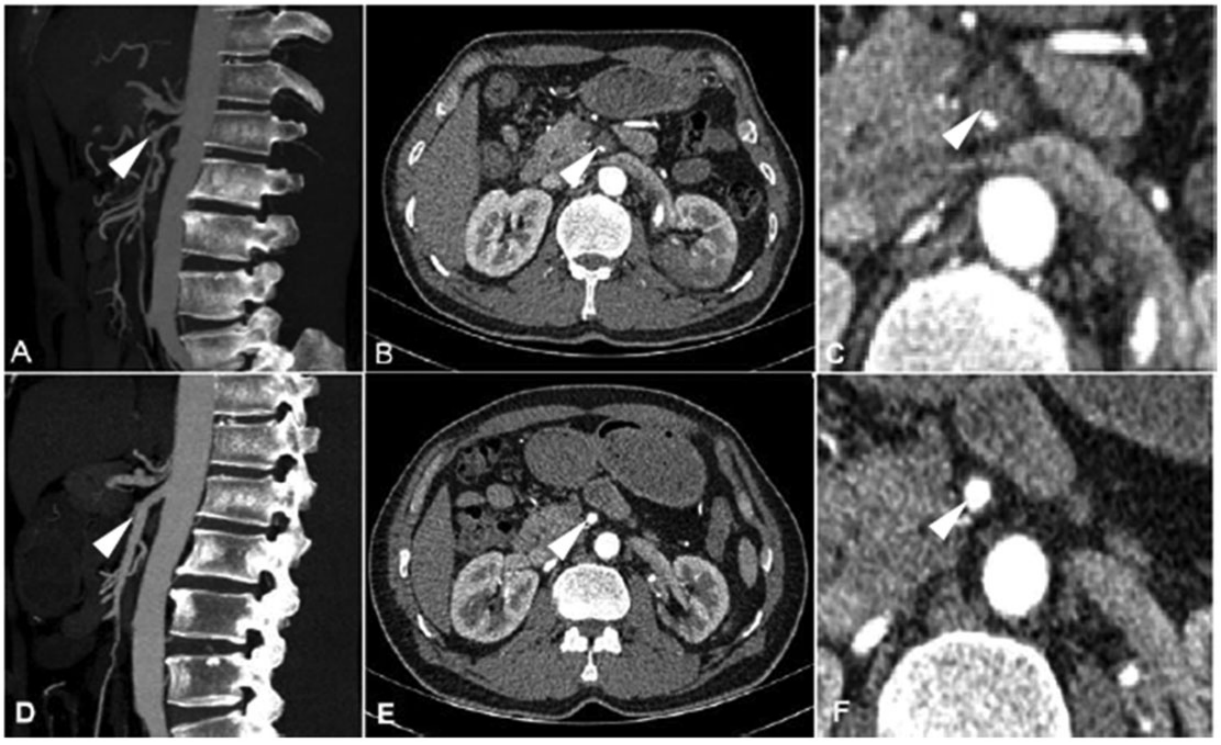

Figure 3. Conservative management was successfully used in a patient with type IIb symptomatic ISMAD. A ISMAD was observed on contrast enhanced CT images (a to c, arrow). Positive remodeling (complete remodeling) of the SMA occurred after conservative management, as shown on a contrast enhanced CT scan performed 12 months later (d to f, arrow).

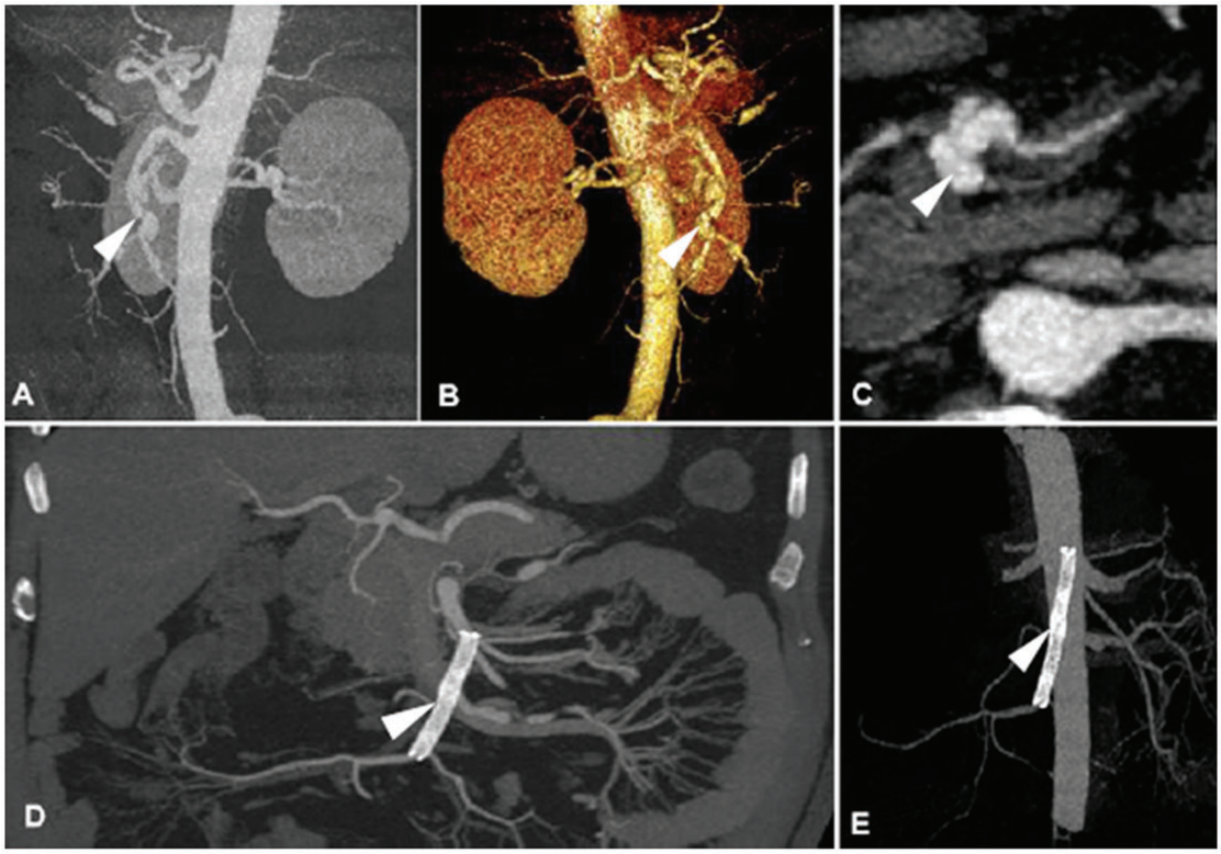

Figure 4. Symptomatic ISMDA was treated with conservative management for 24 months, and enhanced CT showed beaded changes in the SMA during follow-up (a to c, arrow). After the stent implantation for the dissecting aneurysm of the SMA, there was no obvious low-density filling defect in the lumen and the stent expanded well (d and e, arrow).

is unclear. According to the management strategy based on clinical stages previously reported by our group, during the acute and subacute stages,[14] the major complications were intestinal ischemia or necrosis. Subsequently, in the chronic stage, the major concern were intractable postprandial abdominal pain and dissecting aneurysm formation, which may be related to SMA remodeling anomalies. We propose a preliminary prognostic trend for the symptomatic IMAD based on conservative management (Figure 2). However, our experience had some limitations; therefore, our prognostic trend could serve only as a reference.

The course of symptomatic IMAD is more indolent than that of aortic dissection. Given its self-limited, the majority of patients might be obtained positive remodeling after conservative management. The angiographic changes can be classified into positive remodeling (complete remodeling, positive morphological changes, and TLRD improvement) and negative remodeling (dissecting aneurysm formation, negative morphological changes, and TLRD worsening). In the present study, 75.38% (98/130) patients changed into positive remodeling gradually, in which 39.23% (51/130) were completely remodeled. Therefore, positive remodeling is a natural process in the development of most symptomatic IMADs.[15,16] Vascular remodeling is a dynamic and inside-out process slowly, during which the imaging classification based on the initial contrast-enhanced CT scan had the potential to convert to another type. Type IIb showed a tendency to change to complete remodeling ($p = 0.004$), which was consistent with previous reports.[17] However, type IIa had a risk of presenting with aneurysmal dilatation ($p = 0.04$). Thrombosis of false lumen and patent true lumen (type IIb) at initial diagnosis has previously been shown to be associated with complete remodeling of the SMA, accompanied by polarizing absorption of thrombus in false lumen.[13,18] In contrast, due to the high pressure caused by the saclike false lumen, type IIa (without a re-entry tear) prognosis may rupture by dilation or compress the true lumen, which consistent with the previous report.[7] In present study, although no dissecting aneurysm ruptures occurred, type IIa had more tendency to change to negative remodeling ($p = 0.02$). Hence, these risks are widely cited as the main indication for long-term surveillance in IMADs.

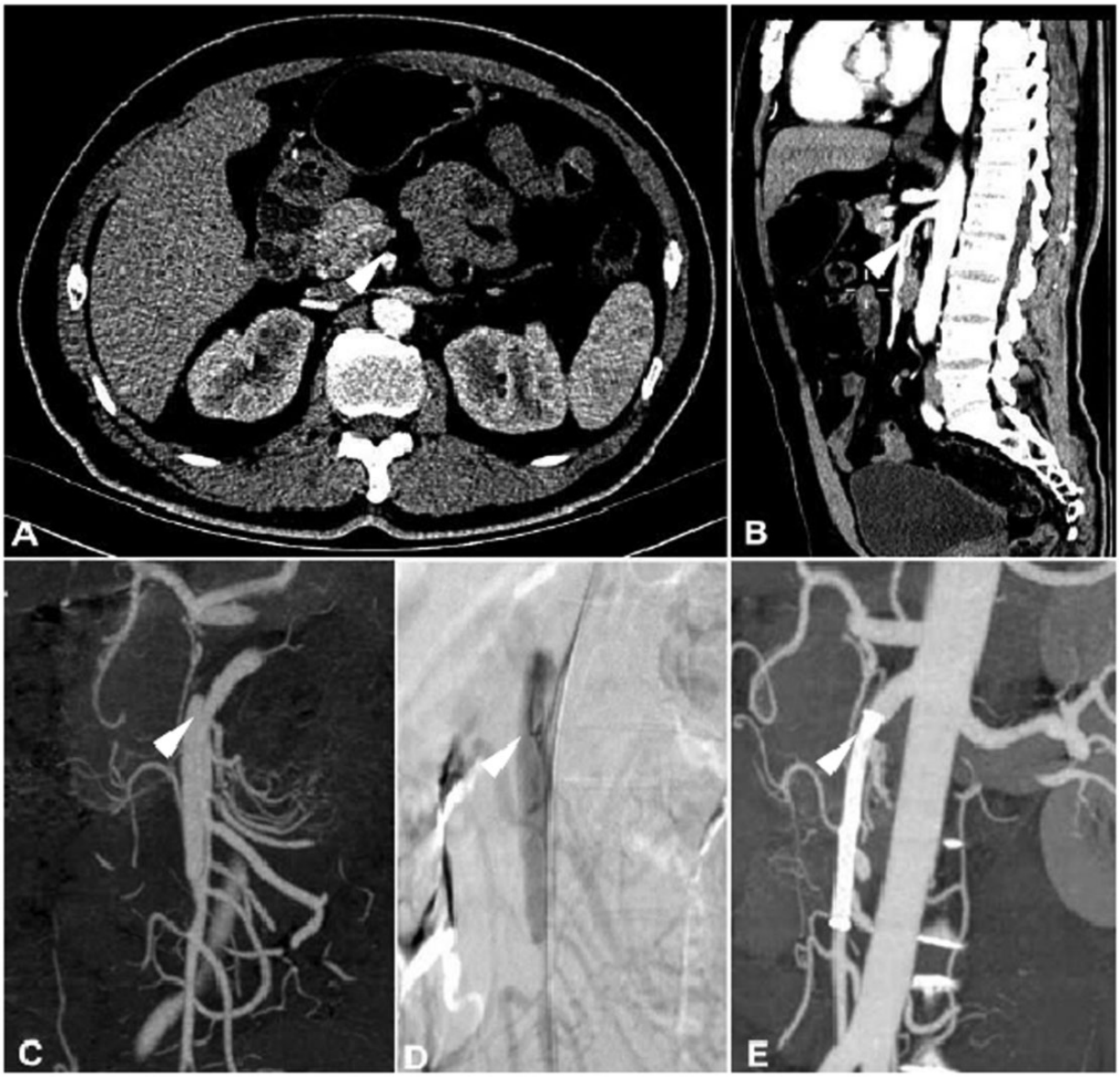

Figure 5. Example of failed conservative management of a symptomatic ISMAD with development of negative morphological changes (TLRD worsening). A 53 years old man presented with acute abdominal pain that had lasted for 3 h. Contrast enhanced CT scan showed a ISMAD (type IIa) (a and b, arrow). Abdominal pain worsened after 3 days of conservative management and superior mesenteric angiography revealed true lumen compression severely (c and d, arrow). Subsequently, two self-expanding bare stent were performed in the segment of the lesion (e, arrow).

This study also found that the length of dissection, TLRD and branch involvement are the risk factors for negative remodeling. Although most patients were managed conservatively, approximately 20% of patients ultimately underwent an endovascular intervention, and 6% patients open revascularization were necessary.[5] The negative remodeling of conservative management were 24.62% (32/130), which showed unusually high rates when compared to the previous document. One reason for this disparity is that invasive therapy was performed earlier with lower threshold criteria than those reported in other studies. Also, our study included patients with symptomatic IMAD only, compared with previous research, which has shown that positive remodeling is more likely to succeed in patients with asymptomatic IMADs. In the acute stage, collateral circulation was not sufficiently compensated, length of dissection, and TLRD were correlated with the distal blood supply of the SMA positively. According to Poiseuille's law of fluid dynamics, flow rate is inversely proportional to distance, and, as such, blood flow is decreased when the

Table 2. Transformation status of symptomatic ISMAD in patients with following up.

Transformation status of IS1v1AD		Initial radiologic type (n patients, %)				
		Type I (n=29)	Type IIa (n = 35)	Type IIb (n = 66)	Total (n = 130)	p value
Positive remodeling	complete remodeling	6 (20.69)	10 (28.57)	35 (53.03)	51 (39.23)	0.004
	positive morphological changes	9 (31.03)	6 (17.14)	14 (21.21)	29 (22.31)	0.395
	TLRD improvement	6 (20.69)	5 (14.29)	7 (10.6)	18 (13.85)	0.44
	Total	21 (72.41)	21(60)	56 (84.85)	98 (75.38)	0.02
Negative remodeling	dissecting aneurysm	2 (6.9)	5 (14.29)	1 (1.52)	8 (6.15)	0.04
	negative morphological changes	4 (13.79)	5 (14.29)	3 (4.54)	12 (9.23)	0.172
	TLRD worsening	2 (6.9)	4 (11.43)	6 (9.09)	12 (9.23)	0.82
	Total	8 (27.59)	14 (40)	10 (15.15)	32 (24.62)	0.02

ISMAD: Isolated superior mesenteric artery dissection; TLRD: true lumen residual diameter.

Table 3. Factors associated with symptomatic ISMAD negative remodeling.

Factors	Negative remodeling			
	Walclχ^2	OR	95% CI	p value
Gender	1.608	0.942	0.306—3.691	0.876
Age(y)	1.852	0.916	0.909—1.451	0.908
Follow up duration (months)	1.326	1.142	0.955—2.351	0.289
Location of laceration(mm)	2.005	1.05	0.122—2.451	0.262
Length of dissection(mm)	13.331	6.945	2.762-10.498	0.014
TLRD (%)	9.626	7.85	1.892-19.063	0.022
Branch involvement	11.812	7.247	1.245-14.830	0.011

ISMAD: Isolated superior mesenteric artery dissection; CI: confidence interval; OR: odds ratio.

dissection is long. Abdominal pain occurs as a consequence.[19] However, in the chronic stage, SMA remodeling anomalies with branch involvement may cause intractable postprandial abdominal pain.

Several limitations have to be noticed. First, the included study was a retrospective analysis. Even so, prospective studies were impossible owing to the extremely low incidence of the disease. Secondly, in addition to positive remodeling and negative remodeling, there may be other outcomes in follow-up examination. Additionally, morphological characteristics of IMAD were determined by contrast-enhanced CT scan rather than by mesenteric angiography. Finally, the clinical follow-up was arranged in the first and sixth months after discharge, and every year thereafter; therefore, the exact time of SMA remodeling was unknown in this study. In conclusion, the prognosis of most symptomatic IMAD has a tendency to positive remodeling after conservative management, in which the initial type IIb classification is common. In contrast, risk factors for negative remodeling were type IIa, length of dissection, TLRD, and branch involvement. Patients with these morphological characteristics may not benefit from conservative management.

Conclusion

Symptomatic IMAD is not uncommon in clinical practice, especially in Asia. Most symptomatic IMAD has a tendency to positive remodeling after conservative management. Also, risk factors for negative remodeling were type IIa, length of dissection, TLRD, and branch involvement.

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Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethics approval

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