Management of isolated dissection of the superior mesenteric artery

Die Behandlung der isolierten Dissektion der Arteria mesenterica superior

Authors

Jonas Knarr[1], Anne Marie Augustin[1], Viktor Hartung[1], Katica Krajinovic[2], Ralph Kickuth[3]

Affiliations

1 Institute of Diagnostic and Interventional Radiology, University Hospital of Würzburg, Germany
2 Surgical Department I, Hospital of Fürth, Germany
3 Institute of Diagnostic and Interventional Radiology, University Hospital of Würzburg, Würzburg, Germany

Key words

abdomen, arteries, vascular, angiography, CT-angiography, stents

received 11.5.2023
accepted 21.11.2023
published online 2023

Bibliography

Fortschr Röntgenstr
DOI 10.1055/a-2221-3813
ISSN 1438-9029

Georg Thieme Verlag KG, Rüdigerstraße 14, 70469 Stuttgart, Germany

Correspondence

Jonas Knarr
Institute of Diagnostic and Interventional Radiology, University Hospital of Würzburg, Oberdürrbacher Straße 6, 97080 Würzburg, Germany
Tel.: +49/09 31/20 13 40 01
Knarr_J@ukw.de

ABSTRACT

Purpose Isolated dissection of the superior mesenteric artery (IDSMA) is an increasingly frequently diagnosed pathology without a predisposing factor. Different therapeutic options including conservative, endovascular, and open surgical treatment are presented in our single-center study. The follow-up is a special task of different specialties.

Methods and Patients A retrospective analysis of six patients with IDSMA was conducted. Patient demographics, clinical presentation, diagnostic management, and therapeutic treatment were assessed. Furthermore, clinical outcome as well as further changes during follow-up were evaluated.

Results The majority of the patients were symptomatic with abdominal pain. Of the symptomatic patients, one was managed conservatively, one was treated surgically by patch plasty, and two patients were treated using an endovascular approach. The two asymptomatic patients were each managed conservatively. Conservative therapy was the treatment of choice, especially in asymptomatic and uncomplicated cases with non-persistent symptoms. This was confirmed in our literature review. Computed tomography angiography is the gold standard for follow-up after the acute event or diagnosis. None of our patients needed further treatment after the acute event/detection of IDSMA during the follow-up period with a mean of 68 months. One patient showed significant changes in the diameter of the superior mesenteric artery.

Conclusion The appropriate diagnosis, treatment, and follow-up of IDSMA must be tailored to the needs of the individual patient and require multidisciplinary decision making.

Key Points:

- IDSMA can cause several symptoms, and is mostly seen in smoking, middle-aged men.
- Therapeutic options include conservative management and surgical and interventional methods.
- Conservative management is the most applicable treatment in asymptomatic patients.
- For diagnosis and follow-up, CTA is the gold standard.
- To avoid an excessive cumulative radiation dose, ultrasound monitoring may be adequate.

ZUSAMMENFASSUNG

Hintergrund Die isolierte Dissektion der A. mesenterica superior (IDSMA) ist eine immer häufiger diagnostizierte Pathologie ohne prädisponierenden Faktor. In unserer Single-Center-Studie werden verschiedene Therapieoptionen vorgestellt, darunter die konservative, endovaskuläre und offen-chirurgische Behandlung. Die Nachsorge ist eine besondere Aufgabe der verschiedenen Fachrichtungen.

Methoden und Patienten Es wurde eine retrospektive Analyse von sechs Patienten mit IDSMA durchgeführt. Bewertet wurden demografische Patientendaten, die klinischen Befunde, das diagnostische Management und die anschließende therapeutische Behandlung. Darüber hinaus wurden die klinische Symptomatik bezüglich des Nachlassens des Schmerzes und weitere Veränderungen während der Nachbeobachtung evaluiert.

Ergebnisse Die Mehrzahl der Patienten war symptomatisch und litt unter Bauschmerzen. Von den symptomatischen Patienten wurde ein Patient konservativ behandelt, ein Patient

wurde chirurgisch mit einer Patchplastik behandelt und zwei Patienten erhielten eine endovaskuläre Therapie. Die beiden asymptomatischen Patienten wurden jeweils konservativ behandelt. Die konservative Therapie war die Behandlung der Wahl, insbesondere bei asymptomatischen und unkomplizierten Fällen mit nicht persistierenden Symptomen. Für die Nachsorge ist die Computertomografie mit Angiografie der Goldstandard. Keiner unserer Patienten benötigte nach dem akuten Ereignis bzw. dem Nachweis einer asymptomatischen IDSMA während der Nachbeobachtungszeit von durchschnittlich 68 Monaten eine weitere Behandlung. Ein Patient wies signifikante Veränderungen des Durchmessers der A. mesenterica superior auf.

Schlussfolgerung Die angemessene Diagnose, Behandlung und Nachsorge von IDSMA muss auf die Bedürfnisse des einzelnen Patienten zugeschnitten sein und erfordert eine multidisziplinäre Entscheidungsfindung.

Kernaussagen:

- IDSMA kann verschiedene Symptome verursachen und tritt meist bei rauchenden Männern mittleren Alters auf.
- Zu den therapeutischen Optionen gehören konservatives Management, chirurgische und interventionelle Methoden.
- Bei asymptomatischen Patienten ist die konservative Behandlung die am besten geeignete Therapie.
- Für die Diagnose und Verlaufskontrolle ist die CTA der Goldstandard.
- Um eine übermäßige kumulative Strahlendosis zu vermeiden, kann eine Ultraschallüberwachung ausreichend sein.

Zitierweise

- Knarr J, Augustin A, Hartung V et al. Management of isolated dissection of the superior mesenteric artery. Fortschr Röntgenstr 2024; DOI 10.1055/a-2221-3813

Introduction

Isolated dissection of the superior mesenteric artery (IDSMA) is an increasingly frequently diagnosed pathology [1]. This is partly due to the availability of computed tomography (CT) scanners, which allow rapid and accurate detection of the dissected superior mesenteric artery (SMA) [1]. In this context, IDSMA is symptomatic in 86 % of cases [1] and accounts for 0.03 % of patients presenting with abdominal pain in an emergency department [2]. Causes of pain symptomatology include bowel ischemia and irritation of periarterial nerve plexuses combined with symptoms like nausea and vomiting [3, 4]. Mechanical stress has been discussed as an initiating cause for IDSMA. In vitro, dissection has been shown to originate mainly from the anterior wall of the convex curvature, or from the inferior end of the pancreas, where the fixed part of the artery runs into a more mobile part [5, 6]. Another factor is an angle between the SMA and the distal aorta of more than 70 degrees that may lead to unfavorable hemodynamics [7]. However, a definite cause has not yet been found. Male gender, hypertension, and smoking have been identified as major risk factors. Diabetes mellitus, hyperlipidemia, and cardiac disease may also be associated with IDSMA but appear to be less relevant [8]. In the acute setting, computed tomography angiography (CTA) with imaging of visceral vessels in an arterial contrast phase is the gold standard [9]. Laboratory values and conventional radiographs of the abdomen are rarely conclusive [10]. In the absence of adequate collateral flow, IDSMA poses a risk to ischemia of the intestine leading to bowel wall infarction and peritonitis. In addition, rupture of the dissected SMA may result in pseudoaneurysm formation. The reported mortality rate is approximately 0.5 % [8].

Various treatment strategies have been discussed in the literature, including conservative medical, endovascular, and surgical therapy [1].

Due to the rarity of the disease, the scarcity of available data, and the complexity of this condition, there are still uncertainties with special regard to appropriate management. Existing data are mostly limited to case reports and small case series. To address the need for better evidence, we present our single center data on the management of IDSMA collected over a period of five years.

Methods and Patients

Patient records were drawn from the electronic medical record database covering a period of five years. Search terms included mesenteric artery dissection, but only patients who had an isolated dissection of the SMA were considered. Dissections based on other entities, i. e., aortic dissection with mesenteric malperfusion, were not included in our study. Imaging data were acquired from the PACS of our institution (picture archiving and communication system, MERLIN Diagnostic Workcenter, version 5.8.1.200625; Phönix-PACS GmbH, Freiburg im Breisgau, Germany). All patients were examined and treated as part of routine care. Informed consent was obtained from all patients before endovascular and surgical treatment. Study design and data acquisition complied with the institutional review board guidelines regarding anonymized retrospective studies.

Study cohort

In total, six patients were identified. All patients were male (6/6) and predominantly smokers (4/6) with a mean age of 52 years (range, 45–58). The majority of patients were symptomatic, with four of six patients (66.7 %) experiencing severe abdominal pain. In total, three of six patients (50 %) were treated conservatively, one of six patients (16.7 %) by a surgical intervention, and two of six patients (33.3 %) by endovascular therapy. Of those cases treated conservatively, two patients were asymptomatic and one patient was symptomatic.

Patient demographics and characteristics are presented in ▶ **Table 1**.

▶ **Table 1** Case specifications. RAS: Renal artery stenosis; VAS: Visual Analogue Scale: 0–10 with 10 the most pain; CV: cardiovascular; CT: computed tomography; US: Ultrasound.

Case	1	2	3	4	5	6	
Gender	m	m	m	m	m	m	100 %
Age	54	56	53	58	46	45	Mean: 52
Submission for[1]	Tumor follow-up	RAS	Pain	Pain	Pain	Pain	Pain: 67 %
Pain specification							
▪ **VAS**	0	0	8	6	7	6	Mean: 4.5
▪ **Location**	None	None	Lower abd left	Epigastric	Epigastric	Epigastric	
CV risk factors:							
▪ **Smoking**	No	Yes	Yes	Yes	No	Yes	67 %
▪ **Hypertension**	No	Yes	Yes	Yes	No	No	50 %
▪ **Stroke**	No	No	No	Yes	No	No	17 %
▪ **Coagulopathy**	No	No	No	Yes	No	No	17 %
▪ **Sleep apnea**	No	No	No	Yes	No	No	17 %
▪ **Atrial fibrillation**	No	No	No	Yes	No	No	17 %
▪ **Obesity**	No	No	No	Yes	No	No	17 %
Hypercholesterolemia	No	No	No	Yes	No	No	17 %
Dissection:							
▪ **Type**[2]	I	IIb	IIb->IIa[3]	IIb	IIb	IIa	
▪ **Length**[4]	67	57	38	55	69	28	
Treatment							
▪ **Medication**	No	No	Yes	No	No	No	
▪ **Surgery**	No	No	No	Yes	No	No	
▪ **Stent + coiling**	No	No	No	No	Yes	No	
▪ **Stent**	No	No	No	No	No	Yes	
Follow-up							
▪ **Modality**	CT	CT/US	CT/US	Lost	CT	CT	
▪ **Months**	19	226	23	Lost	58	14	Mean: 68
▪ **Progression**	No	Yes	No	No	No	No	
Further treatment[5]	No	No	No	No	No	No	

[1] at initial presentation at the hospital
[2] according to Yun et al.
[3] change of type after 6 months
[4] in millimeter
[5] during follow-up period

Diagnostic investigations

The initial diagnostic approach used to identify IDSMA was contrast-enhanced, multislice CTA in five of six patients (83.3 %), and one patient (16.7 %) was examined with CTA and magnetic resonance angiography (MRA). The IDSMA was clearly depicted in all cases (6/6).

Radiologic reading contained descriptions of the entry/re-entry of the false lumen, the dissection length, the degree of stenosis of the patent lumen, and the involvement of side branches of the SMA. Moreover, attention was also paid to collateralization via the celiac trunk (CA).

Follow-up investigations were performed by CTA and ultrasound [US].

IDSMA was classified according to Yun et al. [5]: type I describes a patent true and false lumen with the false lumen showing re-entry. In contrast, type II does not present with re-entry (further subtyping: type IIa: the false lumen is patent, type IIb: the false lumen is thrombosed). In type III, both lumina are throm-

bosed. Symptomatic patients usually present with type II and III dissections.

Outcome measures

The primary outcome measure of our study was complete absence of IDSMA-related symptoms (i. e., abdominal pain, nausea, vomiting) after conservative, endovascular, or surgical treatment during the follow-up period. Symptoms were investigated by physicians of the department of surgery. The secondary outcome measure was worsening of imaging findings such as increasing length of the stenosis, dilatation, or worsening of true lumen compromise as determined by a radiologist.

Follow-up

After the diagnosis of IDSMA, all patients were closely monitored, regardless of treatment. Clinical examination was performed in the outpatient clinic of the surgical department for routine follow-up. All patients were advised to immediately contact the outpatient clinic at the onset of new or worsening symptoms. One patient was lost to follow-up. The mean follow-up time for the remaining five patients was 68 months (range: 14–226 months).

Literature review

A literature search of articles on IDSMA published between May 21, 2009 and November 8, 2022 was performed using PubMed for relevant articles published in English. The search terms included "mesenteric artery dissection". Retrieved results were filtered using information provided in the title and abstract. Studies addressing topics other than isolated dissection of the SMA were excluded. Results were also excluded when a full text was not available (i. e., abstract only or congress contributions). Studies covering other mesenteric vessels than the SMA, experimental or in-vitro studies, and systematic reviews were also excluded.

Results

Dissection specifications

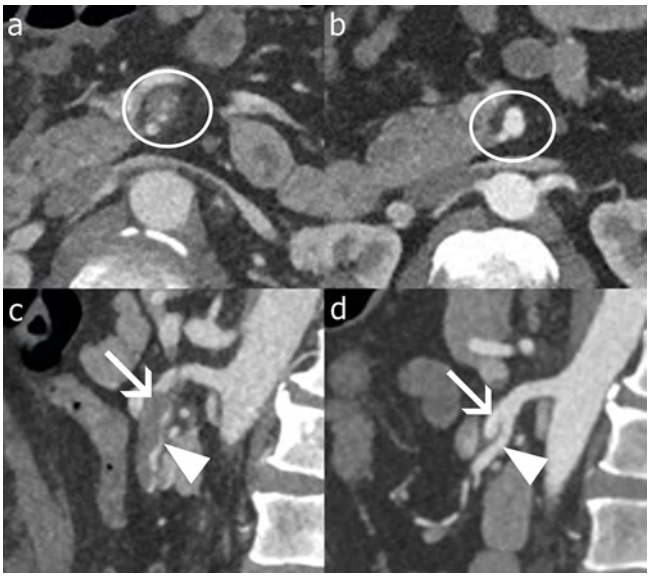
The overall dissection length was 52 mm ± 16 mm (48 ± 18 mm in symptomatic and 62 mm ± 7 in asymptomatic patients).

The two asymptomatic patients in our cohort were classified as type I and II, respectively. The four symptomatic patients were classified as type II. One of those symptomatic patients showed a change of type from IIb to IIa with recanalization of the false lumen in a CTA follow-up one month after the acute event (▶ **Fig. 1**). In this patient, additional recanalization of the true lumen occurred after approximately 6 months with further improvement of perfusion on imaging.

Treatment strategy

At our institution, all treatment decisions were made by multidisciplinary consensus owing to the rarity of the disease, the complex anatomy, and the individual circumstances in each patient.

The asymptomatic patients did not require endovascular or surgical treatment. Instead, their conservative treatment consisted of a watch-and-wait strategy as well as antihypertensive medications. In one symptomatic patient, a conservative therapy regimen was chosen, consisting of full anticoagulation (heparin, 60 mg per day for 6 weeks), single antiplatelet therapy (acetylsalicylic acid) and antihypertensive medication (ramipril) for lifetime as well as analgesics (novaminsulfone/paracetamol), and an antiemetic (metoclopramide).

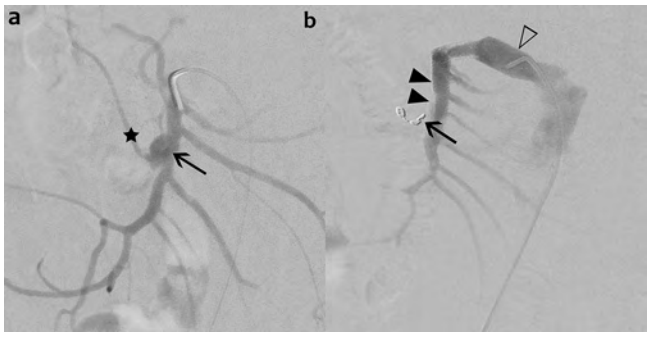


▶ **Fig. 1** (case 3): Patient with symptomatic isolated dissection of the superior mesenteric artery (IDSMA). Computed tomography (CT) scans in axial (**a, b**) and sagittal (**c, d**) orientation and arterial contrast phase. The patient initially presented with dissection type IIb (a, c). After receiving oral medications, a 6-month follow-up examination revealed recanalization of the collapsed or stenosed true lumen and also recanalization of the false lumen, resulting in a change of classification from type IIb to type IIa (c and d) at 0 and 6 months.

In one case, a surgical approach was selected with patch angioplasty of the central SMA with bovine pericardium.

Two endovascular procedures were performed in our local angiography suite equipped with state-of-the-art flat-panel detector angiographic systems (Axiom Artis, Siemens AG, Healthcare Sector, Forchheim, Germany; Azurion 7 C20, Philips Healthcare, Best, The Netherlands). The procedures were carried out under local anesthesia via a retrograde femoral artery approach.

In one of those cases (▶ **Fig. 2**), the SMA was cannulated with a selective catheter (cobra-1 configuration) through a 7F sheath. DSA revealed dissection of the SMA with formation of two pseudoaneurysms directly proximal to the jejunal arcade region, both arising from the true lumen. During the session, there was a detailed interdisciplinary discussion and consensus concerning the findings and the treatment strategy between surgeons and interventional radiologists. For the treatment of the distal segment of the SMA including the more distal pseudoaneurysm, two balloon-expandable bare metal stents (BMS) (Tsunami 6/18 mm, Terumo, Tokyo, Japan; RX Herculink Elite 6/18 mm, Abbott, Redwood City, CA) and four microcoils (VortX 3/2,5, Boston Scientific, Natick, MA) were used. Next, a balloon-expandable covered stent (Advanta V12 7/22 mm, Atrium Medical Corporation, Merrimack, NH)



▶ **Fig. 2** (case 5): Digital subtraction angiography (DSA) of IDSMA; **a**) before and **b**) after endovascular treatment using bare metal stents (BMS) (arrowheads), a covered stent, and a self-expanding BMS (open arrowhead). In this special case, the distal part of the dissection membrane was adapted by bare metal stenting, not to compromise relevant jejunal side branches (star). However, as one of the two pseudoaneurysms originated from the true lumen of the distal segment and could not be cannulated from collateral vessels of the celiac trunk, it was excluded by coil embolization through the struts of the stent (arrow, a: pseudoaneurysm, b: coils). The proximal aneurysm was excluded by prolongation with a covered stent.

was inserted into the region of the proximal pseudoaneurysm in order to exclude it. An extension of the stent tract into the proximal SMA was carried out by a self-expanding BMS (Protégé GPS, Medtronic, Minneapolis, MN) with a high radial strength.

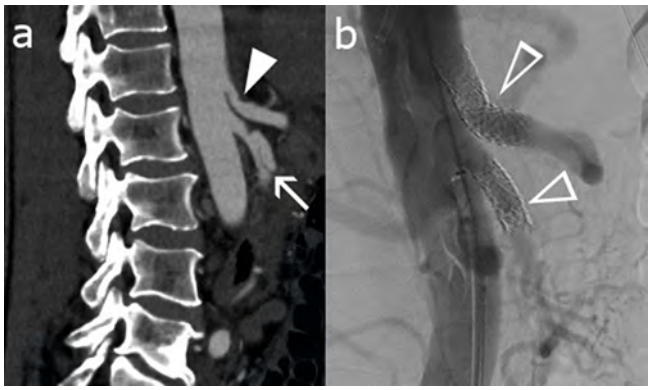
One patient presented with IDSMA plus stenosis of the CA (▶ **Fig. 3**), which was treated via a 6-french sheath by placement of two balloon-expandable uncovered stents into the CA (BeSmooth 10/17 and 10/23 mm, Bentley, Hechingen, Germany) and by implantation of a balloon-expandable covered stent in the SMA (BeGraft 6/23 mm, Bentley, Hechingen, Germany).

After initial treatment, all of our patients (100 %) were symptom-free. During our follow-up period, one patient developed minor progression of the diameter of the dissected SMA after 6 years and significant progression after more than 17 years (▶ **Fig. 4**). As the patient was disinclined to undergo surgery, he agreed to a watch-and-wait strategy with close monitoring of symptoms by our surgical outpatient clinic. One patient presented with stent tract occlusion approximately 30 months after interventional treatment but did not show corresponding symptoms or imaging evidence of mesenteric ischemia. In follow-up CT examinations, distal vessels were perfused via large-caliber collaterals of the inferior mesenteric artery.

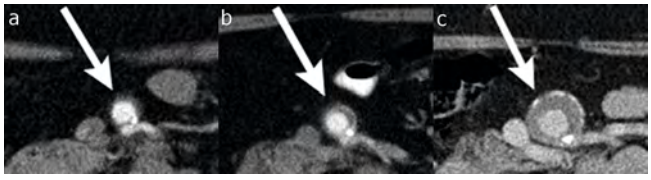
All other patients did not develop worrisome changes of the SMA during the follow-up period and thus did not need any further intervention.

Literature review

A literature search comprising the outlined criteria yielded 12 relevant publications: two larger studies, three case series, and seven case reports. The relevant detailed literature search is outlined in ▶ **Table 2**.



▶ **Fig. 3** (case 6): Images from a patient with symptomatic IDSMA initially presenting with type IIa dissection. (**a**) CT scan in sagittal orientation clearly demonstrates dissection of the SMA and stenosis of the celiac trunk. DSA after therapy in a corresponding angulation (**b**) shows free perfusion of the celiac trunk after implantation of a BMS and the excluded dissection of the SMA after placement of a covered stent (open arrowheads).



▶ **Fig. 4** (case 2): Patient with asymptomatic IDSMA (arrows **a–c**). CT examinations, each in the arterial contrast phase in axial slice orientation. A progression of the diameter of the superior mesenteric artery (SMA) during a period of more than 17 years is shown. The diameter of the true lumen remains stable, with dilatation of the thrombosed part and increasing calcification of the vessel wall. Diameters in a) 17 mm at baseline, b) 19 mm after 6 years, c) 28 mm after 17 years

Discussion

Our patient population exhibited risk factors like male gender and a history of smoking that were in accordance with those in the literature for IDSMA [8]. In addition, half of our patients suffered from arterial hypertension. The majority of patients was symptomatic, a finding that is also consistent with the clinical literature [1]. Similar to other publications [5, 8], IDSMA predominantly occurred in patients between the 4th and 6th decade of life in our small series.

Conservative treatment

In the absence of any strict standards, conservative management consisting of a watch-and-wait strategy and/or anticoagulation, antiplatelet, and antihypertensive therapy is the most common treatment in approximately 62–89 % of patients [1, 8, 11]. This approach seems to be especially beneficial in patients without any symptoms [1]. These findings are in line with the clinical outcome of our asymptomatic patients, in whom conservative treatment was chosen and resulted in satisfying long-term results.

▶ **Table 2** Literature review of patients with symptomatic IDSMA. AC: anticoagulation; AP: antiplatelet agents; BP: optimization of blood pressure control; ET: endovascular therapy; "–": no further information in the manuscript.

Reference	Cases	Initial treatment	Results: Pain resolution	Further treatment	Complications	Follow-up time/clinical outcome
Xu L., et al. (2020) [21]	42	Conservative: 15/42 AC/AP + BP ET: 27/42 23 stenting + in 7 cases additional balloon angioplasty, whereas 4/27 could not be treated by stenting (guide wire could not enter the lumen)	Conservative: pain resolution 14/15 ET: pain resolution 26/27	1 conservatively treated patient with additional ET (stent) after 7 days/ pain resolution 1 patient (stent) with persisting abdominal pain treated with ET/no further treatment	Conservative: No ET: 1/27 (pseudoaneurysm formation in the brachial artery with exclusion by surgery)	38 patients mean follow-up time: 28.5 months Conservative: 6 with recurrent pain during follow-up: 4/6 were successfully stented ET: 4 patients who failed ET did not need further treatment 2/4 with pain recurrence, 2/4 with progression
Chu SY., et al. (2012) [24]	8	Conservative: 1/8 AP + BP ET: 6/8 stent	Conservative: pain resolution 1/8 ET: pain resolution 6/8	No	1 patient without treatment died before intervention (hepatitis and multiple organ failure). ET: injury of a small SMA branch	Mean: 16 months/no recurrence
Katsura M., et al. (2011) [20]	3	Conservative: 1/3 watch-and-wait ET: None 0/3 Surgical: bypass graft 2/3	Conservative: Pain resolution 1/3 Surgical: pain resolution 2/3	No	Thrombotic graft occlusion 1/3	Median: 4.3 years/no recurrence
Funahashi H., et al. (2016) [10]	2	Conservative: 1/2 AC + BP 1/2 BP	Pain resolution 2/2	No	No 2/2	1: 2 years/no recurrence 2: 5 years/no recurrence
Asif S., et al. (2019) [12]	1	Conservative: AC + BP	Pain resolution	No	No	2 weeks/no recurrence
Barnes S., et al. (2017) [14]	1	Conservative: AC	Pain resolution	No	No	–/–
Daoud H., et al. (2018) [13]	1	Conservative: AC + BP	Pain resolution	No	No	3 days/no recurrence
Ezeh KJ, et al. (2022) [17]	1	Conservative: AC	Pain resolution	No	No	–/–
Gao DN., et al. (2017) [19]	1	Conservative: AP + BP	Persistent pain for 5 days	Additional ET (stent)/pain resolution	No	6 months/no recurrence
Miyata T., et al. [15]	1	Conservative: AC + BP	Pain resolution	No	No	2 months/no recurrence
Subhas G., et al. (2009) [16]	1	Conservative: AC	Pain resolution	No	No	5 years/no recurrence

However, in one of our symptomatic patients, conservative management was also chosen as the treatment of choice. In this case, the use of a covered stent was not considered due to a lack of an adequate proximal and distal landing zone. On the one hand, placement of such a stent could have compromised relevant side branches of the small bowel. On the other hand, sealing of the dissection entry could have been hampered. The patient's condition improved with adequate analgesics and antiemetics. Further CT follow-up studies were performed several months after the acute onset of abdominal pain, with the width of the dissected SMA remaining constant. As a result, further treatment was not required.

However, in the literature it is pointed out that conservative medical treatment and bowel rest is the most common initial treatment also in patients with symptoms. In most cases, further treatment is not needed [12–18]. An important question is how to manage patients with persistent pain or those with initial treatment failure. Previously published experience has shown that pain should resolve after 2–5 days of initial conservative therapy [10, 13, 19, 20].

A study with a larger cohort of patients showed that the recurrence rate of pain was higher in conservatively treated patients in comparison to those in the endovascular group, in which patients had been successfully treated by stenting [21]. As a consequence, the need for further treatment was slightly higher in the conservatively treated group.

In general, in patients with longer-lasting pain, the regimen should be adjusted towards endovascular or surgical therapy to avoid the risk of fatal complications [19, 21].

Therefore, a cut-off point with pain lasting longer than 5–7 days seems to be the right interval for reconsideration, with patients being under close clinical monitoring during that time [10, 13, 19, 20].

In our study population, there was no sign of recurrence of abdominal pain during the follow-up.

Endovascular treatment

The need for endovascular therapy of IDSMA varies from 4 % to 33.6 % in the literature and is an additional option in cases with persistent pain or aneurysms/pseudoaneurysms and simultaneous stenosis of the CA [8, 11, 20]. In addition, a more recent study showed that endovascular treatment may prevent the recurrence of symptoms and may also achieve complete remodeling of the dissection compared to conservative therapy [21]. In one of our cases, DSA revealed a dissection of the SMA with the formation of two pseudoaneurysms in the jejunal arcade region (▶ **Fig. 2**), both originating from the true lumen. Initially, two BMSs were implanted in the distal segment of the true lumen to readapt the dissecting membrane to the adventitial layer and not to compromise the relevant jejunal side branches. As the distal pseudoaneurysm originated from the true lumen of the distally stented segment and from collateral vessels of the CA that could not be cannulated, coaxial microcoil embolization was performed through the bare struts of the implanted stent. Using an overlapping technique, a covered stent was placed in the more proximal segment in order to seal the entry of a further pseudoaneurysm. Finally, a self-expanding nitinol stent was inserted into the proximal segment (▶ **Fig. 2**). Completion angiography demonstrated complete exclusion of the pseudoaneurysms as well as preservation of the perfusion of the SMA. Post-interventional CTA did not show any reperfusion of the pseudoaneurysms or evidence of mesenteric ischemia, while the inserted stents were freely contrasted. In this case, interventional treatment was the treatment of choice based on multidisciplinary consensus in terms of minimal invasiveness and a hemodynamically stable patient. A deterioration in clinical status and an impending hemorrhagic shock due to a ruptured pseudoaneurysm would have been clear indications for surgical treatment [1, 8, 21–24].

To date, the role of oral antiplatelet therapy after stent implantation is not clear in the setting of an IDSMA [25]. As demonstrated in patient 5, there is not any guarantee for long-term patency since our patient showed stent occlusion after a follow-up of 30 months post interventional treatment. However, it can be hypothesized that in this particular case, antiplatelet therapy might have contributed to the development of progressive collateralization in addition to the blood supply via vascular anastomoses of the CA and Riolan [26], thus preventing mesenteric ischemia and the recurrence of pain.

In contrast, in symptomatic two-vessel disease consisting of an IDSMA in combination with significant stenosis of the CA and hence impaired collateralization, treatment of both lesions seems to be indicated [11, 22, 27, 28]. One of our patients therefore required stenting of both arteries. He was treated with two balloon-expandable BMSs within the CA and implantation of a balloon-expandable covered stent within the dissected SMA to seal the entry. Abdominal pain was significantly reduced. In control series and follow-up examinations, the CA stenosis resolved without subsequent compromise, making ligamentous stenosis unlikely (▶ **Fig. 3**).

Possible complications that may occur after endovascular therapy are access site complications in terms of pseudoaneurysm formation [21] or abdominal hematoma caused by injury of an SMA branch [24]. However, in our small case series, periprocedural complications were not encountered. On the other hand, failure of endovascular therapy due to technical problems or persistent abdominal pain does not seem to lead to a change in therapy, i. e., escalation to a surgical approach [21].

Surgical treatment

In cases of persistent pain or long-standing stenosis involving multiple side branches of the SMA, surgical treatment with patch angioplasty may be considered. Surgical bypass may serve as an alternative option in the case of reduced blood flow of the SMA. An absolute indication for surgical therapy in the form of bowel resection is bowel necrosis [1, 8, 11, 27–29]. However, as long as there is no evidence of bowel necrosis and the patient is hemodynamically stable, endovascular therapy with recanalization may still be a therapeutic option, especially in acute ischemia. After restoration of perfusion, a "second look" operation may then be performed. Unfortunately, these cases are rare, because patients are usually not transferred to the hospital before necrosis has developed [21].

Cases of surgical treatment are rarely documented in the literature. One publication reported two cases with surgical intervention. In one of these two cases, there was intraoperative evidence of ischemia, and in the other case, prolonged pain led to bypass surgery. In one of these cases, thrombotic graft occlusion was reported on follow-up CT, which did not lead to recurrence of abdominal pain, presumably due to the development of collateral vessels [20]. Our patient, who was treated by surgical bypass, had an uneventful outcome. We want to mention that signs of ischemia are not always present on CT, a fact that may delay a surgical approach [20].

Follow-up

Management and follow-up beyond the acute setting can be challenging for all specialties involved [1, 8, 11]. In the article by Acosta et al., it was shown that approximately 0.5 % of patients required further treatment in the form of surgical or endovascular treatment at an interval of 1–44 months after the initial diagnosis of SMA dissection [8] because of acute vessel occlusion and aneurysm formation after dissection [30–34].

CTA studies have shown that 43 % of conservatively treated patients had complete resolution of the dissection at a mean of 22 months [8]. Further CTA studies showed that there was not any progression of the SMA diameter or false lumen during an average period of 21 and 22 months [5, 35]. A more recent article suggested that such complications may occur within the first 6 months in symptomatic patients. However, relevant changes do not tend to occur after one year [36]. If progression of the diameter of the SMA and/or a compromise of bowel perfusion has been verified, the respective case has to be reevaluated with special regard to endovascular and surgical treatment options [1, 8]. In particular, if the SMA diameter in the dissected area is more than 50 % larger than in the unaffected area, or when a narrowing of more than 90 % of the true lumen occurs [37, 38], invasive or minimally invasive treatment approaches should be considered.

Long-term data on changes in the dissected SMA beyond a 6-year period are lacking in the literature [8]. Due to the cumulative long-term risk, IDSMA can lead to life-threatening complications. One case in our study showed that even after a long follow-up period of more than 17 years, progression may occur and may lead to a critical state with risk of rupture (▶ **Fig. 4**). In this case DSA revealed a dissecting aneurysm of the SMA with exclusive supply of the small bowel via the true lumen (▶ **Fig. 5**). Therefore, interventional therapy would not have been an adequate option. In addition, the patient was reluctant to undergo surgery. Our other patients did not show worsening pathomorphological imaging findings of the SMA and recurrent abdominal symptoms during the follow-up period. There was no further need for intervention at a mean follow-up time of 68 months. These findings support the fact that long-term follow-up may be warranted in those selected cases.

▶ **Fig. 5** (case 2): Follow-up: **a**) Corresponding sonographic control examination of the previously illustrated patient with IDSMA type IIb. **b**) Due to progression of the diameter of IDSMA, DSA was perfomed, which revealed a dissecting aneurysm of the SMA (false lumen: arrow) with exclusive supply of the small bowel via the true lumen (arrow head); branches of the superior mesenteric artery (stars).

Conclusion

To conclude, the appropriate diagnosis, treatment, and follow-up of IDSMA must be tailored to the needs of the individual patient and require multidisciplinary decision making. For the management of IDSMA in most symptomatic patients, we recommend observation and conservative medical therapy with bowel rest, antihypertensive drugs, anticoagulation, and/or antiplatelet agents. In the case of complications such as prolonged pain or evidence of intestinal ischemia, endovascular or surgical therapy should be considered.

CLINICAL RELEVANCE

- IDSMA is an increasingly frequently diagnosed entity.
- Treatment of IDSMA is highly dependent on symptoms and radiomorphological aspects and constellations.
- IDSMA requires multidisciplinary expertise.

ABBREVIATIONS

BMS	bare metal stent
CA	celiac trunk
CT	computed tomography
CTA	computed tomography angiography
CV	cardiovascular
DSA	digital subtraction angiography
IDSMA	isolated dissection of the superior mesenteric artery
mg	milligram
MRA	magnetic resonance angiography
RAS	renal artery stenosis
SD	standard deviation
SMA	superior mesenteric artery
US	ultrasound
VAS	visual analog scale

Conflict of Interest

The authors declare that they have no conflict of interest.

References

[1] Garrett HE Jr. Options for treatment of spontaneous mesenteric artery dissection. J Vasc Surg 2014; 59: 1433–1439

[2] Kim H, Labropoulos N. The role of aortomesenteric angle in occurrence of spontaneous isolated superior mesenteric artery dissection. Int Angiol 2020; 39: 125–130

[3] Furukawa H, Moriyama N. Spontaneous dissection of the superior mesenteric artery diagnosed on multidetector helical CT. J Comput Assist Tomogr 2002; 26: 143–144

[4] Ho KKF, Sivakumaran Y. Management of spontaneous isolated mesenteric artery dissection. Asian Cardiovasc Thorac Ann 2023; 31: 364–368

[5] Yun WS, Kim YW, Park KB et al. Clinical and angiographic follow-up of spontaneous isolated superior mesenteric artery dissection. Eur J Vasc Endovasc Surg 2009; 37: 572–577

[6] Solis MM, Ranval TJ, McFarland DR et al. Surgical treatment of superior mesenteric artery dissecting aneurysm and simultaneous celiac artery compression. Ann Vasc Surg 1993; 7: 457–462

[7] Wu Z, Yi J, Xu H et al. The Significance of the Angle between Superior Mesenteric Artery and Aorta in Spontaneous Isolated Superior Mesenteric Artery Dissection. Ann Vasc Surg 2017; 45: 117–126

[8] Acosta S, Gonçalves FB. Management of Spontaneous Isolated Mesenteric Artery Dissection: A Systematic Review. Scand J Surg 2021; 110: 130–138

[9] He Q, Yu F, Fu Y et al. Evaluation of isolated abdominal visceral artery dissection with multi-scale spiral computed tomography: a retrospective case series. J Cardiothorac Surg 2021; 16: 61

[10] Funahashi H, Shinagawa N, Saitoh T et al. Conservative treatment for isolated dissection of the superior mesenteric artery: Report of two cases. Int J Surg Case Rep 2016; 26: 17–20

[11] Zhu Y, Peng Y, Xu M et al. Treatment Strategies and Outcomes of Symptomatic Spontaneous Isolated Superior Mesenteric Artery Dissection: A Systematic Review and Meta-analysis. J Endovasc Ther 2018; 25: 640–648

[12] Asif S, Qureini A, Bennett J. A Rare Case of Spontaneous Isolated Dissection of the Superior Mesenteric Artery. Cureus 2019; 11: e4725

[13] Daoud H, Abugroun A, Subahi A et al. Isolated Superior Mesenteric Artery Dissection: A Case Report and Literature Review. Gastroenterology Res 2018; 11: 374–378

[14] Barnes S, Kushner B. Isolated Dissection of the Superior Mesenteric Artery. Clin Pract Cases Emerg Med 2018; 2: 43–46

[15] Miyata T, Sannomiya Y, Nagayama T et al. Conservative management of spontaneous isolated superior mesenteric artery dissection: A case report. Clin Case Rep 2022; 10: e05313

[16] Subhas G, Gupta A, Nawalany M et al. Spontaneous isolated superior mesenteric artery dissection: a case report and literature review with management algorithm. Ann Vasc Surg 2009; 23: 788–798

[17] Ezeh KJ, Bellamy SE. Isolated Superior Mesenteric Artery Dissection: A Rare Etiology of Colic Ischemia. Cureus 2022; 14: e24819

[18] Skeik N, Smith J, Olson SL et al. Mesenteric Artery Dissection and Wall-Thickening, Case Study and General Review. Angiology 2023; 74: 7–21

[19] Gao DN, Qi QH, Gong P. Endovascular stenting of spontaneous isolated dissection of the superior mesenteric artery: A case report and literature review. Medicine (Baltimore) 2017; 96: e8598

[20] Katsura M, Mototake H, Takara H et al. Management of spontaneous isolated dissection of the superior mesenteric artery: Case report and literature review. World J Emerg Surg 2011; 6: 16

[21] Xu L, Shao J, Zhang D et al. Long-term outcomes of conservative treatment and endovascular treatment in patients with symptomatic spontaneous isolated superior mesenteric artery dissection: a single-center experience. BMC Cardiovasc Disord 2020; 20: 256

[22] Björck M, Koelemay M, Acosta S et al. Editor's Choice – Management of the Diseases of Mesenteric Arteries and Veins: Clinical Practice Guidelines of the European Society of Vascular Surgery (ESVS). Eur J Vasc Endovasc Surg 2017; 53: 460–510

[23] Fu YF, Cao C, Shi YB et al. Endovascular Bare Stenting for Isolated Superior Mesenteric Artery Dissection. Vasc Endovascular Surg 2020; 54: 12–16

[24] Chu SY, Hsu MY, Chen CM et al. Endovascular repair of spontaneous isolated dissection of the superior mesenteric artery. Clin Radiol 2012; 67: 32–37

[25] Qiu C, He Y, Li D et al. Mid-Term Results of Endovascular Treatment for Spontaneous Isolated Dissection of the Superior Mesenteric Artery. Eur J Vasc Endovasc Surg 2019; 58: 88–95

[26] Rosenblum JD, Boyle CM, Schwartz LB. The mesenteric circulation. Anatomy and physiology. Surg Clin North Am 1997; 77: 289–306

[27] Luan JY, Guan X, Li X et al. Isolated superior mesenteric artery dissection in China. J Vasc Surg 2016; 63: 530–536

[28] Wang J, He Y, Zhao J et al. Systematic review and meta-analysis of current evidence in spontaneous isolated celiac and superior mesenteric artery dissection. J Vasc Surg 2018; 68: 1228–1240

[29] Yuan Z, Hu G, Sheng S et al. Management Strategy and Radiologic Outcomes of Symptomatic Spontaneous Isolated Superior Mesenteric Artery Dissection Based on Angiographic Classification: The Follow-Up Experience in a Single Center. J Endovasc Ther 2022; 8: 15266028221133700

[30] Chen ZL, Zhang XC, Pan GR et al. Clinical features and therapeutic options for isolated visceral artery dissection. Ann Vasc Surg 2016; 30: 227–235

[31] DeCarlo C, Ganguli S, Borges JC et al. Presentation, treatment, and outcomes in patients with spontaneous isolated celiac and superior mesenteric artery dissection. Vasc Med 2017; 22: 505–511

[32] Amabile P, Ouaïssi M, Cohen S et al. Conservative treatment of spontaneous and isolated dissection of mesenteric arteries. Ann Vasc Surg 2009; 23: 738–744

[33] Dong Z, Ning J, Fu W et al. Failures and Lessons in the Endovascular Treatment of Symptomatic Isolated Dissection of the Superior Mesenteric Artery. Ann Vasc Surg 2016; 31: 152–162

[34] Liu B, Chu C, Fan X et al. Endovascular stent placement for isolated superior mesenteric artery dissection with intestinal ischemia. Vasa 2019; 48: 73–78

[35] Takayama T, Miyata T, Shirakawa M et al. Isolated spontaneous dissection of the splanchnic arteries. J Vasc Surg 2008; 48: 329–333

[36] Ichiba T, Hara M, Yunoki K et al. Serial Follow-Up Evaluation With Computed Tomography After Conservative Medical Treatment in Patients With Symptomatic Spontaneous Isolated Superior Mesenteric Artery Dissection. Vasc Endovascular Surg 2017; 51: 538–544

[37] Jia Z, Su H, Chen W et al. Endovascular Treatment of Patients with Isolated Mesenteric Artery Dissection Aneurysm: Bare Stents Alone Versus Stent Assisted Coiling. Eur J Vasc Endovasc Surg 2019; 57: 400–406

[38] Jia Z, Chen W, Su H et al. Factors Associated with Failed Conservative Management in Symptomatic Isolated Mesenteric Artery Dissection. Eur J Vasc Endovasc Surg 2019; 58: 393–399