Staged Endovascular Intervention with Ultrasound-Assisted Thrombolysis and Stent Placement for Spontaneous Isolated Superior Mesenteric Artery Dissection with Total Thrombotic Occlusion

Dyi-Yu Tsai,1 Hung-Shi Tseng,2 Jian-Ming Chen,3 Wei-Lian Phan,1 Jen-Yu Wang1 and Chia-Lun Chao1,4

Key Words: Dissection • Endovascular • Intravascular ultrasound • Stent • Superior mesenteric artery • Thrombolysis

INTRODUCTION

Spontaneous isolated superior mesenteric artery (SMA) dissection is a rare but potentially fatal disease. It is now reported more often due to increasing usage of various image modalities, especially computed tomography (CT) and CT angiography.1 Therapeutic options include conservative management, endovascular stenting, and open surgery, among which, surgery is often recommended for the existence of luminal thrombosis of SMA, or bowel necrosis.1 Recently, endovascular intervention using intralesional thrombolysis with or without stent placement, has been tried for luminal thrombosis as an alternative option other than surgery due to its less invasive procedure.2 However, the effectiveness of thrombus removal plays an important role for either thrombolysis or stent placement.1,2 Here, we report a case of SMA dissection with total occlusion by partially organized thrombus. We performed staged endovascular intervention, which means using catheter-directed thrombolysis (CDT) with urokinase first, and then deploying the stent later. In addition, we tried ultrasound-assisted CDT instead of CDT alone to achieve better thrombolysis. To our knowledge, we first time implemented staged endovascular intervention successfully by using the newly introduced EkoSonic Endovascular System (EKOS, EKOS corporation, U.S.A.) for ultrasound-assisted CDT, then performing stent placement for SMA dissection and atheroma plaque by intravascular ultrasound (IVUS) guidance 2 days later.

CASE

A 46-year-old man presented to our emergency department with a 2-day history of left lower abdominal pain, which was aggravated by meals. He had brain surgery for arteriovenous malformation more than two decades ago, and smoked 1-2 packs of cigarettes daily for 20 years. He denied hypertension, diabetes mellitus, dyslipidemia or recent abdominal trauma. At the onset of abdominal pain, he visited another institution but no definite diagnosis was achieved. The symptoms persisted despite painkiller prescription. On arrival at our hospital, the patient presented with a postprandial abdominal pain with a pain score of 7-8 on a 0-10 pain scale. Physical examination revealed normal blood pressure and mild tenderness over left lower abdomen with no peritoneal sign. Laboratory data showed mildly elevated white blood...
cell count (10.04 K/μL). Abdominal radiography was unremarkable. Contrast-enhanced abdominal CT revealed SMA thrombosis with near total occlusion but no evidence of bowel necrosis; SMA dissection was suspected initially (Figure 1A). Selective SMA angiography, performed with a 5Fr Simmons 2 catheter (100 cm in length, Terumo, Japan) via right femoral artery approach, demonstrated dissecting plaque near SMA orifice complicated with total occlusion of distal SMA by large thrombus burden (Figure 1B). The flow of ileocolic and right colic arteries was supplied from the network anastomosis of distal jejunal and proximal ileal branches. Surgical intervention was suggested but the patient refused. Therefore, we first used a 0.014-inch coronary guidewire (Ultimate Bros 3, 180 cm in length, Asahi, Japan) to pass the total occlusion site with an 8Fr JR4 guiding catheter (100 cm in length, Boston Scientific, U.S.A.), but failed due to the partially organized thrombus. We then selected a 0.035-inch stiff guidewire (260 cm in length, Terumo, Japan) with microcatheter support, and successfully advanced the guidewire through the thrombotic occlusion to the distal ileal branch. Some dark red thrombi were aspirated from the microcatheter. Subsequent angiogram showed partial recanalization of the SMA trunk (Figure 1C). To avoid the high risk of distal vessel and side branch occlusion by direct stenting of SMA under the large burden of thrombus, we decided to undertake staged endovascular intervention, which means pharmacologic thrombolysis first and stent placement for SMA dissection later. We chose the ultrasound-assisted CDT instead of CDT alone to assure more effective thrombolysis of large thrombus burden according to the treatment experience of massive pulmonary embolism.³ An EKOS catheter was inserted to the distal ileal branch, accompanied with urokinase infusion (Figure 1D). Urokinase, not along with heparin, was then infused through the catheter at a rate of 60,000 IU per hour initially and tapered to 49,000 IU per hour on day 2 according to the plasminogen level. There was no gastrointestinal bleeding nor hematoma formation at the puncture site during urokinase infusion therapy. Angiogram 2 days later showed nearly complete recanalization of the SMA trunk with some residual irregular thrombi noted at the distal part of SMA trunk; there were prominent collaterals from distal jejunal and proximal ileal branches though one ileal branch was still occluded (Figure 2A). IVUS (Eagle Eye, Volcano, Phillips, U.S.A.) showed an atherosclerotic plaque about 3.5 cm long extending from the ostium to the proximal part of SMA with a large dissecting false lumen, which was about 2.5 cm long with the entry site 1 cm distal to the orifice of SMA (Figure 2B). A balloon expandable stent with 8.0 mm in diameter and 37 mm in length (Express LD, Boston Scientific, U.S.A.) was then chosen based on IVUS measurement and deployed through an 8Fr JR4 guiding catheter from the ostium of SMA to cover the dissecting false lumen and atheroma plaque (Figure 2C). Post-stenting dilatation at the distal portion of the stent for better wall apposition was done with another balloon catheter (Mustang, Boston Scientific, U.S.A., 10 mm in diame-

**Figure 1.** (A) Abdominal CT with contrast in a coronal plane revealed: 1) the suspected dissection with false lumen thrombosis near the SMA orifice (arrow 1), 2) luminal thrombosis in the distal SMA trunk (arrow 2), 3) the jejunal branch of SMA (arrow 3), 4) superior mesenteric vein (arrow 4), and 5) luminal thrombosis in the ileocolic branch (arrow 5). (B) Selective angiogram of SMA showed a dissecting plaque near SMA orifice complicated with distal total occlusion of SMA by large thrombus burden with faint collaterals. (C) SMA angiogram after thrombosuction showed partial recanalization of the SMA trunk. (D) An EKOS catheter was inserted to the distal ileal branch. CT, computed tomography; EKOS, EkoSonic Endovascular System; SMA, superior mesenteric artery.
ter and 20 mm in length). IVUS and SMA angiogram after stenting showed good stent landing and expansion and there was no dissection of distal SMA trunk (Figure 2D and 2E). Final angiogram also displayed satisfactory distal SMA flow without new distal embolization (Figure 2F). Dual antiplatelet therapy with loading dosages was initiated after the procedure immediately. Postprandial abdominal pain was soon relieved with a pain score of 0 (pain-free) after the stent deployment of SMA. No anticoagulation therapy was given during the hospitalization. He was discharged a few days later. Follow-up abdominal CT 40 days after the stenting of SMA showed fully expanded stent with good distal flow. During the follow-up up to 1 year, the patient had no recurrent symptoms. We discontinued clopidogrel use 3 months after the stenting and kept indefinite aspirin therapy.

DISCUSSION

Spontaneous isolated SMA dissection was first described in 1947. The patient population of such SMA dissection was male predominant, with mean age of 54 years old. The etiology of the disease was not well established, but atherosclerosis, cystic media necrosis, fibromuscular dysplasia, diseases of the elastic tissue, and untreated hypertension, have been mentioned. Acute abdominal pain was the most common symptom, and the presence of peritonitis or not was the most important clinical indicator for bowel necrosis. Laboratory tests and abdominal radiography are usually unremarkable. Contrast-enhanced CT scan, a satisfactory imaging study for detecting SMA dissection, can either reveal the presence of an intimal flap or sometimes provide the clue of dissection by mural thrombus. SMA angiography is an effective confirmatory modality that provides more information of the lesion site and demonstrates collateral blood flow for the further planning of endovascular intervention. The typical entry point of dissection is usually located 1 to 6 cm distal to the orifice of SMA (mean 2.6 cm). It seemed that SMA at its convex curvature has an increased shear stress due to its anatomical charac-

Figure 2. (A) SMA angiogram after EKOS thrombolysis showed nearly complete recanalization of the SMA trunk and prominent collaterals with some residual irregular thrombi noted at the distal part of SMA trunk. (B) IVUS disclosed a dissection flap (white arrow) and a narrow true lumen compressed by a large dissecting false lumen. (C) An Express LD balloon expandable stent was deployed from the SMA ostium. (D) Angiogram by manual injection after stenting revealed fully covered dissecting atheroma by the stent and good stent expansion (white arrow denoting the distal stent edge). (E) Angiogram after stenting showed satisfactory flow of distal SMA trunk without dissection. (F) Final angiogram displayed satisfactory distal SMA flow. CT, computed tomography; EKOS, EkoSonic Endovascular System; IVUS, intravascular ultrasound; SMA, superior mesenteric artery.
teristics of transition from a fixed (retropancreatic portion) to an unfixed segment (mesenteric root). Based on the angiographic findings, isolated SMA dissection had been classified into three types by Yun et al. according to the flow pattern of false lumen and true lumen patency at the dissected segment: type I, patent true and false lumen that show entry and re-entry sites; type II, patent true lumen but no re-entry flow from the false lumen; type III, SMA dissection with thrombotic occlusion.

Several treatment algorithms for the management of SMA dissection have been proposed but there is still no established consensus on the indications for conservative treatment, surgical revascularization, and endovascular intervention. Conservative treatment with bowel rest and anticoagulation therapy was generally suggested if there is no evidence of bowel necrosis, but it hardly prevents disease progression, requires close follow-up, and has a potential failure due to recurrent symptoms. In contrast, surgical intervention was favored under the presence of luminal thrombosis, bowel necrosis, or persistent symptoms despite anticoagulation. In dealing with luminal thrombosis, endovascular intervention with intraslesional thrombolysis and/or endovascular stent placement has been attempted. The effectiveness of intraslesional thrombolysis in total thrombotic occlusion of SMA is related to the age and burden of the thrombus. For example, the successful rate of urokinase therapy is better within 8-10 hours after onset of symptoms in comparison to that after 72 hours. However, the overall clinical failure rate after urokinase therapy is still notable (35-40%), and some cases need further endovascular stenting or surgical intervention.

Recently, endovascular intervention with thrombolysis and subsequent stent placement in Yun’s type III SMA dissection has been tried for its less invasive technique compared to surgery. Kim et al. reported a successful intervention in a 48-year-old woman presenting with acute abdomen for 6 hours. The initial diagnosis by contrast-enhanced abdominal CT was thromboembolic occlusion of SMA. They started the treatment with urokinase infusion (100,000 IU per hour). After 14-h infusion of urokinase, angiography was performed again due to persistent symptoms. They found significantly decreased thrombus burden but also noticed an isolated SMA dissection. They then placed a self-expandable stent for the SMA dissection and revealed a fully expanded stent by CT angiograms 2 months later. The patient was also symptom-free at a 6-month follow-up after the stent placement. However, in this case, Kim et al. initially misdiagnosed the dissection as the thromboembolic occlusion of the SMA and concluded that pharmacologic thrombolysis might be unnecessary for the less luminal thrombus burden. Indeed, aggressive thrombolytic therapy in false lumen thrombosis alone might lead to potential complications such as rapid expansion of the false lumen and dissection-related aneurysmal degeneration; such therapy would be reasonable only if the majority of thrombus is in the luminal space in this situation. As a comparison, our patient had a large luminal thrombus with partial organization in SMA. Therefore, despite the potential risk of propagating dissection, we decided to choose the ultrasound-assisted CDT instead of CDT alone to assure more effective thrombolysis of the large and several days old thrombus burden.

EKOS is designed for ultrasound-assisted CDT that emits low-intensity, high-frequency ultrasound that dissociates fibrin strands without causing thrombus fragmentation, is FDA approved for selective and controlled infusion of thrombolytic agents into occluded peripheral vessels, including acute embolic stroke, pulmonary embolism, deep vein thrombosis, and peripheral artery occlusions. In massive acute pulmonary embolism, EKOS has shown a higher complete thrombus resolution rate (100% vs. 50%), reduced thrombolytic treatment duration (17.4 vs. 26.7 hours) and hemorrhagic complications (0% vs. 3%) compared with CDT alone. In our patient, we used EKOS for the SMA trunk thrombosis and achieved nearly complete recanalization without distal embolization and hemorrhagic complications. To the best of our knowledge, it is the first time that ultrasound-assisted CDT by EKOS was used in Yun’s type III SMA dissection. IVUS-guided stenting for isolated SMA dissection was first reported by Woo et al. in 2010.
vided more accurate information about dissection length and entry point in contrast to CT scan and angiography.\textsuperscript{5} In our patient, we performed IVUS after completing thrombolysis of the SMA trunk, which provided clear-cut tearing site of the intimal flap, and the extent of false lumen and atheroma plaque. In terms of the selection of stent, based on IVUS measurement, we chose balloon expandable stent to achieve precise stenting of the aorto-ostial lesion and less stent shortening.\textsuperscript{9} Self-expandable stents may be used for more distal or longer lesions of SMA trunk given their flexibility.\textsuperscript{9} In terms of the handling of thrombus burden, there were still some residual irregular thrombi distal to the dissection site in our patient after EKOS therapy. Recently, a self-expanding and fully retrievable stent-based thrombectomy system (Solitaire FR revascularization device), initially designed for acute intracranial large artery occlusion, was also applied to thrombotic SMA occlusion to obtain prompt and complete recanalization without distal embolism.\textsuperscript{19} It provides another useful option for reducing thrombus burden other than catheter aspiration in endovascular intervention for SMA thromboembolism, though not entirely suitable for our patient with larger SMA size (> 6 cm). There is still no consensus about the duration of antiplatelet therapy after SMA stenting.\textsuperscript{5} We employed the practice by Woo et al.,\textsuperscript{5} who treated the patient with dual antiplatelet therapy for 3 months and then aspirin alone, as the patients with peripheral artery disease. We initially planned to give dual antiplatelet therapy with aspirin and clopidogrel for a duration of at least 3 months, which was suggested by Woo et al.\textsuperscript{5} In their case, the patient was actually on aspirin and clopidogrel simultaneously for 3 months and then aspirin alone thereafter with a satisfactory result. Since our patient was symptom-free during the follow-up, we discontinued clopidogrel 3 months later and kept aspirin for lifelong use. As to the residual thrombi noted after thrombolysis in our case, we did not put the patient on anticoagulation therapy at the first moment because the collateral flow was prominent and the residual thrombus burden was relatively small. Later, we decided not to use the anticoagulant since the postprandial abdominal pain was relieved quickly. However, we believe that the use or not of the anticoagulant is still a lesson to learn and would be lefted to the physicians’ discretion according to the clinical scenario.

In conclusion, to our knowledge, we first time undertook staged endovascular intervention for spontaneous isolated SMA dissection with total thrombotic occlusion, using EKOS for ultrasound-assisted CDT first, and performing SMA stenting for dissected atherosclerotic lesion by IVUS guidance later. EKOS, a new device used widespread in peripheral occluded vessels in recent years, may gave us a new treatment option in dealing with large SMA thrombosis to provide better opportunity for further feasible stenting of SMA dissection.

**LEARNING POINTS**

1. Staged endovascular intervention with initial pharmacological thrombolysis and subsequent stent placement is applicable to spontaneous isolated SMA dissection with large luminal thrombus burden.

2. Ultrasound-assisted CDT instead of CDT alone is feasible for large SMA thrombosis, especially with potential thrombus organization.

**ACKNOWLEDGMENTS**

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

**DECLARATION OF CONFLICT OF INTEREST**

All the authors declare no conflict of interest.

**REFERENCES**


3. Lin PH, Annambhotla S, Bechara CF, et al. Comparison of percutaneous ultrasound-accelerated thrombolysis versus catheter-directed thrombolysis in patients with acute massive pulmo-