surgical techniques development

Case Report

Retrograde Endovascular Recanalization of the Superior Mesenteric Artery for the Treatment of Acute Bowel Ischemia: Case Report

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Abstract: Acute bowel ischemia is a life-threatening abdominal emergency. In many patients, percutaneous endovascular repair of visceral arteries in an antegrade direction across occluding lesions is challenging and sometimes not possible. We present the case of technically successful percutaneous retrograde recanalization of an occluded superior mesenteric artery in a critically ill 82-year-old patient. The superior mesenteric artery was recanalized via the branches of the celiac trunk; the guidewires were navigated to the target artery through the gastroduodenal and pancreaticoduodenal arteries. Retrograde percutaneous recanalization of the superior mesenteric artery is technically feasible, even in hemodynamically unstable patients.

Keywords: acute bowel ischemia; mesenteric artery occlusion; mesenteric artery stenting; retrograde revascularization

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1. Introduction

Acute bowel ischemia (ABI) is a life-threatening abdominal emergency that can result in death, multiorgan failure, or severe nutritional problems [1]. It primarily affects older patients and usually develops as a consequence of chronic atherosclerotic plaques of the visceral arteries [2]. Typically, there is a pre-existing atherosclerotic stenosis, with abdominal symptoms such as post-prandial pain, weight loss, and abstaining from food. Usually, atherosclerotic plaques are found in the proximal parts of the visceral arteries. Thrombosis resulting in the complete closure of such an artery can be triggered by several clinical situations, comprising severe heart decompensation, surgical procedures, dehydration, or hemorrhage.

Although traditional treatment of ABI comprises emergency open surgical repair, in order to reduce periprocedural morbidity and mortality that are very high, endovascular and hybrid approaches have been suggested [3–8]. Indeed, data from the Swedish Vascular Registry reveal much better results in terms of 30-day mortality in patients who underwent endovascular revascularization. Endovascular procedure as an alternative approach to open surgical repair primarily concerns thrombotic occlusions of the superior mesenteric artery (SMA). However, in many patients, there are important technical problems associated with endovascular repair in this vascular territory. Therefore, endovascular procedures should be performed only in adequately equipped hospitals (hybrid operation room, access to the specialized endovascular armamentarium, etc.) and by interventionalists with high expertise in such procedures. The inability to navigate across occluding plaques of the SMA in an antegrade direction represents one of the important technical challenges; therefore, we decided to present this report, describing details of the repair of a difficult-to-recanalize SMA.

The main objective of this case report is to present current endovascular techniques that can be utilized in critically ill patients suffering from ABI, especially if such patients cannot be managed using an open or hybrid surgical repair and the percutaneous approach remains the only possible life-saving option.

2. Detailed Case Description

Here, we present the case of percutaneous retrograde recanalization of an occluded SMA in a patient presenting with ABI. An 82-year-old female patient developed progressing abdominal symptoms during a hospital stay after a thrombendarterectomy of the femoral artery, which was performed for the treatment of critical lower limb ischemia.

Biochemical blood analysis at admission revealed leukocytosis (12 G/L), which further increased to 20 G/L; c-reactive protein (CRP), which prior to revascularization of the femoral artery was elevated to 150 mg/L (normal values: <10 mg/L), then decreased to 70 mg/L, again increased to 200 mg/L accompanying the onset of abdominal symptoms; serum lactate was slightly elevated: 2.5 mmol/L (normal values: <2.4 mmol/L). Furthermore, on hospital admission, due to lower leg ischemia, there was a significant microcytic anemia (hemoglobin: 7.0 g/dL), probably resulting from chronic bowel ischemia and peptic ulcer disease, which required transfusion of 2 units of packed red blood cells.

Following a thrombendarterectomy of the femoral artery, the patient was managed with therapeutic subcutaneous doses of enoxaparin and oral aspirin 75 mg/daily. However, postoperatively, there were two episodes of gastrointestinal bleeding. Consequently, aspirin was withdrawn, and the dose of enoxaparin was reduced. Gastroduodenal endoscopy did not reveal active bleeding; still, there were ulcerations in the stomach. An additional transfusion of 4 units of packed red blood cells was needed. All these adverse events, together with poor clinical status before the hospitalization, probably contributed to the deterioration of heart function. In addition, this patient presented with an elevated level of serum fibrinogen: 7.6 g/L (normal: <3.2 g/L), which suggested a hypercoagulable state.

CT angiography, which was performed to diagnose the cause of acute abdominal symptoms suggesting intestinal ischemia, revealed calcified plaques in the SMA, located 3 mm distally from the aorta (Figure 1A). This lesion completely occluded the proximal part of the SMA. This examination also demonstrated a patent celiac trunk, wide common hepatic artery (CHA), and patent, although narrow, gastroduodenal artery (GDA). Distal branches of the SMA were not visible. The overall clinical picture suggested thrombosis of the SMA, resulting in bowel ischemia. Probably, this total occlusion of the SMA resulted from thrombosis of the critical atherosclerotic stenosis at the proximal part of SMA in the settings of heart failure and blood hypercoagulability that could not be properly managed pharmacologically because of recent gastrointestinal bleeding.

Since the patient, in addition to abdominal symptoms, presented with heart failure and was hemodynamically very unstable, surgical exploratory laparotomy was not possible. Therefore, the decision to perform a life-saving endovascular intervention was made.

The estimated time of intestinal ischemia in the patient from the first symptoms to the start of the procedure was approximately 3.5 h. The first symptoms were masked by symptoms of circulatory decompensation, and later symptoms suggesting intestinal ischemia appeared, such as abdominal pain and deterioration of the general condition. After the occlusion was confirmed by CT angiography, the patient was referred to the interventional radiology cathlab.

Catheter angiography of the abdominal visceral arteries, which was performed from the left brachial access, did not show the SMA. When the catheter was advanced to the CHA, the proximal part of the SMA was revealed. This artery received inflow through the GDA. Also, several proximal jejunal branches were shown, while other branches of the SMA were not visible (Figure 1B). Considering the fact that the origin of SMA was not visible, we decided to recanalize this artery in a retrograde manner via the branches of the celiac trunk.

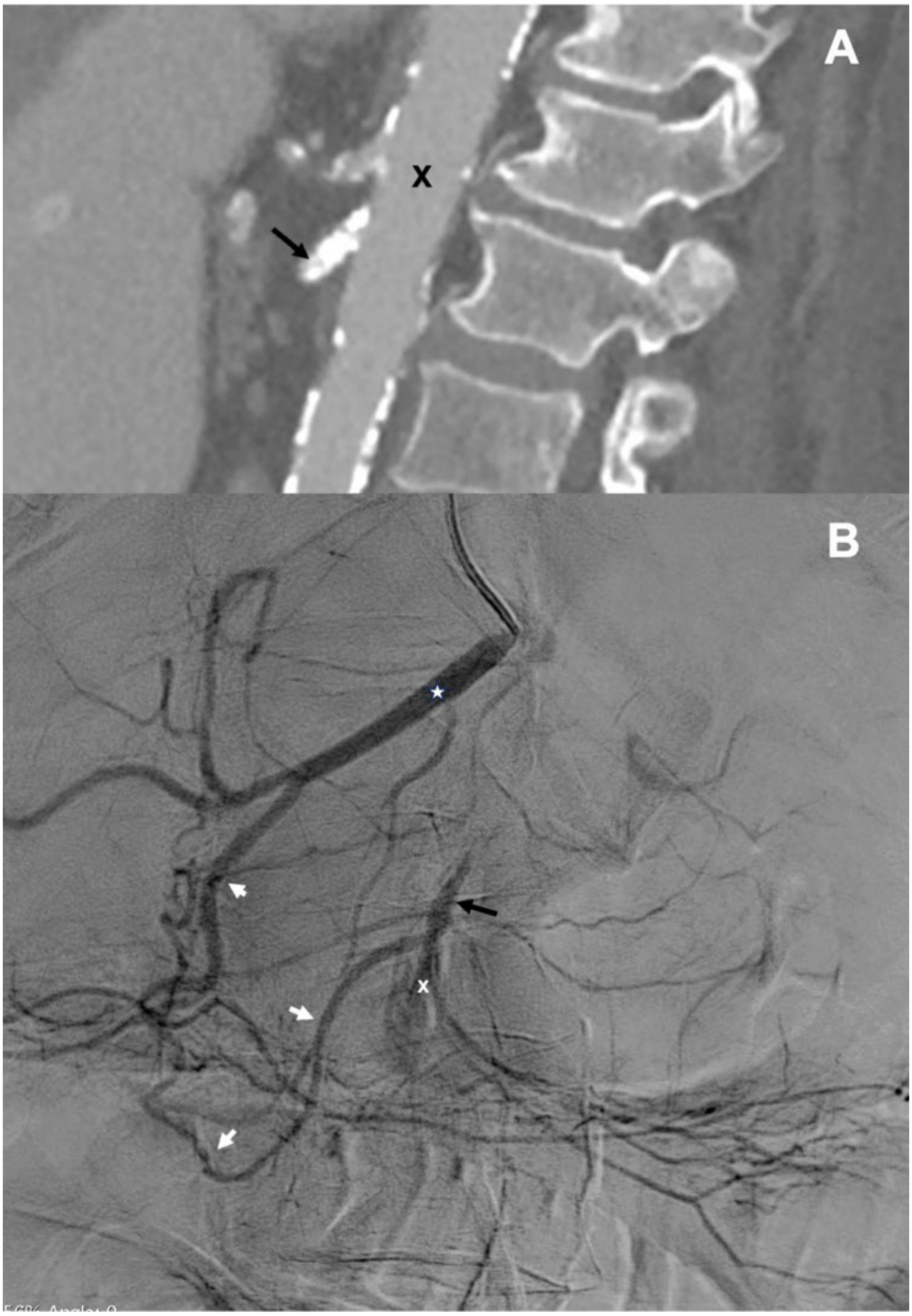

Figure 1. (**A**)—CT angiography of the aorta (X) and visceral arteries (sagittal projection): a highly calcified plaque 3 mm from the aorta, occluding proximal segment of the superior mesenteric artery (black arrow); (**B**)—Catheter angiography of the celiac trunk—common hepatic artery (asterisk) and gastroduodenal artery (white arrows) and retrograde inflow to the proximally occluded superior mesenteric artery (black arrow) and no inflow to the distal part of superior mesenteric artery (X).

First, we introduced a 5F vertebral diagnostic catheter to the distal part of the CHA, then the coaxial Progreat microcatheter (Terumo, Tokyo, Japan), which was navigated through the GDA and the pancreaticoduodenal arteries (PDA) to the SMA distally from the occluding plaque (Figure 2A). Thereafter, the occlusion that was highly calcified was crossed with 0.014″ and then 0.018″ guidewires. From the right brachial access, we introduced another 6F introducer sheath, which was placed at the level of the SMA. Guidewire, which has been previously navigated to the abdominal aorta across the lesion through the celiac trunk, the CHA, the GDA, the PDA, and the proximal SMA, was caught with a loop (Figure 2B). Then, through the 6F introducer sheath, in an antegrade direction, we introduced 2.5/20 mm and 4.0/20 mm Trek coronary dilatation catheters (Abbott Vascular, Abbott Park, IL, USA), and with these balloons, we predilated the plaque under the pressure of 6–18 atm.

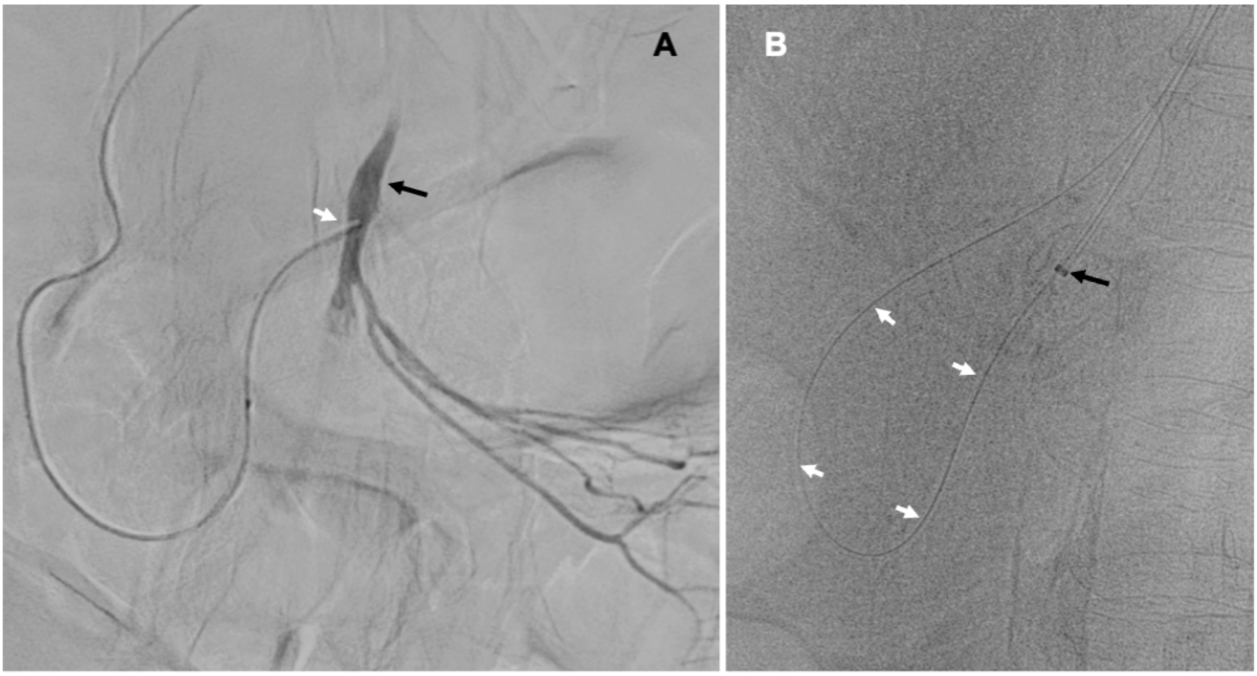

Figure 2. (**A**)—Microcatheter (white arrow) advanced to the superior mesenteric artery (black arrow) through the gastroduodenal and pancreaticoduodenal arteries; (**B**)—Guidewire (white arrows) navigated in a retrograde manner across the lesion to the aorta caught to the introducer sheath (black arrow).

After predilation, there was a good inflow to the SMA and its branches (Figure 3). Finally, the 6.0/38 mm Omnilink Elite balloon-expandable stent (Abbott Vascular, Abbott Park, IL, USA) was implanted in the proximal part of the SMA. After stent implantation, there was a brisk inflow to the target artery and its branches.

The duration of the recanalization procedure using retrograde access is extended compared to the antegrade recanalization procedure. The described procedure using retrograde access through the collaterals lasted 85 min. In the case of retrograde recanalization, the extension of the procedure time is related to two elements of the procedure: a/introducing a microcatheter into the SMA through the branches of collateral circulation, b/capturing the guidewire in the aortic lumen and inserting the catheter into the lumen from another femoral or brachial access.

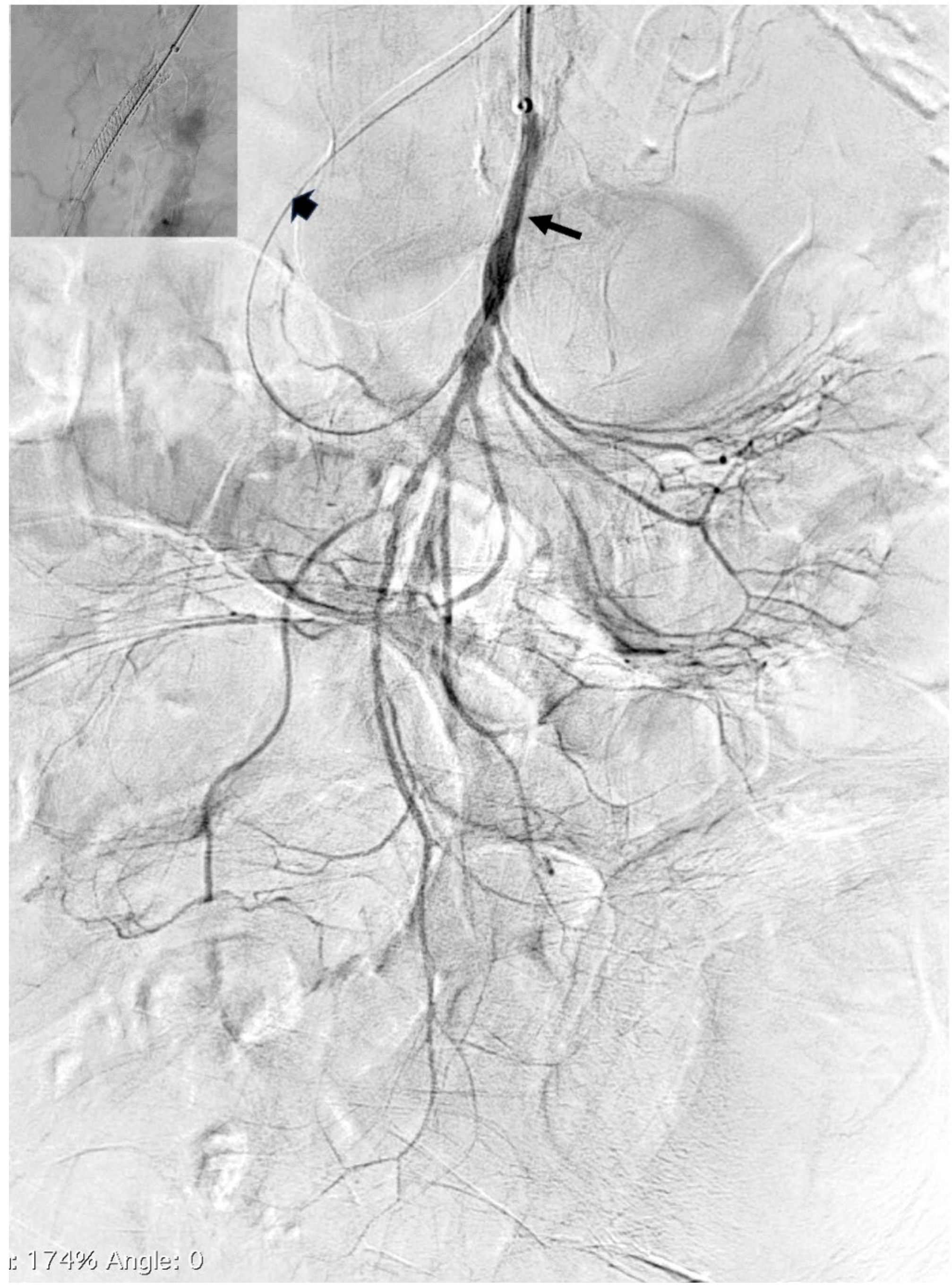

Figure 3. Catheter angiography after predilation of the proximal part of the superior mesenteric artery (black arrow), good inflow to this artery and its branches, thick arrow points the guidewire navigated through the branches of the celiac trunk; in the left upper corner of the picture after stent implantation.

Unfortunately, although the revascularization was successful, abdominal symptoms improved, and there were no longer biochemical signs of bowel ischemia, including normal values of serum lactate, the patient died 2 days after the procedure due to cardiogenic shock.

3. Discussion

We demonstrated that retrograde percutaneous recanalization of the occluded SMA is technically feasible, even in hemodynamically unstable patients. Currently, a recommended procedure in these patients is a hybrid one, comprising open exploratory laparotomy and retrograde endovascular recanalization of the SMA from direct puncture of this artery [8,9]. This is, however, not feasible in critically ill elderly patients, in whom an endovascular repair that is performed before irreversible bowel ischemia occurs remains the only life-saving option.

Of note, endovascular procedures are associated with fewer bowel resections and lower periprocedural mortality; on the other hand, an assessment of bowel viability is easier to perform during open surgical laparotomy. Nowadays, the following endovascular techniques aimed at revascularization of occluded SMA are available:

1. Antegrade (i.e., from the aorta) recanalization: this procedure should optimally be performed from the radial/brachial access since, in case of unfavorable aorta/SMA angle, the procedure is difficult to perform; also, this approach can be complicated by artery dissection,
2. Retrograde recanalization: this type of revascularization is typically performed as a hybrid procedure during the open laparotomy, which requires general anesthesia and is associated with surgical complications; currently, it is the recommended procedure for SMA revascularization;
3. Aspiration embolectomy: this procedure is relatively easy to perform, and clinical outcomes after embolectomy are usually good; still, it can be performed almost exclusively for the occlusions of embolic etiology;
4. Local thrombolysis of SMA: it is rarely performed for the occlusions of SMA since it is associated with frequent life-threatening hemorrhagic complications.

In patients presenting with SMA occlusion, who are unsuitable for hybrid retrograde recanalization of this artery, an antegrade transcutaneous endovascular revascularization is the preferred method. Still, the origin of the SMA should be visible on angiography. Optimally, the patent proximal segment of this artery should be at least 5–10 mm long. This problem cannot be overcome using the combination of CT angiography and catheter angiography (the so-called FUSION mode). A sharp angle between the aorta and SMA is another limitation of this approach since it is difficult to re-open stenotic plaques from the standard femoral access.

Therefore, an antegrade navigation through the proximal part of SMA is not always possible. In such a case, if open surgical exploration and retrograde recanalization during laparotomy cannot be done, the percutaneous endovascular retrograde procedure remains the only reasonable option to save the patient's life. Navigation to the patent segment of SMA can be performed either through the branches of the celiac trunk [4–7] or through the inferior mesenteric artery [10]. Preprocedural diagnostic should reveal which of these two potential routes is better. A relatively non-tortuous option should be preferred since a straight segment in proximity to the target lesion facilitates retrograde navigation of the guidewire to the aorta; otherwise, the SMA would be at risk of dissection and intraparietal guidewire placement. The decision for stent or stentgraft implantation after successful revascularization should depend on the hemodynamic success of the repair. In this particular patient, the predilation resulted in good inflow to the SMA; therefore, an uncovered stent was implanted.

In this particular patient, the endovascular revascularization of the SMA was performed similarly to the cases described before [4–7]. The only relevant technical difference regarded vascular access. Typically, endovascular procedures of the SMA are performed from the femoral access. In our patient, it was not possible, considering the risk of thrombotic re-occlusion of the femoral artery or problems with adequate hemostasis. Brachial access, which was used in our case, requires long catheters and guidewires (300 cm or longer), which are relatively difficult to navigate. Also, withdrawal of such a long guidewire from peripheral intestinal vessels should be performed with caution since the risk of injury to these tiny arteries during this maneuver is quite high.

There is also a potential advantage of the brachial access. In comparison with the femoral access, it is easier to introduce catheters to the SMA from the aorta using the brachial access, especially if the angle between the aorta and SMA is acute (which is typically seen in slim individuals) and plaques in the SMA are calcified.

Current endovascular armamentarium allows for relatively easy and safe navigation through the branches of the celiac trunk, on condition that the interventionalist is experienced in the use of these tiny and flexible catheters and guidewires [11–14]. It should also be noted that the progress in endovascular techniques for revascularization of abdominal visceral arteries particularly regards embolic occlusions. For example, mechanical thrombectomy devices, such as the Rotarex rotational atherectomy system (Becton Dickinson, Franklin Lakes, NJ, USA), allow for the successful removal of embolic material [15]. Still, mechanical thrombectomy cannot be safely used for the revascularization of distally located occlusions. In such cases, there is a considerably high risk of artery injury by the thrombectomy device. Therefore, distally located lesions should rather be recanalized in a similar manner that cerebral arteries. In our three patients (yet unpublished), we used cerebral reperfusion catheters for the thrombus removal from the distally located arteries, such as the ileocecal artery or ileal arteries: the Sofia microcatheter (MicroVention, Aliso Viejo, CA, USA) and React aspiration catheter (Medtronic, Minneapolis, MN, USA). These devices can be safely navigated to the target location with the use of the Progreat microcatheter (Terumo, Tokyo, Japan) and a 0.014″ flexible guidewire. It should be emphasized that the aforementioned reperfusion microcatheters are very flexible and, therefore, can be quite easily navigated into the distally located thin arteries, including very tortuous ones. In addition, these catheters are equipped with an inner lumen, which allows for aspiration thrombectomy of the occluding material. These catheters are available in sizes 5F to 7F, which facilitates a tailored approach to such procedures. Moreover, local catheter angiography can be performed through these devices, which allows for the detailed imaging of the target blood vessels and—if needed—for a modification of the procedure. It is also possible to deploy over these 0.014″ guidewires the coronary artery-dedicated balloon angioplasty catheters or stents. These catheters and stents, which are typically used in the coronary arteries, can also be applied in the arteries supplying the intestines. On the other hand, rheolytic thrombectomy devices, such as the AngioJet (Boston Scientific, Natick, MA, USA), are less frequently used. These endovascular devices are rather dedicated to the revascularization of a secondary embolism associated with the opening of proximally located critical stenosis in the superior mesenteric artery.

It can be summarized that there are several studies demonstrating better clinical outcomes after endovascular revascularization in comparison with open surgical treatment [3,16,17], and further progress should be expected in this field. For example, a consensus document by the European Society of Vascular Surgery recommends an endovascular repair as the first line therapy (class of recommendation IIa, level of evidence B) [3]. Yet, the meta-analysis from 2021 did not reveal significant differences between endovascular and surgical methods in terms of early and late clinical outcomes [18]; therefore, more studies in this field are needed. Still, several technical issues should be solved before these procedures become standard ones. In this paper, we present how one of these challenges can be overcome.

4. Conclusions

It can be concluded that percutaneous endovascular retrograde revascularization of thrombosed SMA in the settings of bowel ischemia is technically feasible, even in critically ill and hemodynamically unstable patients. Still, it should be emphasized that we presented only a case report; the final clinical outcome of this patient was unfavorable despite successful revascularization, and therefore, this conclusion should not be generalized. Obviously, more research is needed to recommend unequivocally the endovascular technique described in this paper as a standard one.

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Informed Consent Statement: Informed consent for publication was not obtained from the participant involved in this study for two reasons: firstly, the patient has deceased (according to legal regulation in the country of the patient, there is no such thing as the representative of a deceased person). Since the purpose of this publication is to disseminate medical knowledge and improve treatment outcomes for future patients, it was decided to publish it in the form of a case report. Moreover, in this article, only angiographic images are presented. It is not possible to recognize a person from the shape of her/his arteries; also, other clinical details presented could help in convicting the person only if the hospital documentation of such a person were screened and compared, but hospital documentation, as all medical records, is strictly confidential.

Data Availability Statement: Anonymized data presented in this case are available on request from the corresponding author. Preprint version of this paper is available at https://www.preprints.org/manuscript/202401.1796/v1 (accessed on 25 January 2024).

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Newton, W.B., 3rd; Sagransky, M.J.; Andrews, J.S.; Hansen, K.J.; Corriere, M.A.; Goodney, P.P.; Edwards, M.S. Outcomes of revascularized acute mesenteric ischemia in the American College of Surgeons National Surgical Quality Improvement Program database. *Am. Surg.* **2011**, *77*, 832.e8. [CrossRef] [PubMed]
2. Ryer, E.J.; Oderich, G.S.; Bower, T.C.; Macedo, T.A.; Vrtiska, T.J.; Duncan, A.A.; Kalra, M.; Gloviczki, P. Differences in anatomy and outcomes in patients treated with open mesenteric revascularization before and after the endovascular era. *J. Vasc. Surg.* **2011**, *53*, 1611.e8. [CrossRef]
3. Björck, M.; Koelemay, M.; Acosta, S.; Goncalves, F.B.; Kölbel, T.; Kolkman, J.J.; Lees, T.; Lefevre, L.H.; Menyhei, G.; Oderich, G.; 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. [CrossRef]
4. Wang, G.; Zhou, X.; Shu, X.; Wang, E.; Wang, L.; Fu, W. Transcollateral recanalization of an occluded superior mesenteric artery. *Ann. Vasc. Surg.* **2021**, *74*, 525.e7–525.e12. [CrossRef] [PubMed]
5. Kersjes, W.H.; Hesse, A. Percutaneous retrograde revascularization of chronic occlusions of the superior mesenteric artery via collaterals of the celiac artery. *CVIR Endovasc.* **2020**, *143*, 81. [CrossRef] [PubMed]
6. Robken, J.; Shammas, N.W. Treatment of a totally occluded superior mesenteric artery facilitated by retrograde crossing via collaterals from the celiac artery. *J. Endovasc. Ther.* **2007**, *14*, 745–747. [CrossRef] [PubMed]
7. Milner, R.; Woo, E.Y.; Carpenter, J.P. Superior mesenteric artery angioplasty and stenting via a retrograde approach in a patient with bowel ischemia—A case report. *Vasc. Endovasc. Surg.* **2004**, *38*, 89–91. [CrossRef]
8. Rebelo, A.; Partsakhashvili, J.; John, E.; Kleeff, J.; Ukkat, J. Current concepts and evidence on open, endovascular and hybrid treatment of mesenteric ischemia: The retrograde open mesenteric stenting. *Surg. Pract. Sci.* **2021**, *5*, 100022. [CrossRef]
9. Oderich, G.S.; Macedo, R.; Stone, D.H.; Woo, E.Y.; Panneton, J.M.; Resch, T.; Dias, N.V.; Sonesson, B.; Schermerhorn, M.L.; Lee, J.T.; et al. Multicenter study of retrograde open mesenteric artery stenting through laparotomy for treatment of acute and chronic mesenteric ischemia. *J. Vasc. Surg.* **2018**, *68*, 470–480.e1. [CrossRef]
10. Saadi, E.K.; Oderich, G.; Medronha, E.; Saadi, R.P.; Saadi, M.P.; Jaegger, C. Endovascular recanalization of occluded superior mesenteric artery using retrograde access through the inferior mesenteric artery. *J. Vasc. Surg. Cases Innov. Tech.* **2017**, *3*, 155–158. [CrossRef] [PubMed]
11. Naazar, A.A.; Omair, A.; Chu, S.H.; Keane, K.G.; Weber, D.G. A shifting trend towards endovascular intervention in the treatment of acute mesenteric ischemia. *Cureus* **2021**, *13*, e18544. [CrossRef]
12. Acosta-Mérida, M.A.; Marchena-Gómez, J.; Saavedra-Santana, P.; Silvestre-Rodríguez, J.; Artiles-Armas, M.; Callejón-Cara, M.M. Surgical outcomes in acute mesenteric ischemia: Has anything changed over the years? *World J. Surg.* **2020**, *44*, 100–107. [CrossRef]
13. Smith, S.F.; Gollop, N.D.; Klimach, S.G.; Murray, P.J. Is open surgery or endovascular therapy best to treat acute mesenteric occlusive disease? *Int. J. Surg.* **2013**, *11*, 1043–1047. [CrossRef] [PubMed]
14. Zhang, Z.; Wang, D.; Li, G.; Wang, X.; Wang, Y.; Li, G.; Jiang, T. Endovascular treatment for acute thromboembolic occlusion of the superior mesenteric artery and the outcome comparison between endovascular and open surgical treatments: A retrospective study. *BioMed Res. Int.* **2017**, *2017*, 1964765. [CrossRef] [PubMed]
15. Latacz, P.; Simka, M.; Mrowiecki, T. Endovascular embolectomy of the superior mesenteric artery using the Rotarex® system for the treatment of acute mesenteric ischemia. *Pol. Arch. Med. Wewn.* **2016**, *126*, 196–197. [PubMed]

16. Arnaoutakis, K.D.; Abularrage, C.J.; Efron, D.T.; Schneider, E.; Black, J.H., III. Comparison of open and endovascular treatment of acute mesenteric ischemia. *J. Vasc. Surg.* **2014**, *59*, 159–164.
17. El Farargy, M.; Abdel Hadi, A.; Abou Eisha, M.; Bashaeb, K.; Antoniou, G.A. Systematic review and meta-analysis of endovascular treatment for acute mesenteric ischaemia. *Vascular* **2017**, *25*, 430–438. [CrossRef] [PubMed]
18. Hou, L.; Wang, T.; Wang, J.; Zhao, J.; Yuan, D. Outcomes of different acute mesenteric ischemia therapies in the last 20 years: A meta-analysis and systematic review. *Vascular* **2021**, *21*, 17085381211024504. [CrossRef]