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Case Report

Endovascular Treatment for a Superior Mesenteric Arteriovenous Fistula Following Pylorus Preserving Pancreatoduodenectomy

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A superior mesenteric arteriovenous fistula (SMAVF) following gastrointestinal surgery represents a rare vascular complication. Enhanced computed tomography with 3-dimensional reconstruction proves to be the most efficacious modality for detecting this uncommon entity. Superior mesenteric angiography becomes imperative to accurately delineate the location and extent of mesenteric vessel involvement, which is essential for devising an optimal treatment strategy. Recently, endovascular therapy has garnered significant favor due to its less invasiveness compared to surgical interventions. Herein, we present a case of SMAVF after pancreaticoduodenectomy, manifesting with symptoms indicative of portal hypertension. Successful endovascular fistula closure using a balloon-expandable stent graft was achieved.

Keywords: superior mesenteric arteriovenous fistula, endovascular treatment, balloon-expandable stent grafts

Introduction

Superior mesenteric arteriovenous fistula (SMAVF) following gastrointestinal surgery or abdominal trauma is a rare vascular complication. It may manifest either acutely following abdominal trauma or insidiously over decades subsequent to gastrointestinal surgery.[1,2] Since its initial documentation in 1947, fewer than 50 cases have been reported in the English literature to date.[3] Clinical presentation varies depending on the size and location of the fistula.[4,5] Enhanced computed tomography (E-CT) with 3-dimensional reconstruction serves as the gold standard for detection, while superior mesenteric angiography is indispensable for precise localization and assessment of mesenteric vessel involvement, as well as the severity of portal hypertension, crucial for therapeutic planning. While surgical fistula ligation has conventionally been the preferred approach, it entails inherent risk. Recently, endovascular intervention has emerged as the preferred modality due to its reduced invasiveness.[4–9] This report outlines our experience utilizing a Viabahn VBX balloon-expandable stent graft (W. L. Gore & Associates, Inc., Newark, DE, USA) for successful closure of SMAVF following pylorus-preserving pancreatoduodenectomy, amendable to additional balloon molding to accommodate luminal caliber changes.

To the best of our knowledge, this presents the first reported case in the English literature employing a VIABAHN VBX balloon expandable stent graft for the treatment of SMAVF.

Case Report

A 63-year-old male patient was referred to our hospital for the treatment of an SMAVF. Pylorus-preserving pancreatoduodenectomy had been performed 3 months prior to the onset of symptoms for advanced pancreatic head cancer. Despite sustaining intermittent abdominal pain postoperatively, detailed examinations failed to reveal specific findings. E-CT did not detect any apparent SMAVF, and the patient was discharged with symptomatic relief achieved through analgesics. Suddenly, he presented with severe lower abdominal pain, subsequent to anorexia and loss of appetite, necessitating emergent transfer to his primary care hospital. E-CT revealed early enhancement of the superior mesenteric vein and abnormal communication between the superior mesenteric artery (SMA) and the superior mesenteric vein via a pseudoaneurysm. Massive ascites was observed (**Fig. 1A**). E-CT with 3-dimensional reconstruction showed an H-type communication between the artery and vein via a pseudoaneurysm, accompanied

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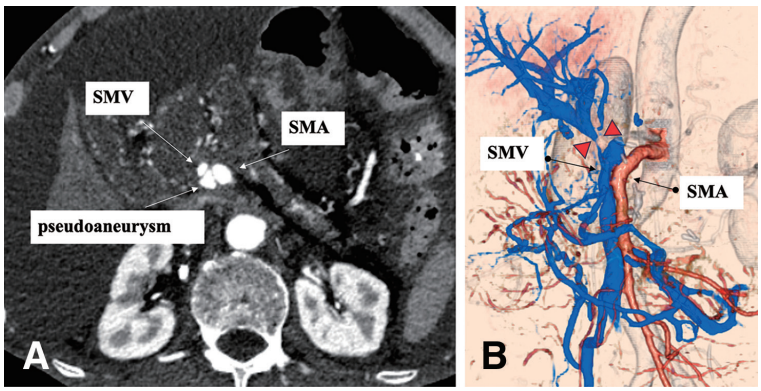

Fig. 1 (**A**) Axial E-CT reveals early enhancement of the SMV, showing the abnormal connection between the SMA and the SMV via a pseudoaneurysm. (**B**) E-CT with 3-dimensional reconstruction displays a fistula between a SMA and SMV in the proximal SMA with H-type communication, accompanied by stenotic changes in the portal vein proximal to the communication site (arrowheads). E-CT: enhanced computed tomography; SMV: superior mesenteric vein; SMA: superior mesenteric artery

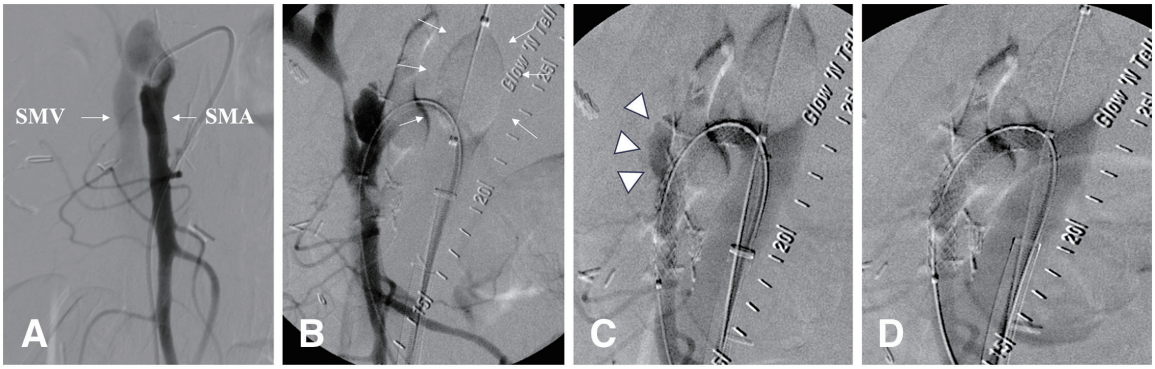

Fig. 2 (**A**) DSA confirms the precise location of the SMAVF, characterized by an H-type communication between the artery and vein. (**B**) The proximal balloon-blocking technique facilitated the smooth insertion of a catheter into the superior mesenteric artery (arrows). (**C**) DSA following stent graft deployment reveals an endoleak in the proximal portion of the fistula (arrowheads). (**D**) Completion angiography demonstrates the resolution of shunting flow following additional balloon molding to accommodate luminal caliber changes. SMV: superior mesenteric vein; SMA: superior mesenteric artery; DSA: digital subtraction angiography; SMAVF: superior mesenteric arteriovenous fistula

by stenotic changes in the portal vein proximal to the communication site[10] (**Fig. 1B**). Selective superior mesenteric arteriography confirmed the diagnosis of SMAVF (**Fig. 2A**). To alleviate his persistent abdominal symptoms, he was transferred to our hospital for further management.

Upon physical examination, he was alert with normotensive but exhibited sinus tachycardia. He was severely emaciated, with a body mass index below 16 kg/m^2 (height: 172 cm, weight: 46 kg). Abdomen distension due to ascites was noted, albeit without rebound tenderness or visible varicosities.

Arterial blood gas analysis demonstrated a normal pH level (7.399), decreased partial pressure of carbon dioxide (PCO_2: 27.8 mmHg), reduced base excess (BE: –7.8 mmol/L), and low bicarbonate (HCO_3–: 17.23 mmol/L), indicative of metabolic acidosis with a compensatory respiratory response. Lactate levels were noted at 2.8 mmol/L. Laboratory results revealed anemia (hemoglobin: 9.8 g/dL), thrombocytopenia (platelet count: 14.8 × 10^4/μL), significantly elevated gamma-glutamyltransferase (396 U/L), increased alkaline phosphatase (244 U/L), and mildly elevated transaminases (alanine aminotransferase/aspartate aminotransferase: 50/51 U/L). Other parameters, including bilirubin, blood urea nitrogen, creatinine, prothrombin time, and activated partial thromboplastin time, were within normal limits. Laboratory data are summarized in **Table 1**. Portal hypertension secondary to acute SMAVF was implicated as the cause of his symptoms, necessitating prompt intervention to prevent further deterioration.[4–6] Given the patient's compromised status, a less invasive approach was deemed preferable to surgical intervention. Endovascular fistula closure instead of surgical fistula ligation was scheduled.

The treatment was performed the following day. Under general anesthesia, the right femoral artery was accessed, and a short sheath was inserted. Although the guide wire was smoothly advanced into the SMA, we could not firmly engage a catheter for the treatment into the SMA due to its sharp curvature at the origin. To facilitate catheter insertion, we applied a balloon-blocking technique. After switching to

Table 1 Laboratory data

Peripheral blood cell		
WBC	6100	/μL
RBC	340	×10⁴/μL
Hb	9.8	g/dL
PLT	14.8	×10⁴/μL
Blood chemistry		
TP	6.8	g/dL
Alb	3.0	g/dL
T-Bil	0.5	mg/dL
AST	50	U/L
ALT	51	U/L
LDH	186	U/L
ALP	396	U/L
γ-GTP	244	U/L
Amylase	29	U/L
BUN	13	U/L
Cre	0.97	mg/dL
NH_3	97	mg/dL
CRP	0.22	μg/dL
Arterial blood gas		
pH	7.399	
$PaCO_2$	27.6	mmHg
PaO_2	141.5	mmHg
SaO_2	100	%
HCO_3−	17.23	mmol/L
BE	–7.8	mmol/L
Na^+	140.1	mmol/L
K^+	3.85	mmol/L
Cl^-	110.6	mmol/L
Ca^{++}	5.23	mmol/L
Lactate	2.8	mmol/L

WBC: white blood cell; RBC: red blood cell; Hb: hemoglobin; PLT: platelet; TP: total albumin; Alb: albumin; T-Bil: total bilirubin; AST: aminotransferase; ALT: alanine aminotransferase; LDH: lactate dehydrogenase; ALP: alkaline phosphatase; γ-GTP: gamma-glutamyl transpeptidase; BUN: blood urea nitrogen; Cre: creatinine; NH_3: ammonia; CRP: C-reactive protein; pH: potential hydrogen; $PaCO_2$: partial pressure of arterial carbon dioxide; PaO_2: partial pressure of arterial oxygen; SaO_2: arterial oxygen saturation; HCO_3–: bicarbonate; BE: base excess

a stiff-type guide wire, a 20-Fr Gore DrySeal sheath (W. L. Gore & Associates, Inc., Newark, DE, USA) was introduced into the abdominal aorta and advanced near the SMA origin. The Gore Molding & Occlusive balloon (W. L. Gore & Associates, Inc., Newark, DE, USA) was inflated proximally to the SMA during the procedure to prevent catheter prolapse. This maneuver enabled the smooth insertion of a catheter into the SMA, and a 7-Fr Parent Cross guiding sheath (Medikit Co., Ltd., Tokyo, Japan) was introduced into SMA via the DrySeal sheath (**Fig. 2B**). Digital subtraction angiography (DSA) confirmed the precise location of the fistula in the proximal SMA, characterized by an H-type communication between the artery and vein via a pseudoaneurysm.[10] Deployment of a balloon expandable stent graft was meticulously executed to ensure optimal coverage of the fistula without compromising adjacent branches. The diameter of SMA is 7 mm proximally and 5 mm distally to the fistula. Given the anatomical configuration of the SMA, a Gore Viabahn VBX balloon-expandable stent graft, 6 mm in diameter and 59 mm in length, was selected to prevent intimal injury or dissection from excessive oversizing. Post-stent graft deployment DSA revealed an endoleak in the proximal portion of the fistula (**Fig. 2C**). To accommodate luminal caliber changes, the proximal portion of the stent graft was dilated gently using an 8 mm short balloon. Completion angiography demonstrated the resolution of shunting flow (**Fig. 2D**).

Fig. 3 E-CT with 3-dimensional reconstruction shows complete closure of the SMAVF. E-CT: enhanced computed tomography; SMAVF: superior mesenteric arteriovenous fistula

Abdominal symptoms ameliorated post-treatment. Postoperative E-CT showed complete closure of the SMAVF (**Fig. 3**). The patient commenced single antiplatelet therapy following the procedure.

No evidence of recurrent SMAVF was observed during short-term follow-up.

Discussion

SMAVF is a rare vascular disorder. Since Nusselt reported the first case in 1947,[3] fewer than 50 cases have been documented in the English literature. The etiology of SMAVF is primarily associated with gastrointestinal surgery and, secondarily, with abdominal trauma.[6,10]

SMAVF may present acutely following abdominal trauma, inducing acute small bowel ischemia,[1] or it may develop gradually without specific symptoms even 2 decades post-initial gastrointestinal surgery.[2] Often, an abdominal bruit can be auscultated over the fistula.

Clinical symptoms vary based on the size and location of the fistula. Mesenteric ischemia due to the steal phenomenon can induce anorexia, abdominal pain, and diarrhea postprandially. Portal hypertension can lead to ascites and esophageal varices, culminating in fatal gastrointestinal bleeding. Right heart failure is a delayed presentation of SMAVF.[4,6,9] In acute cases, as in our case, hemodynamic deterioration may occur if untreated promptly, necessitating precise diagnosis and rapid treatment is the only way to prevent a catastrophic outcome.[4–6]

Doppler ultrasound is convenient for detecting a suspicious case in the presence of an abdominal murmur but requires significant technical expertise for accurate evaluation. E-CT is the most effective modality for detecting this rare condition in clinical settings. E-CT can reveal an abnormal connection between the SMA and vein via a pseudoaneurysm, with the superior mesenteric vein often showing aneurysmal changes in chronic states. E-CT with 3-dimensional reconstruction can define the precise location and extent of mesenteric vessel involvement. Superior mesenteric angiography remains the gold standard for diagnosing SMAVF, as it can determine the location and size of the fistula and assess the severity of portal hypertension.[4,6,7]

Due to its rarity, the optimal treatment for SMAVF remains controversial. Before the 2000s, surgical fistula closure was the primary treatment, showing good outcomes despite posing procedural risks. With advancements in interventional technology, endovascular treatments have recently emerged as less invasive alternatives, showing comparable results to surgical options. To date, more than 30 cases have been treated using endovascular techniques, including coil, plug, and stent placement, with a success rate of 95%–100% as reported in the English literature. In our case, we performed endovascular treatment under general anesthesia, employing an endovascular aneurysm repair technique via a retrograde approach using a large access sheath to stabilize catheter manipulation. The transbrachial antegrade approach, utilizing a low-profile access sheath under local anesthesia, is a more refined and less invasive method in the hands of experienced teams. Donell et al. proposed an anatomical classification of the fistula into U and H types. In the U type, the artery directly connects with the vein, usually following bowel surgery without a distal bowel segment.[10] In this type, coil embolization can be applied. Due to the high-flow nature of SMAVF, coil migration can occur. Plug implantation with a microcatheter system is appropriate to prevent migration.[2,7] In chronic states, the superior mesenteric vein often shows aneurysmal changes. Anticoagulation therapy is recommended to prevent thrombus formation in the superior mesenteric vein (SMV) post-procedure.[2,7] In the H type, the artery and vein communicate side-to-side through a pseudoaneurysm, typically following abdominal trauma. Covered stent graft implantation is preferred if there is a sufficient landing zone proximal and distal portion to the fistula. Currently, 2 types of covered stent grafts are available: self-expanding and balloon-expandable. Self-expanding stent grafts are flexible and resistant to kinking but may migrate.[6,8] Balloon-expandable stent grafts allow precise deployment to prevent side branch occlusion and can be molded to fit luminal changes with additional balloon dilation.[9]

In our case, the proximal SMA diameter was 7 mm and 5 mm distal to the fistula, showing an H-type configuration. A Gore Viabahn VBX balloon-expandable stent graft allowed precise deployment without covering adjacent branches. The endoleak observed after initial stent graft deployment was mitigated with additional balloon dilation. Balloon expandable stent grafts (Gore Viabahn VBX, etc.) may be preferable for treating SMAVF, accommodating natural anatomical configurations in the SMA. If an arteriovenous fistula is located near side branches without a sufficient sealing zone, coil or plug embolization is appropriate.

Conclusion

We reported a case of SMAVF following pylorus-preserving pancreaticoduodenectomy. The endovascular treatment proved effective and preferable to surgical options for this frail patient, given anatomical suitability. A balloon-expandable stent graft is advantageous for treating SMAVF with caliber changes.

Disclosure Statement

The authors declare that they have no conflict of interest.

Author Contributions

Study conception: SK
Data collection: all authors
Analysis: SK
Investigation: all authors
Critical review and revision: all authors
Final approval of the article: all authors
Accountability for all aspects of the work: all authors.

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