Case Report

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Endovascular Reintervention for Stent-Graft Dislocation after Open Surgical Conversion for Thoracoabdominal Aortic Aneurysm Treated by Thoracic Endovascular Aortic Repair

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Complex anatomical restrictions can lead to further interventions after the emergence of a postoperative aneurysm enlargement in thoracic endovascular aortic repair (TEVAR) for a thoracoabdominal aortic aneurysm (TAAA). A 75-year-old male underwent a TEVAR for a Crawford extent I TAAA. The main device and the distal extension were placed using a fenestrated technique, outside of the instructions for use. The aneurysm expanded because of an endoleak and stent graft migration; and was surgically repaired by fully salvaging the previous endografts 38 months after the first TEVAR. However, the distal extension, which was the proximal anastomosis site with a prosthetic graft, became completely dislocated from the main device eight months after the open surgical conversion, resulting again in the enlargement of the aneurysm. An additional TEVAR was successfully performed to correct the dislocated stent graft. An appropriate treatment strategy is crucial to prevent multiple reinterventions for TAAA with complex anatomical restrictions.

Key Words: Thoracic endovascular aortic repair, Thoracoabdominal aortic aneurysm, Stent-graft migration, Endoleak, Open surgical conversion

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INTRODUCTION

Treatment of thoracoabdominal aortic aneurysm (TAAA) includes approaches such as open surgical repair (OSR) and endovascular treatment, which are associated with high mortality and morbidity rates in high-risk patients. In recent years, endovascular treatment has been preferred for patients with complex TAAA who are at high risk owing to old age or the presence of comorbidities [1]. However, complete aneurysm exclusion is sometimes difficult for complex TAAA, resulting in the need for fenestrated or branched thoracic endovascular aortic repair (TEVAR) because complex TAAA is usually outside of the instructions for use (IFU) for current TEVAR devices [2]. In particular, postoperative endoleaks are associated with aneurysm enlargement, stent graft (SG) migration, and an increased need for reintervention [3]. The case report was approved by the Institutional Review Board of the Kushiro Kojinkai Memorial Hospital (IRB no. 2022-10-01). Consent for publication of this case report and related images was obtained from the patient.

CASE

A 75-year-old male was admitted to our hospital for

TAAA. Comorbidities included hypertension, dyslipidemia, bilateral carotid artery stenosis, and chronic obstructive pulmonary disease (COPD). Coronary artery bypass grafting (CABG) was performed for unstable angina pectoris 8 years ago. A TAAA measuring 61 mm along the minor axis, classified as a Crawford extent I aneurysm, was identified (Fig. 1A). No landing zone was observed above the celiac artery (CA). The length between the CA and the superior mesenteric artery (SMA) was only 7 mm, which was outside the IFU because the distal fixation site length needed to be >25 mm (Fig. 1B). However, the JapanSCORE, Japan's nationwide risk model, published by the Japan Adult Cardiovascular Surgery Database (JACVSD), predicted a 30-day operative mortality rate of 7.2% and a 30-day operative mortality plus the main complication rate of 35.9% if OSR was selected. TEVAR was performed as a minimally invasive surgery. A Zenith TX2 TAA endovascular graft (ZTEG-2P-34-202-PF; Cook Medical Inc.) was deployed to cover the TAAA. Although the distal edge of the first SG was directly above the CA, a type IB endoleak was observed during surgery (Fig. 1C). A Zenith TX2 TAA distal extension (ESBE-36-77landing-T-PF-D; Cook Medical Inc.) was placed directly above the SMA to preserve the CA perfusion in preparation for the in situ fenestration procedure. The site of 12 mm fenestration was created using Goose Neck Snares (Medtronic) 7 mm proximal to the distal edge to create a distal landing zone. The post-implantation aortogram showed complete exclusion of the aneurysm, without endoleaks (Fig. 1D). Postoperative contrast-enhanced computed tomography (CT) indicated a poorly enhanced celiac

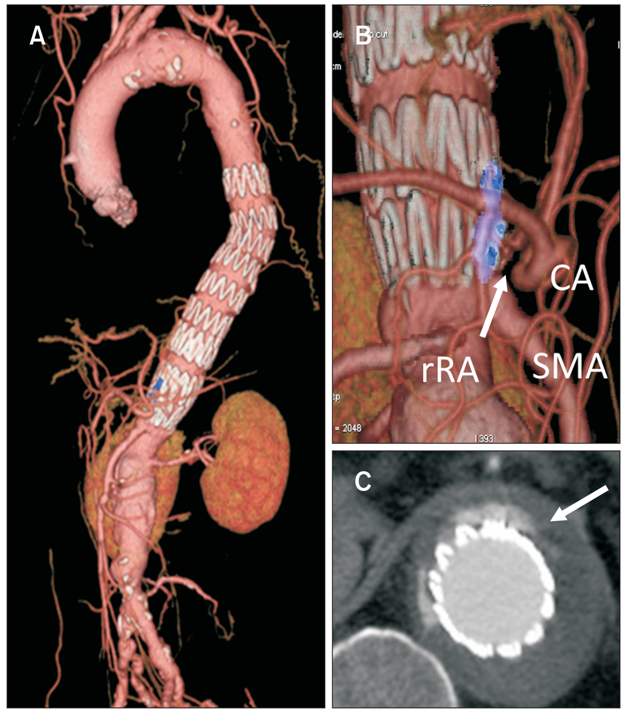

Fig. 2. Postoperative computed tomography (CT) after the first thoracic endovascular aortic repair (TEVAR). (A) Postoperative three-dimensional CT angiography after the first TEVAR. (B) The celiac trunk was poorly enhanced after fenestrated TEVAR; however, perfusion of the CA branches was confirmed (arrow). (C) Axial CT image showed a small amount of endoleak from the fenestration site or the distal edge of the SG (arrow). CA, celiac artery; rRA, right renal artery; SMA, superior mesenteric artery.

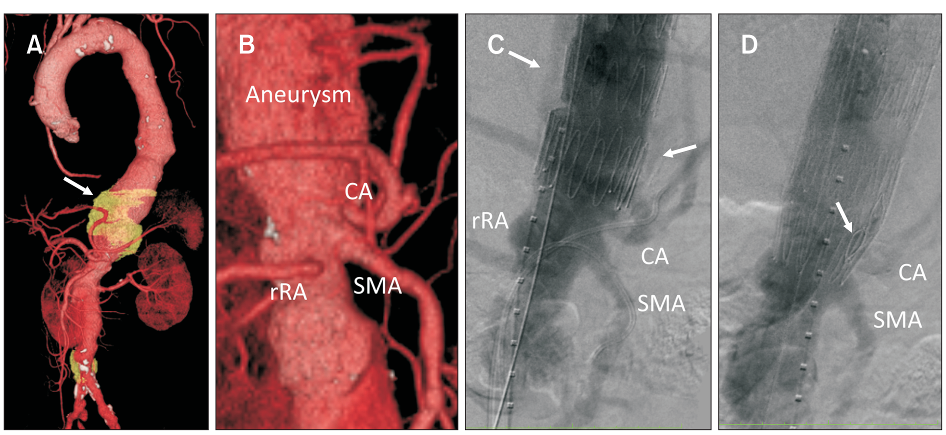

Fig. 1. Preoperative three-dimensional computed tomography angiography (3D-CTA) and the initial treatment. (A) Preoperative 3D-CTA demonstrated a Crawford extent I thoracoabdominal aortic aneurysm (arrow). (B) There was not a sufficient distal landing zone above the celiac artery (CA) to place a stent graft (SG). Only 7-mm space between the CA and superior mesenteric artery (SMA) was observed. (C) Intraoperative angiography showed type IB endoleaks after the first SG deployment (arrows). (D) Distal extension with in situ fenestration using Goose Neck Snares (arrow) was deployed to create a distal landing zone. The type IB endoleaks disappeared. rRA, right renal artery.

trunk and a small number of endoleaks from the distal edge or fenestration (Fig. 2A-C). The aneurysm appeared to have become smaller during the 19 months following the initial TEVAR; however, gradual dilatation of the aneurysm was observed beginning 24 months after the initial TEVAR.

The distal extension was completely separated from the distal landing zone (Fig. 3A). It migrated proximally and caused type IB endoleaks (Fig. 3B, C). The aneurysm enlarged to 68 mm at 37 months after the initial TEVAR (Fig. 3C). Additional TEVAR was inappropriate because of the unfavorable anatomy; both renal arteries and the SMA were involved with the distal landing zone, and an abdominal aortic aneurysm (AAA) with a maximum size of 57 mm was also observed. There are no commercially available devices for preserving the aortic branches in Japan. With the surgeon's modified technique, it seemed to be technically difficult to exclude TAAA and AAA. The JapanSCORE predicted a 30-day operative mortality rate of 8.5% and a 30-day operative mortality plus main complication rate of 40.9% when OSR was selected. The open distal aortic repair was reliable for resolving the disconnection of the distal component and endoleaks. Left thoracotomy and laparotomy were performed with the patient in the right half-side-lying position under general anesthesia. We confirmed that the distal extension was fully overlapping and adhered to the main device. The proximal site of the 28-mm J Graft (Japan Lifeline Co., Ltd.) was anastomosed to the distal extension, which was trimmed, and the distal site was anastomosed to the descending aorta above the CA. The AAA was also resected and replaced with a 20-mm J Graft (Japan Lifeline Co., Ltd.; Fig. 3D). The postoperative course was satisfactory, and the patient was discharged on postoperative day 26.

A contrast-enhanced CT performed during a regular outpatient visit 8 months after the OSR showed that the aneurysm had increased in size despite multiple aortic operations (Fig. 4A). The distal extension migrated approximately 5 cm toward the distal side at an angle of approximately 60° toward the left, and the main device in the central portion was completely dislocated (Fig. 4B). Emergency surgery was performed to prevent a rupture. The JapanSCORE predicted a 30-day operative mortality rate of 22.7% and a 30-day operative mortality plus main complication rate of 65.4% when OSR was selected. TEVAR was considered based on patient comorbidities and multiple aortic surger-

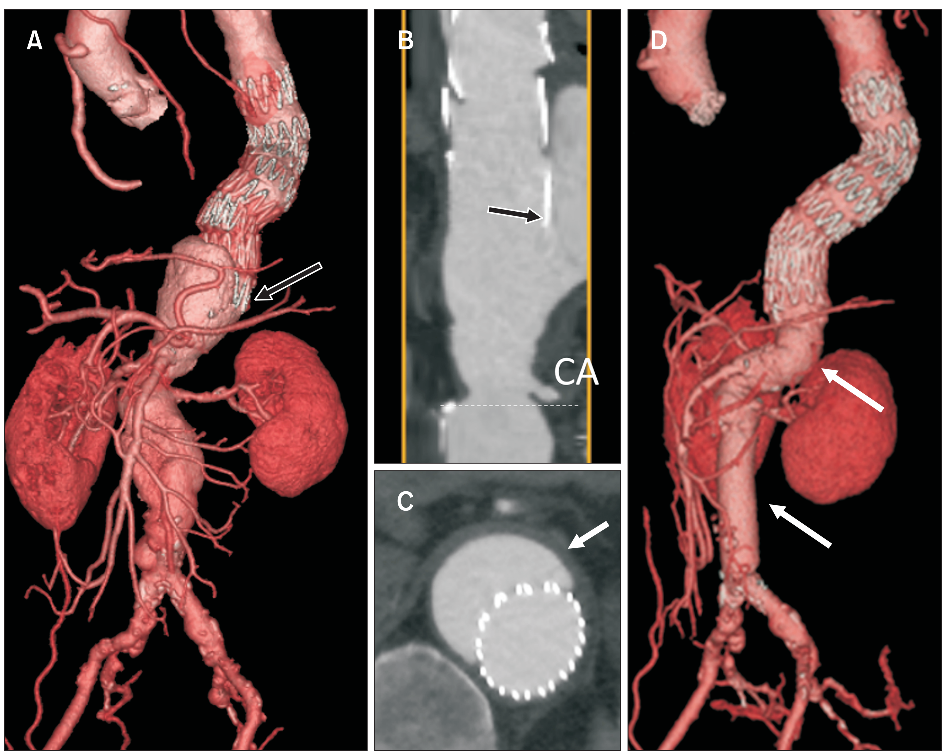

Fig. 3. Aneurysm enlargement due to stent graft migration and open surgical conversion. (A-C) Three-dimensional computed tomography angiography 37 months after the first thoracic endovascular aortic repair demonstrated aneurysm enlargement (white arrow) due to type IB endoleaks and stent graft migration. The distal edge of the distal extension was separated from the distal landing zone (black arrows). (D) Open surgical conversion was performed for the enlarged aortic aneurysm. The proximally migrated distal extension was anastomosed with the synthetic vascular graft (white arrows). The abdominal aortic aneurysm was also replaced with a synthetic vascular graft. CA, celiac artery.

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Fig. 4. Second endovascular aortic repair for stent graft dislocation after the open surgical conversion. (A) Preoperative three-dimensional computed tomography angiography (3D-CTA) at the third operation showed aneurysmal formation again. (B) The distal extension that was anastomosed with the synthetic vascular graft was dislocated from the proximal stent graft (arrow). (C) The guidewire was advanced through the migrated stent graft. (D) An additional stent graft was deployed through the migrated distal extension. (E) No endoleak was confirmed after the deployment. (F) CTA showed that the stent graft was successfully deployed, and there was no endoleak after the surgery.

ies and was performed in the supine position under general anesthesia. Incisions were made into the skin on the bilateral inguinal regions, and the common femoral artery (CFA) was identified and taped. The brachial artery was punctured at the right elbow and a 5-Fr sheath was inserted, considering the possibility that a pull-through wire would be needed. We inserted a 6-Fr sheath from the right CFA and were able to cross the distal extension that had migrated, as well as the proximal SG, using a Radifocus guidewire (TERUMO; Fig. 4C). The angle of the distal extension that migrated was corrected when the guidewire was replaced with the Lunderquist Extra-Stiff Wire Guide (Cook Medical Inc.). Consequently, we determined that TEVAR could be performed without using the pull-through wire technique. The GORE TAG Conformable Thoracic Stent Graft with ACTIVE CONTROL System (TGMR404020, GORE) was placed so that the proximal SG migrated distally and the distal prosthetic graft fully overlapped (Fig. 4D). The final contrast-enhanced image showed no endoleaks, confirming that migration had been corrected (Fig. 4E). The operative duration was 104 minutes, with only a small amount of bleeding. Postoperative CT showed no endoleaks, and the patient was discharged 13 days after surgery (Fig. 4F). Currently, the patient is under outpatient observation without aneurysm dilation.

DISCUSSION

Complex TAAA repair necessitates meticulous preoperative planning based on anatomical and patient comorbidities. Although OSR has been the gold standard for decades, it is a highly invasive procedure, requiring appropriate patient selection in the endovascular era [4]. The clinical outcomes of TAAA using JACVSD revealed that approximately 60% of TAAA cases were treated with OSR, and TEVAR was used in approximately 30% of TAAA cases, especially for high-risk patients. These proportions differed from those of other aortic sites. OSR remains the first-line treatment for TAAA; however, it is a highly invasive procedure, and physicians are hesitant to aggressively treat high-risk patients. When applied to anatomically complicated TAAA, TEVAR has limited reliability and benefits from reduced invasiveness; thus, physicians are hesitant to use this technique aggressively in low-risk patients [5]. In the current case, high 30-day mortality and major complication rates were observed based on the JapanSCORE. These OSR prediction rates may increase in complicated cases; however, OSR can be safely performed as a reliable treatment if performed for the first time. The patient had a short distal seal zone, which was indicated to be outside of the IFU. Nevertheless, TEVAR was performed using a fenestration technique because of the high invasiveness of OSR. Several concerns were considered when selecting TEVAR with one fenestration for the CA: 1) It was difficult to accomplish a TEVAR procedure using a physician's modified endograft with the creation of 3 to 4 fenestrations for the CA, SMA, and both renal arteries; 2) Only one fenestration for the CA would be sufficient to cover the distal landing zone, although the distance between the CA and SMA was less than 10 mm; and 3) Although treatment of the TAAA and endovascular aortic repair at the first time could be effective in preventing type IB endoleak, an increase in postoperative paraplegia risk was considered. Postoperative endoleaks and lesion progression accelerated aneurysm enlargement, resulting in multiple reinterventions.

Delayed development of endoleaks and the resultant continued expansion of the aneurysm sac is a known possibility of endovascular TAAA repair [6]. TEVAR for thoracic aortic aneurysms is frequently performed outside the IFU. The reintervention-free survival rate was lower in patients outside the IFU, with a hazard ratio of approximately 10 for TEVAR-related reintervention [2]. In Japan, several problems are associated with TEVAR for TAAA, including the need for the surgeon to modify the process of creating the fenestration and branch to preserve the abdominal branch [7]. Thus, TEVAR for TAAA can be used for complex TAAA cases that were previously treated with TEVAR outside the IFU. In a Japanese investigation of the therapeutic outcomes of TEVAR for TAAA at a single center, Baba et al. reported a high incidence of endoleaks (23%), requiring reintervention for fenestrated TEVAR [8]. Reintervention-free survival due to endoleaks was significantly lower outside than inside the IFU, with a hazard ratio of 9.7 for TEVAR-related reintervention [2]. In the current case, TEVAR was performed outside the IFU. The short distal landing zone created a small number of endoleaks, regardless of the fenestrated TEVAR. Although the aneurysm exhibited a temporary tendency toward shrinkage, it dilated 2 years postoperatively, which may have been due to gradual aneurysm dilatation caused by minute endoleaks. To reduce endoleaks, one option is embolization without CA preservation if blood flow to the CA via the SMA branch can be confirmed during surgery and the possibility of a postoperative endoleak is considered [9].

Endovascular treatment is less invasive; however, postoperative endoleak development and SG migration are negatively associated with therapeutic outcomes. Reintervention for adverse events after TEVAR should be considered. OSR, as a secondary procedure after endovascular aortic therapy, is an important treatment option in the endovascular era. Recently, the rate of open surgical conversion after TEVAR has been reported to be as high as 8% [10]. The common indications for reintervention following TEVAR were endoleaks (33%) and proximal or distal disease progression (20%), as per the data from a systematic review and meta-analysis. The perioperative mortality rate varies (0%-33%) depending on the indication for surgical conversion [11]. Although most types of endoleaks can be resolved using endovascular techniques, OSR has been suggested for treating aortic enlargement. Type 1 endoleaks are a common indication for OSR after endovascular repair [12]. The current case also had both type IB endoleaks and aneurysm enlargement (Fig. 2). Background risks included a history of CABG, bilateral carotid artery stenosis, and COPD, although the patient was younger than 80 years old; thus, minimally invasive TEVAR was selected as the initial surgical procedure. Migration of the fenestrated device was associated with aneurysm dilatation due to endoleaks. The open surgical conversion was reliable from an anatomical perspective of the aortic branches, although the background risks in the present case were high. Thus, endovascular or surgical reintervention is required to control endoleaks after TEVAR. In complicated cases, such as the current case outside the IFU, surgical reintervention is favorable to overcome the anatomical complexity of the aorta unless surgeons have abundant experience with fenestrated or branched TEVAR and TEVAR using the chimney technique. High-volume centers performing these techniques can expect acceptable outcomes for TAAA repair and endovascular treatment endoleaks after TEVAR in anatomically complex cases [13]. In an open surgical conversion, previous SGs were fully salvaged and used as the proximal anastomosis site. Considering the connection between the SGs, the stability of the distal extension should be noted because the distal extension overlapped only with the proximal SG but was not fixed to the aortic wall. The SG must adhere well to the aortic wall; otherwise, an anastomosis with the surrounding arterial wall is required. Alternatively, it may be better to deploy additional SG with scallops to create stable anastomosis sites. Eight months postoperatively, the aneurysm recurred. The cause of the second aneurysm dilatation was reduced overlap between the proximal main SG and the distal extension owing to the pulling down of the distal extension in a caudal direction for anastomosis with the synthetic vessel. Therefore, in reducing the fixed force between the main devices, the distal extension migrated toward the distal side and was completely dislocated. This is believed to have resulted in SG migration. The reason for anastomosis of the prosthetic graft to the distal extension was that solid fixation of the distal extension on the proximal SG was intraoperatively confirmed, and proximal dissection and exposure of the proximal SG were avoided in the current case. Based on the dislocation of the distal extension from the proximal main SG, it would have been ideal to remove the distal extension and perform OSR with the proximal SG, in which case the subsequent dislodgement of SGs would have been prevented. Fortunately, we were able to insert a guidewire to bridge the union between the main device and the dislocated distal extension in the present case. This made TEVAR possible and ensured a satisfactory postoperative course without complications.

We present a high-risk case that required endovascular reintervention after open surgical conversion for a TAAA initially treated with TEVAR. TEVAR plays a crucial role in the treatment of TAAA, particularly in high-risk patients; however, TEVAR outside of the IFU can result in multiple reinterventions, including open surgical conversion and endovascular treatment for aneurysm enlargement due to endoleaks and SG migration.

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CONFLICTS OF INTEREST

The authors have nothing to disclose.

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