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Case report

Diagnosis and treatment of carotid-left subclavian bypass graft infection complicated with mitral valve aneurysm and perforation following hybrid TEVAR: A case report

Jinting Ge [1], Chengxin Weng [1], Jichun Zhao, Ding Yuan, Bin Huang, Tiehao Wang [*]

Division of Vascular Surgery, Department of General Surgery, West China Hospital, Sichuan University, Chengdu, 610041, China

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ABSTRACT

Hybrid thoracic endovascular aortic repair (TEVAR) has been proved to be an effective and reliable treatment option for aortic arch diseases requiring extension of the proximal landing zone. However, hybrid TEVAR was associated with potential risk of post-operative complications, including cerebral infarction, endoleaks and paraplegia. Here we reported a rare case of bypass graft infection complicated with mitral valve aneurysm and perforation following landing zone 2 hybrid TEVAR procedure, who presented with symptoms of fever, major bleeding and anastomotic pseudoaneurysm and received emergency bypass graft removal and stent implantation with acceptable short and midterm follow-up results.

1. Introduction

Thoracic endovascular aortic repair (TEVAR) has been accepted as the first-line treatment for acute "complicated" type B aortic dissection (TBAD), or to prevent future aneurysmal degeneration in high-risk patient [1]. However, TEVAR in patients with aortic arch or proximal thoracic aortic diseases is challenging due to the limited proximal landing zone (LZ) for stent graft placement [2]. Therefore, hybrid TEVAR, which combines open surgical supra-aortic trunk (SAT) revascularization and TEVAR, has been introduced to preserve the SAT and provide sufficient proximal LZ [3]. Despite the technical soundness and effectiveness in treating aortic arch pathologies, hybrid TEVAR carries a relatively high risk of post-operative complications (endoleaks, stroke, spinal cord ischemia, e.g.). The standard treatment for these complications remains controversial [2,4–6].

Herein we presented a rare case of a 38-year-old male with bypass graft infection accompanied by aneurysm and perforation of mitral valve (MV) following hybrid TEVAR. The patient presented with persistent fever, anastomotic pseudoaneurysm and major bleeding and made a full recovery after emergency hybrid procedures.

2. Case presentation

A 38-year-old male was admitted to our hospital due to persistent and aggravated chest pain for 3 months. The patient had a medical history of hypertension, which was well controlled with oral medication (Nifedipine 30mg/day) for the past 2 years. He had no

* Corresponding author. Division of Vascular Surgery, Department of General Surgery, West China Hospital, Sichuan University, 37 Guo Xue Alley, Chengdu 610041, China.
E-mail address: tiehao.wang@wchscu.cn (T. Wang).
[1] These authors contributed equally to this work.

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past medical and family history of connective tissue disease. Emergency computed tomography angiography (CTA) revealed expansion and dissection of proximal descending aorta with a maximum diameter of 4.6 × 4.0 cm (Fig. 1A–B). Therefore, a diagnosis of descending aortic dissecting aneurysm was proposed.

Further CTA examination showed no significant abnormalities in coronary arteries and cerebral vessels. Blood auto-immune test was normal. Routine echocardiography revealed mild mitral and aortic valve regurgitation with no signs of endocarditis, valve aneurysm or valve perforation (Fig. 1C–D). The pulse of bilateral upper and lower extremity arteries was normal.

Because dissecting aneurysm was in close proximity to left subclavian artery (LSA) and there was insufficient LZ for stent graft, a hybrid procedure involving left carotid-subclavian bypass and TEVAR surgery was performed under general anesthesia. Initially, two

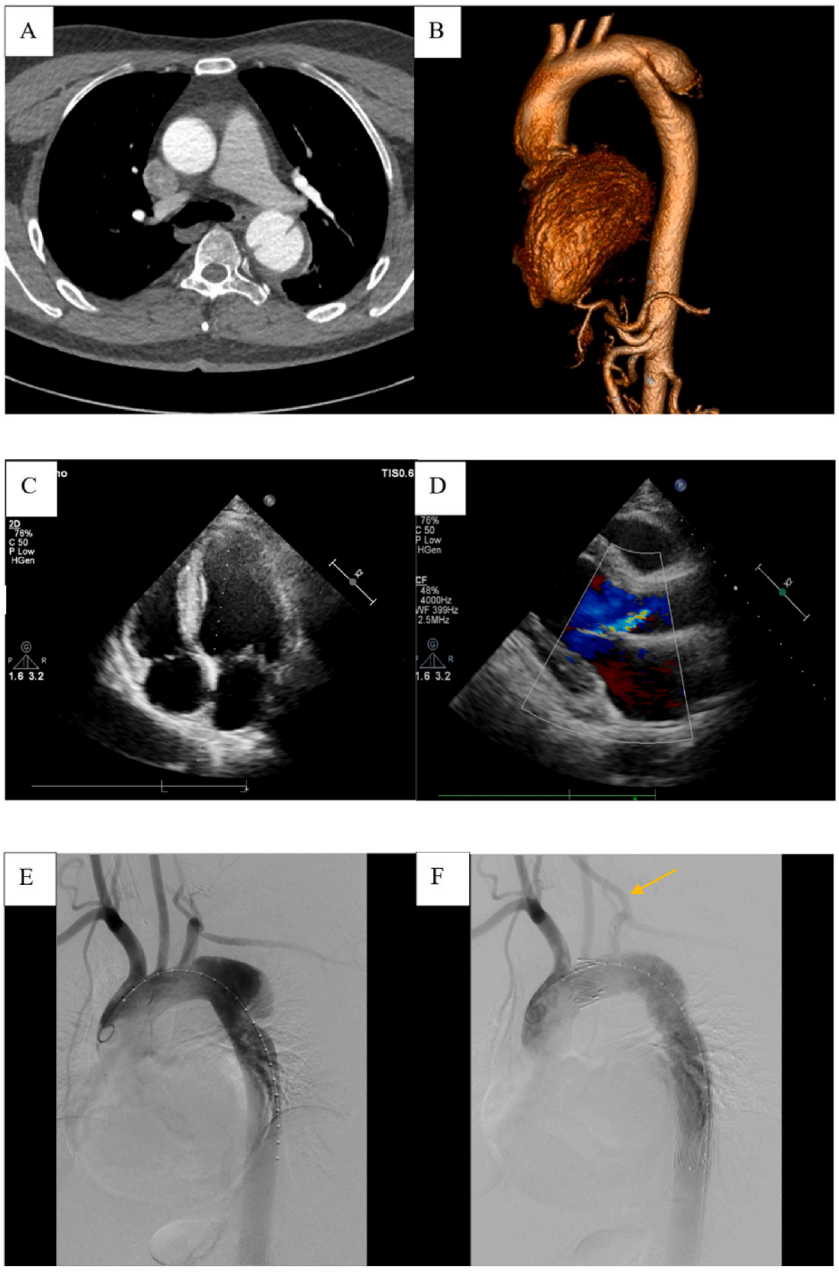

Fig. 1. Peri-operative CTA and DSA images. (A)–(B) Pre-operative cross-sectional and 3D reconstructive CTA image indicated the diagnosis of descending aortic dissecting aneurysm (Maximum diameter 4.6 × 4.2cm). (C)–(D) Pre-operative echocardiography revealed no signs of endocarditis, valve aneurysm or valve perforation. (E) Intra-operative DSA confirmed the existence and anatomical location of dissecting aneurysm. (F) DSA revealed the complete isolation of dissecting aneurysm and patency of bypass graft after stent implantation (Yellow arrow indicates bypass graft).

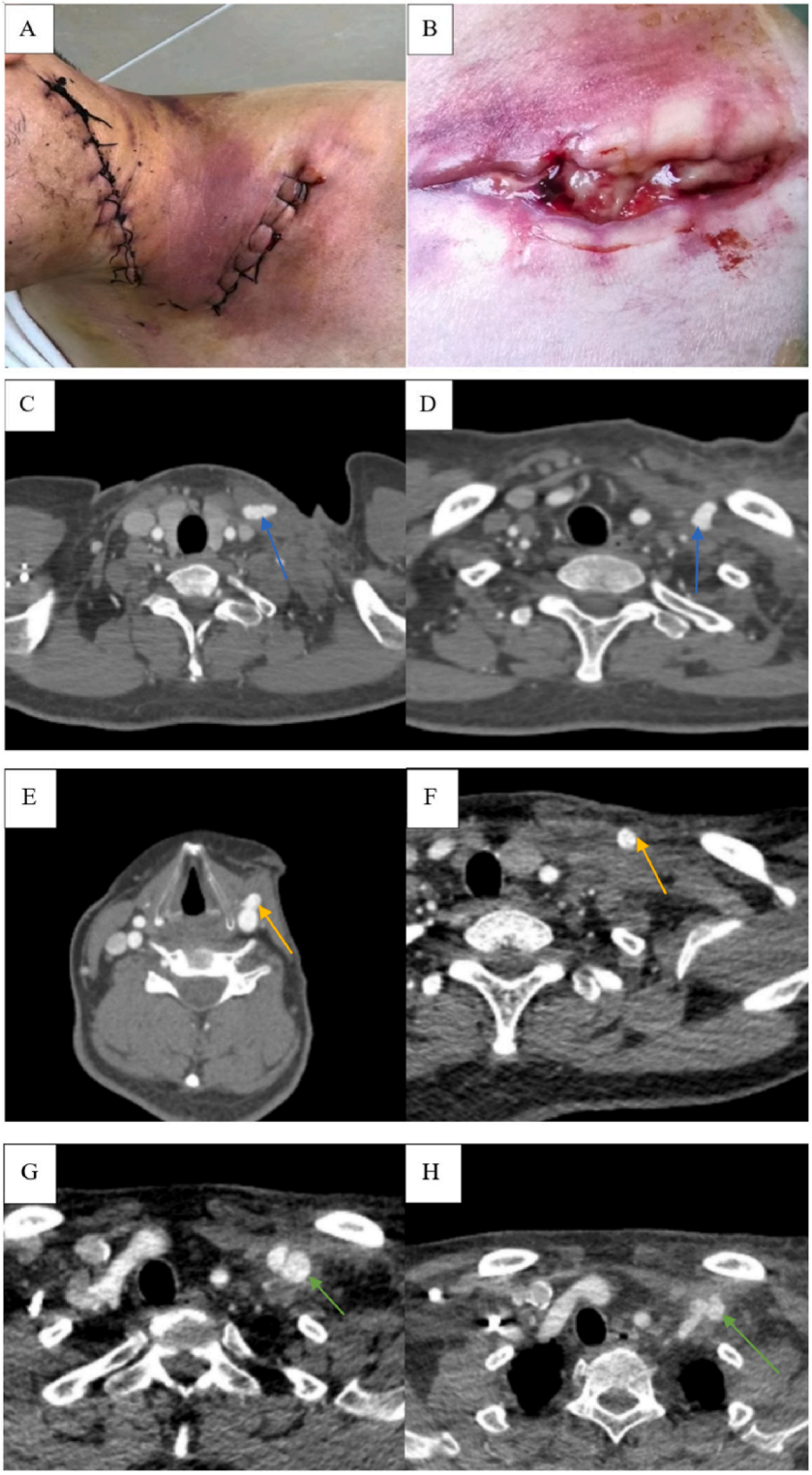

Fig. 2. PE and CTA image during re-admission. (A) Left carotid and supraclavicular wound at 1 week after first operation; (B) Swollen wound with oozing blood and fluid at 2 month after hybrid TEVAR; (C)–(D) CTA showed no obvious signs of graft infection (peri-graft gas or abscess), graft thrombosis or pseudoaneurysm during second admission (Blue arrow indicates bypass graft); (E)–(F) CTA image revealed carotid-LSA bypass graft infection (Yellow arrow indicates infected bypass graft and peri-graft abscess); (G)–(H) CTA demonstrated anastomotic pseudoaneurysm (Green arrow indicates anastomotic pseudoaneurysm).

conventional incisions were made to expose left common carotid artery and LSA separately. Left carotid-LSA bypass was conducted with a 6mm GORE PROPATEN® vascular graft (W.L.Gore & Associates, Flagstaff, AZ, USA) by using end-to-side anastomosis. Then angiography was performed to confirm the relationship between the aneurysm and SAT (Fig. 1E). A 14-12mm occluder (Starway Medical, Beijing, China) was implanted in the proximal end of LSA via branchial artery approach and a Medtronic Valiant Captiva stent graft (VAMF3030C200TE, Medtronic, Minneapolis, MN, USA) was deployed to isolate the dissecting aneurysm. Final angiography revealed complete isolation of aneurysm (Fig. 1F), left carotid-LSA bypass was patent with no endoleak. Cefazolin (1000mg iv q8h) was prescribed to the patient to prevent infection for 24 hours. The postoperative course was uneventful and he was discharged on the sixth post-operative day.

Two months later, the patient developed chills and a fever up to 40°. He was diagnosed with pulmonary infection in a local hospital and was given anti-infection treatment (levofloxacin and moxifloxacin), however, his symptoms did not improve. The patient was then admitted to our hospital. Oozing blood and fluid and sinus of supraclavicular wound were observed during physical examination (Fig. 2A–B). CTA demonstrated no obvious signs of anastomotic pseudoaneurysm, graft thrombosis or graft infection (Fig. 2C–D).

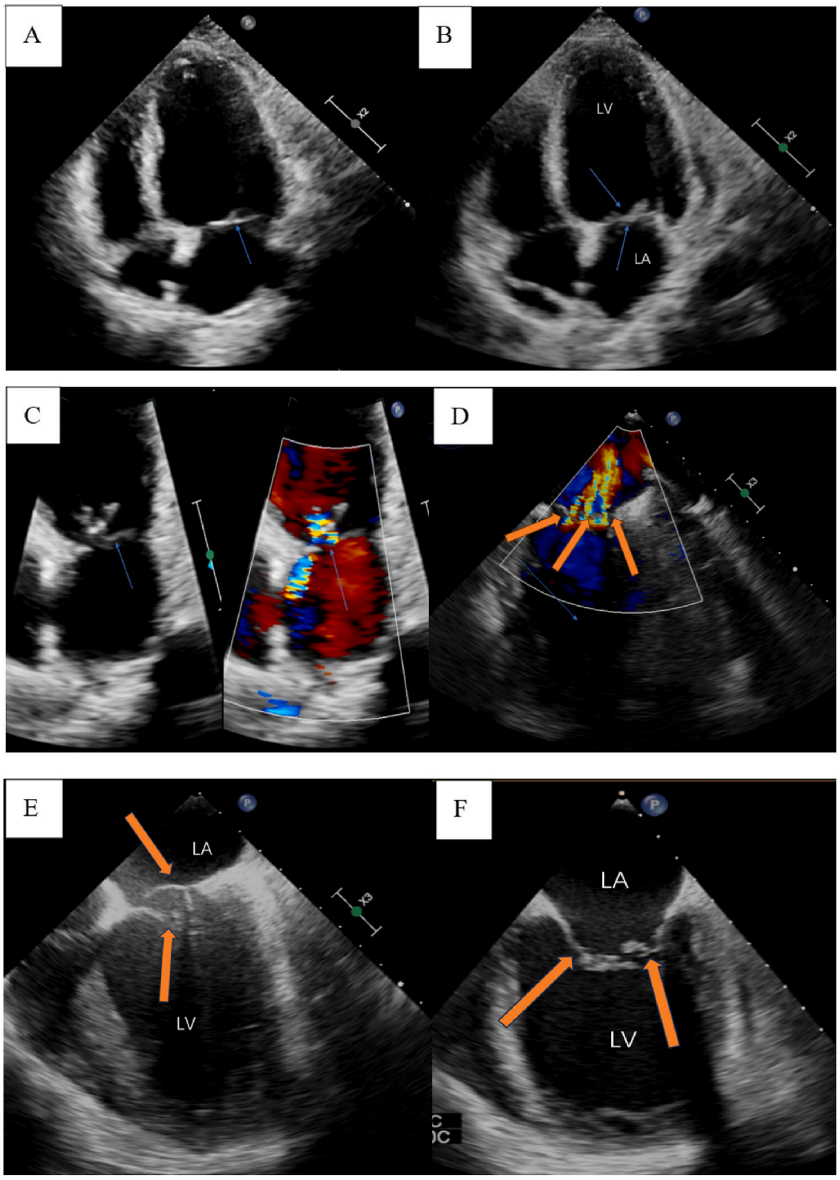

Fig. 3. TTE and TEE images of mitral valve during third admission. (A)–(C) Routine TTE revealed enlarged left heart and irregular thickening mitral valve (blue arrow in Fig. 3A), along with the aneurysm, perforation and vegetation formation of mitral valve (blue arrow in Fig. 3B). Mild mitral and aortic valve regurgitation were also detected (blue arrow in Fig. 3C). (D): TEE demonstrated subdivided blood flow of mitral valve (orange arrow); (E)–(F): TEE revealed that posterior mitral leaflet prolapses into the left atrium and interrupted anterior mitral leaflet and vegetation formation (orange arrow).

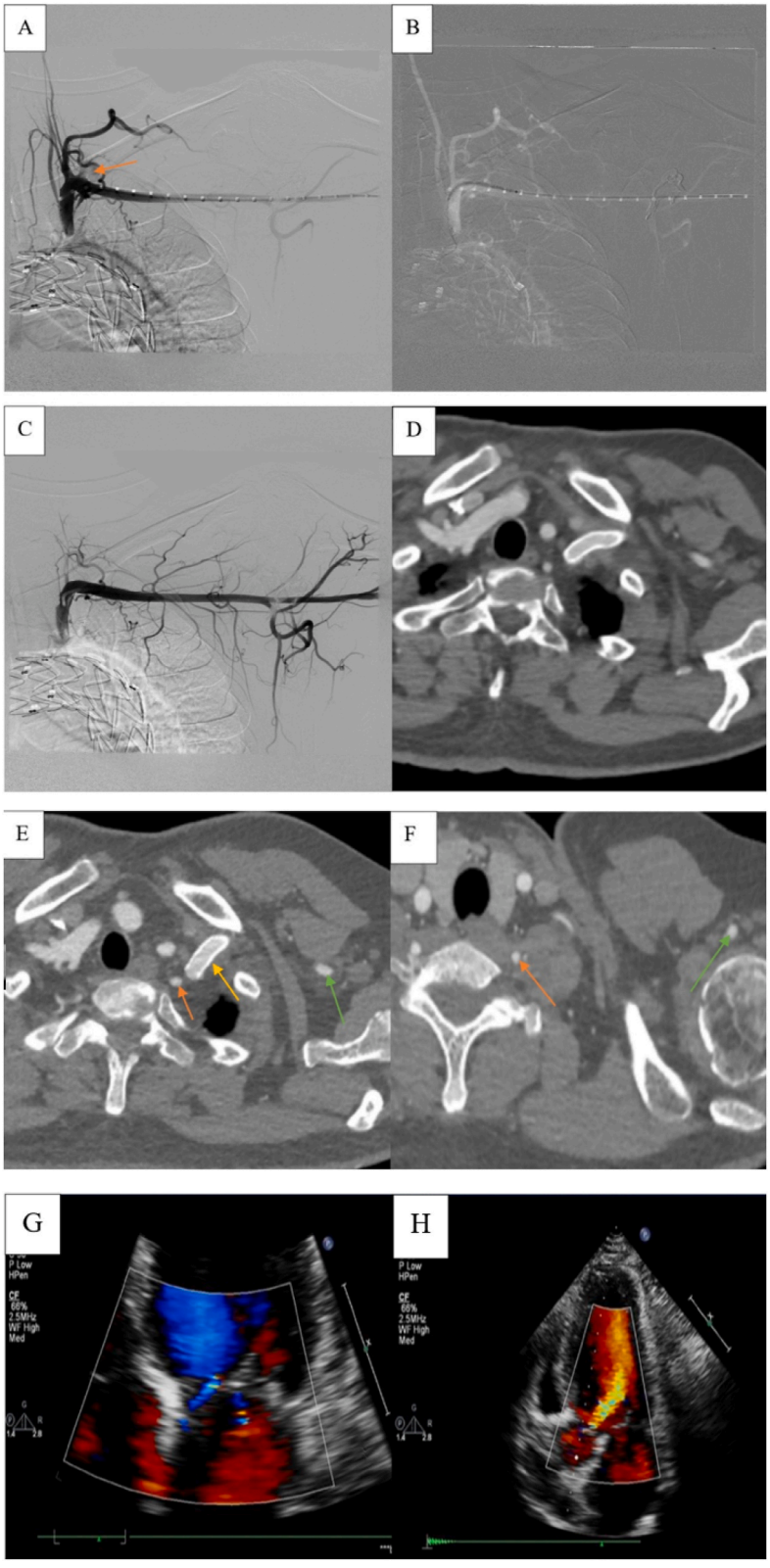

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Fig. 4. DSA image and follow-up results of second operation. (A) DSA showed anastomotic pseudoaneurysm of bypass graft (orange arrow indicates pseudoaneurysm); (B) Viabahn stent graft implantation; (C) DSA image after stent implantation demonstrated the complete isolation of pseudoaneurysm; (D) Post-operative CTA revealed no signs of RI and stent graft thrombosis; (E)–(F) 18 months follow-up results showed no RI and the patency of stent graft, left vertebral and upper limb artery (Yellow arrow indicates stent graft, orange and green arrow indicate left vertebral and upper limb artery, respectively). (G)–(H): TTE at 18 months after reintervention revealed no signs of progression of mitral valve pathologies or heart failure.

Ultrasound showed subcutaneous abscess of left supraclavicular wound. Further examinations, including 18F-fluoro-D-deoxyglucose positron emission tomography (18F-FDG-PET) and single photon emission computed tomography (SPECT), were proposed by us to detect the graft infection during consultation. However, the patient refused to undergo additional examinations because his symptoms were relieved after anti-infection therapy. Laboratory tests indicated severe infection but no signs of heart, hepatic, kidney or coagulation dysfunction, blood and wound fluid culture showed Methicillin-resistant *Staphylococcus aureus* (MRSA) infection. Vancomycin (1000mg iv q12h) and levofloxacin (500mg iv qd) were prescribed and his symptoms were significantly relieved. The patient was discharged after 14 days of normal body temperature and 3 consecutive negative blood and wound fluid culture results, his anti-infection therapy was also downgraded to levofloxacin alone (500mg po qd).

3 months later, the patient suffered a recurrence of fever up to 38.5° despite continuing oral anti-infective medication. Physical examination showed purulent secretion and swelling of the left supraclavicular wound, and pulse of left radial and brachial artery was not detected. Lab tests revealed high WBC counts and MRSA infection. CTA indicated carotid-LSA bypass graft infection and LSA anastomotic pseudoaneurysm (Fig. 2E–H). *Trans*-thoracic echocardiography (TTE) revealed MV aneurysm and perforation and mild mitral and aortic valve regurgitation, which was confirmed by transesophageal echocardiography (TEE) later (Fig. 3A–F). Because the patient was complicated with bypass graft infection and had no obvious cardiac symptoms, anti-infection treatment and close observation were suggested by the cardiovascular surgeons for the MV diseases. His symptoms were relieved, and bacterial culture results turned negative after anti-infection treatment (vancomycin 1500mg iv q12h and nemonoxacin 500mg po qd) and drainage of the wound.

However, the patient developed major bleeding from the sinus of left supraclavicular wound. Auxiliary examinations revealed hemorrhagic shock. Emergency angiography revealed that the pseudoaneurysm was located 2 cm from the opening of left vertebral artery (Fig. 4A). A 8 × 50mm Gore Viabahn stent graft was implanted in LSA to isolate the pseudoaneurysm (Fig. 4B). Post-operative angiography revealed the complete isolation of pseudoaneurysm and reverse blood flow of left vertebral artery (Fig. 4C). The reflux pressure in distal LSA was 45 mmHg, which means the revascularization of LSA was unnecessary. During the exploration of left carotid and supraclavicular wound, bleeding and a pseudoaneurysm of anastomotic stoma of LSA were observed, and purulent secretions were seen at the sinus of supraclavicular wound. Bacterial culture of peri-graft fluid confirmed MRSA. Therefore, bypass vascular graft was removed and anastomotic stoma of left carotid artery and LSA was ligated by Prolene sutures and the infected region was irrigated. The patient received a full recovery and was discharged at 1 month after his second operation, post-operative CTA showed no signs of re-infection (RI) and patency of stent graft (Fig. 4D). Continuous anti-infection therapy for at least 24–36 months was recommended by specialists in infectious diseases and patient's current oral anti-infection medication was nemonoxacin alone (750mg po qd).

Follow-up in 6, 12 and 18 months demonstrated no RI, left upper extremity ischemia or neurological complications. CTA also confirmed the patency of stent graft, left vertebral and upper limb artery without any evidence of RI, thrombosis or pseudoaneurysm (Fig. 4E–F). The patient refused the advice of surgical intervention for his MV diseases, therefore, strict follow-up was conducted every six months with echocardiography and blood tests. The most recent echocardiography revealed no obvious progression of valve pathologies or indications of heart failure (Fig. 4G–H). Timeline of treatment history is shown in Table 1.

3. Discussion

Vascular graft and endograft infection (VGEI) affected about 1–6 % of patients who underwent vascular surgery [7]. Despite European Society for Vascular Surgery (ESVS) published clinical guidelines for VGEI, the optimal treatment for bypass graft infection following hybrid TEVAR remains unclear, as it is rare with only one case reported previously [4,8]. However, in this case, the patient suffered recurrent attacks of fever caused by MRSA. Although his fever subsided after anti-infection treatment, the infection eventually progressed to bypass graft infection, MV pathologies and bleeding, necessitating surgical intervention. Previous research combined

Table 1
Timeline of treatment history.

Time point	Event
2021.4.22	Initial hybrid TEVAR operation
2021.7.4	Second admission because of chill and fever, anti-infection treatment
2021.11.6	Third admission for recurrence of infection
2021.11.7	TTE and TEE revealed MV aneurysm and perforation
2021.11.9	Major bleeding caused by anastomotic pseudoaneurysm, emergency Viabahn implantation and open bypass graft resection
2021.12.15	Third hospital discharge, post-operative CTA revealed no RI and patency of stent graft
2022.6.23	6 months follow-up, no RI and MV disease progression
2022.12.20	12 months follow-up, no RI and MV disease progression
2023.6.12	18 months follow-up, no RI and MV disease progression

endovascular and open surgery to treat the bleeding caused by infection of carotid-carotid bypass graft and may be a potential choice in cases of emergency with active bleeding in patients with graft infection of SAT [9]. Our experience indicated that combined therapy is also effective for patients with bypass graft infection and major bleeding following hybrid TEVAR. Although covered stent implantation was associated with the risk of RI,stent graft infection was relatively rare in patients with SAT VGEI, thus we believe that Viabahn implantation may be safe and effective for this patient [10].

Current practice guideline for TEVAR recommended LSA revascularization prior to or concomitant with TEVAR when LSA coverage is required [11]. Previous research reported that LSA coverage without revascularization may increase the risk of stroke, ischaemic and possibly spinal cord ischemia, however, other research found no association between LSA coverage and neurological or other complications [12,13]. The authors believe that multi-centre, randomized clinical trial should be performed to determine the necessity of LSA revascularization in TEVAR. Numerous open or endovascular strategies had been introduced for LSA revascularization, including carotid subclavian bypass, chimney graft, single branched stent graft and physician-made fenestration. Despite endovascular technique can provide effective options for LSA revascularization during zone 2 TEVAR and had shorter procedure time, hospital stay and intensive care unit (ICU) stay, certain technique was associated with higher risk of limb ischemia symptoms, midterm events and re-intervention, which indicate that endovascular procedures are novel and need further follow-up and assessment [14,15]. Carotid subclavian bypass has excellent patency rates at mid-term and long-term follow-up and may be considered as "gold-standard" for LSA revascularization in the settings of TEVAR [16]. In our case, the patient is only 38-year-old, the authors preferred to perform LSA revascularization to reduce the chance of neurological or ischaemic events and carotid subclavian bypass can provide acceptable long-term patency for young patients, thus avoid high medical and time cost caused by peri-operative complications.

Previous literature defined MV perforation as defects or discontinuation of mitral valve structure, which results in the development of mitral regurgitation [17]. MV aneurysm and perforation are mostly associated with infective endocarditis (IE), which were rare but devastating cardiology diseases with the incidence of 0.2–0.3 % [18]. A multicentre registry study demonstrated that IE was detected in only 0.8 % of patients with ascending aortic prosthetic graft and a small number of cases reported successful surgical treatment for bypass graft infection patients complicated with IE [19–21]. However, we found no reports of vascular graft infection accompanied by MV aneurysm and perforation following hybrid TEVAR during the literature review. It is suggested that more positive treatment strategies should be taken for patients with bypass graft infection following hybrid TEVAR to reduce the risk of complex complications, such as stent graft infection or IE. Moreover, a carefully designed surgical plan is vital for patient's prognosis.

In this case, the severity of major bleeding caused by anastomotic pseudoaneurysm compelled us to perform an emergency stent graft implantation and bypass graft removal. Furthermore, the risk of IE and MV diseases recurrence can be reduced by removing the infected bypass graft and total debridement of supraclavicular wound [20]. It is worth emphasizing that MV diseases and endocarditis are associated with the risk of stroke and peripheral artery embolization, and previous studies have revealed that the risk of these complications increases over time [20,22]. Therefore, we advised our patient to undergo surgical repair for his MV aneurysm and perforation despite he had no obvious symptoms or signs of heart failure. Regretfully, the patient refused surgical intervention, and the persistent anti-infection therapy were arranged. The long-term follow-up results are still pending, although no obvious disease progression was detected.

In our case, bypass graft infection was most likely to be associated with wound infection because bacterial culture of wound purulent secretion and infected bypass graft both indicated MRSA infection. However, it can't be completely certain that MV diseases was derived from wound infection because the patient refused surgical intervention for his MV diseases, thus we were unable to acquire and analyze heart pathology tissues and identify the exact pathogenic bacteria of MV aneurysm and perforation. Therefore, it remains a possibility that MV pathologies were caused by unknown bacteria or infection, which was not detected before. Further diagnostic examinations should be conducted to explore the evidence of infection for patients with persistent fever or inflammatory symptoms after TEVAR because early identification of pathogenic bacteria are vital for patients' prognosis, which is also recommended by ESVS [8,23]. Moreover, recent research has indicated that 18F-FDG-PET or SPECT should be considered as an additional investigation to improve the diagnostic accuracy in the settings of negative or non-convincing CTA results for patients with suspicion of VGEI [24]. Accurate identification of infected pathogens is important for effective anti-infection therapy cause previous studies have shown that patients infected with MRSA or other multi-resistant bacteria, just like our case, were associated with more severe symptoms and worse clinical outcomes, while patients infected with low virulence pathogens may have a better outcome [25].

4. Conclusion

In conclusion, bypass graft infection complicated with MV aneurysm and perforation is a rare post-operative complication following hybrid TEVAR. Combined endovascular and open surgery may be an effective treatment for major bleeding caused by graft infection with acceptable results. Early diagnosis of VGEI and accurate identification of pathogenic bacteria are essential for patient's treatment and prognosis.

Ethics statement and consent for publication

Submission and publication of case report do not require ethics approval in our institution. Written informed consent form was collected from the patient and his authorized proxy.

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Data availability statement

Data associated with our study has not been deposited into a publicly available repository. Data will be made available on request.

CRediT authorship contribution statement

Jinting Ge: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Writing – original draft, Writing – review & editing. **Chengxin Weng:** Data curation, Formal analysis, Investigation, Software, Visualization, Writing – original draft, Writing – review & editing. **Jichun Zhao:** Funding acquisition, Supervision, Writing – original draft, Writing – review & editing. **Ding Yuan:** Conceptualization, Project administration, Resources, Writing – original draft, Writing – review & editing. **Bin Huang:** Conceptualization, Supervision, Writing – original draft, Writing – review & editing. **Tiehao Wang:** Conceptualization, Data curation, Project administration, Supervision, Writing – original draft, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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