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Combined FET and TEVAR via the Ascending Aorta for Complex Aortic Arch Aneurysms

Kenji Sakai, Yushi Okumura, Tetsuya Yoshida*

Department of Cardiovascular Surgery, Hokushin General Hospital, Nakano, Nagano, Japan
Email: *tyoshida-cvs@umin.ac.jp

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Abstract

The Frozen Elephant Trunk (FET) technique using the FROZENIX® J-graft simplifies total arch replacement but poses challenges in patients with anatomically complex aortas. We report two cases of simultaneous ascending and aortic arch replacement using FROZENIX and thoracic endovascular aortic repair (TEVAR) via the ascending aorta in such anatomically challenging cases. Case 1: A 78-year-old man with a prior Y-graft replacement and TEVAR for abdominal aortic aneurysm presented with a tortuous descending aorta, which made device advancement difficult. He underwent successful total arch replacement using FROZENIX combined with TEVAR via the ascending aorta. Case 2: A 77-year-old man with chronic renal failure and a large aortic arch aneurysm underwent the same combined procedure with favorable results. Both patients recovered without neurological or renal complications and were discharged in stable condition. Simultaneous FET and TEVAR via the ascending aorta may offer a viable single-stage alternative for high-risk or anatomically complex cases.

Keywords

Frozen Elephant Trunk, TEVAR, Aortic Arch Aneurysm, Hybrid Aortic Repair, Antegrade Access

1. Introduction

The Frozen Elephant Trunk (FET) technique is widely used for the treatment of aortic arch aneurysms [1]. The incorporation of the FROZENIX® J-graft (Japan Lifeline Inc., Tokyo, Japan) into FET procedures facilitates distal anastomosis and expands surgical options for complex arch pathology [2]. However, device delivery can be technically challenging in patients with significant aortic tortuosity. Although a two-stage strategy with TEVAR is generally recommended, anatomi-

cal limitations, such as severe tortuosity or changes due to previous aortic surgery, may preclude endovascular access via the femoral artery. We describe two cases of successful simultaneous total arch replacement using the FET technique combined with TEVAR via the ascending aorta in patients with such challenging anatomical settings.

2. Case Presentation

2.1. Case 1

A 78-year-old man with prior Y-graft replacement for an abdominal aortic aneurysm and TEVAR for a descending thoracic aortic aneurysm presented with progressive dilation of the aortic arch to 70 mm. Preoperative CT revealed a 25 mm distance from the left coronary ostium to the aneurysm and an 86˚ curvature within a 125 mm segment of the intended FROZENIX proximal deployment site (Figure 1), raising concerns regarding successful endovascular navigation.

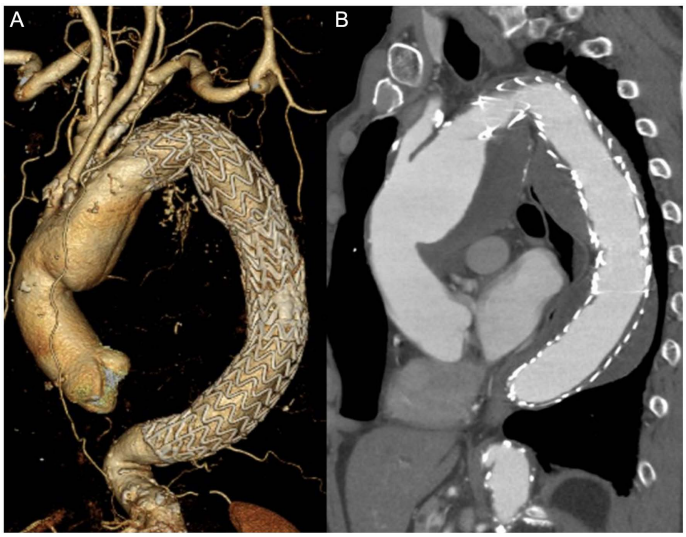

Figure 1. (A, B) Computed tomography scans (A: 3D reconstruction, B: sagittal view) showing an ascending aortic and arch aneurysm, a previously placed TEVAR device in the distal arch, and severe aortic curvature.

A staged approach was initially attempted; however, due to severe arch angulation and previous interventions, transfemoral delivery of the stent graft proved infeasible. Thus, a simultaneous ascending aortic replacement with FROZENIX and TEVAR via the ascending aorta was performed. After median sternotomy and establishment of cardiopulmonary bypass, systemic cooling was initiated to 28˚C. A Gore DrySeal sheath was introduced into the ascending aorta via the Seldinger technique. During the procedure, we confirmed the cervical branch origins adequately via direct visualization and fluoroscopy without using contrast. The GORE TAG® stent graft was then advanced antegradely to the planned deployment site, with continuous monitoring of its spatial relationship to the cervical branches under fluoroscopic guidance (Figure 2).

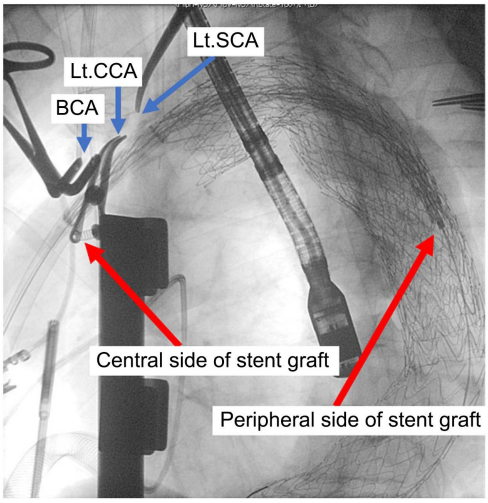

Figure 2. Intraoperative fluoroscopic image showing the positioning of the stent graft (red arrow indicates the device). BCA: brachiocephalic artery; Lt. CCA: left common carotid artery; Lt. SCA: left subclavian artery.

Because stent graft deployment risked obstructing cervical branch flow, we initiated antegrade cerebral perfusion before placing the stent graft to maintain continuous brain perfusion during the procedure. Following circulatory arrest, a FROZENIX graft was deployed under direct vision within the previously placed GORE TAG. Next, full expansion of the stented segment was achieved, followed by creation of the stoma and peripheral and central anastomoses of the ascending aorta. While rewarming, cervical vessel reconstruction was carried out, and the patient was weaned from cardiopulmonary bypass.

Postoperatively, paraplegia was prevented by avoiding hypotension and hypoxia while also correcting anemia. Early mobilization was promoted, and the patient remained stable.

Postoperative CT demonstrated no endoleak (**Figure 3**), and the patient was discharged on postoperative day (POD) 18 with no complications.

Figure 3. Postoperative computed tomography (CT) scan of the repaired arch in Case 1, demonstrating no endoleak.

2.2. Case 2

A 77-year-old man with chronic renal failure (serum creatinine 3.5 mg/dL) was referred for treatment of a 72 mm aortic arch aneurysm. CT imaging showed a 30 mm distance from the left coronary ostium to the aneurysm and an 84˚ arch curvature over a 120 mm segment. A small saccular aneurysm was noted distal to the primary lesion (Figure 4).

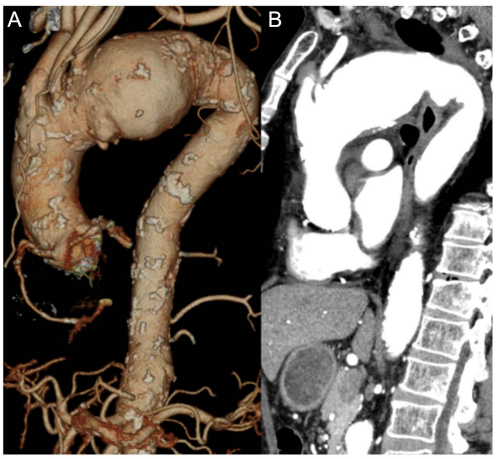

Figure 4. (A, B) Computed tomography scans (3D reconstruction in A, sagittal view in B) of Case 2 showing an ascending aortic and arch aneurysm with severe aortic curvature. A small saccular aneurysm is visible distal to the primary lesion.

Given the high surgical risk and concern for aneurysm rupture, a one-stage repair with FROZENIX and TEVAR via the ascending aorta was planned. The procedure was carried out in the same manner as in Case 1. Since the stent graft's position did not threaten cervical branch perfusion, antegrade cerebral perfusion was initiated after circulatory arrest. The procedure was completed without complications, and postoperative imaging confirmed successful graft placement without endoleak (Figure 5).

Figure 5. Postoperative CT scan of the repaired arch in Case 2, confirming successful graft placement without endoleak.

The patient was discharged home independently on POD 22, without requiring dialysis.

Informed consent for the reporting of these cases was obtained from both patients, and the local ethical committee approved the case report.

A comparison of patient backgrounds and perioperative details is presented in Table 1.

Table 1. Patient profiles and surgical parameters.

	Case 1	Case 2
Age	78	77
Sex	Male	Male
Comorbidities	Old myocardial infarction, hypertension, hyperlipidemia, thoracic aortic aneurysm (post-TEVAR), abdominal aortic aneurysm (post-Y-graft replacement)	Old myocardial infarction, chronic renal failure, hypertension, hyperlipidemia, diabetes mellitus
Arch curvature	86˚	84˚
Device size (FET)	39 mm × 9 cm	37 mm × 9 cm
Device size (TEVAR)	37 mm × 20 cm	34 mm × 20 cm
Operative time	405 min	386 min
Cardiopulmonary bypass time	219 min	244 min
Cardiac arrest time	64 min	89 min
Circulatory arrest time	37 min	58 min
Contrast volume	0 mL	0 mL
Fluoroscopy time	7 min	11 min
Postoperative day of discharge	18 days	22 days

3. Discussion

The FET technique has emerged as a hybrid solution to address complex aortic pathology involving the arch and descending thoracic aorta. However, it presents several technical challenges. One of the technical challenges is that FET device insertion and proper positioning are highly dependent on the surgeon's skill. These challenges become particularly significant in cases with a highly tortuous arch, especially when the stoma site of the open stent falls within zone 0. In such cases, although a staged TEVAR after the arch replacement is often a useful strategy, when a femoral approach is difficult, our simultaneous procedure offers a viable solution.

We consider this technique to be less susceptible to variability in surgeon experience; however, it remains contingent upon an operative setting that supports both cardiopulmonary bypass and intraoperative fluoroscopy.

Antegrade cerebral perfusion is initiated before stent graft deployment if interference with cervical branches is expected. If there is no interference, selective antegrade cerebral perfusion is started after stent graft deployment and circulatory arrest at 28˚C, as in standard total arch replacement.

In Case 1, severe aortic arch angulation and a history of prior aortic surgeries rendered transfemoral delivery of the stent graft unfeasible. In Case 2, the risk of aneurysm rupture during the waiting period, as well as the potential deterioration of renal function due to increased contrast exposure associated with a staged approach, were key factors in the decision-making process.

In cases with severely tortuous distal aortic arch aneurysms, it has been reported that insertion of the frozen elephant trunk (FET) graft can be technically challenging [3]. Recent studies have demonstrated the feasibility of performing TEVAR via the ascending aorta during total arch replacement. For example, Tsagakis *et al.* have reported the successful use of antegrade stent graft deployment in conjunction with the FET technique in patients with complex anatomical features [4]. These findings underscore the importance of a patient-specific surgical strategy that accounts for anatomical suitability and individualized risk profiles.

One important technical consideration in this approach is the potential interaction between the stent structures of the TEVAR device and the FET graft. In our strategy, we deliberately selected the GORE TAG device, which features an external stent skeleton, to be deployed prior to the FROZENIX graft, which incorporates an internal stent. A review of the literature revealed no clear evidence that differences in stent skeleton design directly contribute to endoleak formation. A study by Lee and Park systematically examined this issue and reported no increase in type III endoleaks or device-related complications [5]. Nevertheless, from a theoretical perspective, mechanical interference between dissimilar stent structures may increase the risk of type III endoleaks. Therefore, careful attention to device selection and overlap configuration remains essential.

One concern regarding long-term outcomes is the durability of the distal segment and the maintenance of proper stent graft alignment. Although our short-term results were favorable, meticulous long-term follow-up using contrast-enhanced imaging is essential for the early detection of potential complications such as endoleak, graft kinking, or distal stent graft-induced new entry (dSINE). Nomura *et al.* reported an incidence of dSINE in 12.9% of patients following total arch replacement using the J Graft FROZENIX [6]. Additionally, another study suggested that due to its spring-back force, the J Graft FROZENIX may pose a risk of dSINE when the distal end of the stent graft is positioned in a curved segment of the aorta [7].

We consider that extending the distal landing zone with additional TEVAR beyond the FET segment may be beneficial in preventing dSINE.

Long-term follow-up plans should include routine surveillance with CT at regular intervals (e.g., 3, 6, and 12 months postoperatively, and annually thereafter), along with clinical assessment to detect graft-related complications early.

While simultaneous FET and TEVAR via the ascending aorta is technically demanding and requires a high level of surgical expertise, it can offer a definitive and durable solution in selected patients for whom conventional approaches are either high-risk or anatomically infeasible. However, the long-term safety, durability, and reproducibility of this approach require further investigation through larger case series and multicenter studies.

4. Conclusions

In anatomically challenging cases of aortic arch aneurysm, simultaneous total arch replacement using the FET technique combined with TEVAR via the ascending aorta may provide a safe and effective single-stage solution. Nevertheless, conclusions on efficacy and generalizability must be made cautiously due to the limited number of cases.

This strategy may reduce the risks associated with delayed interventions and complex endovascular access routes. Further clinical experience and long-term follow-up are needed to validate its broader applicability. Future studies should focus on identifying optimal patient selection criteria, refining device design for antegrade delivery, and comparing outcomes with conventional staged or transfemoral approaches.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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