"Loss of landing zone"—Stabilizing endovascular treatment solutions in the aortic arch after thoracic endovascular aortic repair

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ABSTRACT

Addressing proximal complications that arise after endovascular aortic repair for type B aortic dissection, such as type Ia endoleaks, "bird-beaking" of the thoracic endovascular aortic repair (TEVAR) stent, retrograde type A dissection, and postdissection aneurysms, bears considerable complexities. We present a novel and safe method for open arch repair that can ensure a secure and efficient approach for TEVAR complications. The key element of the operative technique is approximating the grafted stent portion to the aortic wall and the arch prosthesis. The technique has successfully been implemented in 11 patients, who received secondary open arch repair from 2019 to 2022 after TEVAR for type B dissection. Our objective is not only to introduce this reliable concept but also to provide a comprehensive demonstration of its advantages and disadvantages compared with currently used open treatment methods and discuss patient outcomes after secondary open arch repair. (J Vasc Surg Cases Innov Tech 2024;10:101498.)

Keywords: Aortic arch replacement; Aortic dissection; TEVAR; Type Ia endoleak

Since its first application at Stanford University in 1994, thoracic endovascular aortic repair (TEVAR) has been the gold standard for descending thoracic aortic pathologies and has demonstrated superior mortality and morbidity compared with conventional open approaches.[1] However, several device- and patient-related complications have since been encountered and required secondary repair. Endoleaks, especially type Ia, are the most common and feared complications because they can result in further aneurysm expansion and potential rupture. Landing zones proximal to the origin of the left subclavian artery (zones 1 and 2) and the "bird-beak" configuration, with an unsealed portion between the graft and the inner curvature of the aorta, predict for these adverse events. Furthermore, these can result in direct penetration of the graft through the aortic wall. In such cases, open aortic repair can be a valuable and durable option in a situation that has been successfully bridged from the acute dissection event to a chronic problem.[2] This case series presents our surgical technique of secondary aortic arch replacement after TEVAR for acute aortic type B dissection.

METHODS

Study design and case series presentation. The local ethics committee approved this retrospective single-center study (institutional review board approval No. 22-0011; February 16, 2022). Prior written patient consent for our clinic's aortic database was obtained. Between 2019 and 2022, 11 patients underwent total arch replacement subsequent to TEVAR in zone 3 for type B dissection. Three patients had undergone previous sternotomy, with two having had aortic root and ascending aortic repair and one, root-sparing ascending aortic repair. One had been diagnosed with a hereditary connective tissue disorder (ie, Marfan syndrome). The average interval to the index procedures was 5 years. Their mean age was 54 ± 15 years, and 55% were men. The reason for intervention was a type Ia endoleak in seven (63%), bird-beaking with perforation in one (10%), an enlarging postdissection aneurysm in the aortic arch in one (10%), and retrograde type A aortic dissection in two (17%) patients. Of the 11 patients, 9 (81%) exhibited type III aortic arches according to the preoperative computed tomography scans, and 3 presented with type I or II arches.

Surgical technique. The perioperative management during arch surgery has been described previously.[3] In brief, the procedural conditions were moderate hypothermic circulatory arrest at 25° to 26°C with selective antegrade cerebral perfusion at 22°C. Aortic valve repair or replacement with or without root replacement was performed proximally. Distally, the aortic arch was

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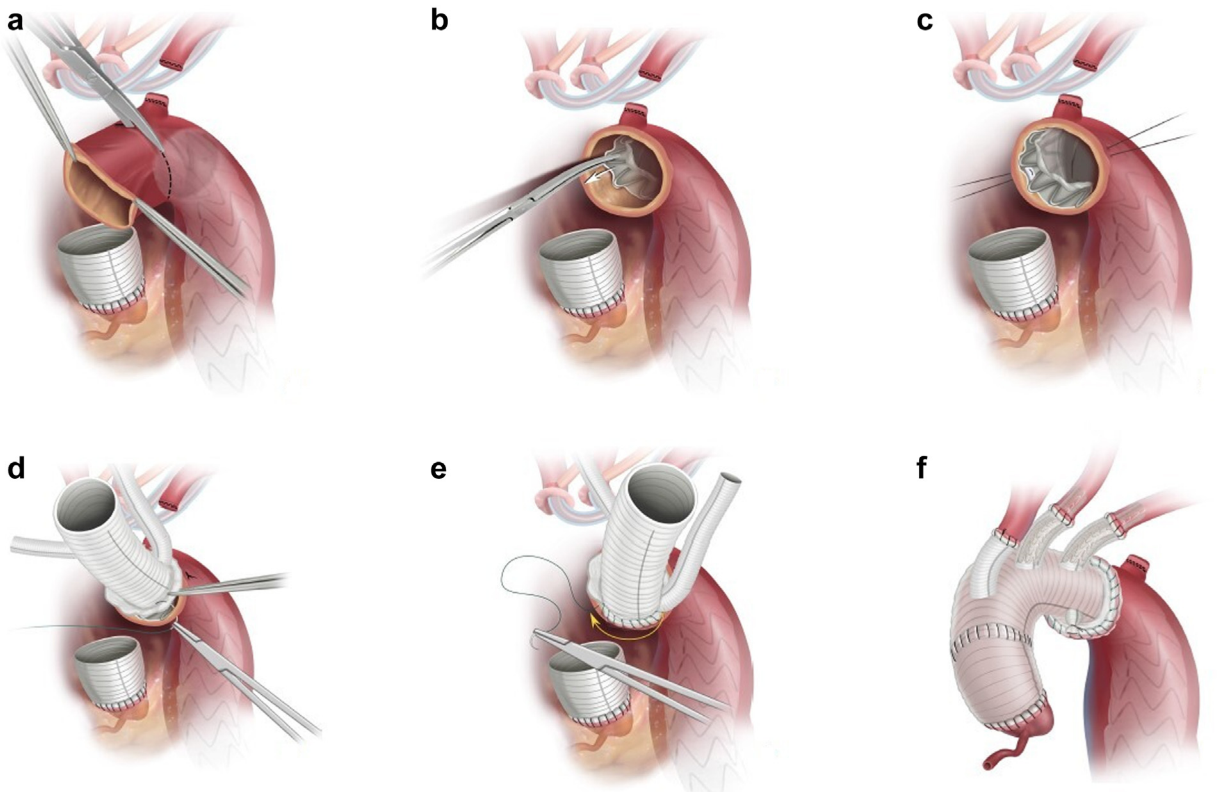

Fig 1. Surgical setup. **A,** Resection of the aortic arch in zone 2. **B,** Mobilization of the endograft. **C,** Fixation of the endograft to the aortic wall. **D,** Anastomosis between the prosthesis, aortic wall, and the endograft. **E,** Completion of the distal anastomosis. **F,** Connection between proximal and distal sites.

resected for anastomosis in zone 2 (Fig 1, *A*). The left subclavian artery was transected close to the arch using a cutting vascular stapler for a quick and efficient approach during circulatory arrest, and the TEVAR endograft was mobilized under direct vision and pulled into zone 2 (Fig 1, *B and C*). In the case of noncovered bare springs, these were cut off using a wire cutter. A Siena Plexus or Anteflo prothesis was anastomosed to the arch and TEVAR graft using 2-0 or 3-0 Prolene suture with a round point needle (Fig 1, *D and E*). The supra-aortic vessels were then reattached using the SAVSTEB (stent-bridging of the supra-aortic vessel anastomoses) technique[4] or the island technique, followed by careful de-airing and re-establishment of circulation via the perfusion branch. The island technique was applied in a single case characterized by unfavorable anatomy but with preserved aortic arch integrity, where stenting of the supra-aortic vessels was not possible. In the remaining 10 cases, our center's established gold standard, the SAVSTEB technique, was used. The repair was completed by joining the ascending aortic graft to the arch graft (Fig 1, *F*). All the suture lines were sealed with BioGlue (Artivion), as is standard procedure at our center.

RESULTS

In all 11 cases, but one, the pathology was successfully treated using this technique. The circulatory arrest time averaged 85 ± 42 minutes and the selective antegrade cerebral perfusion time, 90 ± 34 minutes. The hospital stay was 20 ± 6 days, of which 9 ± 4 days were in the intensive care unit. The technique, however, was not successful in the case of a 76-year-old woman with a >8 cm aortic aneurysm and aberrant right subclavian artery, who received aortic arch replacement 8 years after TEVAR stent placement. The aorta had advanced deeply into the left thoracic apex, and we did not succeed in approximating the aortic wall to the covered stent portion. Thus, intraoperative bleeding was not manageable and an intraoperative bailout switch to a frozen elephant trunk (FET) also failed. The intraoperative bleeding became uncontrollable, resulting in low-output failure with subsequent implantation of an extracorporeal life support system. The thoracic cavity was left open and the mediastinum packed. However, re-exploration was necessary within 1 hour, and the bleeding was determined to be unstoppable during this second procedure, leading to circulatory failure and subsequent cardiac arrest.

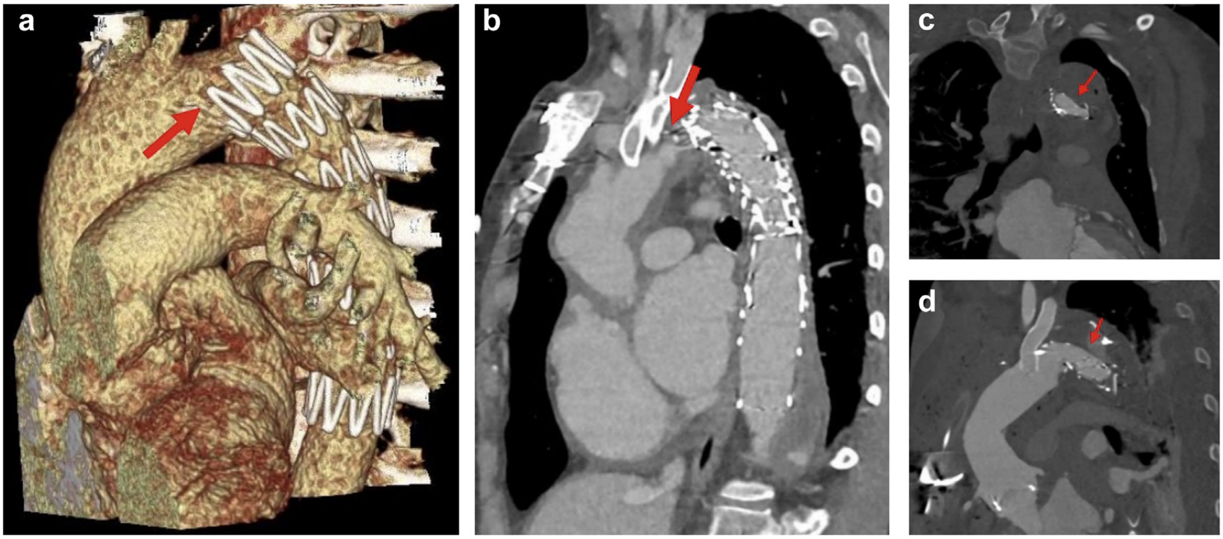

Fig 2. Computed tomography images illustrating complications from previous frozen elephant trunk (FET) cases at our center. **A,** Three-dimensional reconstruction of a computed tomography scan showing bird beaking (*red arrow*). **B,** Type III endoleak caused by penetration of FET by the thoracic endovascular aortic repair (TEVAR; *red arrow*). **C and D,** Type II endoleak caused by flattening of the FET due to pulling forward of the prosthesis (*red arrow*).

In relation to major adverse events, only one case of a nondisabling stroke occurred, resulting from overstenting of the left vertebral artery. Additionally, one patient experienced delayed awakening with extubation after 3 days. In contrast, all other patients were extubated either on the same day or during the first postoperative day. Notably, there were no occurrences of spinal cord injury, myocardial infarction, or reduced left ventricular function on discharge or during follow-up. No patient required a pacemaker. Respiratory complications were observed in two patients, both requiring reintubation within the initial 3 days. Four patients required dialysis, although it is crucial to note that all four of these individuals had preexisting renal failure, and three were already undergoing dialysis before surgery.

The average duration from surgery to discharge was 25 days (range, 8-84 days). Of the 10 living patients, 6 were discharged to a rehabilitation facility, 1 to the referring clinic, and 3 to their homes.

All the patients were observed according to the department's follow-up protocol. The mean follow-up time was 2.1 years (range, 84 days to 4.2 years). All the patients presented in good physical condition during their follow-up visits, and no further deaths occurred. The computed tomography scans indicated technical success, with no evidence of a recurring endoleak, infection, or a pseudoaneurysms at the suture lines. Two patients required additional endovascular extension with TEVAR due to a type Ib endoleak 1 year after the arch surgery.

DISCUSSION

Failing endovascular techniques, leading to complications such as the bird-beak configuration (Fig 2, *A*), in the aortic arch are challenging to repair. Thus, total arch repair using fenestrated or branched stent grafts is often limited due to unsuitable proximal landing zones in the ascending aorta, limiting the use of current devices and methods.[5] Conventional open surgical treatment of aortic arch pathologies is still the gold standard for patients who can endure the procedure.[6]

The current, established technique for arch pathologies is the FET. The hybrid graft is either anastomosed directly to the graft or excludes the pathology by landing at the stented portion of the TEVAR.[7] However, there are a few technical issues with the FET technique anchoring in a TEVAR. First, if the TEVAR stent is placed close to the left subclavian artery or is already approaching into the curvature of the arch, the orientations of the TEVAR stent and FET could potentially not align anatomically. This can lead to a kink in the FET and cause the FET prosthesis to ride on the proximal springs of the stent, which can lead to fabric damage and, subsequently, penetration of the FET and cause a type III endoleak over time (Fig 2, *B*). Second, the higher restoring forces and powerful anchoring of the FET in the TEVAR, compared with that in the native aorta, in combination with aortic movement could cause flattening of the prosthesis if the FET is incidentally pulled forward for the proximal anastomosis and again predispose to damaging the prothesis and the formation of a type II endoleak[8] (Fig 2, *C and D*).

The singular instance of the 76-year-old woman with a massive aortic aneurysm, who succumbed to irreparable bleeding within a few hours postoperatively, underscores the importance for tailored care and meticulous operative planning. In this specific case, a hybrid procedure using a staged approach, initially entailing open replacement of the ascending aorta and proximal arch, followed by subsequent endovascular completion, could potentially have led to a more favorable outcome. Furthermore, this case reinforces the importance of precisely approximating all three layers: the aortic wall, covered stent, and prosthesis. Only this practice ensures optimal sealing, thereby mitigating the risk of postoperative bleeding. Proper mobilization might be aggravated if the TEVAR endograft has already been extended distally or if the proximal landing zone is located below the proximal descending aorta (zone 4). For such cases, the FET technique seems to be the better option.

CONCLUSIONS

Our expert opinion, supported by a comprehensive case series, underscores that open total arch replacement represents a viable surgical treatment approach for managing failing TEVAR in patients with aortic dissection type B in contrast to emerging endovascular options. Essential to the success of this method is adequate displacement of the proximal covered stent end toward the anastomosis in zone 2, coupled with circumferential approximation of the aortic wall to the stent and anastomosis. These procedural considerations are imperative to ensure a securely sealed anastomosis, effectively preventing complications such as pseudoaneurysms. Our findings affirm that these steps can be performed safely and contribute to the overall success of the intervention.

DISCLOSURES

None.

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