

# Total endovascular aortic arch repair using chimney and periscope grafts for treatment of ruptured aortic arch pseudoaneurysm

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## ABSTRACT

Aortic arch pseudoaneurysms are rare but quite fatal when ruptured. Owing to its less morbidity and mortality compared with the surgical approach, endovascular and hybrid treatment methods are increasingly preferred. In this report, we present a 58-year-old male patient who has a ruptured saccular aortic arch pseudoaneurysm treated by endovascular approach using parallel grafts.

**P**seudoaneurysms of the ascending aorta or aortic arch usually develop as a rare complication of surgery, and have a high rate of mortality when ruptured (1). Today, treatment options are surgical methods, embolization and hybrid (surgical and endovascular) methods (1, 2). However, repeat open surgery for aortic arch has specific challenges; in particular, proximity of the aneurysm to the sternum or presence of comorbid factors significantly increase the risk for morbidity and mortality. In these patients, endovascular and hybrid treatment methods that have less morbidity and mortality compared with surgical treatment are being increasingly used in recent years (2). To the best of our knowledge, the present case is one of the first examples of total endovascular treatment of a localized aortic arch pseudoaneurysm rupture using parallel graft technique in the emergency setting.

## Technique

A 58-year-old current smoker male with a history of Stanford A (DeBakey Type-1) aortic dissection and status post supracoronary aortic replacement 13 years ago presented to our hospital with sudden onset chest and back pain. The patient was agitated, conscious, and cooperative. He also had hypertension controlled by medication, his blood pressure was 100/60 mmHg and pulse was 130/min at the time of admission. Initial laboratory work-up was insignificant with hemoglobin (13 g/dL), hematocrit (42%), and creatinine (1.1 mg/dL) levels within normal limits. American Society of Anesthesiologists physical status classification was ASA 2. Thoracic computed tomography angiography (CTA) showed a ruptured saccular pseudoaneurysm comprising the aortic segment between the distal of the ascending aorta (also distal surgical anastomosis line) and the origin of the left subclavian artery. Pseudoaneurysm was ruptured toward the pericardial and left pleural space with significant left hemothorax (Fig. 1). There was incidental severe stenosis (approximately %90) in the origin section of the left vertebral artery. Right brachiocephalic artery, left common carotid artery, and left subclavian artery measured 13 mm, 6 mm, and 11 mm in diameter, respectively. Nonthrombotic pseudoaneurysm measured 40×65×43 mm. Despite transfusion, hemoglobin levels dropped to 9 g/dL. Endovascular treatment was planned for the right brachiocephalic artery using chimney configuration and for the left common carotid artery using periscope configuration. The ascending aorta prior the pseudoaneurysm was 30 mm in diameter, and there was cone-shaped narrowing at the immediate segment after pseudoaneurysm (24 mm in diameter). Due to this discrepancy in diameters, two stent grafts, 40×120 mm to proximal and 36×120 mm to distal were planned for insertion. Within 3 hours after admission, following the patient's informed consent, the patient was transferred to the operation room. Under general anesthesia, the right common femoral artery and right

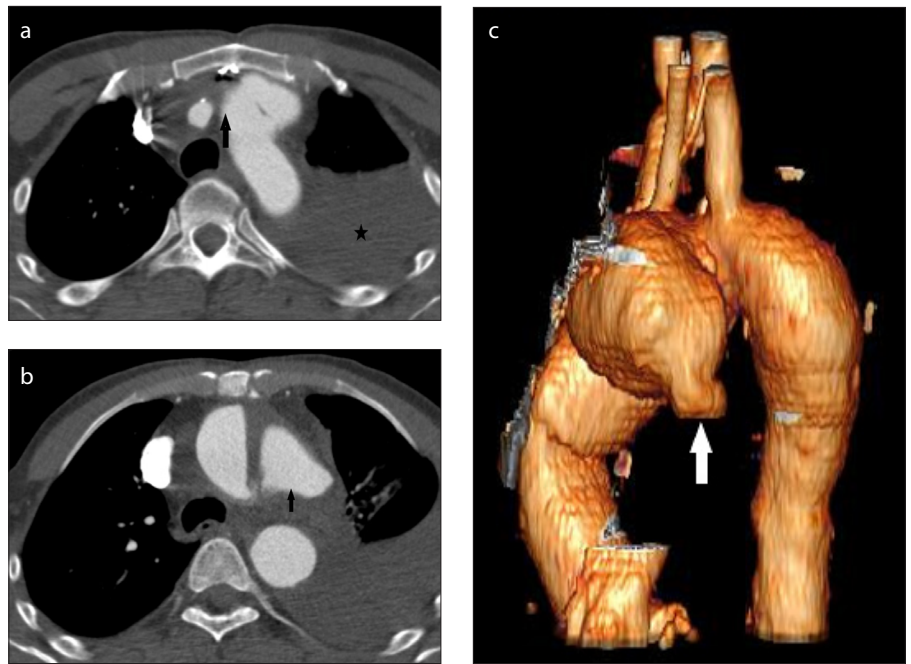
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axillary artery were released with surgical cut down method and ultrasound-guided percutaneous left common femoral artery puncture was performed. A 12 F 45 cm guiding sheath (Flexor Ansel, Cook Inc.) was inserted from the right axillary artery and a 7 F 90 cm guiding sheath (Flexor Check-Flo, Cook Inc.) from the left common femoral artery. Concurrently 80 IU/kg IV heparin was administered. Left subclavian artery closure was planned to reduce the Type-II endoleak due to parallel grafts; therefore, initially a 4×20 mm bare metal balloon expandable stent (Simflex, Simeks Medical) was inserted through the 7 F 90 cm guiding sheath in the narrowing of the left vertebral artery origin in order to maintain subclavian artery flow. Then the left subclavian artery was closed with 16 mm Amplatzer vascular plug II (Abbott Vascular) through the same guiding sheath. Chimney graft was advanced to the right axillary artery toward the ascending aorta with concurrently advanced periscope graft from the left common femoral artery toward the left common carotid artery, and thoracic stent-graft from the right common femoral artery toward the level of aortic arch. First, a 8×150 mm covered stent (W. L. Gore & Associates) was inserted from the left common carotid artery to the descending thoracic aorta in the guidance of digital subtraction angiography (DSA) and fluoroscopy as the periscope stent. Then, a 8×59 mm balloon expandable covered stent (Atrium Advanta V12, Maquet) was advanced to the distal extension of the Viabahn stent, but was not opened. Thoracic stent-graft (Ankura, Lifetech Scientific) was then released where its distal end terminates in the descending aorta, and then atrium covered stent was opened and inserted. Thus, the periscope graft extending from the left common carotid artery to the distal was inserted. "Internal iliac artery side branch" extension (distal: 10 mm, proximal: 16 mm) manufactured by Gore for iliac side



**Figure 1.** a–c. Preoperative images (a, b) show CT images of the aortic arch with pseudoaneurysm (arrow) and left hemothorax (star). 3D volume rendering image (c) shows pseudoaneurysm of the aortic arch and nipple (white arrow).

branch was preferred as chimney graft to be inserted toward the ascending thoracic aorta. Chimney stent grafts (two grafts 16×10×70 mm) were inserted with the guidance of DSA and fluoroscopy from the brachiocephalic artery toward the ascending aorta, and right after the wider second aortic stent (Ankura, Lifetech Scientific) was inserted from the ascending aorta toward the aortic arch (to overlap with the graft at distal). Balloon angioplasties were performed concurrently with the aortic stent-grafts and the parallel grafts. Postoperative DSA examination showed patent chimney and periscope grafts, left subclavian artery supplied from the right vertebral artery by steal, and minimal proximal type-1 endoleak (Fig. 2). Minimal proximal type-1 endoleak from the bending point of the surgical graft which had been previously inserted into the ascending aorta (because the endografts were not properly inserted in this section) had not disappeared despite consecutive balloons. Additional embolization was not considered since the endoleak was minimal. Procedure time was 1 hour and 52 minutes and fluoroscopy time was 38 minutes. About 90 mL of iohexol was used. Surgical left carotid-subclavian bypass was performed when the patient developed ischemic symptoms in his left arm 5 hours post-surgery while extubated in the intensive care unit. He was given enoxapa-

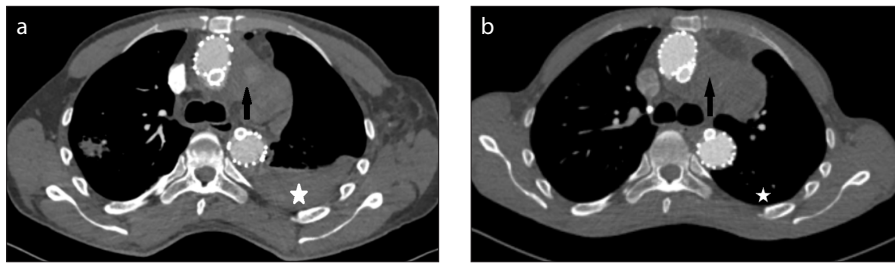


**Figure 2.** Postoperative digital subtraction angiogram shows patency of aortic stent grafts and chimney and periscope stent grafts. The left subclavian artery is filled through the left vertebral artery (arrows).

rin sodium 2×0.4 mL during hospitalization. The patient underwent ultrasound-guided catheterization for drainage of hematoma in the left hemothorax on postoperative day 6, and was discharged on day 12 with medications (acetylsalicylic acid per oral 100 mg/day, lifelong, clopidogrel per oral 75 mg/day, 1 month). Minimal proximal type-1 endoleak and left hemothorax was detected on CT examination on postoperative day 5 and hemoglobin levels did not decrease postoperatively. Type-1 endoleak disap-

#### Main points

- Pseudoaneurysm of the aorta usually develops as a rare complication of surgery and has a high rate of mortality.
- Endovascular and hybrid treatment methods, which have less morbidity and mortality compared with surgical treatment, are being increasingly used in recent years.
- Parallel graft technique can be applied in emergency conditions.



**Figure 3.** a, b. Postoperative CT image (a) shows minimal endoleak (arrow). Postoperative CT image after 9 months (b) shows no sign of endoleak or left hemothorax (arrow).

peared at 9-month control CT (Fig. 3). The patient is being clinically followed for a year.

## Discussion

Although surgery is the current first treatment of choice in aortic arch and ascending aorta aneurysms and pseudoaneurysms (3), endovascular treatment methods are more commonly preferred in cases where conventional surgery poses high risk of mortality, such as when there is prior surgical aneurysm/dissection repair, comorbid factors and close association of pseudoaneurysm to the sternum (2, 4). Total endovascular aortic repair in which cerebral vascularization is maintained with parallel grafting was considered to be the most appropriate method for our patient, who had a rapid decline in hemoglobin and findings of rupture into the left hemithorax and pericardial area on tomography.

Parallel grafting technique (chimney) was introduced during endovascular aneurysm repair by Greenberg et al. (5) in 2003, and has been increasingly used since then. Parallel grafting method, which has been initiated with subclavian artery for the supraaortic main branches has been introduced especially in emergency patients to involve all arcus branches over time (2).

In addition to parallel grafting, fenestrated and branched grafts are used as alternatives in endovascular treatment of aortic arch and ascending aorta pathologies (2). Although pseudoaneurysms are involved in the patient group in which these grafts are used, most of these patients consisted of planned cases. However, in some countries including our country, about 2–3 months are needed for patient specific fenestrated and branched grafts to be available for use, which hinders the use of these grafts in emergency patients (2, 4).

Several technique-related perioperative complications may develop in parallel grafting methods. Among these is type-1 endoleak, which develops due to gutter occurring in the vicinity of parallel grafts. In the literature, the incidence of type-1 endoleaks in thoracic chimney grafting shows a wide range (0%–44%) (4). In a review of 312 patients who underwent thoracic chimney grafting, the rate of type-1 endoleak was found to be approximately 11% with chimney grafts, with 2 of them fatal and 20 requiring re-intervention (6). We took the risk of type-1 endoleak in our patient due to the emergency setting, but ended up observing minimal proximal type-1 endoleak. This endoleak was caused by improper settlement of both chimney graft and aortic stent graft to the inward folding region in the previously inserted surgical graft. In addition, we preferred internal iliac extension of Gore iliac side branch, which we thought to have a stronger radial force in order to prevent the chimney graft from being crushed in the folding area of this graft. Another reason for this preference was that the distal end of this tubular graft could be selected as 10 mm instead of 16 mm, meaning that chimney graft would occupy less area in the ascending aorta and could attach to the brachiocephalic artery at proximal. We decided to follow-up the patient, because of the nonserious degree of endoleak and above-mentioned literature information. No additional procedure was needed during follow-up because the patient was stable, and the type-1 endoleak resolved in the months following the operation. Since the amount of gutter will be increased when more than one parallel graft is placed between the aortic stent and aortic wall, the risk for the occurrence of type-1 endoleak will also increase (7). For this purpose, we did

not consider performing parallel grafting to the left subclavian artery in our patient. The left subclavian artery was closed in order to prevent type-2 endoleak after left vertebral artery stenting in the patient in whom filling of the left subclavian artery was planned by steal from the vertebral artery. There are similar cases of subclavian artery closure in the literature and in our experience. Carotid subclavian bypass surgery should be added to the procedure in these patients in cases where ischemic symptoms develop in the left arm or there are neurologic symptoms, as in our patient (8).

In conclusion, total endovascular aortic arch repair using parallel graft technique is a method that can be preferred in emergency situations where surgical treatment is high risk as in the case presented herein.

## Conflict of interest disclosure

The authors declared no conflicts of interest.

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