

# Single-Stage Open Repair of Extensive Arch and Descending Thoracic Aneurysm through Sternotomy: A Case Report

Joon Young Kim, M.D., Hong Rae Kim, M.D., Joon Bum Kim, M.D., Ph.D.

Department of Thoracic and Cardiovascular Surgery, Asan Medical Center, Ulsan University College of Medicine, Seoul, Korea

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## Corresponding author

Joon Bum Kim

**Tel** 82-2-3010-5416

**Fax** 82-2-3010-5416

**E-mail** jbkim1975@amc.seoul.kr

## ORCID

https://orcid.org/0000-0001-5801-2395

Extensive thoracic aortic disease involving the ascending aorta, the aortic arch, and the descending thoracic aorta may require multiple surgical and interventional managements, which impose a burden in terms of cumulative surgical trauma and the risk of interval mortality. Herein, we describe a single-stage arch and descending thoracic aorta replacement via sternotomy in a patient with multiple comorbidities presenting with an extensive thoracic aortic aneurysm.

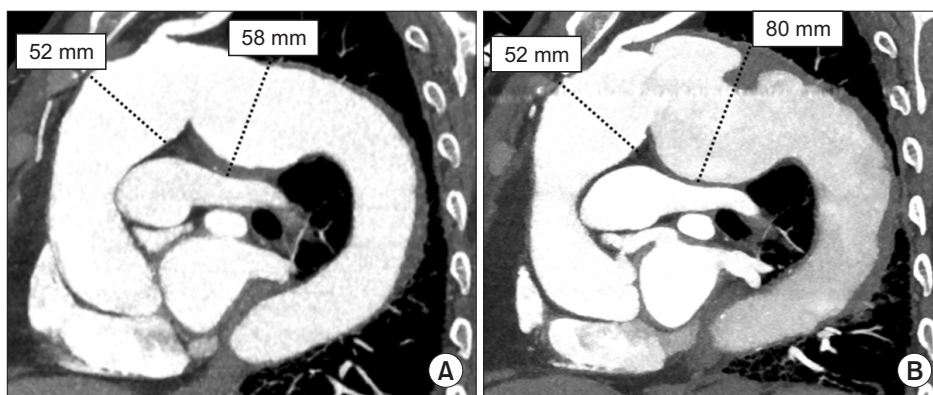
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## Case report

A 78-year-old man presented with an incidentally found large aortic aneurysm from the arch to mid-descending thoracic aorta (DTA) that was discovered during management for underlying interstitial lung disease. He had a previous history of multiple hospitalizations due to community-acquired pneumonia associated with his underlying lung condition, including episodes of intensive care unit care and subsequent delirium. During the most recent 8 months, computed tomography (CT) evaluations had shown progressive dilatation of the thoracic aorta with the

maximal aortic dimension at the proximal DTA from 58 to 80 mm (Fig. 1). Coronary angiography demonstrated 70% stenosis in the left anterior descending artery and 90% stenosis of the left circumflex artery. Pulmonary function testing revealed a forced vital capacity of 57%, forced expiratory volume in the first second of 73%, and a diffusing capacity of 30% of the reference values. After a comprehensive consideration of the patient's underlying conditions and the extent of aortic disease requiring surgical repair, single-stage aorta replacement combined with coronary artery bypass grafting (CABG) was planned.

After median full sternotomy, and harvesting the left in-



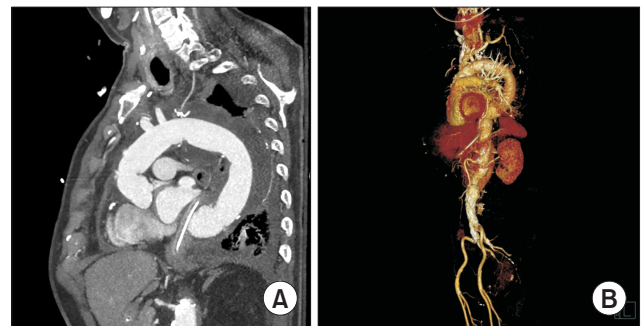
**Fig. 1.** Images of preoperative computed tomography scans showing progressive dilatation of the descending thoracic aorta. (A) First visit. (B) After 8 months.

ternal thoracic artery (LITA) and left saphenous vein graft (SVG), cardiopulmonary bypass (CPB) was initiated through cannulations on the innominate artery and right atrial appendage. Under full CPB support, the core temperature was lowered to the target nasopharyngeal temperature of 28°C. Under full decompression of the left ventricle by venting through right upper pulmonary vein, the heart was retracted cephalad and the posterior pericardium was incised to expose the DTA during the cooling phase (Fig. 2A). At the target temperature, the mid-ascending aorta was clamped and a single shot of del Nido cardioplegia (1,000 mL) was administered through the aortic root. Thereafter, arch vessels were clamped to allow unilateral antegrade cerebral perfusion during circulatory arrest simultaneously with the release of aorta clamping, which was followed by division of the aortic arch. Another aortotomy was made at the distal DTA through the posterior pericardiotomy, and then a commercially available 4-branch Dacron graft (Hemashield 4-branch 30 mm; Getinge, Gothenburg, Sweden) was passed through the DTA lumen from the distal DTA to the distal arch. The distal anastomosis was made at the distal DTA by a continuous running suture (3-0 polypropylene) with the inclusion of the proximal margin of aortotomy in the DTA so that intercostal backward bleeding could be sealed off within the remnant native aortic sac (Fig. 2B). Lower body perfusion was then resumed through a side branch of the 4-branch graft after the proximal graft clamp (Fig. 2C). The entire circumference of the anastomotic margin was reinforced by multiple pledget-mattress sutures. Proximal DTA sealing was also performed by enclosing the anastomosis with a pledget-mattress suture.

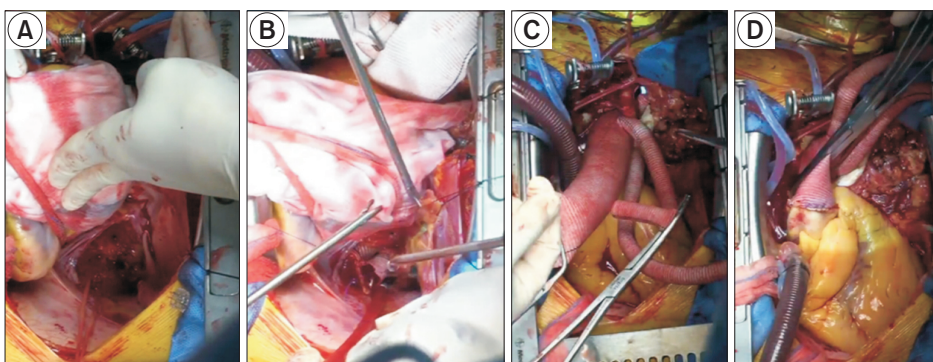
As soon as the left subclavian and left common carotid arteries were reconstructed serially, body warming was initiated, and then the proximal aortic anastomosis was made at the mid-ascending aorta (Fig. 2D). Subsequently, CABG was performed (LITA to the left anterior descending artery

and SVG to the obtuse marginal branch). Aortic clamping was released, and then the innominate artery was reconstructed under an on-pump beating heart. After smooth weaning from CPB, surgery was finished in the usual manner (Supplementary Video 1). The lower body ischemic, cardiac ischemic, and CPB times were 19 minutes, 96 minutes, and 134 minutes, respectively. The amount of perioperative transfusion given was 8 packs of red blood cell, 5 packs of fresh-frozen plasma, and 18 packs of platelet concentrate.

Although the patient did not experience major postoperative complications such as neurological injury, low cardiac output, renal impairment, or surgical site bleeding, the postoperative course was compromised by prolonged mechanical ventilation (extubation on postoperative day [POD] 7) and delirium. The patient was transferred to the general ward on POD 13, and after a long period of general care he was discharged on POD 65. Postoperative CT demonstrated excellent configuration of the replaced aorta (Fig. 3) and patent CABG grafts without any significant abnormality. On a CT examination performed 10 months after surgery, the perigraft thrombus within the native aortic sac had undergone resorption with resultant shrinking



**Fig. 3.** (A, B) Postoperative computed tomography demonstrates an excellent configuration of the replaced aorta with complete thrombosis in the native aortic sac.



**Fig. 2.** Surgical images. (A) The heart was retracted cephalad and the posterior pericardium was incised. (B) Distal anastomosis was made at the distal descending thoracic aorta. (C) Lower body perfusion was resumed through a side branch of the 4-branch graft. (D) Proximal aortic anastomosis was made at the mid-ascending aorta.



**Fig. 4.** (A, B) Postoperative computed tomography 10 months after surgery. The perigraft thrombus within the native aortic sac had undergone resorption with resultant shrinkage of the sac.

of the sac (Fig. 4). No backward extravasation from the intercostal arteries were observed at either immediate (Fig. 4A) or late postoperative time points (Fig. 4B).

This study was approved by the Institutional Review Board of Asan Medical Center (no., 2020-1565). The requirement for informed consent was waived.

## Discussion

Open surgical repair of extensive thoracic aneurysms involving the ascending aorta, the aortic arch, and the descending aorta is a complex and technically demanding procedure, which carries considerable risks of perioperative morbidity and mortality. The staged “elephant trunk” technique is a widely accepted treatment option for patients with disease affecting these areas. Complications after the first operation, however, may interfere with the second operation or the delay until the second operation itself may pose a considerable risk of interval morbidity and mortality from fatal aortic events.

To reduce the risks of the staged approach, a single-stage frozen elephant trunk technique using hybrid stent-grafts has emerged as an attractive treatment option in recent years. This approach may eliminate the risk of interval mortality and is expected to offer a solution for high-risk patients who cannot undergo the second-stage descending aorta replacement. However, this technique remains controversial because of its unknown long-term durability in addition to well-known serious stent-graft-related complications [1]. In this regard, there have been calls for better solutions to treat these challenging patients, especially when they present with considerable anatomical difficulties.

For single-stage extended aortic repair in such cases, median sternotomy combined with left anterolateral thoracotomy and a clam-shell incision are typical methods to be considered. These 2 approaches, however, inevitably in-

volve extensive surgical trauma and may also result in severe postoperative pain that hampers postoperative respiratory function.

The technique used in the present case may alleviate the complications of these extensive incisions, in which the approach technique using posterior pericardiotomy has previously been reported in patients with coarctation of the aorta [2]. Despite using the same approach, the major difference between prior reports of aortic coarctation surgery and the present technique is that former bypasses the aorta by extra-anatomic reconstruction while the latter “replaces” the aorta inside the native aortic lumen. This approach is expected to reduce postoperative pulmonary complications by avoiding the thoracotomy incision, as compared with more extensive incisions. It also allows the surgeon to perform other concomitant cardiac procedures in standard fashions, as was done for the present patient, who underwent CABG simultaneously. In addition, since all lesions are surgically replaced, we expect freedom from stent-graft complications such as distal malperfusion, endoleak, and stent-induced injuries that might have been issues if the patient had been treated using a hybrid endovascular intervention [3,4].

The approach used in the present case does not allow re-implanting the intercostal arteries, and this may leave concerns for postoperative spinal cord injury. Given the reported incidence of paraplegia of around 3% following stent-grafting of the entire DTA, the risk of paraplegia is expected to be similar or even better in open DTA repair because of the use of hypothermic protection even without the revascularization of intercostal arteries [5]. Furthermore, the risk of paraplegia may further be reduced by minimizing the duration of lower body ischemia—one of the most important risk factors of paraplegia—as was done for the patient described herein (19 minutes) [6].

In the DTA, suture ligation of the intercostal arteries is unavailable in the present approach and therefore they

were left open (i.e., unligated). As these arteries may become surgical bleeders, the sites of both the proximal and distal anastomoses were sealed off by conjoining the edges of native aorta and anastomosis sites using a running suture so that the intercostal bleeding is collected into a blind sac of the remnant aortic tissue. As a result, follow-up CT showed complete thrombosis of the sac with a size regression of the space.

Among several technical issues, preventing kinking and anatomical disorientation is thought to be pivotal. When passing the graft inside the DTA, it is important to maintain the anatomical orientation, which can be achieved by making a guiding mark on the graft, accurately estimating the graft length, and carefully pulling the graft out through the aorta. The appropriateness of the graft orientation can be inferred by intraoperatively monitoring the blood pressure between the upper and lower extremities.

Based on the outcomes observed in the present case, this surgical approach may be a reasonable option to treat extensive aneurysms involving both the arch and DTA. The safety and efficacy of this approach, however, should be confirmed in larger studies.

## Conflict of interest

No potential conflict of interest relevant to this article was reported.

## ORCID

Joon Young Kim: <https://orcid.org/0000-0002-1804-6870>

Hong Rae Kim: <https://orcid.org/0000-0001-9527-9689>

Joon Bum Kim: <https://orcid.org/0000-0001-5801-2395>

## Supplementary materials

Supplementary materials can be found via <https://doi.org/10.5090/jcs.20.148>. **Supplementary Video 1.** Operative video of single-stage open repair of arch and descending aorta via sternotomy.

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