

**Case Report**

# Stent Graft Collapse after Zone 0 Landing Thoracic Endovascular Aortic Repair

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A zone 0 landing thoracic endovascular aortic repair was performed on a 69-year-old man with a saccular aortic arch aneurysm. Seven days after the surgery, the patient experienced diminished consciousness and lower limb paralysis. Stent graft collapse was seen on a computed tomography scan. Thereafter, the patient underwent total arch replacement and emergency stent graft removal.

**Keywords:** fenestrated TEVAR, saccular aneurysm, bird-beak

## Introduction

Stent graft collapse is an uncommon event after thoracic endovascular aortic repair (TEVAR), and majority of reports have been of zone 2 or 3 landing TEVAR, with very few reports of zone 0.<sup>1)</sup> In this case report, we describe the clinical course and management of a stent graft collapse following zone 0 landing TEVAR. The patient's informed written consent was acquired.

## Case Report

A 69-year-old man with advanced stomach cancer underwent preoperative computed tomography (CT) while receiving medication for hypertension. On the lesser curvature of the aortic arch, the CT revealed a saccular aneurysm with an aneurysmal height of 35 mm (Fig. 1A). Aortic diameters in the ascending and descending direc-

tions were 37 and 31 mm, respectively. The angle of the aortic arch was high (angulation 73.9°). Blood testing, coronary artery imaging, and echocardiography all came back negative for any serious issues.

As the patient planned to have cancer surgery, he sought minimally invasive care. Using Najuta (SB-Kawasumi Laboratories, Inc., Tokyo, Japan), we suggested fenestrated TEVAR. A three-dimensional model was made for Najuta's preoperative planning, and the stent graft design was adjusted to make sure that the implantation position would not result in bird-beak and that the opening for fenestration would be adequate (Fig. 1B).

An introducer sheath was inserted after the left femoral artery was cut open. Najuta (AR09f-V42S3fA8A8-3U95) was advanced to the ascending aorta and inserted in the appropriate location. When the device was being removed, its tip interfered with the Najuta's first stent, causing it to migrate into the brachiocephalic artery. On the final digital subtraction angiography, a bird-beak was observed, but no stent graft oscillation was observed (Fig. 2A). The bird-beak length was two-thirds of the Najuta's first stent (approximately 8 mm).

The postoperative course was uneventful, and the patient was discharged from the hospital 5 days after the surgery. However, the patient had lower extremity numbness and diminished consciousness (Glasgow Coma Scale E3 V2 M5) 7 days postoperatively and was taken to the emergency room. Blood pressure was immeasurable in both the upper extremities, but both the femoral arteries were palpable. The Glasgow Coma Scale score increased to E4 V5 M6 during the test. CT showed a collapsed Najuta with lesions on the proximal three stents, graft obstructing the cervical branch orifice, and no retrograde type A dissection (Fig. 2B).


Emergency surgery was required to remove the collapsed Najuta, and a total arch replacement was done.

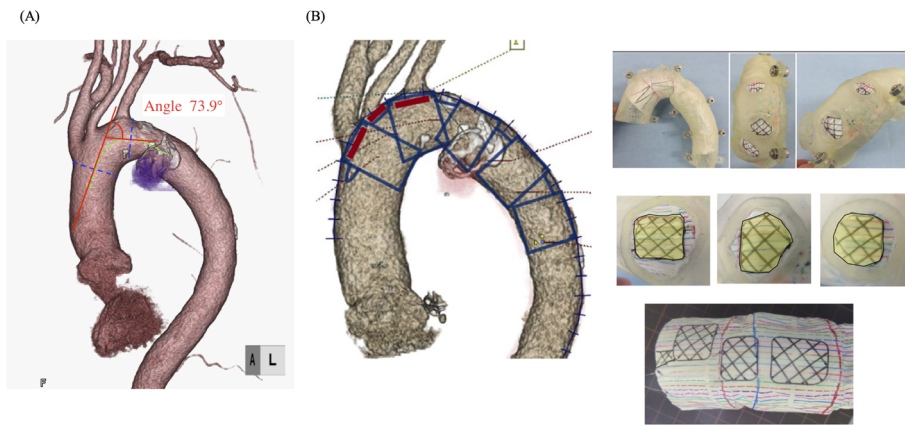
We established a cardiopulmonary bypass with right femoral perfusion and right atrial drainage. A left ventricular vent catheter was inserted through the right superior pulmonary vein. After circulatory arrest at 25°C, aortotomy was performed, and the collapsed Najuta was removed (Fig. 3). A selective brain perfusion circuit was

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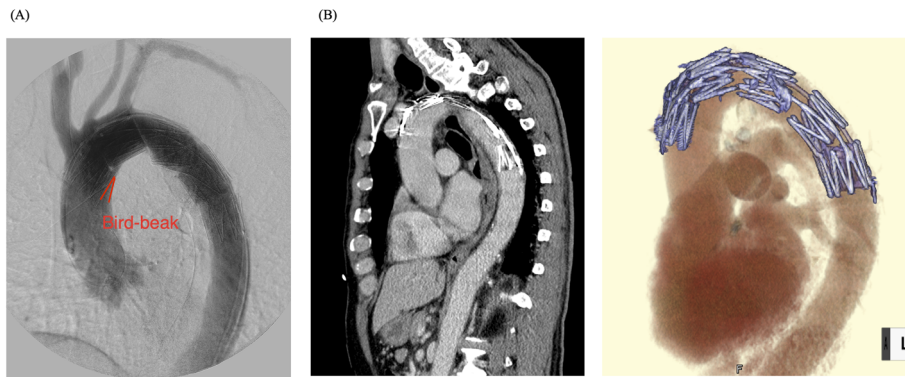
Received: April 11, 2023; Accepted: June 30, 2023

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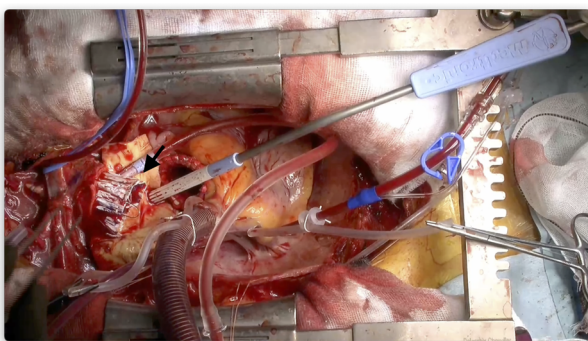
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**Fig. 1** Preoperative computed tomography and preoperative planning. **(A)** A saccular-type aneurysm is observed in the aortic arch. Aortic arch angulation is 73.9°. **(B)** A prior three-dimensional model is created to determine the graft design.



**Fig. 2** Digital subtraction angiography during stent graft and computed tomography images at the time of stent graft collapse. **(A)** A bird-beak happened during stent graft deployment. **(B)** Sagittal and three-dimensional views show complete collapse of the proximal three stents.



**Fig. 3** Intraoperative view. When the aorta was cut open under mild hypothermic circulation arrest, the proximal stent entirely collapsed (arrow).

then created. After confirming no intravascular damage to the aorta, a frozen elephant trunk ( $\phi = 35$  mm, length = 120 mm) was placed. Subsequently, total arch replacement was performed utilizing a four-branched graft ( $\phi = 26$  mm).

The patient was transferred to the intensive care unit and was promptly awakened. The patient had no neurological symptoms and was extubated 5 h postoperatively. He was discharged from the hospital 15 days after the surgery with no complications.

### Discussion

There have been very few reports about the collapse of Najuta, a zone 0 landing device. Stent graft collapse is a rare complication of TEVAR with 0.4% occurrence.<sup>1)</sup> No variations in the frequency of stent graft collapse among the graft devices are reported.<sup>1-4)</sup> The proximal landing zone is often located in zone 2 or 3.<sup>2)</sup> Risk factors for stent graft collapse include a steep aortic arch, young patients, elastic aorta, and small aortic diameter as patient factors and bird-beak configuration, small device size, oversizing of the stent graft, and devices with low radial force as device factors.<sup>1-3)</sup> Depending on the device, location of the implantation, and extent of the collapse, there are

several interventions, including artificial graft replacement and endovascular treatment (balloon dilation and an additional stent).<sup>3)</sup>

Zone 0 landing TEVAR less likely causes bird-beak.<sup>5)</sup> However, a previous study reported that an aortic arch angulation, the angle between the tangent line drawn for origin of brachiocephalic artery and distal edge of the left subclavian artery, of  $>59.15^\circ$  is a risk factor for bird-beak configuration.<sup>6)</sup> According to a different study, the chance of type Ia endoleak increases with the length of the bird-beak, with bird-beak lengths of 10 and 14 mm corresponding to 50% and 80% risk, respectively, in the TEVAR with proximal landing in zones 1 to 3.<sup>7)</sup> Similarly, the longer protrusion of the bird-beak increases the area receiving blood flow, which increases the likelihood of stent graft collapse.<sup>4,8)</sup> According to SB-Kawasumi laboratories, Najuta's oscillation linked with cardiac pulsation is a risk factor for stent graft collapse. In our case, there was no oscillation, but considering the fact that collapse occurred, the bird-beak was the direct cause of stent graft collapse. It is probable that Najuta was not appropriate for such a steep aortic arch due to its lack of conformability in the inner curvature of the aortic arch.

Forty-five percent of stent graft collapses occur within 1 week after TEVAR.<sup>1)</sup> Some patients who experienced stent graft collapse following zone 2 or 3 landing TEVAR complained lower extremity malperfusion and chest pain at onset of collapse, but most were asymptomatic.<sup>2)</sup> Stent graft collapse after zone 0 landing TEVAR causes acute occlusive symptoms in the neck vessels, causing consciousness disorder and weakness of limbs. Stent graft collapse following zone 0 landing TEVAR is a more disastrous complication and requires urgent treatment. Najuta is an endoskeletal stent graft device; there is a high possibility of a guidewire straying outside the stent frame. Additionally, balloon dilatation for Najuta is likely to cause the stent graft to shift distally, pushed by blood flow. Therefore, in our case, open surgery was chosen as a reliable method, although prompt method might be endovascular therapy.

In our case, the bird-beak was not anticipated to appear during the preoperative planning stage. However, owing to the steep aortic arch, unexpected migration occurred intraoperatively and a bird-beak was configured, causing stent graft collapse. Even a moderate bird-beak length (about 8 mm) would cause stent graft breakdown in zone 0 landing TEVAR.

## Conclusion

In this case, despite prior three-dimensional modeling of the aortic arch, a bird-beak occurred in zone 0 landing TEVAR, resulting in stent graft collapse. The patient presented with signs of acute occlusion of the neck ves-

sels and recovered without any residual disability after emergency stent graft removal and total arch replacement. The importance of zone 0 landing TEVAR is to plan not to configure a bird-beak; if a bird-beak is configured, it should be followed up cautiously and in the stent graft collapse, dependable and fast intervention is required.

## List of Abbreviations

TEVAR: thoracic endovascular aortic repair  
CT: computed tomography

## Acknowledgments

None.

## Conflict of Interest

None declared.

## Author Contributions

Study conception: DA  
Data collection: DA  
Analysis: DA  
Investigation: DA  
Manuscript preparation: DA  
Funding acquisition: none  
Critical review and revision: all authors  
Final approval of the article: all authors  
Accountability for all aspects of the work: all authors

## References

- 1) Kasirajan K, Dake MD, Lumsden A, et al. Incidence and outcomes after infolding or collapse of thoracic stent grafts. *J Vasc Surg* 2012; 55: 652-8; discussion, 658.
- 2) Tadros RO, Lipsitz EC, Chaer RA, et al. A multicenter experience of the management of collapsed thoracic endografts. *J Vasc Surg* 2011; 53: 1217-22.
- 3) Canaud L, Alric P, Desgranges P, et al. Factors favoring stent-graft collapse after thoracic endovascular aortic repair. *J Thorac Cardiovasc Surg* 2010; 139: 1153-7.
- 4) Alhaizaey A, Aljabri B, Alghamdi M, et al. Delayed aortic stent collapse in blunt traumatic aortic injury repair. *Aorta (Stamford)* 2019; 7: 129-36.
- 5) Kudo T, Kuratani T, Shimamura K, et al. Determining the optimal proximal landing zone for TEVAR in the aortic arch: comparing the occurrence of the bird-beak phenomenon in zone 0 vs zone 1 and 2. *J Endovasc Ther* 2020; 27: 368-76.
- 6) Cao L, Ge Y, He Y, et al. Association between aortic arch angulation and bird-beak configuration after thoracic aortic stent graft repair of type B aortic dissection. *Interact Cardiovasc Thorac Surg* 2020; 31: 688-96.
- 7) Ueda T, Fleischmann D, Dake MD, et al. Incomplete endo-

graft apposition to the aortic arch: bird-beak configuration increases risk of endoleak formation after thoracic endovascular aortic repair. *Radiology* 2010; 255: 645-52.

8) Pasta S, Cho JS, Dur N, et al. Computer modeling for the prediction of thoracic aortic stent graft collapse. *J Vasc Surg* 2013; 57: 1353-61.