► **Original Article** ◀

Utility of Chimney Stentgraft Technique for Patients with Short Zone 1

Yosuke Inoue, MD,¹ Hitoshi Matsuda, MD,¹ Tetsuya Fukuda, MD,² Yoshihiro Sanda, MD,²
Yoshiaki Morita, MD,² Tatsuya Oda, MD,¹ Yutaka Iba, MD,¹ Hiroshi Tanaka, MD,¹
Hiroaki Sasaki, MD,¹ Kenji Minatoya, MD,¹ and Junjiro Kobayashi, MD¹

Purpose: Arch aneurysm combined with insufficient Zone 1 length remains challenging. While a chimney stentgraft with supra-aortic bypass is a recognized solution for arch aneurysm, no definite strategy has been established yet. The aim of this study was to investigate efficacy of chimney stentgraft for patients with zone 1 of insufficient length.

Methods: Between 2011 and 2013, 10 consecutive patients with aortic arch aneurysm who were treated with a chimney stentgraft were retrospectively reviewed. The minimum length of zone 1 and length of landing zone inside zone 0 were measured on pre-/post-operative 3D-CT.

Results: Neither in-hospital mortality nor postoperative stroke was encountered. The minimum median length of zone 1 (zone 2 for bovine aortic arch of two patients) on preoperative 3D-CT was 10.1 mm [range: 3.9–15.3]. On postoperative 3D-CT, the median proximal landing length on a major curvature proximal to brachio-cephalic artery was 37.5 [range: 20.9–63.9] mm. Type Ia endoleak was observed in two patients with a landing length along the major curvature of less than 30 mm.

Conclusion: For patients with insufficient length of zone 1, aneurysm exclusion could be achieved with a chimney stentgraft ensuring sufficient length (>30 mm) of the landing zone inside the ascending aorta along major curvature.

Keywords: aorta, aneurysm, chimney stentgraft technique, insufficient zone 1 length, thoracic endovascular aortic repair

Introduction

Sufficient length of the proximal landing zone is the key for successful thoracic endovascular aortic repair (TEVAR) of an aortic lesion.

¹Department of Cardiovascular Surgery, National Cerebral and Cardiovascular Center, Suita, Osaka, Japan

²Department of Radiology, National Cerebral and Cardiovascular Center, Suita, Osaka, Japan

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Corresponding author: Hitoshi Matsuda, MD. Department of Cardiovascular Surgery, National Cerebral and Cardiovascular Center, 5-7-1, Fujishirodai, Suita, Osaka 565-0858, Japan
Tel: +81-6-6833-5012, Fax: +81-6-6833-5982
E-mail: hitmat@mist.ocn.ne.jp
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In clinical situations, however, the length of the proximal landing zone is often insufficient since many diseases affecting the thoracic aorta occur in the immediate proximity of the left subclavian artery (LSCA).¹⁾

The aim of this study was to investigate the safety, feasibility and efficacy of chimney stentgraft technique for patients with zone 1 of insufficient length.

Methods

Patients

Prospectively corrected data, obtained between 2011 and 2013, 10 consecutive patients (average age: 80; range: 76–86; 4 males) who underwent hybrid arch TEVAR combined with a chimney stentgraft were retrospectively reviewed (Table 1). The median EuroSCORE II was 8.6 [range: 2.1–28.2] and one emergency operation was performed for rupture with hemothorax. Etiology of all aneurysms was degeneration, except for one patient with chronic aortic dissection. Two patients had the bovine aortic arch configuration (Table 1).

Operation time was 372 ± 79 min and clamping times for the right common carotid artery (RCCA) and LCCA were 11 ± 2 and 8 ± 2 min, respectively. As expected, the chimney stentgraft technique was complicated endoleak at the proximal landing zone (type Ia) through the gutters between the two stentgrafts in the ascending aorta and was therefore indicated only for patients whose aorta was short (<20 mm) but of substantial length in zone 1 from brachio-cephalic artery (BCA) to LCCA. Patients were examined for endoleak evaluated by CT angiography one week after the procedure.

For this study, we hypothesized that minimal length of zone 1 and length of the landing zone inside the ascending aorta on a major and minor curvature were the factors that might be related to type Ia “gutter” endoleak. If the patient showed the bovine aortic arch, we used zone 2 length as a substitute for zone 1 length. These lengths were measured by using the pre- and post-operative 3-dimensional data and utilization of a Zio workstation (AMIN Inc., Tokyo, Japan) by an experienced radiologist (Fig. 1).

Table 1 Patient demographics

Age/ Gender	Comorbidities	Emergency	Supra-aortic bypass	Bovine arch	Length (mm)			Op time (min)	Bleeding (ml)	Hospital stay (days)
					Major	Minor	Zone 1			
82/F	AAA, sarcoidosis	Elective	RAxA-LCCA+LxA	-	24.9	28.6	11.1	155	700	16
76/F	HTN, DCM, eAP	Elective	RAxA-LCCA+LVA+LxA	-	24.8	38.4	7.8	462	1393	26
80/M	HTN, sigmoid cancer	Elective	RCCA-LCCA+LSCA	-	54.4	51.7	15.3	392	1155	9
83/F	LEIAVF, CHF, HTN	Elective	RCCA-LCCA+LSCA	-	20.9	28.4	3.9	374	1450	110
86/M	HTN, cerebral hemorrhage	Emergent	RCCA-LCCA+LxA	+	31.6	27.9	12.8	370	2142	23
84/F	Interstital pneumonia	Elective	RCCA-LCCA+LxA	+	47.1	40.1	8	456	2160	33
79/M	-	Elective	RCCA-LCCA+LxA	-	52.5	60.7	10.5	353	630	10
80/F	Dementia	Elective	RCCA-LCCA+LxA	-	43.4	30	7.4	390	1165	9
82/F	CRF, dementia	Elective	RCCA-LCCA+LxA	-	30.5	29.8	14	397	990	36
71/M	SLE (steroid), obesity	Elective	RCCA-LCCA+LxA	-	63.9	43.9	9.7	375	2187	17

AxA: axillary artery; CCA: common carotid artery; AAA: abdominal aortic aneurysm; HTN: hypertension; DCM: dilated cardiomyopathy; eAP: effort angina pectoris; SCA: subclavian artery; LEIAVF: left external iliac arteriovenous fistula; CHF: congestive heart failure; SLE: systemic lupus erythematosus; CRF: chronic renal failure

Operative technique

First, we initiated the supra-aortic bypass from right side (RCCA 8, RAxA 2) with an 8 × 8 mm T-shaped ringed EPTFE graft (GoreTex, W.L. Gore & Associates, Flagstaff, AZ) to LCCA and LAxA. Second, for the seven patients who needed two pieces of Gore TAG (W.L. Gore), a distal stentgraft was deployed in the usual fashion. Finally, a proximal stentgraft was inserted inside the ascending aorta to the aortic arch from the femoral or iliac artery and the iliac limb, or an extender of the Excluder (W.L. Gore) was inserted inside the ascending aorta up to the BCA through a 12 Fr sheath from the RAxA. These deployments were carried out during ventricular tachycardia induced by right ventricular pacing (180 beats/min) quickly and in a step-wise manner. The proximal portion of the BCA stentgraft was deployed inside the ascending aorta to prevent the embolus from ascending to the aortic arch and flowing into the cerebral circulation, with the entire TAG deployed and the distal portion of the BCA stentgraft deployed inside the BCA.

The size of the TAG inside the ascending aorta was set at one size larger than the size recommended in the instructions for use to prevent “gutter” endoleak. The size of the BCA stentgraft depended on the diameter of the BCA and was finally decided after insertion of a sizing catheter over the hard guide wire during the procedure.

To prevent cerebral embolism through the left vertebral artery we used balloon protection of the LSCA, a procedure which was indicated for the last two cases in this series. Coil embolization of the LSCA orifice was performed routinely. Figure 2 shows a case of aneurysmal exclusion.

Results

Neither hospital mortality nor postoperative stroke was encountered. Two patients needed tracheostomy. One of them suffered congestive heart failure just before discharge from our department and was referred to another hospital for tracheotomy. The other patient was already suffering from arteriovenous fistula at the common iliac vein due to iliac aneurysm perforation followed by congestive heart failure before TEVAR, so that tracheotomy had to be performed after TEVAR. This patient was discharged 3 weeks after TEVAR.

All patients were discharged after postoperative hospitalization for 24 [range: 9–110] days, except for one patient who was transferred due to prolonged respiratory failure.

The median minimum length, measured on preoperative 3D-CT, of the proximal landing zone distal to the BCA, that is, zone 1 for the aneurysms in the normal aorta or zone 2 for aneurysm in the bovine aortic arch of two patients, was 10.1 mm. The length ranged from 3.9 to 15.3 mm and was more than 7 mm in all but one patient.

Fig. 1 Examples of measurements by radiologists using pre- and post-operative 3-dimensional data. (A) Measurement of zone 1 length using pre-operative 3-dimensional data. (B) Measurement of landing length on a major curvature. (C) Measurement of landing length on a minor curvature.

Fig. 2 Example of the chimney stentgraft technique. (A) Post-operative CT angiography showing achievement of aneurysmal exclusion using a chimney stentgraft with supra-aortic bypass. (B) Intra-operative imaging just before the concomitant deployment of TAG and Excluder limb.

Postoperative 3D-CT revealed the median length of the landing zone inside zone 0 was 34.2 [range: 27.9–60.7] mm on the minor curvature and 37.5 [range: 20.9–63.9] mm on the major curvature.

Type Ia endoleak was observed in two patients. An 82-year-old female patient who suffered from the enlargement of distal arch aneurysm due to the type Ia endoleak after first TEVAR with zone1 landing was treated with repeated TEVAR with chimney stentgraft. The length of landing zone inside the ascending aorta along the major curvature was 24.9 mm long and type Ia endoleak was still residual through a bird-beak formation at the minor curvature. This was successfully treated with third TEVAR

with the extension of chimney stentgraft near the sinotubular junction. The other patient was a 76-year-old female with a 8 mm-long zone 1, whose postoperative CT revealed type Ia endoleak but without further enlargement of the aneurysm. The length of zone 0 along the major curvature was 24.8 mm (Fig. 3). No type Ia endoleak was detected in the other eight patients, including the two patients with bovine aortic arch, and the length of the landing zone along the major curvature was longer than 30 mm except for 21 mm in one patient.

Table 2 shows the plotted lengths of the landing zone inside the ascending aorta along major curvature and of zone 1 (zone 2 for bovine aortic arch). Zone 1 of all patients was shorter than 20 mm but longer than 7 mm, except for one patient whose zone 1 was 3.9 mm long. This particular patient was exceptional because the etiology of the aneurysm was chronic dissection. For this patient, the length of the landing distal from the BCA equaled the length between the orifice of the BCA and the site of entry to the dissection, which might be sufficiently long for aneurysmal exclusion.

The proximal landing length on the major curvature proximal to BCA of both patients who developed type Ia endoleak was less than 30 mm. No residual endoleak was detected in the patients with aortic arch aneurysm when zone 1 was longer than 7 mm and the landing length on a major curvature was longer than 30 mm.

Discussion

Sufficient length of the proximal landing zone is the key for successful TEVAR of an aortic lesion. Especially for patients requiring zone 1 repair, when sternotomy is necessary to perform bypass surgery for the ascending aorta,

Fig. 3 Type Ia endoleak after TEVAR with chimney stentgraft technique. A 76-year-old female patient. Preoperative CT revealed 8 mm long zone 1 (A) and postoperative CT showed the landing length on a major curvature was 25 mm (B) and type Ia endoleak (C). TEVAR: thoracic endovascular aortic repair

Table 2 Relationship between occurrence of Type Ia endoleak and landing length

several reports have mentioned that the shorter the proximal landing zone is, the higher the rate of endoleak.^{2,3)} To achieve aneurysmal exclusion, various maneuvers including fenestrated, branched and chimney stentgrafts have been recommended to clarify the limitations of the landing zone for thoracic endografting imposed by aortic arch vessels.⁴⁻⁶⁾ The fenestrated or branched stentgraft, which can ensure preservation of perfusion of the supra-aortic arch vessels, seems to be currently the best solution.⁷⁾ However, either of these stentgrafts is a custom made device, which is time consuming to manufacture and can therefore not be used in an emergency setting.^{8,9)} In view of these limitations, and for current clinical situations, the chimney stentgraft technique may be a provisional solution and has been widely discussed.¹⁰⁾

The optimal strategy for the chimney stentgraft, especially in terms of the proximal landing length, has not been fully discussed yet. Melissano and colleagues concluded that the appropriate criterion for Zone 1 endograft deployment is a proximal landing zone of >30 mm.⁴⁾ According to their report, patients whose proximal landing length in

Zone 1 is not long enough must undergo Zone 0 repair including a chimney stentgraft. In terms of results for in-hospital mortality, postoperative complications and need for recurrent interventions during a median follow-up of 12 months [range: 2–29 months], this strategy is thought to be safe and feasible.

Now that the short-term results for chimney stentgraft have been found satisfactory, it should be developed to the next stage to ensure durability, for which control of type Ia endoleak is an important contributory factor. In this study, the length of the landing zone inside the ascending aorta on the major curvature of both patients with type Ia endoleak relatively short, less than 30 mm. This suggests two speculations to us. First, since the stentgraft to the BCA is deployed at various location inside the ascending aorta, a longer (>30 mm) landing zone inside the ascending aorta may protect against type Ia endoleak through the gutter between the two stentgrafts and ensure the landing length along the major curvature. Second, bird-beak formation at the minor curvature, which was observed in one patient with type Ia endoleak, may be avoided by placement of the TAG proximally to the curve at the middle of the ascending aorta.

We had speculated that a short yet significant length for zone 1 is the key to prevention of type Ia “gutter” endoleak after chimney stentgraft placement and that this critical length should be 5 to 10 mm. However, since the patient with the shortest length, 3.9 mm for zone 1, was not complicated with type Ia endoleak, it appears that it is not possible to decide on a minimum length for the proximal landing zone distal to BCA to prevent type Ia endoleak. However, this patient was the only patient whose indication for TEVAR was chronic dissection. In other patients with aneurysm, type Ia endoleak was not observed when zone 1 was 7 mm or longer and the length of the landing zone inside the ascending aorta

along the major curvature of 30 mm or longer. This study has several limitations. The first is its retrospective design with a small sample size and single-center experience and the second limitation is the short follow-up period. For future studies, we therefore need to increase the number of patients and length of the follow-up periods.

Conclusion

For patients with an insufficient yet significant length of zone 1 (zone 2 in the bovine aortic arch), aneurysm exclusion can be achieved by means of TEVAR with a chimney stentgraft to ensure sufficient length (>30 mm) of the length of the landing zone inside the ascending aorta along the major curvature.

Disclosure Statement

All authors did not have conflict of interest in this paper.

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