

Simplified Elephant Trunk Technique Promotes Thrombo-Occlusion of the False Lumen in Acute Type A Aortic Dissection

Shinji Miyamoto, MD, Tetsuo Hadama, MD, PhD, Hirofumi Anai, MD, Tomoyuki Wada, MD, Eriko Iwata, MD, Hideyuki Tanaka, MD, Masato Morita, MD, Satoshi Takebayashi, MD, and Takashi Shuto, MD

Objective: We developed a “simplified elephant trunk (SET) graft technique” as a refinement of the original elephant trunk. A cuff is created in a single 4-branched graft, which is used for the distal anastomosis; the residual distal graft is used as the trunk. We expected the SET would secure the anastomosis and promote the thrombo-occlusion of the false lumen in the down stream of the aorta. In this paper, we highlight the usage of the SET for arch replacement of acute aortic dissection cases in comparison with the same arch replacement without the SET method.

Patients and Methods: Between March 1996 and March 2002, 35 patients underwent arch replacement for acute aortic dissection. Twenty-two of them had a patent false lumen in the downstream aorta at the operation and 17 (SET: 8, non-SET (NSET) : 9) out of 22 underwent enhanced computed tomography (CT) scan 2 weeks after and 1 year after operation. We calculated the ratio of the false lumen in the aorta (F ratio) and the ratio of the patent false lumen in the whole false lumen (E ratio) by CT scan. These values were calculated every 3 cm down to 15 cm below the anastomosis, thus resulting in 5 segments.

Results: The false lumen throughout all segments disappeared (F ratio =0) in none of both group 2 weeks after operation. One year thereafter, in 5 (63%) patients in the SET group, no false lumen in any segment existed, while in contrast a false lumen still existed in some of the segments in all NSET patients. Although neither the F and E ratio of the NSET group change during this period in any segments, those of the SET group decreased significantly in all the segments except for the E ratio of segment 5.

Conclusion: The SET promoted thrombo-occlusion thus leading to the disappearance of the residual false lumen, possibly by avoiding persistent endoleakage at the anastomotic site. (*Ann Thorac Cardiovasc Surg* 2006; 12: 412–6)

Key words: elephant trunk, arch replacement, aortic dissection

Introduction

The “elephant trunk” graft was originally developed to facilitate the performance of the 2-stage of an operation

From Department of Cardiovascular Surgery, Oita University, Faculty of Medicine, Yufu, Japan

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Address reprint requests to Shinji Miyamoto, MD: Department of Cardiovascular Surgery, Oita University, Faculty of Medicine, 1-1 Idaigaoka, Hasama-machi, Yufu, Oita 879-5593, Japan.

on the aorta. We have refined this procedure and called it the “simplified elephant trunk (SET) graft.” This involves using a single branched graft and employing it for acute aortic dissection. Endoleakage of the distal anastomosis in aortic dissection leads to an encasement of the patent pseudolumen. We expected that the SET would help secure the anastomosis, thereby promoting the thrombo-occlusion of the false lumen in the down stream of the aorta. In this paper, we highlight the usage of this SET method for the arch replacement of acute aortic dissec-

tion cases in comparison to the same arch replacement without the SET method, while especially focusing on the thrombo-occlusion of the residual false lumen in the descending aorta.

Patients and Methods

From March 1996 through to March 2002, 35 patients underwent arch replacement for an acute aortic type A dissection at our institute. Twenty-two of them had a patent false lumen in the downstream aorta extending to below the renal artery. Among them, there were 3 hospital deaths; 6M, hepatic failure, 5M methicillin-resistant *Staphylococcus aureus* mediastinitis and 3M bowel necrosis. One of 22 was unable to undergo enhanced computed tomography (CT) because of renal failure. Finally, 18 of 22 were able to undergo enhanced CT scanning at both 2 weeks after and 1 year after the operation. One patient who underwent the Bentall procedure concomitantly with an arch replacement using a mechanical valve and who was taking warfarin was excluded because the anticoagulation was considered to affect the thrombo-formation. We divided the remaining 17 patients into 2 groups according to distal anastomotic techniques. In the SET group (n=8), the SET method was employed and in the non-SET (NSET)(n=9) group a simple turning-up method was used. The choice of the methods was made at random by each operator except for cases in which no entry was found in either the ascending aorta or the arch aorta. In such retrograde dissection (Stanford type A, DeBakey type IIIb), SET was specifically employed expecting the trunk to obstruct the entry that might be close to the anastomosis or considering the second operation for a chronic dissecting aneurysm which occurs years after the first operation. The characteristics of groups are shown in Table 1. All cases demonstrated DeBakey type I dissection but 2 cases showed DeBakey IIIb retrograde dissection, in the SET group. The SET group also had one Marfan syndrome patient.

We calculated the ratio of the false lumen in the aorta (F ratio) and the ratio of the patent (enhanced) false lumen in the whole false lumen (E ratio) by a CT scan by the following formula, using the Image-Pro® Express software package (Media Cybernetics, Inc., Silver Spring, USA). These values were then calculated every 3 cm down to 15 cm below the distal anastomosis, thus resulting in 5 segments (S1–S5). Segment 5, the most distal segment, corresponds to the diaphragm level aorta (Fig. 1).

Table 1. Characteristics of the groups

	SET (n=8)	NSET (n=9)
Age	59 (42–72)	59 (48–74)
Male/female	6/2	5/4
DeBakey type		
DBI	5	9
DBIII (R)	3	0
Marfan syndrome	1	0

SET, simplified elephant trunk group; NSET, non-simplified elephant trunk group.

Volume of the false lumen (VF)

= area of the false lumen × 1 (slice width)

Volume of the aorta (VA)

= area of the aorta × 1 (slice width)

Volume of the patent false lumen (VP)

= area of the aorta × 1 (slice width)

Adding the above values of 3 consecutive slices gives the values of each segment (3 cm width).

Then values below are calculated for each segment.

F ratio = VF/VA

E ratio = VP/VF

Operative techniques

The technique of SET has been described in detail previously.¹⁾ Briefly, on the prosthesis (4-branched graft impregnated with gelatin), a sword guard-like cuff is made by sewing the inner and outer walls. Usually, in aortic dissection cases, the cuff is created just distally from the last branch of the graft. The trunk measures 5 cm in length (Fig. 2A). Under selective cerebral perfusion and systemic profound hypothermic circulatory arrest, the aorta is transected and the aneurysm is excised. For the distal anastomosis, first we put about 12 stay sutures through a Teflon felt strip and the aorta and then placed through the cuff of the graft. After tying the graft down, a 3-0 continuous suture is used to secure the anastomosis. As for NSET group, the cuff was created just by turning up the end of the graft (Fig. 2B) and then the prosthesis was anastomosed to the distal stump of the aorta in the same way as SET.

Statistical Analysis

All results were expressed as the mean ± standard deviation (SD). The groups were compared by the unpaired t-test. The values 2 weeks after and 1 year after surgery in each group were compared by the paired t-test. Probability values of <0.05 were considered to be significant.

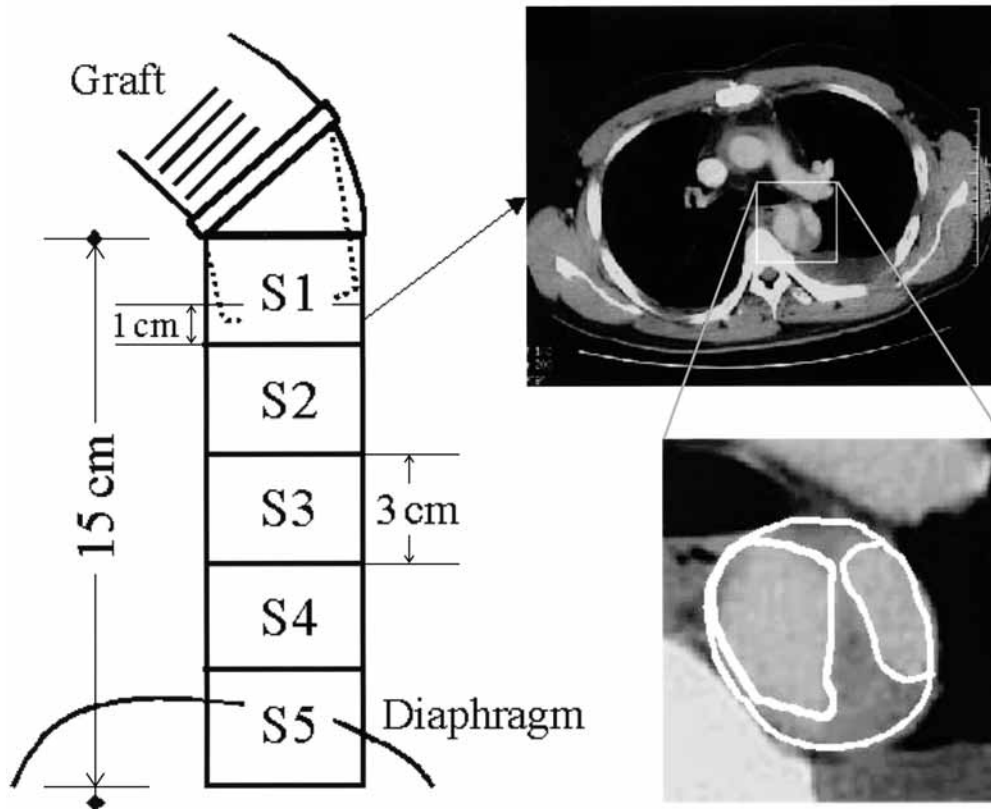


Fig. 1. The descending aorta is divided into 5 segments from the anastomosis down to 15 cm below for calculation. The area of each lumen is measured every 1 cm (slice width) by tracing the contour of the lumens on the screen.

Results

The false lumen throughout all segments disappeared (F ratio =0) in none of the groups at 2 weeks after operation. However, even 2 weeks after operation thrombo-occlusion was completed (E ratio =0) in 3 cases (37.5%) of SET group, whereas some sections could not be occluded in any members of the NSET group. One year later, the false lumen no longer existed (F ratio =0) in any segment in 4 patients (50%) from the SET group, in contrast the false lumen still existed in some of the segments in all NSET patients. The F ratio of the SET group is significantly lower than that of the NSET group in segments 1 and 2 even 2 weeks after the operation and a significant difference appears in all segments except segment 5, 1 year later (Fig. 3). The E ratio of SET was significantly lower than that of the NSET group at 2 weeks after the operation (Fig. 4). Although both the F and E ratio of the NSET group did not change during the period in any segments, while those of the SET group decreased significantly in all segments except for the E ratio of segment 5.

Discussion

Borst et al. created the elephant trunk graft to repair extending arch aneurysms as the first stage in a 2-stage operation.^{2,3)} The second stage is the replacement of the residual aneurysm of the descending aorta. Svensson and Crawford considered the elephant trunk technique to be contraindicated for patients with acute type A aortic dissection.⁴⁾ Heinemann et al. reported 100% mortality in 3 patients during treatment for acute type A dissection using the “elephant trunk technique”.⁵⁾ Kieffer et al. suggested an interesting indication could be an emergency treatment for an acute type A dissection in patients with Marfan syndrome, since the replacement of the aortic arch is commonly followed by replacement of the distal aorta at a later time.⁶⁾ Morota et al. first suggested that the elephant trunk technique could be used in cases of acute aortic dissection to assure thrombo-occlusion of the pseudo-lumen.⁷⁾ We therefore developed the “SET graft technique” as one of the modifications of the elephant trunk technique since 1996. A fragile distal aortic wall

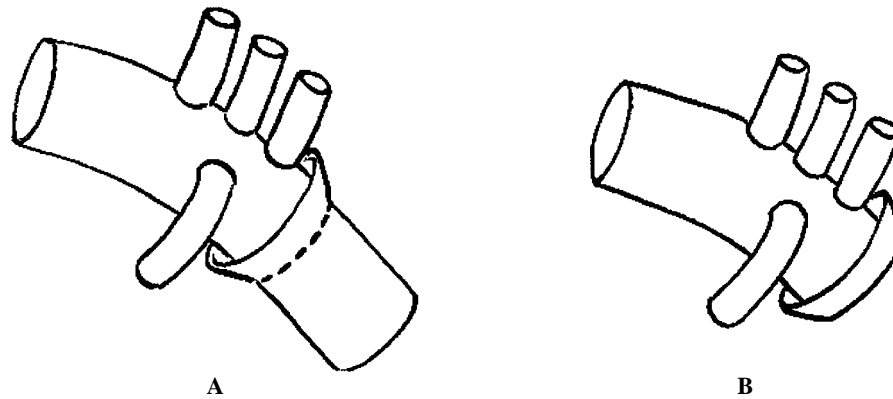


Fig. 2.
A: A graft having a sword guard-like cuff for simplified elephant trunk.
B: A graft with a cuff at the distal end.

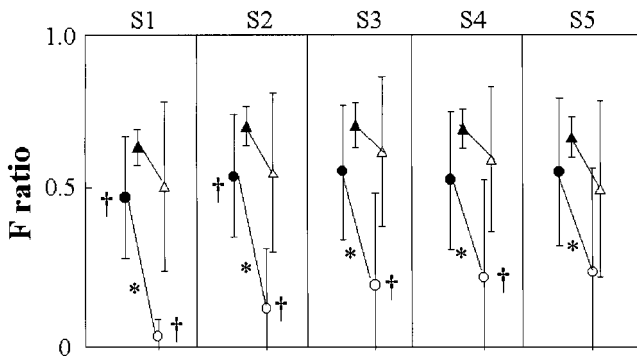


Fig. 3. F ratio of each section.
 *, P<0.05 comparing 2 weeks to 1 year; †, P<0.05 comparing SET to NSET.
 SET group: ●, 2 weeks after; ○, 1 year after.
 NSET group: ●, 2 weeks after; ○, 1 year after.

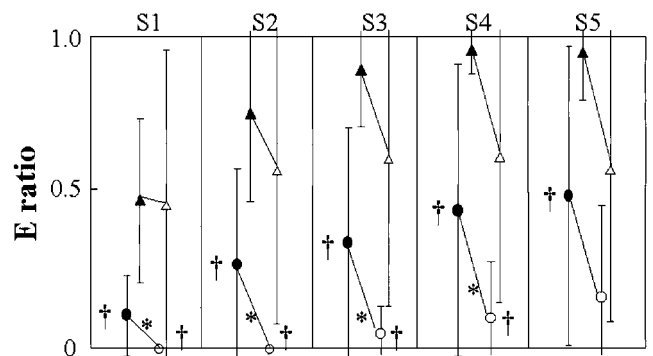


Fig. 4. E ratio of each section.
 *, P<0.05 comparing 2 weeks to 1 year; †, P<0.05 comparing SET to NSET.
 SET group: ●, 2 weeks after; ○, 1 year after.
 NSET group: ●, 2 weeks after; ○, 1 year after.

was considered to be the primary indication for performing SET among our patients. We used this method at the beginning in some acute dissection cases, which had a dissecting space in the descending aorta, while expecting thrombo-occlusion to occur in the remainder of the dissection.

We began to use stay sutures prior to running a continuous suture after we experienced bleeding from the anastomosis created with a 3-0 continuous suture only. The continuous suture can be run quickly and easily once the graft is fixed to the stump with stay sutures. Bleeding was occasionally experienced from the anastomosis between the main graft and the trunk in the original elephant trunk technique, but this never happened in the SET because it is an integrated single graft as a matter of course.

Only the SET group included 2 cases of DBIII dissection. The so-called “DBIII retrograde dissection” in this series had also an open false lumen at operation. We thus chose SET when we found no primary entry in the ascending or arch aorta and thus expected the elephant trunk to cover the invisible close entry or the later second operation for the descending aorta. Not resecting the primary entry works against thrombo-occlusion because the remaining open entry must exist somewhere in the distal aorta. The SET group also contained one Marfan syndrome patient that was not in the NSET group. Takahara et al. reported Marfan syndrome to be one of the factors that discourage postoperative thrombo-occlusion in cases of acute type A dissection.⁸⁾ Therefore, it is of profound significance that the SET group with retrograde DBIIIb

dissection cases and a Marfan syndrome patient showed superiority in terms of thrombo-occlusion.

Satisfactory thrombo-occlusion of the pseudo-lumen in the descending aorta was obtained in all patients who underwent SET in our series. Ando et al. performed the elephant trunk procedure in 9 acute dissection cases and demonstrated that thrombotic closure in the dissecting lumen of the descending aorta (the level of the aorta is not shown) in all cases whereas they experienced a 28% patency of distal false lumens without that procedure (follow-up 9–30 months).⁹ Konishi et al. showed that thrombo-exclusion proceeded down to the distal end of the elephant graft in 1 patient and to the diaphragmatic level in 3 patients and a total obliteration was observed in the remaining 1 patient (follow-up 4–18 months).¹⁰ Ishihara et al. performed 19 arch replacements for the acute type A dissections while inserting a synthetic graft with a distally anchored stent in the descending aorta and gained 100% of disappearance of the false lumen distal to the hilar level and 56% of that of that distal to the diaphragmatic level during the follow-up period (2–30 months).¹¹ Mizuno et al. reported the descending aorta at the point of stented graft attachment and the aorta surrounding the stented graft to return to normal in all (=7) patients but the residual false lumen still existed distally to the stent graft in 6 of 7 patients after the same procedure as Ishihara's¹¹ (the follow-up range, 13–66 months).¹² Our results and those reports confirm that the elephant trunk technique provides thrombotic closure of the false lumen in the descending aorta. Using a stent or not does not strongly affect thrombotic obliteration. For one thing, as our results show, the most significant factor favoring thrombo-formation is endoleakage at the distal anastomosis, and the stent has nothing to do with that. Another reason is that the stented graft cannot completely eliminate the false space because of the expanded adventitia even if the stent can expand the graft fully and the graft can thus adhere to the intima. Moreover, re-entry, which cannot be resected by the initial operation, must exist in the abdominal aorta in cases where a patent false lumen extends below the renal artery.

In conclusion, SET promoted thrombo-occlusion thus leading to the disappearance of the residual false lumen,

possibly by avoiding persistent endoleakage at the anastomotic site.

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