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TECHNICAL NOTE

Double-Barreled and Branched Endografting for Thoracoabdominal Aortic Aneurysm: The Hexapus Technique

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Abstract
Objective To treat thoracoabdominal aortic aneurysm (TAAA), we introduced an alternative "Hexapus" technique by double-barreled and branched endografting.
Technique and Result We established 2 transfemoral and 2 transaxillary access routes first and then deployed two abdominal bifurcated stentgrafts landing at the descending thoracic aorta through transfemoral routes, respectively. Two pairs of parallel stentgrafts were deployed via bilateral transaxillary route from each of contralateral limbs of main body stentgrafts to visceral arteries. Finally, we extended the ipsilateral limbs of main body stentgrafts to bilateral common iliac arteries as distal landings. The creation of six branches (four viscerals and two iliacs) resembles a hexapus. We have executed this Hexapus technique in three patients, and the final angiography during operation and postoperative 12-month image follow-up showed patent visceral branches and no any endoleaks.
Conclusion Our Hexapus technique is feasible in treating TAAA if patient is inoperable or no commercial fenestrated or branched stentgraft is available.

Keywords Thoracoabdominal aortic aneurysm · Endovascular aortic repair · Stentgraft · Double-barreled · Hexapus

Introduction

Thoracoabdominal aortic aneurysm (TAAA) repair is always challenging for vascular interventionists because the thoracoabdominal aorta lies deep in the body and gives rise to four important visceral branches. Open surgical repair remains the gold standard in most of the hospitals [1, 2]; however, various types of endovascular repair, such as T-branch graft [3, 4], fenestrated graft [4], chimney technique, sandwich technique [5], and octopus technique [6], have been developed in recent years for some inoperable patients.

Here, we describe an alternative hexapus technique, derived from a double-barreled cannon and branched stenting as a modification of Kasirajan's octopus technique [6] by using off-the-shelf products to treat TAAA.

Patients and Results

Institutional Review Board has approved our study, and we performed hexapus technique in three patients. All of them were TAAA, Crawford type III, IV, and V, respectively. The average age was 71 years old. In the preoperative evaluation, the diameter of thoracic aorta as the proximal landing zone could not be greater than 40 mm, so that two

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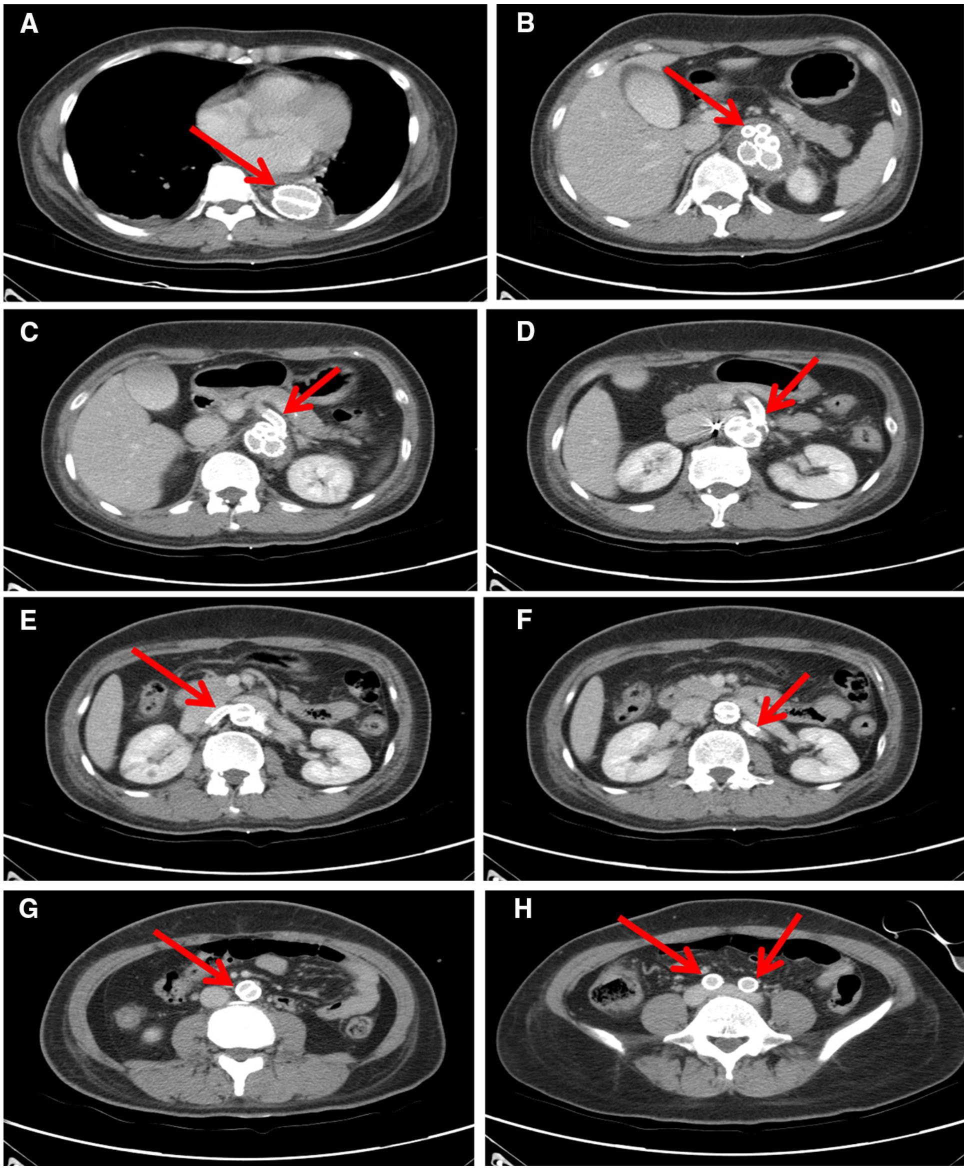

Fig. 1 Postoperative computed tomography angiography of the aorta. **A** The red arrow depicts double-barreled main body stentgraft in the thoracic aorta. **B** The red arrow depicts four renovisceral stentgraft from two contralateral limbs. **C** The red arrow depicts the stentgraft in the celiac trunk with good patency. **D** The red arrow depicts the stentgraft in the superior mesentery artery with good patency. **E** The red arrow depicts the stentgraft in the right renal artery with good patency. **F** The red arrow depicts the stentgraft in the left renal artery with good patency. **G** The red arrow depicts the two ipsilateral limbs in the distal abdominal aorta. **H** The two red arrows depict the two ipsilateral limbs extended to bilateral common iliac arteries

AAA main body grafts could be parallelly landed. All of them received preoperative lumbar drainage for prevention of paraplegia. The average operation time was 721 min. Technical success was defined as successful exclusion of aneurysm without any endoleaks in final angiography during operation, and technical successful rate is 100%. There were no paraplegia, no new-onset hemodialysis, and no acute myocardial infarction after operation. We routinely prescribe clopidogrel at least one year after operation. Computed tomography angiography (Fig. 1) with 3-dimensional reconstruction (Fig. 2) at postoperative months 3, 6, 12 revealed no endoleaks, and all branches were patent.

Technique

Step 1 Under general anesthesia, bilateral femoral and axillary arteries were exposed and isolated.

Fig. 2 Three-dimensional reconstruction of computed tomography angiography of the aorta. No endoleaks were observed, and all visceral arteries were patent

Step 2 We inserted an 8-French sheath in each of the common femoral arteries and two stiff wires into the ascending aorta.

Step 3 We changed two 8-French sheaths to 24-French sheaths because it could accommodate an 18-French main body stentgraft and a 12-French connection stentgraft.

Step 4 We inserted two C3 Excluders (W.L. Gore and Associates, Inc., Flagstaff, AZ, USA) over each stiff wire and deployed them in parallel at the healthy descending thoracic aorta as the double-barreled method. The opening of both contralateral limbs was kept at least 4 cm higher than the orifice of celiac trunk (CT).

Step 5 A floppy guidewire was inserted into the aorta through one of the 24-French sheaths to cannulate one of the contralateral limbs, and then a $16 \times 70 \times 10$ or $16 \times 70 \times 12$ mm in size, depending on the diameter of visceral branches, stentgraft was deployed to connect the contralateral limb. This connection stentgraft was designed to accommodate two stentgrafts coming from one of the axillary arteries for visceral stenting.

Step 6 The other contralateral connection stentgraft was deployed in the same manner.

Step 7 Kissing balloon dilatation over the proximal landing zone was performed using two Reliant (Medtronic, Minneapolis, Minnesota) balloons through the wires of contralateral limbs.

Step 8 We inserted another two 8-French sheaths in each of the axillary arteries and followed two guidewires into one of the connection stentgrafts; then, we changed the short sheaths to 90-cm sheaths.

Step 9 Through one of the long sheaths via one of the axillary arteries, we cannulated the superior mesentery artery (SMA) and CT and then advanced the long catheters to exchange the stiff wires with 1-cm soft tip.

Step 10 Two stentgrafts, Viabahn (W.L. Gore and Associates, Inc., Flagstaff, AZ, USA), were deployed in SMA and CT through the long sheaths with the other ends of stentgrafts parallel to the top of the connection stentgraft as a sandwich technique.

Step 11 We cannulated bilateral renal arteries from the other long sheaths via the other axillary artery through the other connection stentgraft and deployed Viabahns in the same manner.

Step 12 After ballooning over all the stent junctions, we deployed the two ipsilateral limbs and extended stenting to bilateral common iliac arteries. These limbs were not deployed until completion of the visceral stentings to ensure that the main body stentgrafts did not float downward.

Step 13 We performed the final angiography to check endoleaks and branch patency. Because the four visceral stentings and two iliac extensions make totally six limbs, we name our design as the hexapus stentgrafting (Fig. 3).

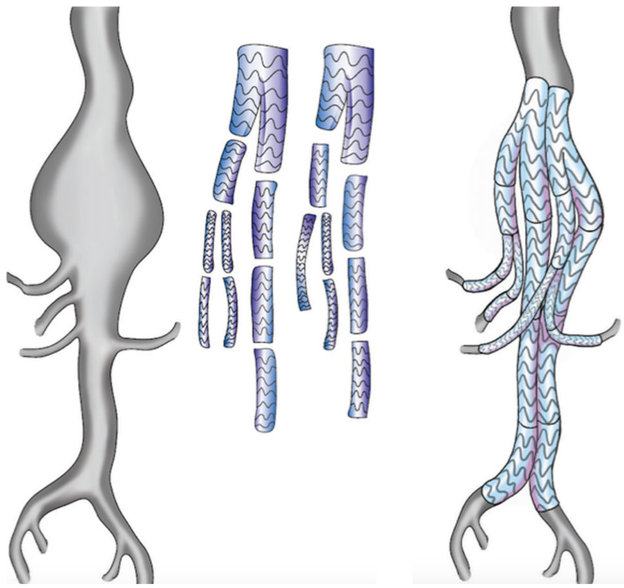

Fig. 3 Hexapus stentgrafting. To exclude thoracoabdominal aortic aneurysm, we used two C3 Excluder main body stentgrafts and two stentgrafts through each contralateral limb to preserve the four vital visceral arteries. The other two ipsilateral limbs were extended to bilateral common iliac arteries

Discussion

Although open repair for TAAA is efficacious, it is associated with a relatively high incidence of complications [1, 2]. Hybrid abdominal visceral debranching surgery plus stentgrafting avoids cardiopulmonary bypass; however, a long longitudinal laparotomy is still inevitable. Designing a customized fenestrated TAAA stentgraft may be time-consuming and not be available in an emergency case, and an off-the-shelf T-branch graft is not available in many countries. Therefore, some other strategies must be employed to treat the troublesome TAAA if the patient is inoperable.

Kasirajan described an attractive octopus technique [6], and Silveira et al. [7] reported a modified octopus technique to treat TAAA. Their techniques were impressive, and we used them as a base for our technique. Because the diameters of visceral arteries are relatively smaller in the Taiwanese population, the stentgraft may not be extendable from a visceral artery, especially a 5- or 6-mm-in-diameter renal artery, to the limbs (13 mm in diameter) of C3 Excluder. We therefore designed the extra connection stentgrafts (distal 10 or 12 mm in diameter) in both contralateral limbs of the C3 Excluder to accommodate two of the visceral stentgrafts. The major difference between our hexapus technique and the octopus technique from Kasirajan is that we used two main body stentgrafts, while Kasirajan's octopus technique used three main body stentgrafts. And the major difference between our hexapus technique and the modified octopus technique from Silveira is that each short limb accommodates two visceral branches in our technique, while three visceral branches are accommodated in one short limb in Silveira's modified octopus technique, which might be too crowded for three visceral stents in one limb. We also used the C3 Excluder in all cases because reposition helped us to adjust the opening of the contralateral limbs to facilitate wiring visceral arteries.

Our technique has some limitations. First, the double-barreled design for proximal landing may cause thoracic aorta dilatation or type 1a endoleak occurs. An extension cuff or a short thoracic stentgraft could be deployed first, followed by two C3 Excluder deployments from the middle of this stentgraft; this might prevent the proximal landing overdilatation, and proximal extension could be achieved with a bigger extension cuff or thoracic stentgraft in the future. Second, it is possible to develop type 3 endoleak since there are many stent overlappings in the aneurysm sac. Thus, each stent overlapping has to be greater than 3 cm in length to avoid intersegmental endoleaks. Besides, kinking may occur in our technique. Although no any bare stents were applied in our small series, additional bare stent for reinforcement might be needed if configuration was not satisfactory. Third, to prevent main body stentgraft from floating downward during visceral stenting, we do not release the ipsilateral limbs. Under this circumstance, the 12-French connection stentgrafts must be delivered through the same 24-French sheath. Therefore, the quality and size of the iliofemoral arteries for accommodating a 24-French sheath is the key element for our technique. Finally, since there are several overlapping prostheses in fluoroscopy, there might be a risk to misinterpret the radiopositive marks of the grafts causing misplacement. Despite these drawbacks, our hexapus technique appears to be a potential alternative treatment to treat TAAA. However, larger series and long-term follow-up are warranted.

Conclusion

Our hexapus stentgrafting for TAAA repair is an alternative treatment to exclude an aneurysm and preserve all visceral arteries if a patient is fragile to receive open repair or no fenestrated or branched stentgraft is available.

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Compliance with Ethical Standards

Conflict of interest The authors declare no conflicts of interest.

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