Management of left subclavian artery in total arch replacement and frozen elephant trunk procedure

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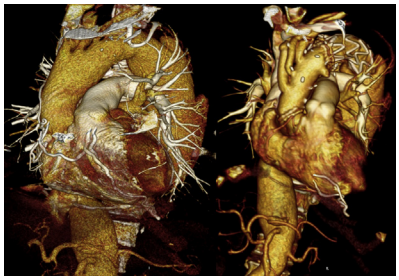


Preoperative and postoperative 3D-CT showing arch branch anastomosis with frozen elephant trunk.

CENTRAL MESSAGE

The 20-mm cuff–to–last branch distance in E-vita OPEN NEO facilitates left subclavian artery anastomosis and the overall graft orientation in total arch replacement with frozen elephant trunk.

See Commentaries on pages 41 and 43.

Video clip is available online.

The advent of frozen elephant trunk (FET) revolutionized open surgical management of total aortic arch aneurysm disease.[1,2] However, one of the challenges is the left subclavian artery (LSA) anastomosis, which is often deep and difficult to visualize. The emerging use of E-vita OPEN NEO (JOTEC, Hechingen, Germany) is a promising approach to tackling this challenge. We report our early experience and describe the advantages of its design in facilitating anastomosis of the LSA.

The new arch branched graft E-vita OPEN NEO was introduced to our center in October 2020. Between October and November 2020, 3 patients underwent total arch replacement using FET with the branched version of E-vita OPEN NEO. The operations were elective, the pathology was type III aortic dissection with arch aneurysm, and none had undergone previous aortic surgery. Perioperative data were collected retrospectively from institutional database with the patients' informed consent (Table 1). Mean operative time and circulatory arrest time were 315 ± 79 minutes and 47 ± 2 minutes, respectively. Selective antegrade cerebral perfusion (SACP) was delivered to all 3 supra-aortic branches during the procedure, and the mean SACP time was 138 ± 1 minutes. The mean hospital length of stay was 10 ± 1 days. No permanent spinal or neurologic complications or injury to the recurrent laryngeal nerve were observed. There was no in-hospital mortality.

OPERATIVE TECHNIQUE

We previously reported our approach to total arch replacement using FET.[3] Using the novel device, we adopted the distal-proximal-supra-aortic sequence of anastomosis, under diastolic cardiac arrest, moderate hypothermic circulatory arrest between 25°C and 28°C, and SACP to all 3 supra-aortic vessels. In all cases, the left subclavian artery was perfused with antegrade cerebral perfusion during circulatory arrest and before revascularization. It was the first revascularized supra-aortic branch after the proximal aortic anastomosis. Two patients had deployment of FET with a 0.035" guidewire passed

TABLE 1. Perioperative data of the initial experience of E-vita OPEN NEO

Characteristic	Patient 1	Patient 2	Patient 3	Mean ± SD
Age, y	60	46	72	
Sex	Female	Female	Male	
Pathology	Arch aneurysm with type III aortic dissection			
Previous aortic surgery	No	No	No	
Operative time, min	420	295	230	315 ± 79
CPB time, min	195	196	173	188 ± 11
Cross-clamp time, min	101	119	73	98 ± 19
MHCA time, min	45	50	45	47 ± 2
ACP* time, min	137	138	139	138 ± 1
LSA anastomotic technique	Axillary bypass	Extension technique	Direct anastomosis	
Resternotomy for hemostasis	No	No	No	
Total transfusion, units				
Packed cells	2	3	3	
Platelet concentrate	6	6	6	
Plasma	2	3	3	
Cryoprecipitate	6	6	6	
Stroke	No	No	No	
Paraplegia	No	No	No	
Hoarseness	No	No	No	
Postoperative dialysis	No	No	No	
ICU stay, d	2	1	1	
Hospital stay, d	12	10	9	10 ± 1
Survival for 30 d	Yes	Yes	Yes	
Endoleak	No	No	No	

SD, Standard deviation; *CPB*, cardiopulmonary bypass; *MHCA*, moderate hypothermic circulatory arrest; *ACP*, antegrade cerebral perfusion; *LSA*, left subclavian artery; *ICU*, intensive care unit. *All patients had selective ACP to all 3 supra-aortic branches.

through a 5 Fr arterial sheath at the right common femoral artery under fluoroscopic guidance in the hybrid theatre. On-table angiography and transesophageal echocardiography confirmed satisfactory stent opening and no aortic injury.

The 3 patients in this series had 3 different orientations of the supra-aortic branches (Figure 1), hence the variation in LSA anastomotic strategies, including direct anastomosis, extension technique, and left axillary artery extra-anatomic bypass (Video 1). When the LSA had a favorable exposure (Figure 1, *A*-1 and *A*-2), direct anastomosis was feasible, and the orientation of the postoperative computed tomography (CT) aortogram showed satisfactory results (Figure 2, *A*-1 and *A*-2). Figure 1, *B*-1 shows a more commonly presented orientation in which the LSA was found deeper into the mediastinum (Figure 1, *B*-2), with an extension of the LSA required for better exposure. The extension of the LSA was done with a segment of the 10-mm branched graft from the E-vita OPEN NEO on circulatory arrest (Figure 2, *B*-1). After stent deployment into the descending aorta and distal anastomosis, the LSA anastomosis was completed with a graft-to-graft anastomosis (Figure 2, *B*-2).

On rarer occasions (as in Figure 1, *C*-1 and *C*-2), the LSA was not only deep, but also apically located, an extra-anatomic bypass of the left axillary artery and ligation of the LSA origin was required. The left axillary artery bypass was performed with a 6-mm graft under an infraclavicular incision. After stent deployment into the descending aorta and distal anastomosis, the vascular graft was tunneled through the first intercostal space and the left pleural cavity to reach the mediastinum for anastomosis

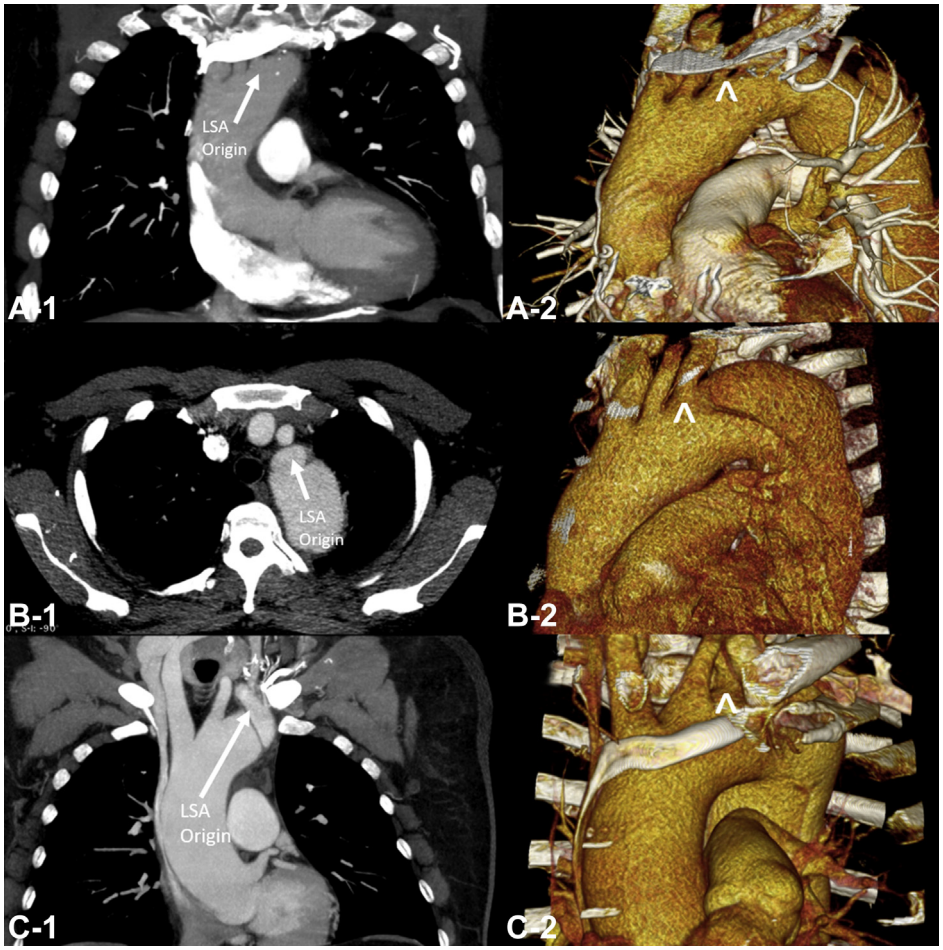
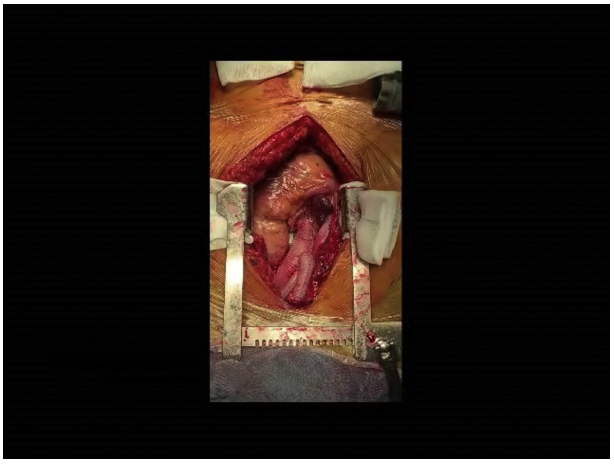


FIGURE 1. Preoperative computed tomography reconstruction of the aortic arch anatomy showing the variations of left subclavian artery (*LSA*) origin and hence the different options for LSA anastomosis. ˆdenotes the LSA origin in 3-dimensional reconstruction. The panels are presented in pairs with (A-2), (B-2), and (C-2) the 3-dimensional reconstructions of (A-1), (B-1), and (C-1) respectively.



VIDEO 1. Early experience with the E-vita OPEN NEO branched device for total aortic arch replacement with frozen elephant trunk, and surgical video on approaches to left subclavian artery anastomosis. Video available at: https://www.jtcvs.org/article/S2666-2507(21)00269-8/fulltext.

with the 8-mm side branch of the E-vita OPEN NEO (Figure 2, *C*-1 and *C*-2). Internal ligation of the LSA origin was done with transfixing pledgeted sutures. The postoperative CT aortogram showed patent supra-aortic branches with satisfactory orientations without kinking of grafts (Figure 2, *C*-2).

DISCUSSION

In total arch replacement with FET, zone 2 anastomosis has been associated with improved survival.[4-7] However, this approach is fraught with technical challenges, as the LSA can be deep and thus challenging, and various approaches and decision algorithms have been described.[6-8] The 3 approaches to LSA anastomosis described here allow better planning for full restoration of the supra-aortic branches, including the anticipated approach to achieve proximal control for anastomosis with good hemostasis in our experience. The 20-mm

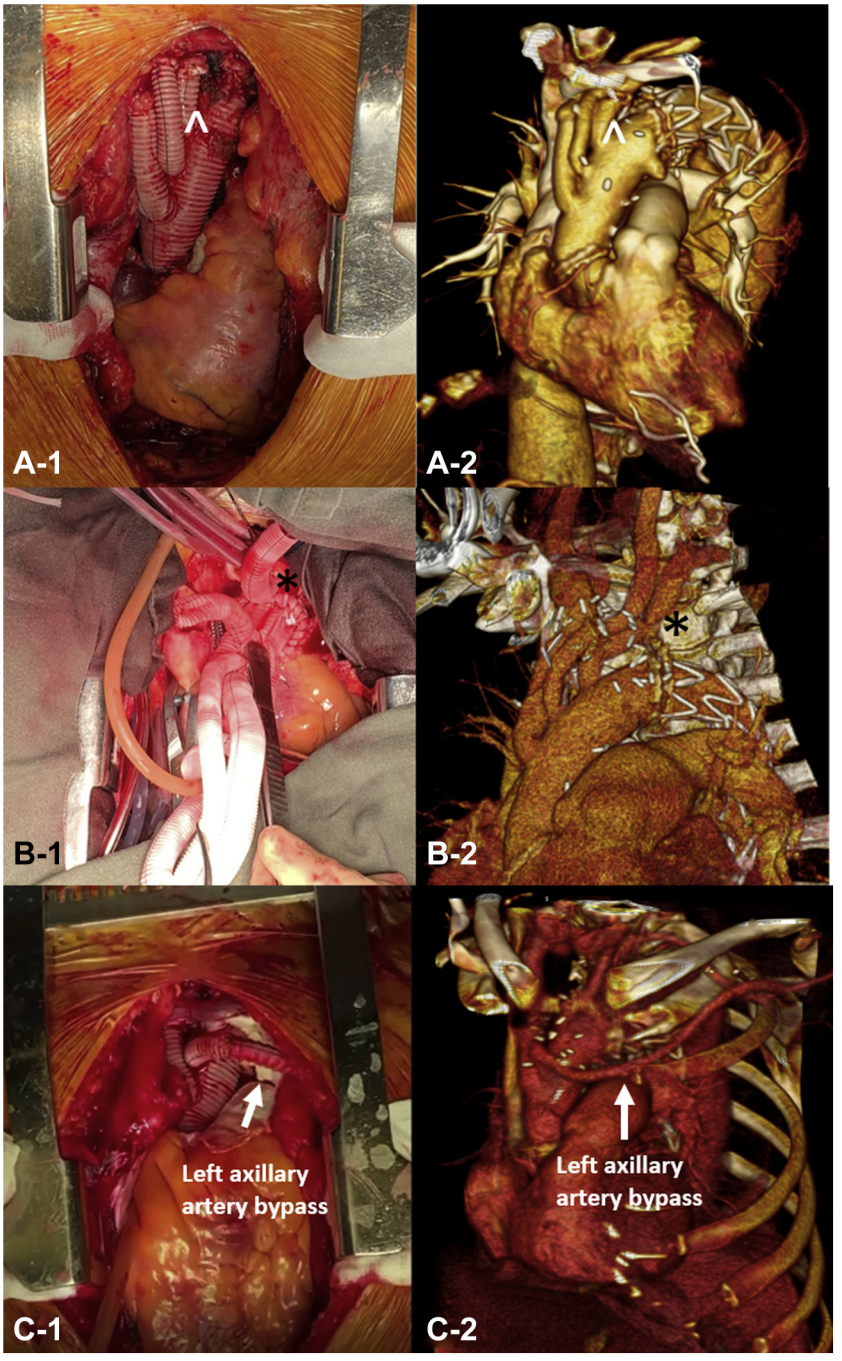


FIGURE 2. Intraoperative photos and computed tomography reconstruction of total aortic arch replacement with frozen elephant trunk with the variations of left subclavian artery (LSA) anastomosis considering the different origins. ˆand * denote the LSA anastomosis. The panels are presented in pairs with (A-2), (B-2), and (C-2) the 3-dimensional reconstructions of (A-1), (B-1), and (C-1), respectively. LSA anastomosis was performed with direct anastomosis (A-1), extension technique (B-1), and left axillary extra-anatomic bypass (C-1).

distance between the sewing collar and the third-side branch of the E-vita OPEN NEO offers a wider anastomotic space to the LSA and reduces the risk of kinking.

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