Art of Operative Techniques

T-NEXT graft: step by step operative technique

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The frozen elephant trunk (FET) technique has become a cornerstone in the management of complex aortic arch disease, yet reinterventions, both proximally on the root and distally on the thoracoabdominal aorta, remain common. Conventional FET prostheses were designed to recreate standard arch anatomy with the distal anastomosis beyond the left subclavian artery (LSA) and the supra-aortic branches in proximal-to-distal sequence. However, the current trend towards more proximal anastomosis in zones 0–2, brings the arch branches closer to the aortic root, which can limit root access during reoperation by reducing the available clamping zone, and also creates unfavorable angulations for antegrade visceral vessel cannulation during distal endovascular repair. Here, we describe the step-by-step operative technique for a new graft, the T-NEXT, a customized modification of the Thoraflex hybrid prosthesis, designed for improved life-time management of complex aortic disease, featuring a transverse and distal alignment of the arch branches. This configuration leaves an unobstructed proximal graft segment to facilitate safe distal clamping in future proximal reoperations, while preserving a smooth, bidirectional pathway for antegrade and retrograde endovascular access.

Keywords: Frozen elephant trunk (FET); T-NEXT graft; total arch replacement

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Introduction

Aortic pathology is progressive, and reinterventions, both proximally on the aortic root and distally on the thoracoabdominal aorta, are frequently required after frozen elephant trunk (FET) procedures. Available FET grafts were originally designed to recreate normal arch anatomy with the distal anastomosis beyond the left subclavian artery (LSA). However, many surgeons now favor a more proximal anastomosis (zone 2, zone 1, zone 0). This "proximalization" of the side branches can limit root access during reintervention, as it requires a very low aortic clamp, and may also pose challenges for endovascular thoracoabdominal aortic repair (ETAR) due to the double angulation that makes visceral vessel cannulation from an upper-body approach difficult.

The T-NEXT graft is a customized Thoraflex prosthesis designed to improve life-time management of patients with complex aortic disease. Unlike the traditional proximal-to-distal configuration of the neck vessels, it features a new distal and transverse alignment of the side branches to facilitate both proximal and distal interventions after FET. Here, we present the step-by-step operative approach for T-NEXT implantation (1).

Surgical technique

Preparation

The patient is positioned supine, with the neck slightly extended by placing a soft pad behind the shoulders. The operation is performed under general anesthesia according to the standard protocol. Monitoring includes 12-lead electrocardiogram (ECG), invasive arterial pressure via bilateral radial lines, central venous pressure, rectal and pharyngeal core temperature, SpO_2, end-tidal CO_2,

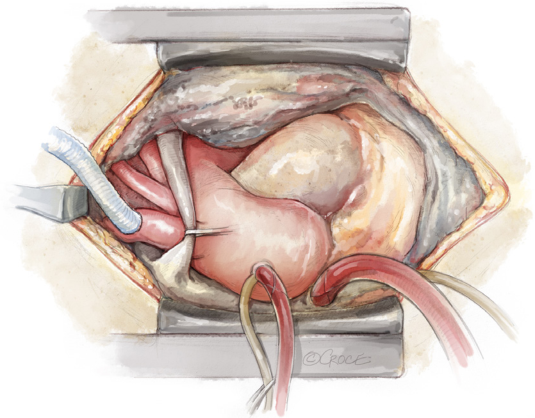

Figure 1 Extensive dissection of the BCT from its origin to the bifurcation, the left common carotid artery, and the left subclavian artery from its origin to the vertebral artery take-off is carried out. Cardiopulmonary bypass is established by cannulation of the BCT using an interposition 8 mm vascular graft. Venous drainage is achieved through right atrial cannulation, and left ventricular venting is performed via the right superior pulmonary vein. BCT, brachiocephalic trunk.

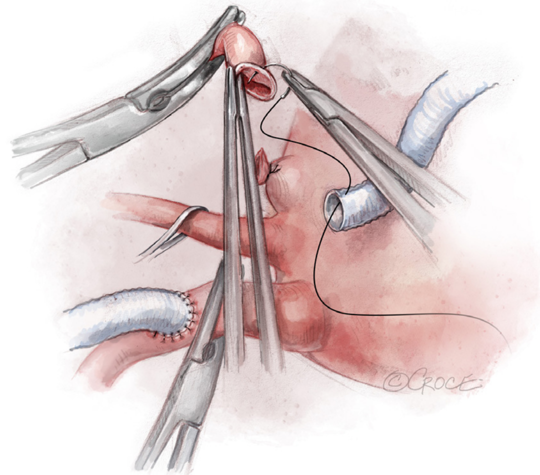

Figure 2 During the cooling phase, the LSA is ligated proximally, transected, and the proximal stump oversewn. The distal LSA is anastomosed end-to-end to an 8-mm Dacron graft using a running 5-0 polypropylene. This can minimize distal visceral ischemia time and facilitates subsequent LSA reimplantation on the beating heart. This graft is cannulated with a dedicated cannula for antegrade selective cerebral perfusion and connected to the circuit. LSA cannulation is routinely included to enhance cervical spinal cord protection via the vertebral arteries. LSA, left subclavian artery.

urine output, intermittent arterial blood sampling, trans-esophageal echocardiography and activated clotting time. Cerebral oxygenation is monitored using near-infrared spectroscopy (NIRS). Prophylactic antibiotics are administered according to institutional protocol.

Exposition

The procedure is performed through a median sternotomy. The brachiocephalic vein is identified and fully mobilized to facilitate exposure of the epi-aortic vessels and the aortic arch. Extensive dissection of the brachiocephalic trunk (BCT) from its origin to the bifurcation, the left common carotid artery (LCCA) and the LSA from its origin to the vertebral artery take-off is carried out. The LCCA and LSA are slung with vessel loops. Once the epi-aortic arch vessels are delineated and controlled, the pericardium is opened with an inverse “T” incision and suspended using 4–6 stay sutures. The ascending aorta, proximal arch (up to the target distal anastomosis zone), right atrium and right superior pulmonary vein are then adequately exposed.

Operation

After systemic heparinization, the BCT, when free from atheroma, calcification or clots, is partially side-clamped approximately 4–5 cm distal to its origin from the aortic arch. A longitudinal arteriotomy of about 1 cm is performed, and an 8-mm Dacron vascular graft is anastomosed in an end-to-side fashion to the BCT using a 6-0 polypropylene suture, then connected to the arterial line. During tangential clamping, adequate distal perfusion to the right arm and right cerebral circulation is ensured by monitoring right radial artery pressure and NIRS. Venous drainage is achieved via right atrial cannulation, and the right superior pulmonary vein is cannulated for left ventricular venting (*Figure 1*).

Cardiopulmonary bypass is initiated, and the patient is cooled to a target temperature of 26 ℃. During the cooling phase, the LSA is ligated proximally, transected and the proximal stump oversewn. The distal LSA is anastomosed end-to-end to an 8-mm Dacron graft with a 5-0 polypropylene running suture (*Figure 2*). This graft is cannulated with a dedicated cannula for antegrade selective cerebral perfusion (ASCP) and connected to the circuit. LSA perfusion is initiated at a flow rate of 250 cc/min and adjusted to obtain similar arterial pressure on both

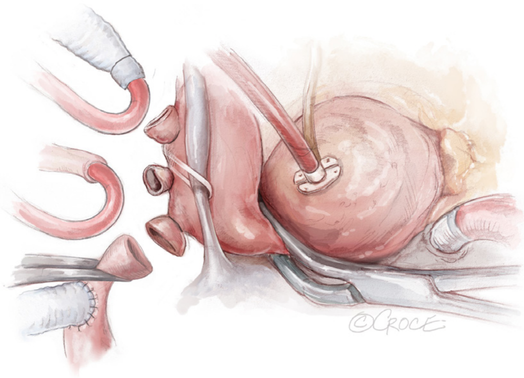

Figure 3 During cardioplegia delivery, the left common carotid artery is transected and a dedicated ASCP cannula is inserted to ensure bilateral cerebral perfusion during circulatory arrest. ASCP is delivered at 10 mL/kg/min, equally divided between, equally distributed to the right and left hemispheres, and adjusted to maintain a right radial arterial pressure between 40 and 80 mmHg. Cerebral perfusion is monitored with near-infrared spectroscopy and adjusted accordingly. ASCP, antegrade selective cerebral perfusion.

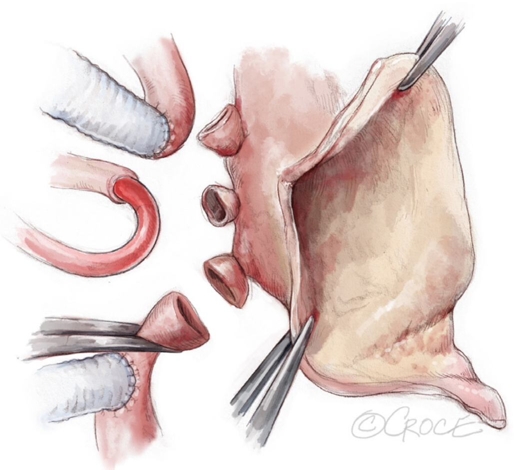

Figure 4 After reducing the pump flow, the brachiocephalic trunk is clamped, and the aortic cross-clamp removed. The ascending aorta and the proximal aortic arch (up to the target landing zone) are resected.

radial artery lines between 40 and 80 mmHg. Just before reaching the target temperature, the aorta is clamped and cardioplegic arrest is induced. The LCCA is then occluded with a tourniquet, transected, and cannulated with a second ASCP cannula (*Figure 3*). The pump flow is reduced, the

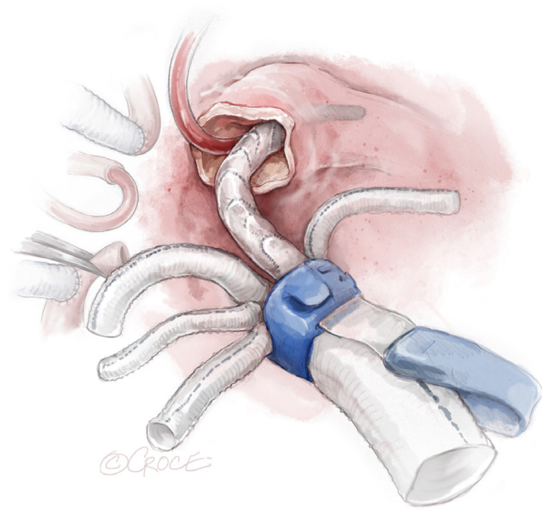

Figure 5 The stent-graft is gently bent to match the curvature of the descending thoracic aorta and stabilized with the delivery handle. A black orientation marker, aligned with the brachiocephalic trunk branch, ensures accurate positioning. The release sequence is identical to that of a conventional Thoraflex graft: the sheath is retracted through the splitter to deploy the self-expanding stent, the splitter is removed, the sewing collar freed and the stent tip released by removing the central locking pin.

BCT gently clamped, and the aortic clamp removed. Our ASCP protocol uses a flow rate of 10 mL/kg/min, equally distributed to the right and left hemispheres, and adjusted to maintain a right radial arterial pressure between 40 and 80 mmHg. Cerebral perfusion is monitored with NIRS and adjusted accordingly. Total antegrade brain perfusion always includes LSA cannulation to improve protection of the cervical spinal cord, which relies on the vertebral arteries.

The ascending aorta and aortic arch are excised according to the selected zone for distal anastomosis. A drop sucker is placed into the mid-to-distal arch to evacuate blood and facilitate inspection of the distal aortic arch (*Figure 4*). The T-NEXT release and implantation technique is no different from that of a standard Thoraflex. The stented portion of the selected T-NEXT hybrid graft is slightly bent to match the curvature of the descending thoracic aorta, and the handle is used to stabilize the graft in position (*Figure 5*). A black orientation marker, aligned with the BCT branch, ensures accurate positioning. The sheath is retracted back through the splitter to deploy the self-expanding stent. The splitter is then removed, and the sewing collar is freed. Finally, the stent tip is released by removing the central locking pin through the device handle

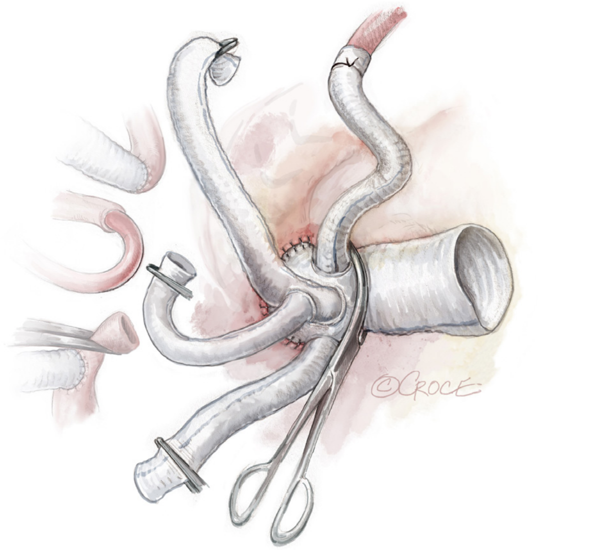

Figure 6 Distal aortic anastomosis. The sewing collar of the T-NEXT graft is sutured to the distal aortic arch stump using a running 3-0 or 4-0 polypropylene suture. A circumferential Teflon felt strip is used for reinforcement.

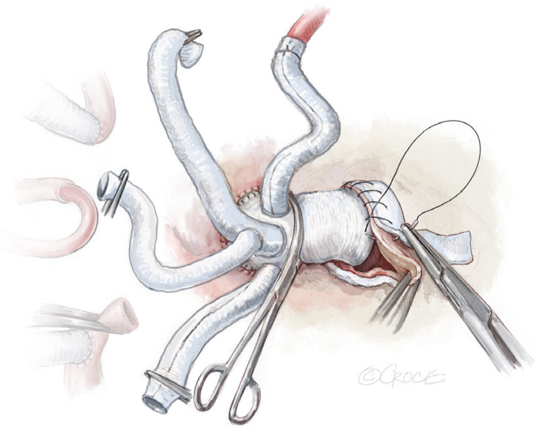

Figure 7 After completion of the distal anastomosis, a perfusion cannula is inserted into the T-NEXT side branch, the graft is de-aired, and antegrade distal organ perfusion is initiated. Hemostasis is checked, and systemic rewarming is started. The proximal anastomosis to the ascending aorta is performed with a running 4-0 polypropylene suture, and the heart reperfused.

and the delivery system is detached from the hybrid graft.

Distal aortic reconstruction is performed by suturing the sewing collar of the T-NEXT graft to the distal aortic arch stump using a 3-0 or 4-0 running polypropylene suture. The anastomosis may be reinforced with a circumferential

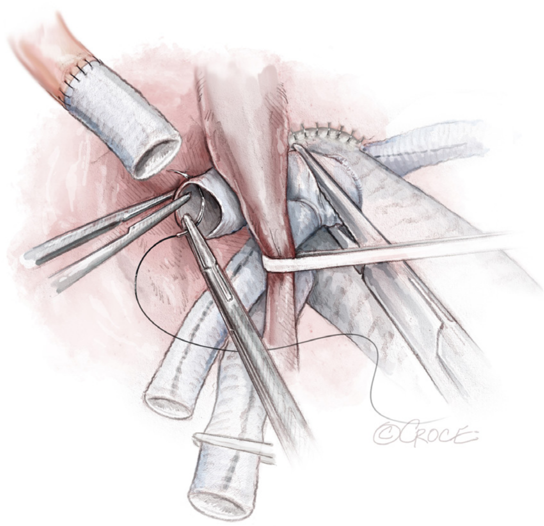

Figure 8 On the beating heart, the interposition left subclavian artery graft is anastomosed end-to-end to one limb of the bifurcated branch of the T-NEXT graft using a running 5-0 polypropylene suture.

Teflon felt strip if deemed necessary.

After completion of the distal anastomosis, a perfusion cannula is inserted into the side branch of the T-NEXT graft. The graft is de-aired, and antegrade distal organ perfusion is initiated by clamping the Dacron graft at its proximal end (*Figure 6*). The distal aortic reconstruction is inspected for hemostasis, and systemic rewarming is commenced. The proximal anastomosis between the graft and the ascending aorta is then performed using a 4-0 polypropylene running suture (*Figure 7*). After meticulous de-airing, the aortic clamp is removed and myocardial reperfusion is achieved. Reconstruction of the supra-aortic vessels is carried out next using the dedicated branches of the T-NEXT graft: a bifurcated branch for the LSA and LCCA, and a single branch dedicated to the BCT. First, the interposition LSA graft is anastomosed end-to-end to one limb of the bifurcated branch using a 5-0 polypropylene running suture (*Figure 8*). The LCCA is then reimplanted onto the second limb of the bifurcated branch. Finally, the BCT is reimplanted end-to-end onto the single dedicated branch (*Figure 9*).

Completion

Hemostasis is carefully checked, and the patient is weaned from cardiopulmonary bypass. Protamine is administered

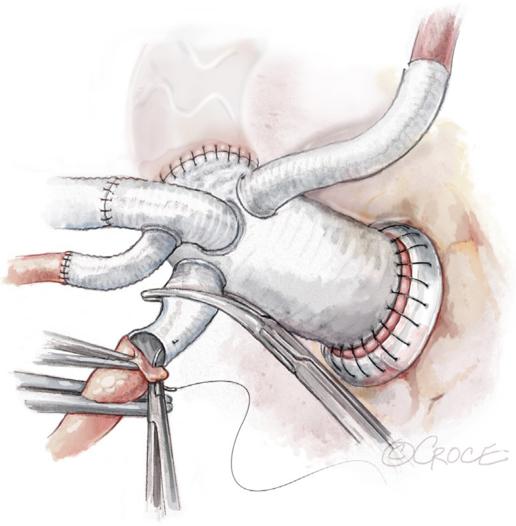

Figure 9 The left common carotid artery is reimplanted onto the second limb of the bifurcated branch, while the brachiocephalic trunk is reimplanted end-to-end onto the single dedicated branch of the T-NEXT graft.

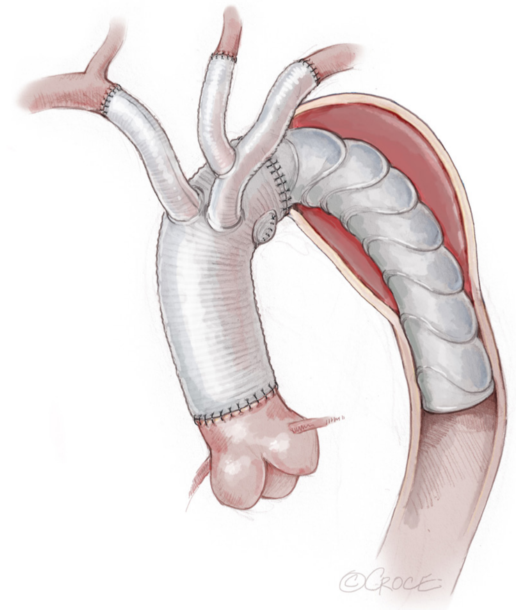

Figure 10 Schematic of the T-NEXT graft configuration. The graft features a transverse distal alignment of branches: a bifurcated branch for the LSA and LCCA, and a single branch for the BCT, each oriented at 90° to the graft body. This design leaves the proximal graft segment unobstructed, facilitating distal clamping in future reoperations and preserving a bidirectional catheter pathway between upper and lower body vessels for subsequent endovascular interventions. BCT, brachiocephalic trunk; LCCA, left common carotid artery; LSA, left subclavian artery.

to reverse the effect of heparin. Bipolar pacing wires and soft drains are positioned as per routine. The main vascular graft and the epi-aortic branches are carefully covered with pericardium to facilitate potential future chest re-entry. The operation is then completed in the standard fashion.

Comments

Traditional FET grafts were conceived to reproduce the standard aortic arch configuration, with the distal anastomosis typically positioned in zone 3 and the supra-aortic branches aligned in a proximal-to-distal sequence (2). In current surgical practice, however, many teams prefer a more proximal landing in zones 0, 1 or 2. This shift brings the arch branches closer to the aortic root, which may limit exposure and clamping options during subsequent root or ascending aorta procedures. Moreover, the conventional arrangement can create acute double angulations between the supra-aortic branches and the graft body, making visceral vessel cannulation from upper-body access more technically demanding during later ETAR procedures. The T-NEXT graft addresses these issues through a redesigned branch configuration that relocates the origins of the arch vessels, leaving an unobstructed proximal graft segment (*Figure 10*). This facilitates safer and easier distal clamping in reoperations and reduces the risks associated with re-sternotomy. In addition, compared with other FET grafts featuring a single trifurcating branch, the use of a dedicated single 90° branch for the BCT provides an unimpeded, bidirectional route for catheter navigation between upper and lower body vessels (3,4). This design is particularly advantageous when secondary visceral stenting is required, or when diagnostic or therapeutic endovascular procedures on the cerebral circulation are performed via femoral access. By enabling smooth wire and catheter passage across the arch, the T-NEXT graft supports both antegrade and retrograde endovascular strategies.

Conclusions

The T-NEXT graft, with its modified branch configuration, improves access for proximal and distal aortic interventions and optimizes compatibility with future open or endovascular procedures. Its design may simplify reoperations and facilitate complex hybrid treatments, although long-term results remain to be established.

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Footnote

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Conflicts of Interest: The authors have no conflicts of interest to declare.

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