Technical Note

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Stent Graft Modification to Preserve Intercostal Arteries Using Thoracoabdominal Off-the-Shelf Multibranched (t-Branch) Endograft

Marcelo Ferreira, MD[1], Matheus Mannarino, MD[1,2], Rodrigo Cunha, MD[1], Diego Ferreira, MD[1], Luis Fernando Capotorto, MD[1], and Gustavo S. Oderich, MD[3]

Abstract

Purpose: To demonstrate an off-the-shelf multibranched (t-Branch) modification to allow intercostal arteries preservation during juxtarenal, pararenal, paravisceral, and extent IV thoracoabdominal aortic aneurysm repair. **Technique:** The t-Branch is an off-the-shelf device not customized for specific patient anatomy and may be offered for urgent endovascular repair for patients with complex aortic aneurysms. However, a concern when treating patients who do not aneurysms extending above the celiac axis is that the more proximal extension which is required with this device may render patients at high risk for spinal cord injury. We report a novel technique with t-Branch modification performing a 180° fabric back windows at the first 2 sealing stents that allow perfusion to the intercostal arteries. **Conclusion:** T-Branch-PIA (preserving intercostal arteries) modification limits intercostal arteries coverage while optimizing proximal seal zone in juxtarenal, pararenal, paravisceral, and extent IV thoracoabdominal aneurysms, thereby may decrease the risk of spinal cord injury.

Keywords

thoracoabdominal aneurysm, juxtarenal aneurysm, endovascular aneurysm repair, pararenal aneurysm, ruptured aneurysm, physician-modified stent-graft, multibranched stent-graft

Introduction

Urgent endovascular repair of patients with rapidly expanding, symptomatic, or ruptured juxtarenal, pararenal, paravisceral, or extent IV thoracoabdominal aortic aneurysms (TAAAs) is challenging since these patients cannot await the 6- to 8-week time required for custom-made device (CMD) manufacturing. Aside of open surgical repair or techniques of parallel grafting, these patients may be offered repair using a thoracoabdominal off-the-shelf (OTS) multibranched stent graft (t-Branch Endoprosthesis, Cook Medical, Bloomington, IN, USA), but more extensive coverage of the distal thoracic aorta may increase risk of spinal cord injury.

Open surgical repair (OSR) has been long considered the gold standard against which novel endovascular techniques need to be compared. Fenestrated and branched endovascular aneurysm repair (F-BEVAR) has become widely accepted as a less invasive approach and is associated with lower morbidity and mortality in many centers.[1,2] A recent meta-analysis has shown that F-BEVAR is associated with lower risk of acute kidney injury and less major complications, but higher rates if secondary interventions as compared with OSR.[3] Parallel stent-grafts ("chimney" or "snorkels") remain a viable option in urgent cases, but technical result is compromised in patients who need more than two vessels incorporated due to higher rates of endoleaks. Other limitations are need for multiple trans-brachial sheaths, risk of stroke, and long-term risk of stent compression and occlusion.[4–6]

[1]Department of Vascular and Endovascular Surgery, SITE Endovascular, Casa de Saúde São José, Rio de Janeiro, Brazil
[2]Department of Vascular and Endovascular Surgery, Hospital Universitário Pedro Ernesto, Rio de Janeiro, Brazil
[3]Advanced Endovascular Aortic Program, UTHealth, McGovern Medical School, Cardiothoracic & Vascular Surgery, Memorial Hermann Texas Medical Center, Houston, TX, USA

Corresponding Author:
Marcelo Ferreira, Department of Vascular and Endovascular Surgery, SITE Endovascular, Casa de Saúde São José, Rua Macedo Sobrinho 21, Humaitá, Rio de Janeiro 22271-080, Brazil.
Email: marceloferreira1959@gmail.com

The anatomic feasibility of the t-Branch OTS device has been assessed with up to 88% of patients considered anatomically suitable.[7] Increasing experience has shown that several limitations can be overcome by modifications in the technique that allow successful vessel incorporation, such as patients with <4 targets, narrow aortic lumens or chronic dissections.[8] Nonetheless, a major concern when treating patients who do not aneurysms extending above the celiac axis is that the more proximal extension which is required with the t-Branch device may render patients at high risk for spinal cord injury.[9] We report a novel technique of physician modification of the t-Branch OTS endoprosthesis to preserve blood flow to the intercostal arteries, while maximizing proximal sealing zone and allowing 4-vessel incorporation with directional branches.

Technique

Device Modification

The t-Branch stent graft consists of a 202-mm length covered stent-graft with three 34-mm proximal sealing stents that taper to 18-mm diameter distal stent. The device has 4 directional branches with caudal orientation for incorporation of the celiac axis, superior mesenteric artery and both renal arteries.

The delivery system should not be flushed with saline solution prior to modifications. The three proximal sealing stents of the t-Branch endoprosthesis are unsheathed for customization (Figures 1 and 2). The device is rotated backward and the modifications for intercostal artery preservation are marked on with the posterior aspect of the device. The diameter reducing ties (gold trigger wire) is released to allow full expansion of the sealing stents and the modifications. The t-Branch-PIA (preserving intercostal arteries) windows are cut in the first 2 sealing stents, allowing at least one 360° sealing stent to remain unchanged. Each window encompasses 180° circumference of the sealing stent, leaving remanent a few millimeters of polyester fabric intact between the connection of each Z-stent. This allows the graft structure to be maintained and easier resheathing into the delivery system. Once the modification is completed, the t-Branch stent-graft is resheathed into its original delivery system by using silk ties to sequentially collapse the Z-stents. The device is then flushed with heparinized saline solution.

The procedure is performed using standard technique previously described. Our preference is to select one femoral artery to introduce and deploy the endograft, while leaving the contralateral femoral artery open at all times. This limits lower limb ischemia, which may help minimize postoperative inflammatory response and risk of spinal cord injury. Right side upper extremity access is used for sequential catheterization of the directional branches. We have moved away from using left side access whenever possible due to prior studies that showed no difference in cerebrovascular events.[10] We favor positioning the imaging gantry from the left side of the patient, while the surgical team works from the right side.

Discussion

Despite the development of new technologies in complex endovascular aortic aneurysm repair, spinal cord injury and the risk of paraplegia remains a very challenging issue.

Previous studies[9,11] demonstrated that the strongest predictor of spinal cord injury is the extent of aortic coverage in the descending thoracic aorta due to sacrifice of intercostal arteries. Although the t-Branch stent-graft was designed for TAAAs, it has been also utilized in patients with juxtarenal, pararenal, and extent IV TAAAs who do not need extensive coverage of the thoracic aorta. In these patients the p-Branch stent graft may be an alternative, but the device is not yet widely available and anatomic feasibility studies have shown that nearly 40% of patients do not meet anatomic criteria.[12] The indications for using t-Branch in patients with less extensive aneurysms is primarily urgent repair on patients who are not suitable candidates for CMD fenestrated or branched devices because of symptoms, contained rupture or an excessive large aneurysm (>8 cm). The long waiting time for device manufacturing, which can reach months in some countries, is prohibitive in cases of rupture or symptoms and carries risk of interval rupture in those with larger aneurysms. The technique herein described helps offset the risk of spinal cord injuries in these cases, where more limited coverage of the thoracic aorta is the ideal. As demonstrated in the final angiogram and completion computed tomography angiography (Figures 3 and 4) perfusion of intercostal arteries is still preserved after deployment of the stent-graft while achieving adequate proximal sealing.

The t-Branch device offers a versatile option because of wider anatomical application. Techniques such as the snare ride allow also treatment of upgoing vessels.[13] In the event of a late proximal type I endoleak from progression of aortic disease, the windows may be covered in secondary procedures with short aortic cuffs or even thoracic grafts. In Figure 5, we demonstrate the currently available devices for thoracoabdominal aortic aneurism repair and comparison of descending aortic coverage.

Conclusion

T-Branch-PIA (preserving intercostal arteries) modification may have a future role as another off-the-shelf stent graft to specifically treat juxtarenal, pararenal, paravisceral, and extent IV TAAA, optimizing proximal seal zone and limiting intercostal arteries coverage.

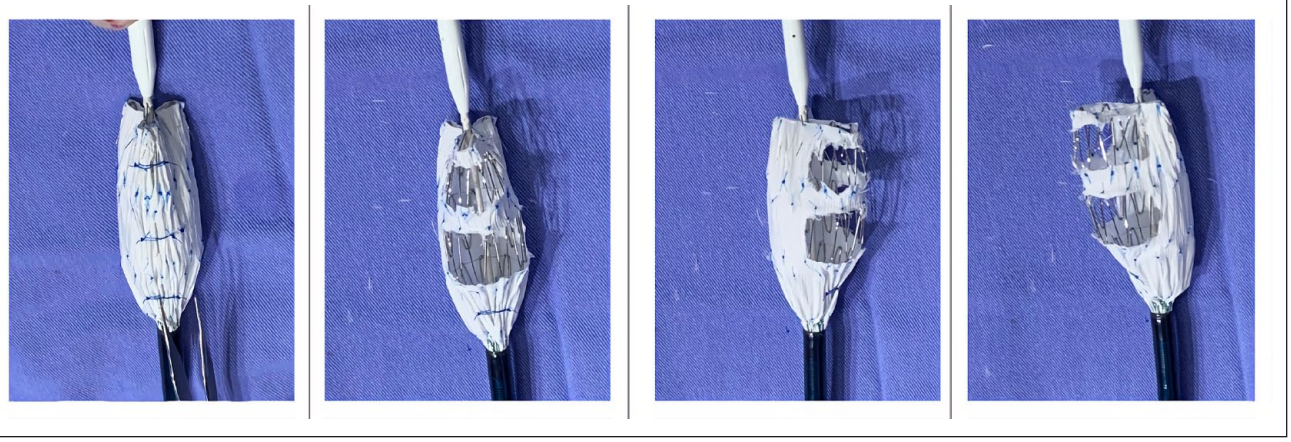

Figure 1. Backtable customization of t-Branch off-the-shelf showing back windows encompassing 180° circumference of the first 2 stents.

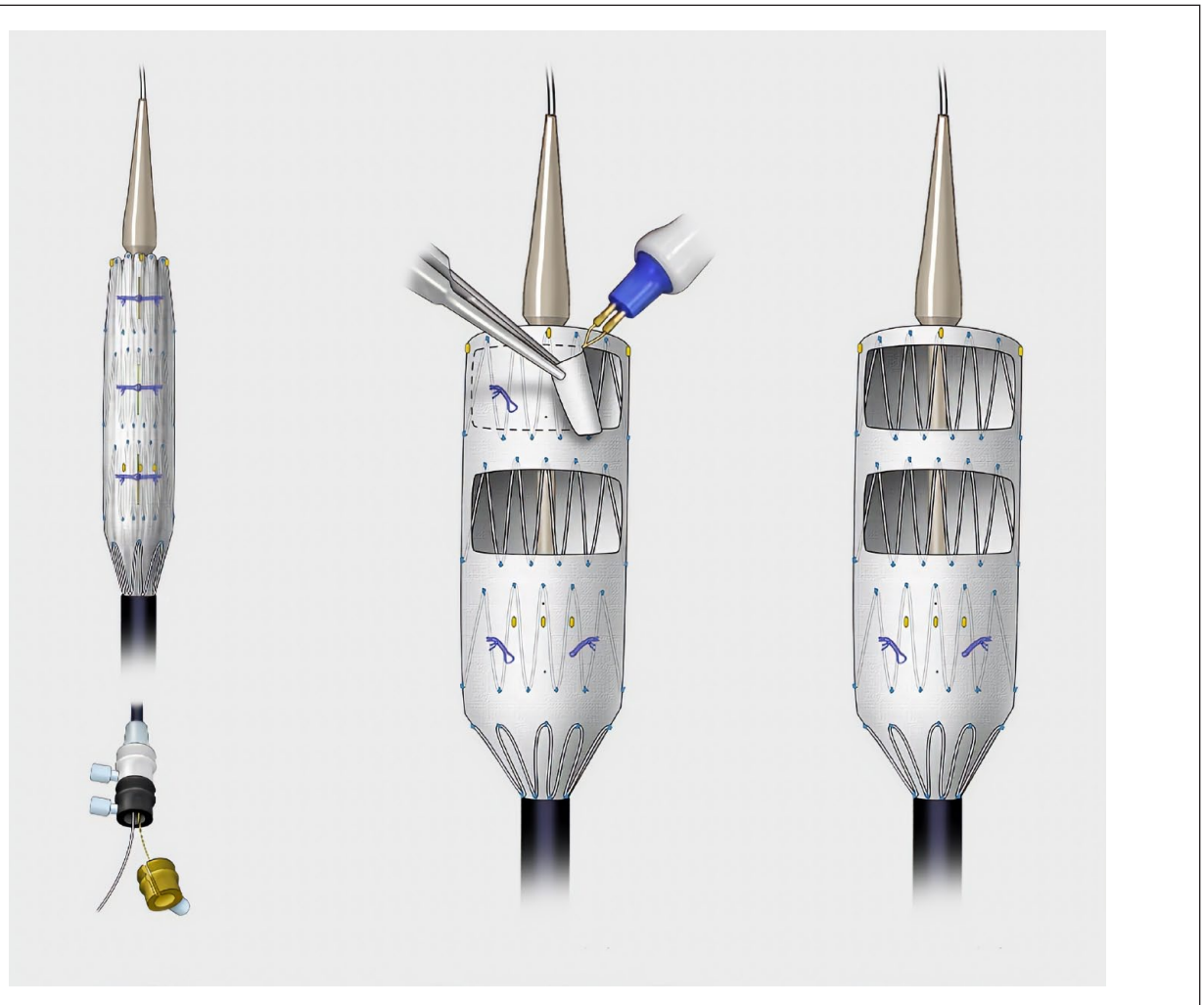

Figure 2. Schematic drawing demonstrating the sequential steps of modification. After unsheathing the first 3 sealing stents, the gold trigger reducing ties wire is released and a 180° cut is performed at the first 2 sealing stents, leaving few millimeters of polyester fabric intact between the connection of each Z-stent.

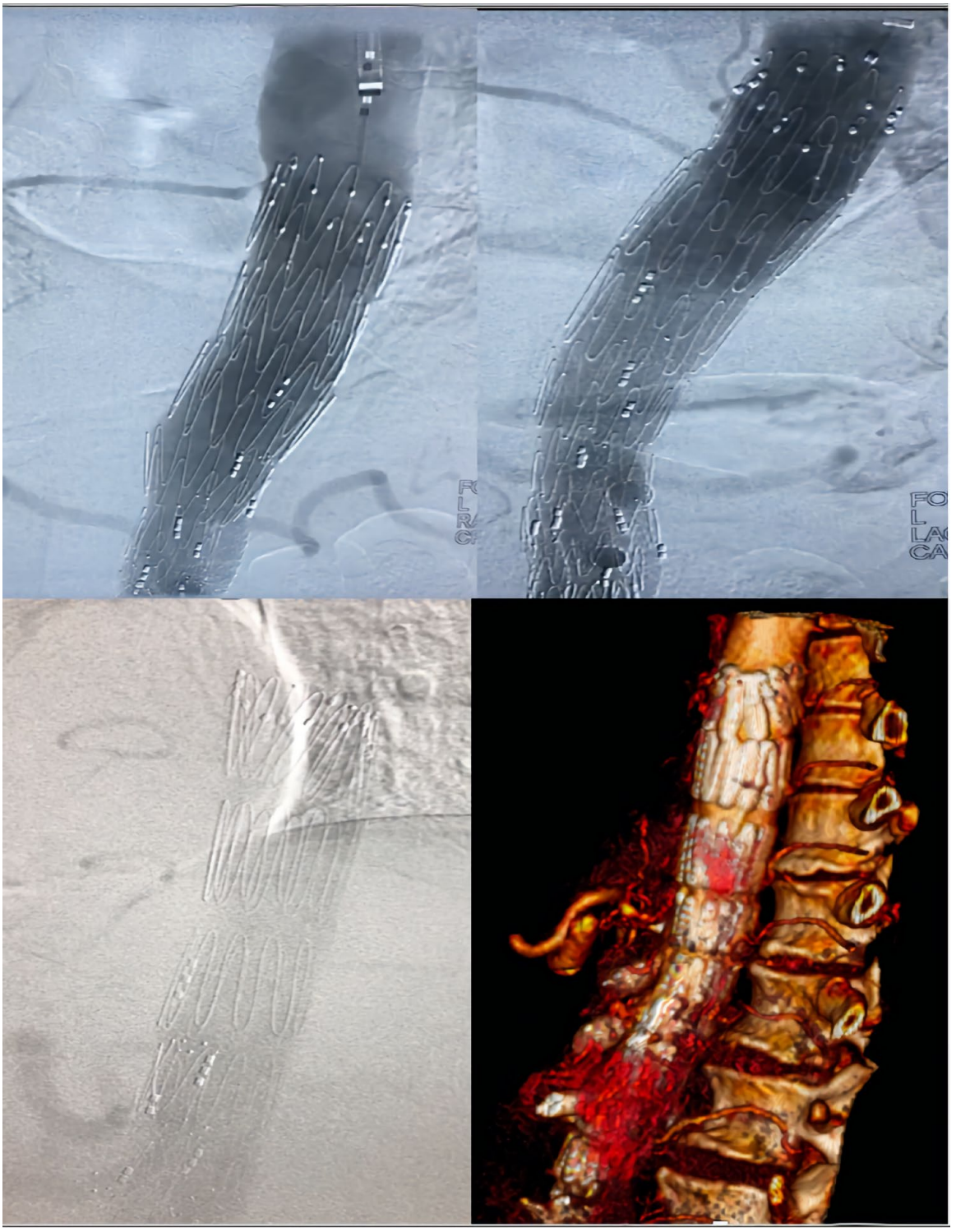

Figure 3. Intraoperative final angiogram in 3 different patients (a, b, c) after deployment of the stent graft with maintained perfusion of intercostal arteries and a postoperative computed tomography scan showing patent intercostal arteries (d).

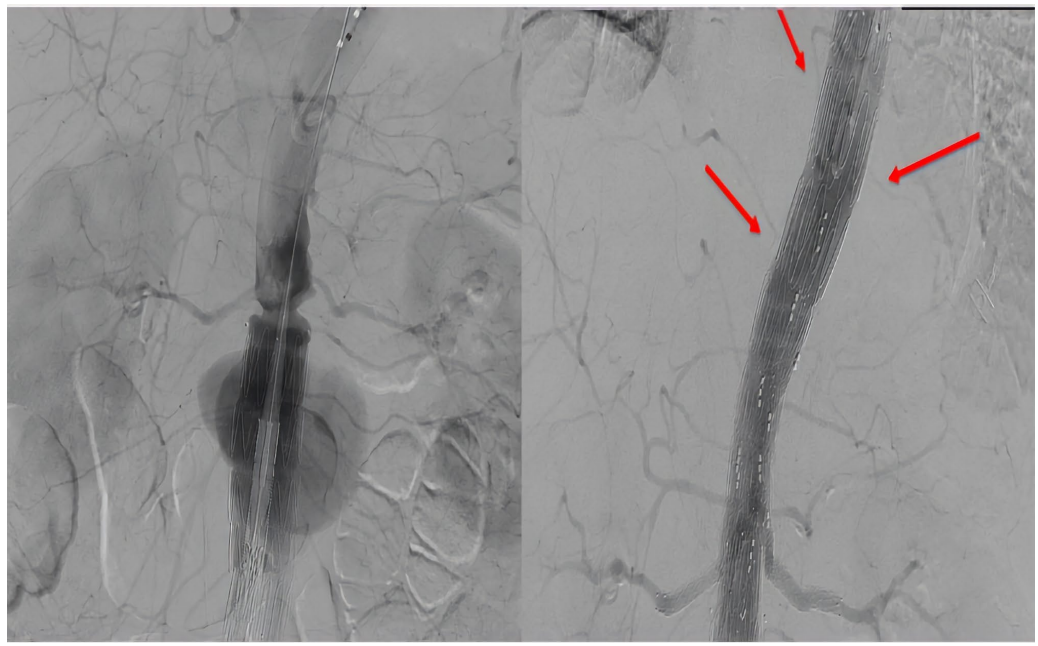

Figure 4. Late type 1a endoleak with aneurysm sac enlargement and contained ruptured, treated with proximal extension of the neck with t-Branch-PIA (preserving intercostal arteries). Note the persistent perfusion of the intercostal arteries after deployment of the stent graft.

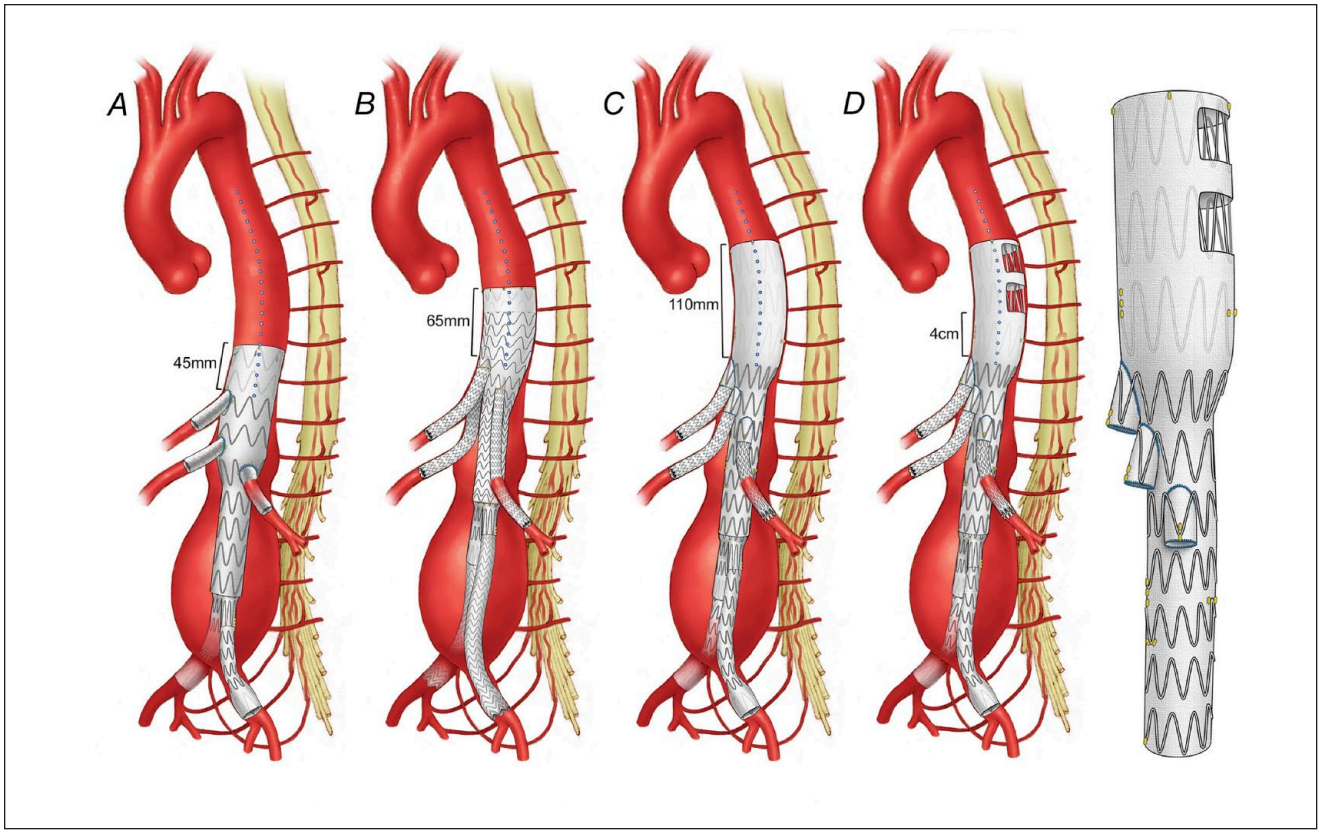

Figure 5. Schematic drawing of currently available devices for thoracoabdominal aortic aneurism repair and comparison of descending aortic coverage. (a) Cook ZFEN+, (b) Gore–TAMBE, (c) t-Branch, and (d) t-Branch-PIA (preserving intercostal arteries).

Declaration of Conflicting Interests

The author(s) declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: Marcelo Ferreira is a proctor for Cook Medical. Gustavo Oderich has received consulting fees and grants from Cook Medical, Gore Medical, and GE Heathcare (all paid to Mayo Clinic). Stock options for Centerline Biomedical.

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ORCID iDs

Marcelo Ferreira https://orcid.org/0000-0003-1342-8033

Matheus Mannarino https://orcid.org/0000-0001-5641-151X

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