Tips and tricks about surgeon-modified fenestrated stent grafting for celiac truncus

Çölyak trunkus için cerrah modifiye fenestre stent greftlemenin ipuçları ve püf noktaları

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ABSTRACT

Currently, thoracic endovascular aortic repair is usually the first-line treatment option for descending aortic pathologies. Supra-aortic or visceral branches sometimes involve assistive thoracic endovascular aortic repair techniques; hybrid procedures or intentional coverage may be performed during the procedure to achieve a sufficient proximal or distal landing zone. Most surgeons may agree on selective coverage of celiac truncus, but revascularization is preferred to reduce the risk of ischemic complications. Herein, we present the first successful surgeon-modified fenestrated stent graft procedure for celiac truncus in a patient with Crawford type V descending aortic aneurysm in Türkiye.

Keywords: Ankura™ thoracic stent graft, celiac truncus, thoracic endovascular aortic repair, Surgeon-modified fenestration stent grafting.

ÖZ

Günümüzde torasik endovasküler aort onarımı, inen aort patolojileri için genellikle ilk tedavi seçeneğidir. Supra-aortik veya visseral dallar bazen yardımcı torasik endovasküler aort onarım teknikleri içerir; hibrit işlemler veya işlem sırasında yeterli bir proksimal veya distal iniş bölgesi elde etmek için kasıtlı kapama yapılabilir. Çoğu cerrah çölyak trunkusun seçici olarak kapsanması konusunda hemfikir olabilir; ancak, iskemik komplikasyon riskini azaltmak için revaskülarizasyon tercih edilir. Bu yazıda, Türkiye'de Crawford tip V inen aort anevrizmasında çölyak trunkus için yapılan ilk başarılı cerrah modifiye fenestre stent greft işlemi sunuldu.

Anahtar sözcükler: Ankura™ torasik stent greft, çölyak trunkus, torasik endovasküler aort onarımı, Cerrah modifiye fenestre stent greftleme.

The endovascular journey first started with the courage of the physicians who attempted to develop handmade devices and carefully treated aneurysm patients. The involvement of supra-aortic or visceral branches sometimes makes it more challenging for vascular surgeons. Thoracic aortic aneurysms treated by thoracic endovascular aortic repair (TEVAR) may require coverage of the celiac truncus in about 4 to 14% of cases.[1-3] Considering a high risk for celiac truncus territory ischemia, the current guideline recommends open or endovascular revascularization.[1] In such cases, assistive TEVAR techniques such as parallel graft technique (chimney-TEVAR, periscope) or surgeon-modified fenestration stent grafting (SMFSG), hybrid procedures, or mainly open surgery take place as the treatment of choice according to the patients' status and anatomic specifications. Intentional coverage of the celiac truncus is also a treatment of choice depending on the variability of the collateral circulation.[3] The applicability of custom-made endografts is limited due to economic conditions and time-consuming manufacturing delays. However, SMFSG seems to be a rapid and reliable solution to overcome this issue.

Herein, we present the first successful SMFSG performed for celiac truncus in a Crawford type V aortic aneurysm patient in Türkiye.

SURGICAL TECHNIQUE

A 69-year-old Caucasian male patient with abdominal pain was consulted by the Emergency Department. The patient was in the American Society of Anesthestiologists (ASA) Class III status and the associated comorbidities were chronic obstructive

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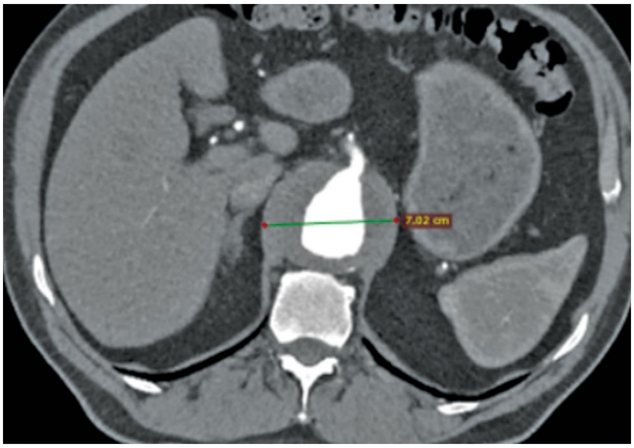

Figure 1. Crawford type V descending aortic aneurysm with a 7 cm of diameter around the celiac truncus.

Table 1. Preoperative anatomical measurements

The anatomic measurements	
Celiac truncus ostial diameter (mm)	0.7×0.8
SMA ostial diameter (mm)	0.9×1.1
Proximal aortic diameter (mm)	32
Distal aortic diameter (mm)	28
Suprarenal aortic angle (°)	20
Celiac-SMA distance (mm)	34.8
Maximum aortic aneurysm diameter (mm)	70
Celiac truncus active lumen diameter (mm)	29

SMA: Superior mesenteric artery.

pulmonary disease, hypertension, and hyperlipidemia. After computed tomography angiography (CTA), the patient was diagnosed with a Crawford type V descending aortic aneurysm with a diameter of 7 cm (Figure 1). Due to the patient's comorbidities and ASA class, open surgery was not an option.

Procedure planning and device sizing were performed using three-dimensional vascular imaging (RadiAnt DiCOM viewer, version 2021.2.64 bit). The diameter of the aortic visceral branches, the distance between the branches, and the clock position of each branch were identified over the aortic axis (Figure 2a, b). All these anatomic measurements are given in Table 1. Oversizing was planned for approximately 15% for both proximal and distal ends. Therefore, a tapered 34/28/160-mm thoracic stent graft (Ankura™ TAA Stent Graft, Lifetech Scientific, Shenzhen, China) was selected for the procedure. Surgeon-modified fenestrated stent graft was planned for celiac truncus. The procedure was performed under general anesthesia in the hybrid operating room. The right femoral artery was surgically exposed and left percutaneous femoral artery access was obtained. After heparin administration, a pigtail catheter was inserted and parked between the thoracic 12th - lumbar 1st vertebra for direct visualization of the celiac truncus and the superior mesenteric artery (SMA) with the anteroposterior position. Following the preparation of the femoral access routes, the stent graft was unsheathed completely on the surgical back table in a sterile manner. The endograft covering material (expanded polytetrafluoroethylene [ePTFE]) was fenestrated upon the previous meticulous measurements performed by the CTA, using an 11-sized scalpel (Figure 3a). The unsheathing procedure, fenestration, and re-sheathing procedure

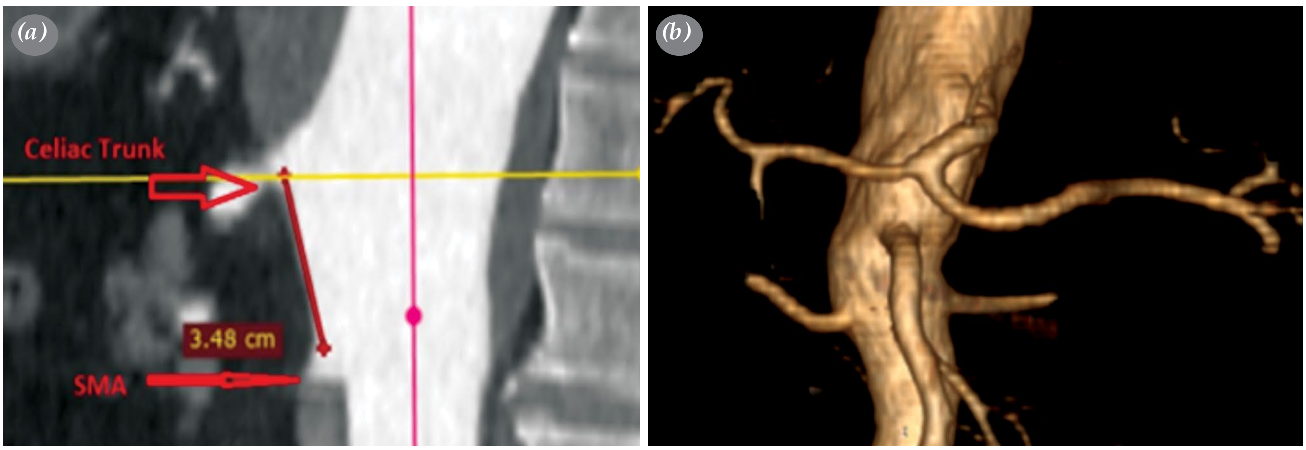

Figure 2. (a) The meticulous measurements for the distance between celiac truncus and superior mesenteric artery. **(b)** The clockwise location of the visceral branch ostium.

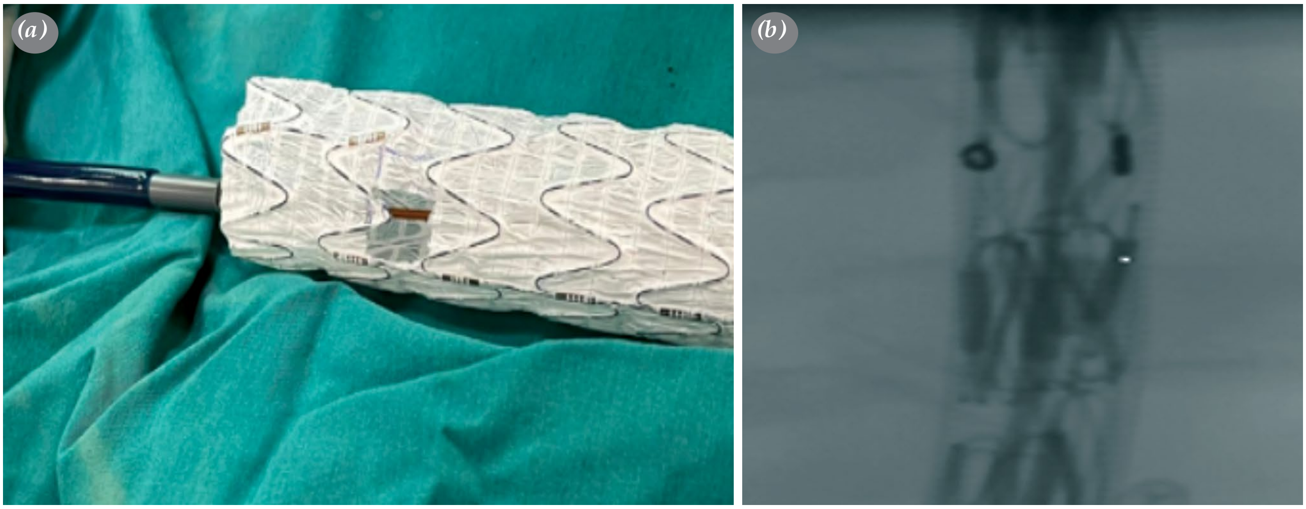

Figure 3. (a) Surgeon-modified fenestration was performed on the surgical table with a larger diameter than the original celiac truncus (0.8×0.7 mm to 1.0×1.2 mm). The connecting bar can be easily seen near the fenestration. **(b)** The radiopaque marker '8' should be on the greater curvature and seen as a line.

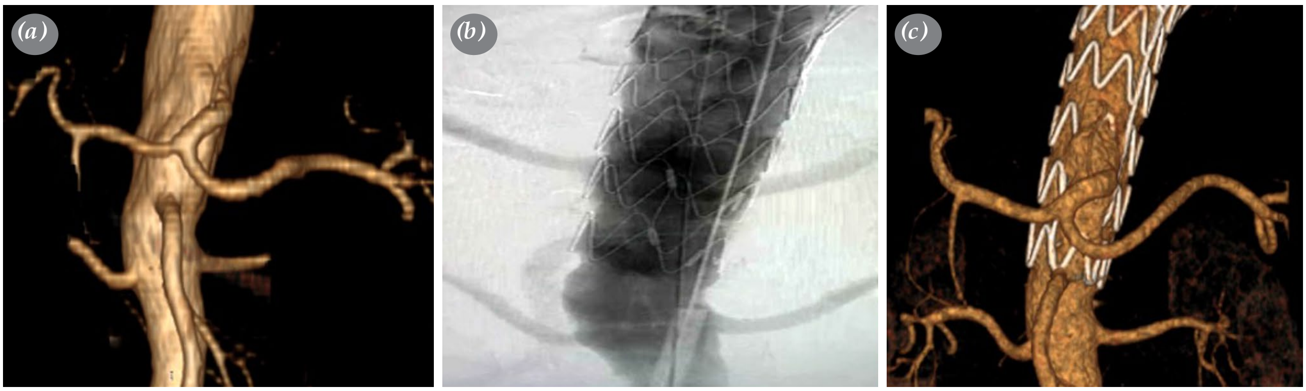

Figure 4. (a) Preprocedural CTA, **(b)** The completion angiography, **(c)** Postoperative first-month CTA showing no endoleak and orientation of the fenestration and the ostium of the celiac truncus.
CTA: Computed tomography angiography.

took around 15 min. Approximately 1.0×1.2-cm single fenestration was made for celiac truncus by giving special attention not to damage the metal braces to preserve the endograft integrity and catching the perfect orientation. The diameter of the fenestration was larger than the celiac truncus which was 0.8×0.7 mm. Of note, while introducing the endograft, marker '8' should be on the greater curvature and seen as a line. Being able to read the marker '8' or '0' during fluoroscopy confirmed the positioning of the endograft (Figure 3b). Once the fenestration was ensured to be oriented toward the aortic target vessel, the deployment was performed. The mean arterial blood pressure was lowered to 70 to 80 mmHg during the deployment to optimize accuracy. The completion angiography showed the coverage of the aneurysm sac, patency of celiac truncus, and no endoleak and no need for balloon intervention (Figure 4b). At one-month of follow-up, computed tomography demonstrated a perfect positioning of the endograft, no presence of endoleak, and intact visceral branches (Figure 4c).

DISCUSSION

Most surgeons may agree that celiac truncus can be intentionally covered depending on the mesenteric collateral circulation and, for each coverage case, a selective SMA angiography is indicated. However, instead, revascularization with parallel grafts, fenestrated or branched custom-made endografts, hybrid procedures, SMFSGs, multi-layer flow modulators, or open surgery is usually preferred.[1] Intentional coverage not only carries the risk of ischemic complications and higher morbidity or mortality, but also uncertainties in the long term still exist.[1,3] Regarding the chimney technique of deploying parallel grafts poses the risk of peri graft gutter endoleaks and branch vessel occlusions are possible complications.[4-6] Branched endograft is another option, which has the disadvantages of waiting time with a high cost. Therefore, a surgeon-modified fenestrated TEVAR was the treatment of choice for our patient.

The SMFSG requires experience and a learning curve for accurate planning to position the fenestration. Aortic angulations and tortuosity, superior mesenteric, celiac, and renal artery distances are the most important criteria for fenestration orientation. Our first case was for Zone 2 left subclavian artery (LSA) endo-revascularization with back table fenestration nearly two years ago for subacute type B aortic dissection and was the first documented SMFSG for LSA in Türkiye.[7] For a successful procedure, the surgeon must be accustomed to the endograft used. Every brand may be used for this purpose; however, we preferred the Ankura™ TAA Stent Graft owing to its conformity. This endograft has an ePTFE, dual-membrane material for biocompatibility and durability with nitinol endoskeleton. Two different shaped radiopaque markers (“8” and “0”) on each side of the proximal landing zone increase the accuracy and facilitate the orientation. The perfect positioning is ensured, when the markers look like a line. There is a connecting bar just distal to radiopaque marker “8” on the greater aortic curvature, and the bar avoids shortening and provides axial support as seen in Figure 3a. While restoring the graft to the sheet after fenestration is complete, special care must be taken not to rotate the graft. Also, the markers “8” and “0” may rotate depending on the aortic neck angle and tortuosity during deployment.

Fenestrated stent graft technology requires preoperative accurate measurements to ensure precise matching of the native vessel and the fenestration. Using this method, proper patient selection is the key to success. The anatomical limitations must be recognized, as the greatest attention should be given to the length between the celiac truncus and SMA.[8,9] In this case, our endograft was distally deployed at zero distance to SMA and the distance of SMA to celiac truncus (3.48 mm) was very suitable for this procedure. Despite the increasing experience, a margin of error in placing fenestrations always exists and the mismatch possibility may lead to complications. That is the reason why we fenestrate the endograft larger than the ostium of the celiac truncus. Such endovascular interventions should be performed, particularly in large-volume centers and in experienced hands. The structural and technical characteristics of the endografts used must be well known. A protective distance of at least 1 cm should be left before, after, or between fenestrations.

Poor or delayed blood flow of the branch vessel on completion angiography creates a requirement for stenting.[5] While entering this procedure, we planned not to stent the celiac truncus as it may be complicated due to the short body and the splitting of the truncus at a short distance. Without a complication, we were not willing to use any of it.

Achieving successful results with a modified device is a work of art; however, there are also some limitations. There is a risk of spoiling the endograft integrity by the fenestration and the absence of bench testing of the endograft before clinical use is not possible. Although a homemade device may not go through the same integrity or durability as an approved one, the series of SMFSG shows perfect durability and successful early and mid-term results.[5,6] Legal issues involved with surgeon-modified devices conclude that device modification is legal and unregulated in most instances.[10]

In conclusion, surgeon-modified fenestration stent grafting is a fast, widely applicable, and safe both in elective and acute settings, and is also readily available, inexpensive, and effective method of preserving celiac flow during thoracic endovascular aortic repair procedures without sophisticated instruments. Nonetheless, the durability concerns necessitate additional studies.

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