Technique for treating complex aneurysms with Hercules stent graft modified by the surgeon

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Endovascular treatment of thoracoabdominal aneurysms with fenestrated stent grafts expands its applicability because of good technical results. However, stent graft customization requires an average of 6 to 12 weeks, which makes this technique ineligible for symptomatic or ruptured aneurysms. Authors advocate perioperative fenestration by the surgeon, allowing this technique to be used for emergency cases with good results and favorable prognosis. This article describes a technique for intraoperative changes of the Hercules stent graft (MicroPort Scientific Corporation, Shanghai, China) to include the ostia of visceral arteries by making fenestrations and scallops, with a temporary diameter-reducing wire as a further modification to facilitate positioning and catheterization of fenestrations with guidewires. (J Vasc Surg Cases 2016;2:184-9.)

Stent graft fenestration for juxtarenal aortic aneurysm treatment was first described in 1996.[1] This technique has benefits over conventional surgery because of risk of visceral ischemia caused by suprarenal aortic cross-clamping and prolonged surgical time.

Studies of the fenestrated stent graft consider its applicability to patients unfit for conventional endovascular treatment. Some authors advocate perioperative fenestration, allowing this technique to be indicated for emergency cases, with good results and prognosis.

This article describes intraoperative modifications of the Hercules stent graft (MicroPort Scientific Corporation, Shanghai,China) to include the ostia of visceral arteries for treatment of complex aneurysms. Temporary constriction of the original diameter of the stent graft is made to promote easier device positioning and visceral branch catheterization.

TECHNIQUE

Stent graft modification. The technique described here was used for treatment of a juxtarenal aortic aneurysm in a female patient, 77 years old, with frequent abdominal pain (Fig 1). Treatment was performed by endovascular technique with Hercules stent grafts.

Stent graft modifications were conducted during anesthesia induction, with vascular accesses by a scallop to the celiac artery and fenestrations for renal and superior mesenteric arteries. Temporary constriction of the original diameter of the endograft facilitates positioning near ostia of the visceral arteries.

A thoracic stent graft is modified on the basis of distances and angulations among visceral branches. The endograft is released on the table for handling, and the sheath is saved for recapping of the device.

Fenestrations and scallops are positioned according to measurements obtained with centerline analysis. Three fenestrations and one scallop are made with a scalpel and reinforced with radiopaque wire markers fixed with polypropylene 5-0.

One radiopaque marker is placed in a longitudinal posterior position and another cross in the previous position for orientation under fluoroscopy.

A diameter-reducing wire at the device's posterior portion is positioned by using a long 22-gauge spinal needle to route the wire through and through the fabric of the stent graft, exposing the wire on the outer surface of the stent graft fabric at the level of self-expanding stents (Fig 2).

The next step is to constrict the diameter of the stent graft. Once the diameter-reducing wire is in place, 3-0 polypropylene ties are made to constrict the original diameter of the stent graft by bringing together the stent's metal structures along its posterior portion using the support wire (Fig 3). This technique allows reduction of around 30% of the original diameter without modifying the relationship among fenestrations.[2] It also promotes the return of original diameter after complete support wire withdrawal.

Constriction of the stent graft's original diameter provides its axial and longitudinal movements, facilitating catheterization of visceral arteries.

Stent graft implantation. The procedure is performed under general anesthesia. Access is obtained by percutaneous puncture of the left axillary artery and right and left brachial arteries and by femoral artery dissection; 7F sheaths are placed in the upper access and 8F sheaths in the femoral access.

Lunderquist wire (Cook Medical, Bloomington, Ind) is advanced by right femoral access up to the thoracic aorta.

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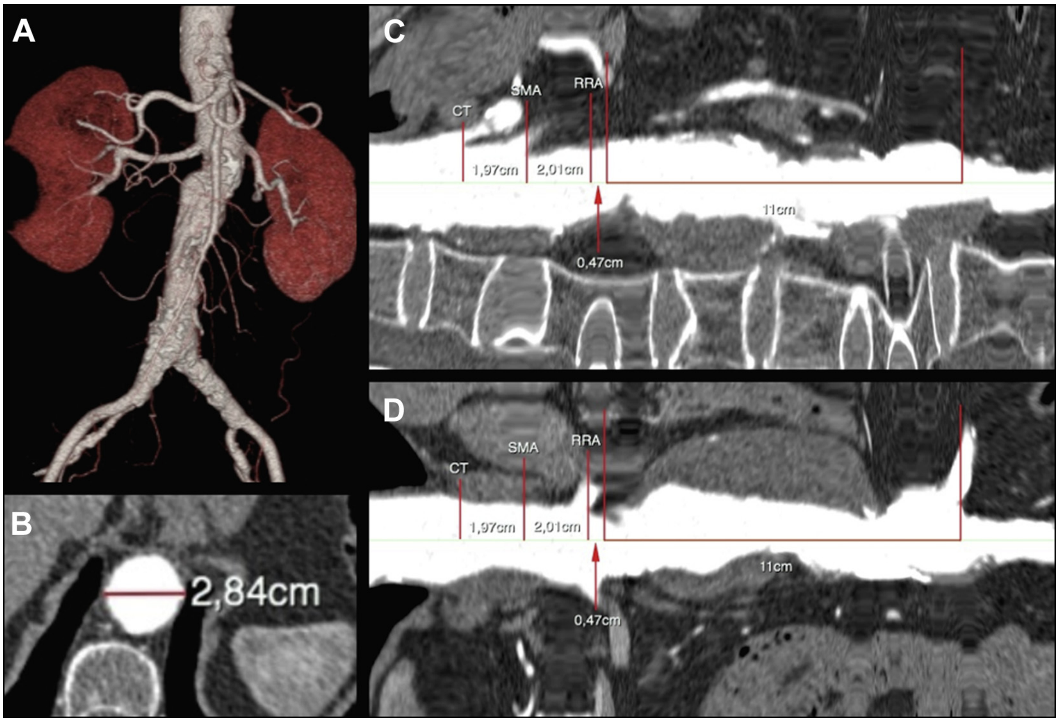

Fig 1. Computed tomography angiography with three-dimensional image in a patient with juxtarenal aortic aneurysm **(A)**. Landing zone diameter is measured in detail right above the celiac trunk (*CT*) origin **(B),** and the aneurysm is further evaluated by centerline flow analysis for measurement of length **(C** and **D)**. *RRA,* Right renal artery; *SMA,* superior mesenteric artery.

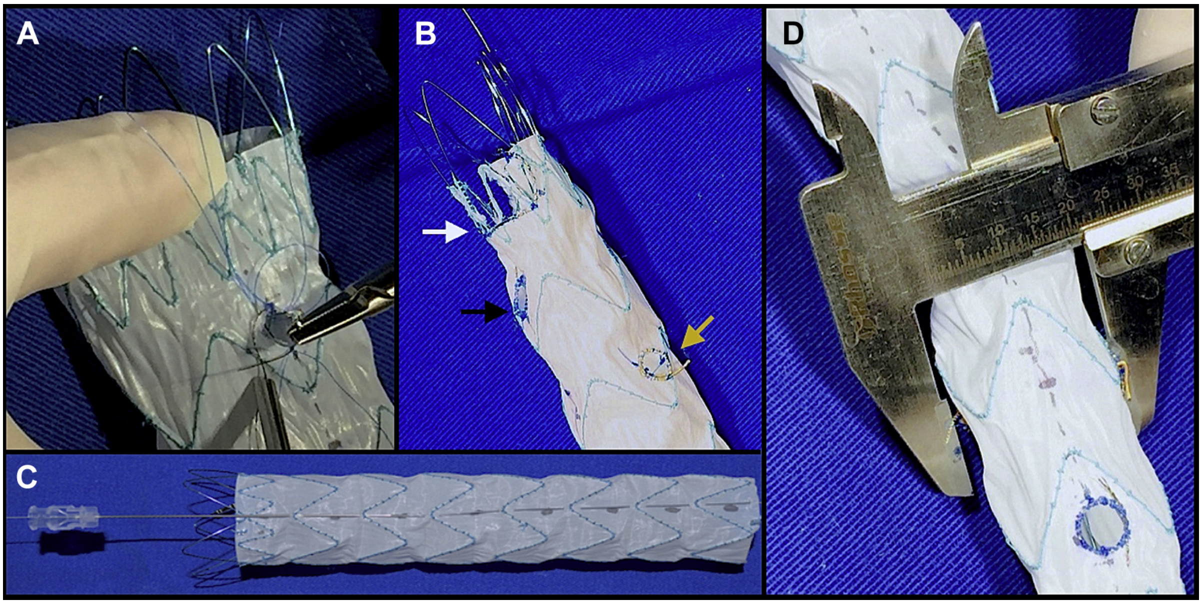

Fig 2. Modification of the stent graft. **A,** Strengthening of the fenestration with nitinol wire and continuous suture of 5-0 polypropylene. **B,** Scallop to the celiac artery (*white arrow*) and fenestration to the superior mesenteric artery (*black arrow*), left renal artery (*yellow arrow*), and right renal artery (not shown). **C,** Positioning of diameter-reducing wire. **D,** Reduction of the stent graft's original diameter. Hercules T stent graft of 34 × 34 × 160 mm, with diameter reduced to 20 mm (40% of the original diameter).

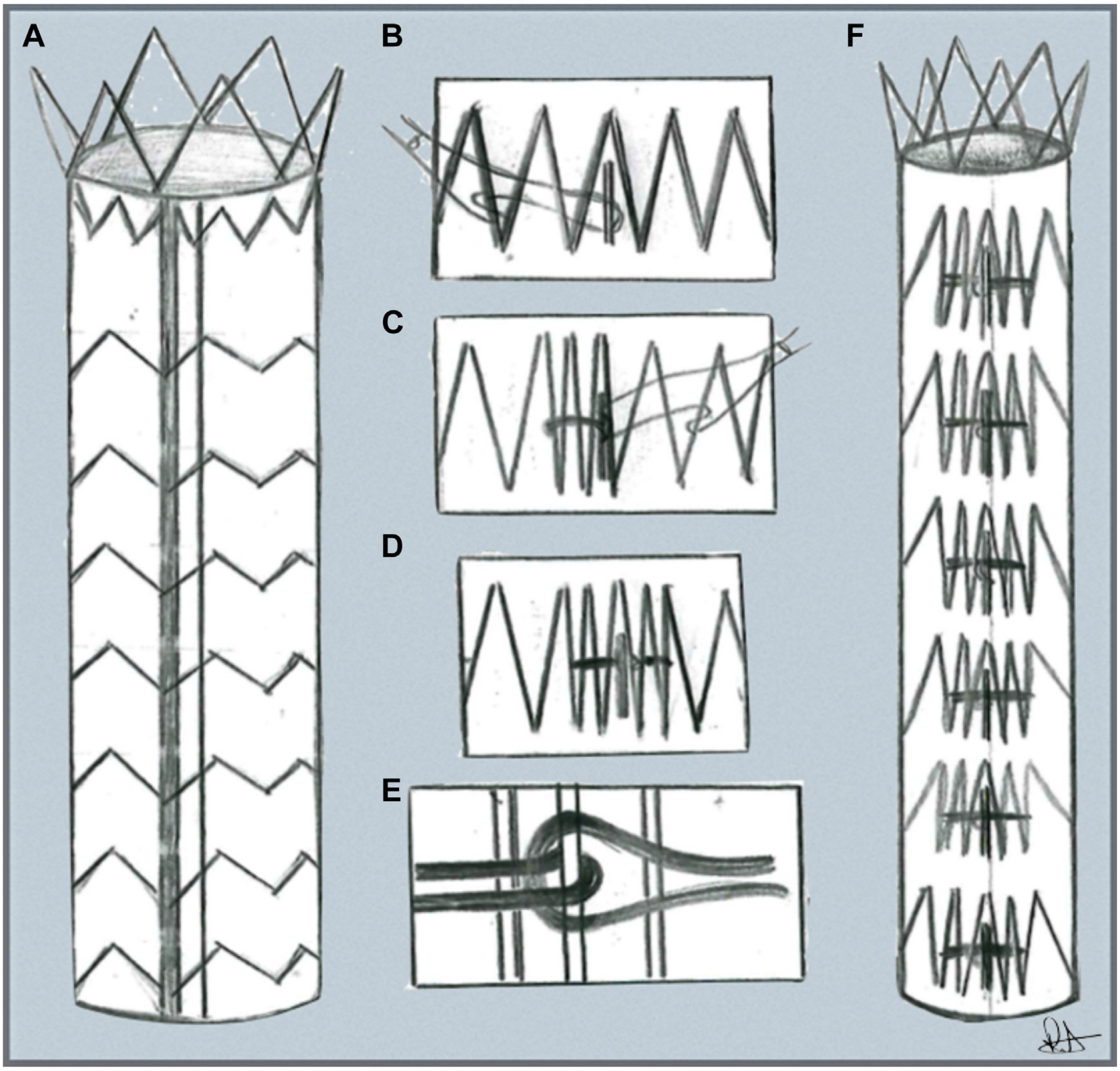

Fig 3. Schematic picture of diameter-reducing technique. **A,** Endoprosthesis fully released. **B,** The first loop enclasps the main wire and extends to the side to wrap two stent segments and is fixed in the stent graft fabric. **C,** The second loop passes through the first loop without going through the support wire and heads to the second segment of the contralateral stent, also fixed in the stent graft fabric. **D,** The metal structures are approximated. **E,** In detail, loops surrounding the support wire and knots are apart after wire removal. **F,** Endoprosthesis prepared to be resheathed.

Before resheathing of the stent graft, 0.014-inch guidewires from each access on the upper limbs are taken to the femoral artery and captured by femoral arteriotomy. These guidewires preload each fenestration and end out through holes along the stent graft sheath (Fig 4). The endograft is completely resheathed using silk knots.

Through right femoral access, the modified stent graft is positioned under fluoroscopy using the anterior and posterior radiopaque markers for orientation. The proximal portion is released for proper fenestration alignment with target vessels.

The procedure is performed primarily by brachial and axillary accesses. Angiographic catheters are advanced through each fenestration, out of the stent graft, by the through-and-through technique. Renal and superior mesenteric arteries are then catheterized with hydrophilic guidewires. Long sheaths are advanced on an Amplatz guidewire through the inner lumen of visceral arteries.

Atrium V12 (Atrium Medical, Hudson, NH) balloon-expandable covered stents are positioned: 7- × 22-mm for the mesenteric branch and 6- × 22-mm for each renal branch. The diameter-reducing wire is fully removed, and the endograft is completely released.

The compliant balloon expands the proximal sealing stents and sheaths are retracted, keeping the balloon-expandable stents in position, extending 5 mm into the aorta lumen. Stents are expanded and flared with a 10- × 20-mm balloon for perfect accommodation (Fig 5).

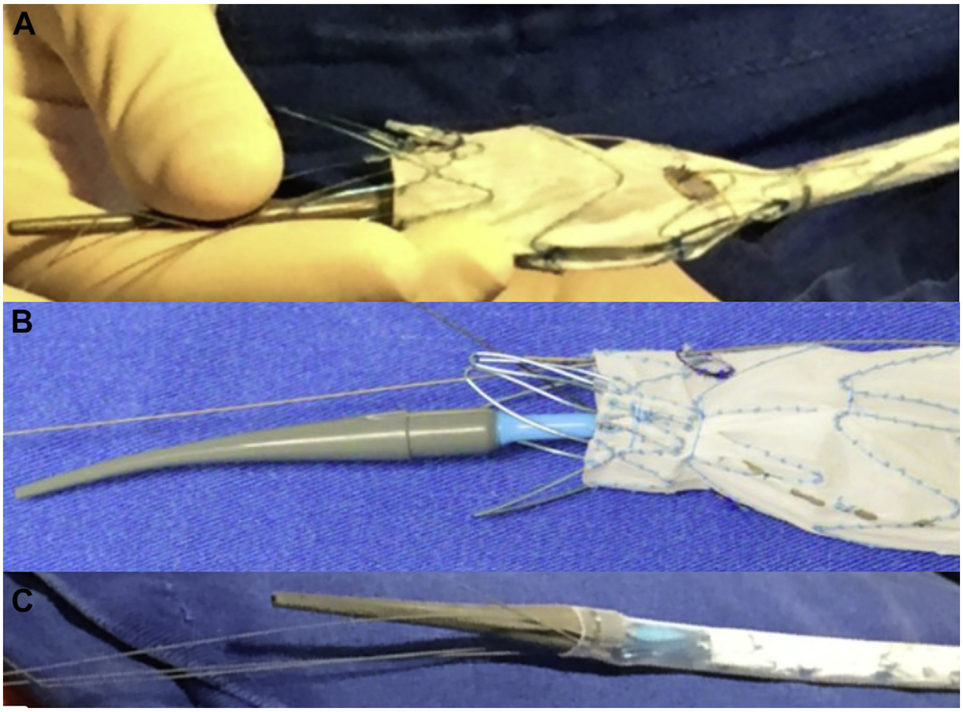

Fig 4. **A** and **B,** Fenestrated stent graft with 0.014-inch guidewires already in place. **C,** The stent graft is resheathed, and guidewires from each fenestration end out through holes along the stent graft sheath.

Control angiography is performed to confirm visceral branch patency and absence of type III endoleaks. The procedure continues with implantation of a bifurcated Hercules stent graft, such as in the standard treatment of infrarenal aortic aneurysm.

DISCUSSION

Endovascular treatment of abdominal aortic aneurysms was first described by Parodi in 1991.[3] Despite the improvement of devices and techniques, in 50% of cases, anatomic factors such as short or angulated necks contraindicate conventional endovascular technique.[4]

The fenestration technique, first described by Park in 1996,[1] expands the applicability of endovascular treatment for complex aneurysms. Visceral branch inclusion allows adequate proximal sealing without increased risk of endoleaks.

Physician-modified endovascular grafts (PMEGs)[5] are good options in cases of symptomatic or ruptured aneurysms. Custom-made fenestrated stent grafts require a delay time of 6 to 12 weeks for device manufacturing, which restricts their use to elective cases. Those devices are usually sold for twice the value of a standard endograft. Therefore, PMEGs reduce the procedure cost, making it accessible to a larger number of patients.

This is the first article that emphasizes Hercules stent graft for treating complex aneurysms. A simplified delivery

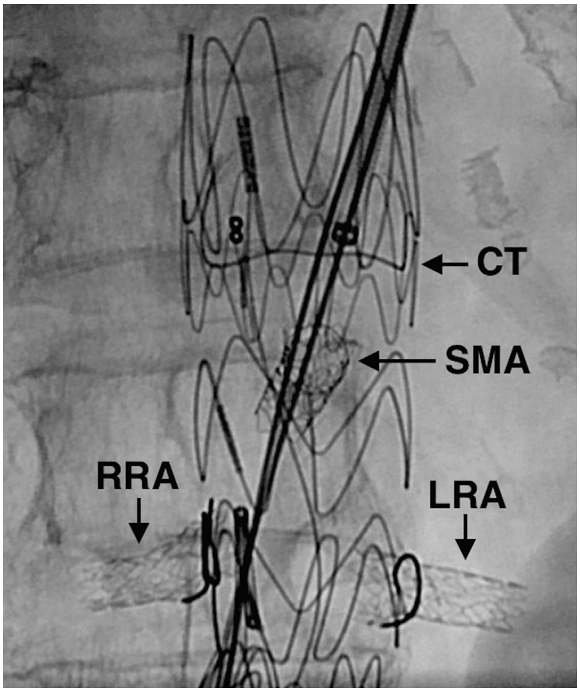

Fig 5. Fluoroscopy image after release of the stent graft: scallop to celiac trunk (*CT*) and stents for superior mesenteric artery (*SMA*), right renal artery (*RRA*), and left renal artery (*LRA*).

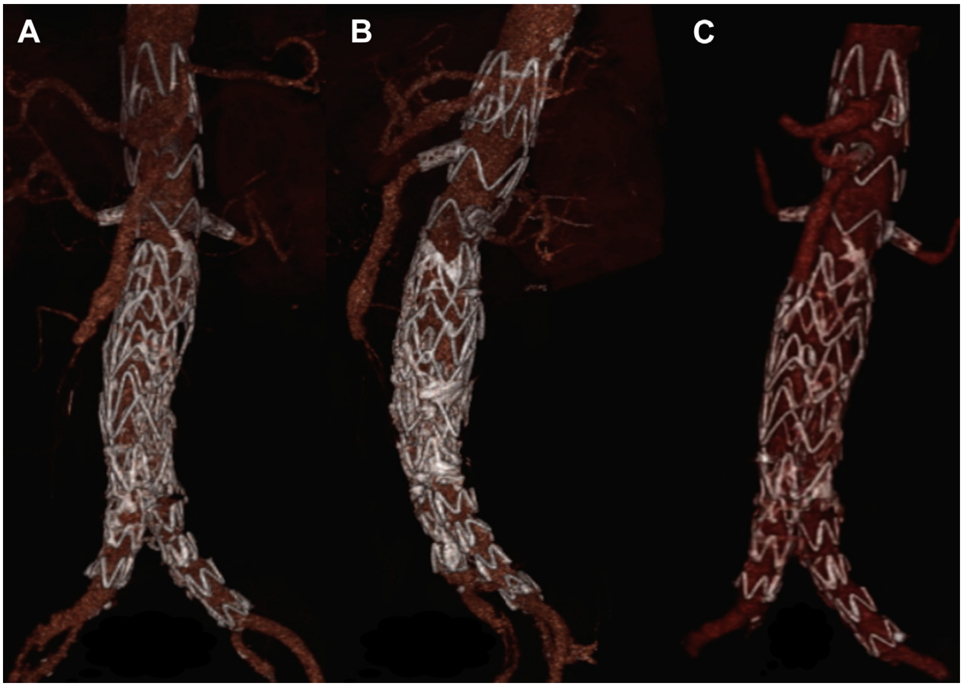

Fig 6. Computed tomography angiography: 30-day control in frontal **(A)** and lateral **(B)** views and 8-month control **(C)**. Imaging confirms successful aneurysm exclusion, no endoleak, and preserved visceral perfusion.

system provides lower material cost, with a positive economic impact on its commercialization.

The nitinol structure has stable radial strength and is covered with terylene fabric that promotes low blood leakage with thin thickness and easy handling for fenestrations. As the delivery system is uncomplicated, the stent graft is easily resheathed.

To create a diameter-reducing wire, the Zenith TX2 (Cook Medical) stent graft uses its own nitinol wire from the inner cannula of the device.[2] For the Hercules endograft technique, a 0.014-inch PT2 wire is placed at the device's posterior portion to promote diameter reduction.

Different from the Zenith endograft technique,[6] the endovascular repair using the Hercules stent graft always requires a brachial approach. When fenestrations are only for renal arteries, axillary access is not required.

Precatheterization of the visceral arteries minimizes injection of contrast material during device deployment.

Previous denomination of guidewires positioned through each upper limb access facilitates the procedure. Each fenestration receives the respective wire on the table, before the stent graft is resheathed, facilitating catheterization of visceral branches after proximal release of the endograft. The technical success rate for PMEG endovascular repair varies from 98% to 100%,[2,7,8] and visceral branch patency is estimated at 98% of cases during 5 years[8] (Fig 6).

Operative mortality is reported to be 1.3%,[9] and type I endoleaks are observed in 1.5% to 4% of patients.[8] Permanent deterioration of renal function occurs in up to 8% of patients, which is comparable to open repair.[9]

Endovascular treatment of complex aneurysms with PMEGs has achieved satisfactory results. Off-the-shelf fenestrated stent grafts have also been designed to eliminate the time delay required for custom-made devices. However, nearly 40% of juxtarenal or pararenal aneurysms do not meet anatomic criteria for current designs, justifying the need for physician-modified stent grafts in emergency cases.[10]

The fenestrated Hercules stent graft is a feasible option for complex ruptured or symptomatic aneurysms when time to manufacture the endoprosthesis is the main limiting factor to endovascular technique.

CONCLUSIONS

Hercules stent graft fenestration is a safe technique for treating complex aneurysms in urgent cases. Larger series with long-term follow-up will show if this technique has results comparable to those of other commercially available and physician-modified stent grafts.

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