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Directional tip control technique for optimal stent graft alignment in angulated proximal aortic landing zones

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ABSTRACT

Angulated anatomy in the aorta, such as tortuous infrarenal aortic necks or steep aortic arches, is a significant challenge for endovascular aortic repair because it often causes inadequate sealing and fixation, which may lead to treatment failure. We have developed a technique using off-the-shelf equipment to precisely control the deployment of stent grafts in challenging landing zones. The key of this technique is to create a through-and-through wire between two access sites and to use a guiding device over the wire. This technique is best used with stent grafts without nose cones. We present an endovascular aneurysm repair case and a thoracic endovascular aortic repair case with challenging proximal landing zones treated by this technique. In both cases, technical success was attained, and follow-up imaging demonstrated well-aligned stent grafts. Our directional tip control technique is easy and effective. It can be a good technical solution for endovascular aortic treatment in angulated anatomy. (*J Vasc Surg Cases and Innovative Techniques* 2017;3:51-6.)

Endovascular treatment of aortic disease is proven to be safe and effective in the descending thoracic aorta and infrarenal abdominal aorta.¹ Because good sealing is essential for successful endovascular repair, a long and straight neck in intact aorta is desirable for the stent graft landing zone.² In reality, however, the native aorta of aneurysm patients may be associated with severe angulation in the aneurysm neck, and angulated anatomy is often a serious problem for endovascular aneurysm repair (EVAR). A stent graft deployed in a severely angulated neck may be deployed in a nonparallel manner, leading to unfavorable results, such as stent graft collapse, migration, type I endoleak, and ultimately late aneurysm rupture.³ To address this challenge, we developed the directional tip control technique, which requires only basic endovascular skills and standard equipment and supplies. This technique is best used with stent grafts without nose cones.

DIRECTIONAL TIP CONTROL TECHNIQUE

Fig 1 provides an overview of our directional tip control technique. After placement of a standard large-bore

sheath and stent graft over a stiff wire, the first step is to exchange the stiff wire for a hydrophilic soft wire and snare it to make a through-and-through wire between both groin access sites (Fig 1, C). Over the through-and-through wire, a steerable guiding sheath or an angulated guiding catheter is advanced until its tip engages the stent graft device tip (Fig 1, D). The stent graft's position and direction can be adjusted by rotating the engaged guiding sheath or catheter to an optimal position (Fig 1, E). Finally, the stent graft is deployed precisely orthogonal to the centerline of the aorta (Fig 1, F).

We present two cases applying this technique: an abdominal EVAR case and a thoracic endovascular aortic repair (TEVAR) case. Institutional review board approval was waived because this study involved retrospective review of two cases.

EVAR CASE

A 72-year-old man presented with an infrarenal abdominal aortic aneurysm, found by screening ultrasound. As the aneurysm size was 5.6 cm on computed tomography (CT) scan, he consented to endovascular treatment.

Procedure details

1. Bilateral groin accesses were established by puncture of the common femoral artery (CFA) under ultrasound guidance with a Cook Micropuncture access set (Cook Medical, Bloomington, Ind), followed by deployment of a 10F preclose device, Prostar XL (Abbott Vascular, Abbott Park, Ill), bilaterally. An 18F DrySeal sheath (W. L. Gore & Associates, Flagstaff, Ariz) was advanced on the right side, and a 12F DrySeal sheath was advanced on the left side. We first embolized an accessory left renal artery to prevent type II endoleak.

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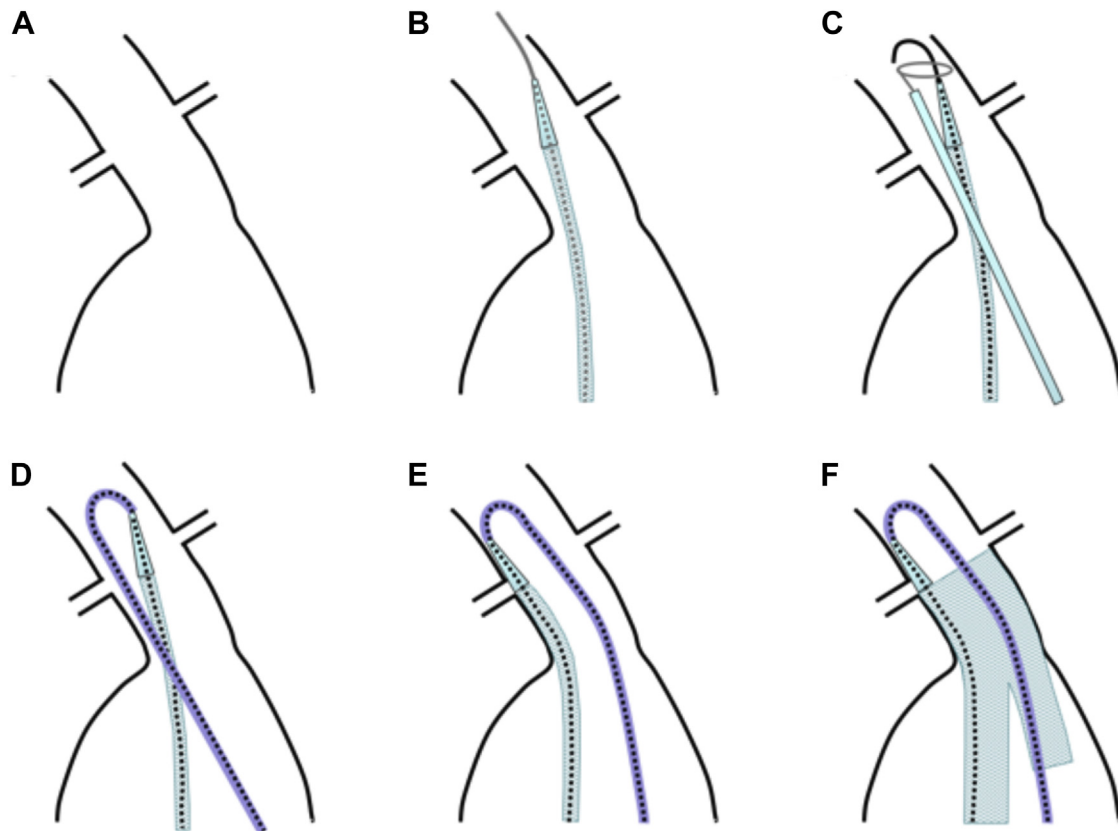


Fig 1. Overview of the directional tip control technique. **A**, Infrarenal abdominal aortic aneurysm with angulated neck. **B**, Stent graft device does not fit the angulation by standard approach. **C**, Exchange the stiff wire to a floppy wire and snare it to create a through-and-through wire between bilateral groin access sites. **D**, Insert a steerable guiding sheath or angulated guiding catheter over the through-and-through wire from contralateral access site. Engage the tip of the guiding sheath or catheter to the device tip. **E**, Adjust the position of the device by manipulating the engaged guiding sheath or catheter so that the device fits the angulation of the aorta. **F**, Precisely deployed stent graft.

2. A Gore Excluder main body, RMT281416 (W. L. Gore & Associates), was inserted from the ipsilateral (right) groin access over an Amplatz ultrastiff wire (Cook Medical). We decided to use the directional tip control technique for a precise deployment for two reasons: the EVAR device failed to follow the neck angulation, although the angle measured 35 degrees (Fig 2, A); and the actual sealing length was short because of mural thrombus in the aneurysm neck (Fig 2, B). The stiff wire was exchanged to a 260-cm Glidewire (Terumo Medical, Somerset, NJ). A steerable guiding sheath, 6.5F/45-cm Destino (Oscor, Palm Harbor, Fla), was inserted from the contralateral (left) groin access, and a through-and-through wire was established between groin access sites by snaring the Glidewire. The EVAR device tip and the guiding sheath were engaged over the through-and-through wire (Fig 2, C). The EVAR device was deflected to be precisely parallel to the aortic wall in the infrarenal neck, immediately below the main left renal artery (Fig 2, D). An appropriate tension to

the through-and-through wire was applied when rotating the device so the wire did not wrap around the device. The EVAR main body device was then deployed under precise control. Note that the directional tip control stabilized both angulation and longitudinal placement.

3. A Gore Excluder leg device, PLC201400, was deployed to the left common iliac artery, and a Gore Excluder leg extender device, PXL161407, was deployed to the right common iliac artery. Completion aortography demonstrated good exclusion of abdominal aortic aneurysm. The groin access sites were closed by deploying the preclosure sutures.

Brief postoperative course. The patient was discharged the next day after the procedure. A follow-up CT scan taken 6 months after the procedure demonstrated a well-aligned stent graft, precisely orthogonal to the centerline of the aorta (Fig 2, E); a minimal amount of type II endoleak originated from a lumbar artery.

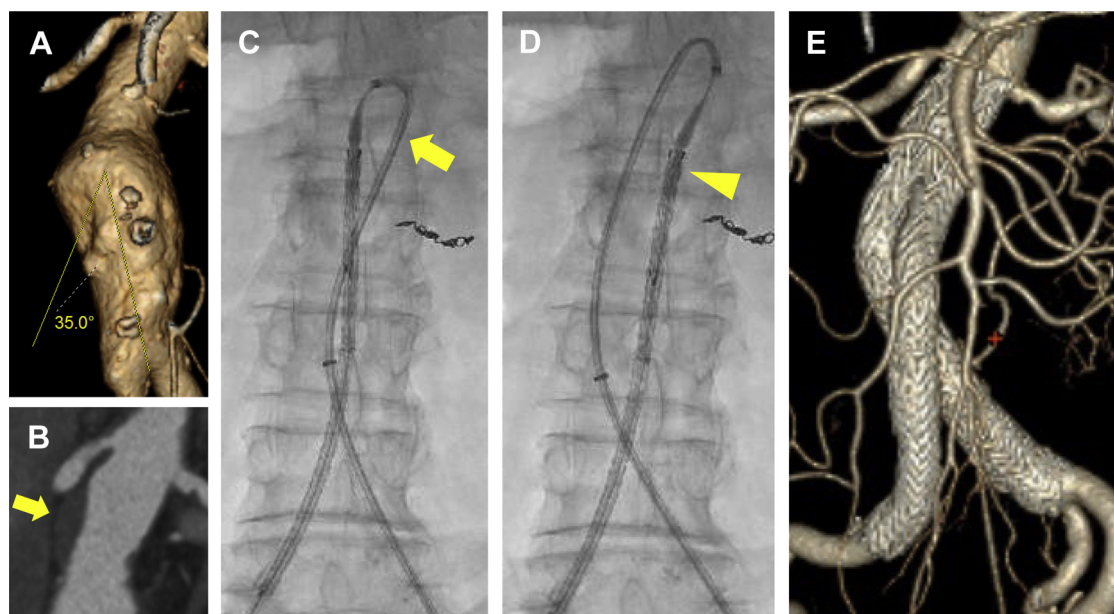


Fig 2. An endovascular aneurysm repair (EVAR) case with the directional tip control technique. **A**, Preoperative computed tomography (CT) angiogram demonstrates infrarenal neck angle of 35 degrees. **B**, There was mural thrombus in the aneurysm neck (*arrow*). **C**, A 6.5F steerable guiding sheath engages to the stent graft device tip over the through-and-through wire (*arrow*). **D**, Deflected stent graft device position by manipulating the engaged steerable guiding sheath (*arrowhead*). **E**, Postoperative CT angiogram demonstrates an EVAR stent graft deployed orthogonal to the aortic centerline, just below the left renal artery.

TEVAR CASE

An 84-year-old man presented with acute chest and abdominal pain, radiating to his back, without any sign of neurologic deficits. CT angiography demonstrated acute intramural hematoma in the descending aorta. Despite medical management, he had persistent pain and difficult to control hypertension. Repeated CT angiography 2 days later demonstrated a new pseudoaneurysmal area with extravasation and significant left pleural effusion. Because of these radiographic findings and persistent symptoms and hypertension, an emergent endovascular intervention was indicated. A spinal protection protocol including spinal drainage was initiated preoperatively and continued perioperatively.

Procedure details

1. The right CFA was punctured under ultrasound guidance, and two preclose sutures with ProGlide closure system (Abbott Vascular) were placed. A 12F sheath was inserted into the right CFA.
2. Intravascular ultrasound was used to evaluate the aorta, and the following strategy was determined: proximal landing zone in the aortic arch zone 2 because intramural hematoma extended to near the left subclavian artery; total 28 cm of treatment length that required three stent grafts; 31-mm-diameter stent graft for proximal landing and 28-mm-diameter stent graft for distal landing; and preserved antegrade flow of the left subclavian artery with snorkel stenting.
3. The left brachial artery was punctured under ultrasound guidance, and a 7F sheath was placed. Snare

loop technique was used to establish a through-and-through wire between brachial and femoral access sites using 260-cm Glidewire. All stent grafts were inserted over this through-and-through wire (tug-of-wire technique⁴).

4. The CFA sheath was exchanged to a 22F sheath. Aortography was performed in a steep right anterior oblique projection to identify the celiac artery, and the first Gore TAG, TGU282815 (W. L. Gore & Associates), was deployed, most distally about 1 cm above the celiac artery. The second Gore TAG, TGU313115, was deployed in the midthoracic aorta, overlapping the first graft by 3 cm.
5. The third Gore TAG, TGU313110, was advanced to the aortic arch zone 2. We used the directional tip control technique for the third device because of the steep angulation of the aortic arch (the angle between the centerlines of aortic arch zone 2 and proximal descending aorta was 70 degrees; Fig 3, A). For the controlling device, we selected a 6F angled guiding catheter, 55-cm MPA1 (Cordis, Fremont, Calif), which was inserted from the brachial access over the through-and-through wire, and its tip was engaged to the TEVAR device tip (Fig 3, B). By rotating the catheter angle, the TEVAR device was directed toward the lesser curve of the arch (Fig 3, C). While stabilized in this position, the stent graft was deployed precisely parallel to the aortic arch (Fig 3, D).
6. Antegrade left subclavian artery perfusion was preserved with snorkel stenting. Completion aortography revealed antegrade flow up the left vertebral artery, no significant compromise of the left

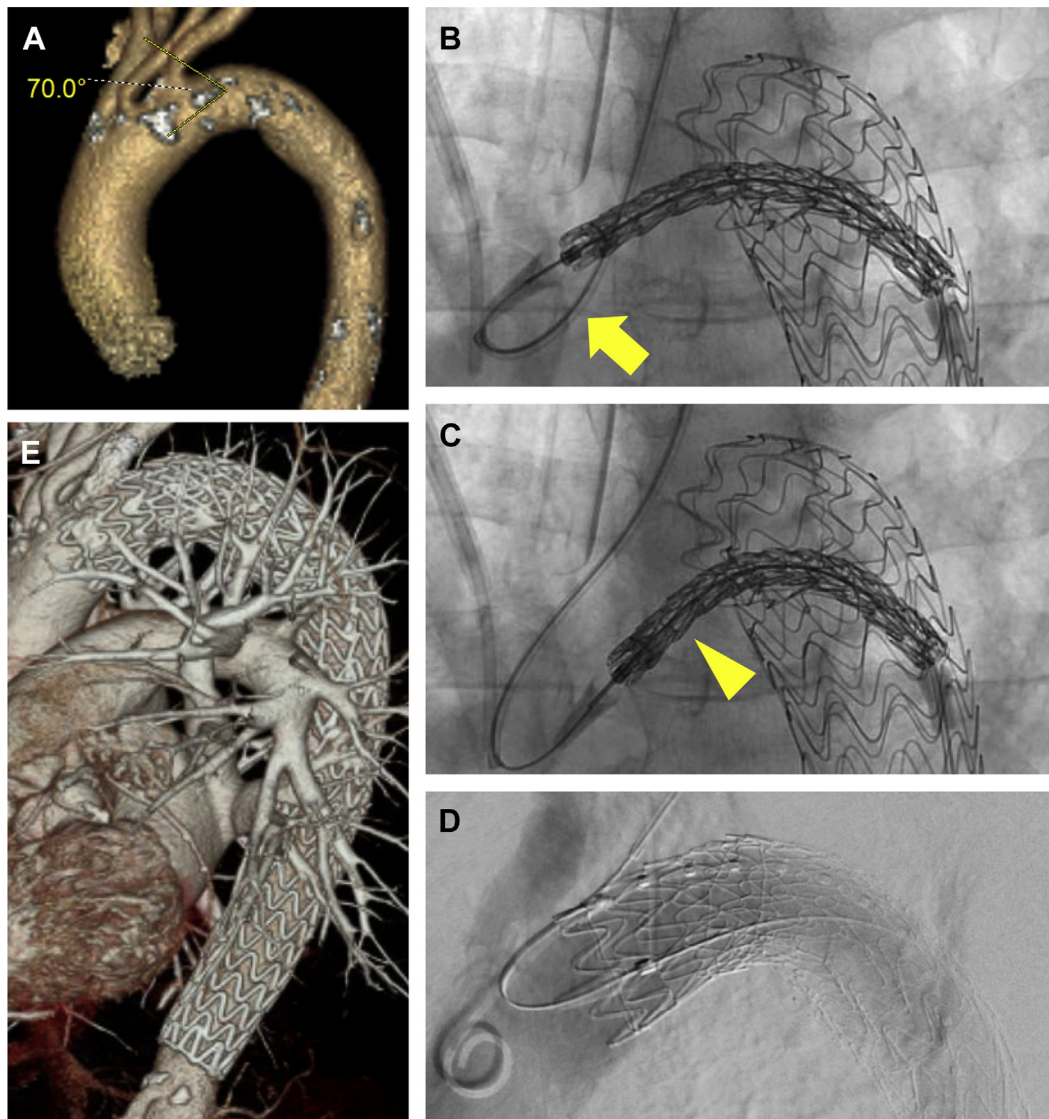


Fig 3. A thoracic endovascular aortic repair (TEVAR) case with the directional tip control technique. **A**, Preoperative computed tomography (CT) angiogram demonstrates that the angle between the centerlines of aortic arch zone 2 and proximal descending aorta was 70 degrees. **B**, A 5F angled catheter engages to the stent graft device tip over the through-and-through wire (arrow). Note that the through-and-through wire was between groin access and left brachial artery access. **C**, Deflected stent graft device position by manipulating the engaged catheter (arrowhead). **D**, Stent graft deployed parallel to the aortic arch without bird-beak configuration. **E**, Postoperative CT angiogram demonstrates well-aligned stent grafts and patent left subclavian artery snorkel stent.

common carotid artery, and total exclusion of the pseudoaneurysm. The groin access site was closed by deploying the preclosure sutures. Hemostasis of the left brachial access was completed by manual pressure.

Brief postoperative course. The patient recovered from surgery uneventfully and was discharged to home on postoperative day 4. Follow-up CT angiography, performed 2 months later, demonstrated well-sealed pseudoaneurysm without endoleak, disappearance of

left pleural effusion, parallel deployed stent grafts, and patent left subclavian artery (Fig 3, E).

DISCUSSION

The effective exclusion of aortic disease by EVAR requires adequate sealing of the aneurysm neck by the stent graft. Unlike direct suture anastomosis in conventional open surgery, fixation of a stent graft relies on the radial force from metallic stents and anchoring features.⁵ For this reason, sealing performance of stent grafts is best in a straight, parallel aortic segment;

angulated anatomy often prevents precise parallel placement in the landing zone, thereby leaving some segment of the neck unopposed by graft and effectively shortening the length of seal. This leads to increased risk of treatment failure in the short term or long term.² Antoniou et al reported a systematic meta-analysis of 1559 patients, comparing EVAR performed in either favorable or unfavorable proximal neck anatomy. Strikingly, patients with unfavorable proximal neck anatomy had a fourfold increased risk for development of type I endoleak and a ninefold increased risk of aneurysm-related mortality within 1 year of treatment.⁶ Angulated anatomy in the thoracic aorta is also a problem. When the proximal landing zone is in a steeply angulated aortic arch, a stent graft is often deployed with “bird-beak configuration,” an inadequate apposition to the lesser curvature of the arch. This configuration is related to high risk of late complications, such as stent graft collapse, migration, and type I endoleak.⁷ Ueda et al reported that 29% of patients with bird-beak configuration needed additional treatment, 21% of them had stent graft collapse or infolding, and 11% of them died of an early aorta-related event.⁷ Creative techniques have been reported to deal with angulated anatomy in the landing zone. Park and Kim reported the “kilt technique” for EVAR in a severely angulated infrarenal aorta.⁸ A TEVAR graft was deployed in the infrarenal aorta first to provide a stable landing zone for a subsequent EVAR procedure. Ben Abdallah et al reported a TEVAR procedure involving the aortic arch using a custom-made proximal scalloped stent graft.⁹

Our directional tip control technique is versatile; it requires no special devices and can be used whenever necessary, even after a stent graft is inserted but not deployed. This technique precisely stabilizes angulation and longitudinal deployment, thus maximizing the available sealing zone. It has a synergistic effect with the Gore Excluder because of the conformable stent graft design and repositionable deployment system. Although we have performed only two cases with this technique so far, we have become comfortable enough to use it. The key is to create a through-and-through wire between two access sites and to engage a manipulating device over the wire. Extra attention must be paid to a through-and-through wire between brachial and femoral access because it can cause brain stroke by “scissoring” the neck arteries. Always protecting the wire with a guiding sheath or a catheter is crucial. The controlling catheter must be stiff enough to overcome stiffness of the stent graft device. The radius of the catheter tip curvature will also determine how far from its neutral position the stent graft can be deflected. We have found that a 6F to 7F steerable guiding sheath is particularly useful as a controlling device because it enables the deflection of the stent graft’s tip angle by

adjusting the catheter’s curvature. Although insertion of a 6F to 7F sheath from the contralateral groin access site is usually safely performed for EVAR procedures, it must be used with caution for TEVAR procedures in which brachial access is required. In this situation, a 6F angled guiding catheter is a good substitute as shown in our TEVAR case. An added benefit of the second access is the easy availability of control arteriography immediately before and during stent graft deployment. In terms of cost-effectiveness, despite use of those relatively expensive steerable sheaths, we believe that this technique ultimately reduces total cost because precise deployment and maximum purchase of the sealing zone will spare additional, more expensive stent graft placement.

There are some limitations in our technique. First, not all stent grafts would be well suited, particularly those with nose cones or suprarenal fixation (Cook Zenith and Medtronic [Santa Rosa, Calif] Endurant, for example), because precise deflection of the device tip angle may be more difficult with such devices. Second, owing to lack of case accumulation, we cannot provide a clear indication as to when to use this technique. We hope to publish an indication once we experience enough cases.

CONCLUSIONS

Our directional tip control technique is easy and effective. It can be a good technical solution for endovascular aortic treatment in angulated anatomy.

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