Treatment of late-presenting malperfusion and aneurysmal degeneration in chronic type B aortic dissection with an off-the-shelf four-vessel inner-branched endograft

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ABSTRACT

Acute complicated type B aortic dissection is increasingly treated with endovascular techniques to manage contained rupture or end-organ malperfusion. Most cases of malperfusion occur during the acute phase of the dissection. We report a case of a patient treated for late presentation of lower body malperfusion 4 years after successful endovascular intervention for contained rupture of an acute type B dissection. The anatomic complexity required multiple staged procedures culminating in endovascular repair of the paravisceral aorta with an off-the-shelf four-vessel inner-branched endograft, used for the first time, to the best of our knowledge, in North America in the present case. The patient involved provided written informed consent for the report of his case details and imaging studies. (J Vasc Surg Cases Innov Tech 2023;9:101273.)

Keywords: Aortic dissection; BEVAR; Malperfusion

Late aortic interventions for patients with chronic type B aortic dissections are usually indicated to prevent rupture if the aorta degenerates and becomes aneurysmal over time.[1] In some cases, intervention could be indicated for malperfusion that develops in delayed fashion due to changes in the native aorta or stent graft-induced new entry tears.[2] In cases in which concern exists for both rupture from aneurysmal degeneration and malperfusion, anatomic complexity can severely limit endovascular options to treat the entire thoracoabdominal aorta with off-the-shelf endovascular devices and techniques.[3] We describe the successful treatment of late malperfusion and aneurysmal degeneration in a chronic type B aortic dissection after previous thoracic endovascular aortic repair (TEVAR) using an off-the-shelf, four-vessel, inner-branched stent graft.

CASE REPORT

A 66-year-old man presented with acute kidney injury, uncontrolled hypertension with six antihypertensive agents, paroxysmal relapsing and remitting lower extremity paralysis and paraplegia, and new-onset minor tissue loss of the left forefoot that had rapidly progressed within days. His surgical history included previous repair of a ruptured type B aortic dissection with thoracic stent grafting and right-to-left femorofemoral artery bypass for left leg malperfusion 5 years before his current presentation. At his last surveillance appointment 6 months before presentation, his blood pressure was well controlled with two antihypertensive agents, and he was asymptomatic. A computed tomography scan was performed that demonstrated stent graft-induced new entry tears at the lower edge of his TEVAR stent graft causing enlargement of the distal descending thoracic aorta and resulting in a 7-cm aneurysm with severe compression of the true lumen distally. The true lumen was compressed to 4 mm in the minor axis of the supraceliac aorta, which was causing malperfusion to the lower half of his body (Fig 1).

A decision was made to treat the patient in stages, with the first stage to treat the malperfusion, and the second stage to treat the remainder of the thoracoabdominal aorta to prevent rupture. In the first stage, the patient was taken to the hybrid operating room and through open surgical exposure of the right superficial femoral artery, a 32-mm $\times$ 150-cm Valiant Captivia (Medtronic) thoracic stent graft was placed from the previous stent graft proximally into the compressed true lumen distally, landing 2 cm above the celiac artery to preserve options for future intervention. Intravascular ultrasound guidance was used intraoperatively to assess the major and minor axis of the true lumen's diameter in systole and diastole before and after the intervention (Supplementary Video 1, online only). Given the size discrepancy between the compressed supraceliac true lumen and the previous thoracic stent graft, the true lumen was splinted open to 20 mm in the minor axis. However, the aneurysm remained untreated because of a type Ib endoleak, which was not unexpected given the oversizing in the distal landing zone (Fig 2). The patient tolerated the procedure well, and his acute kidney injury, lower limb malperfusion, and refractory hypertension resolved during his hospital stay, with a brisk diuresis of >10 L and suitable blood pressure control with two antihypertensive agents. One week later, he was brought back to the operating room, and left foot transmetatarsal amputation

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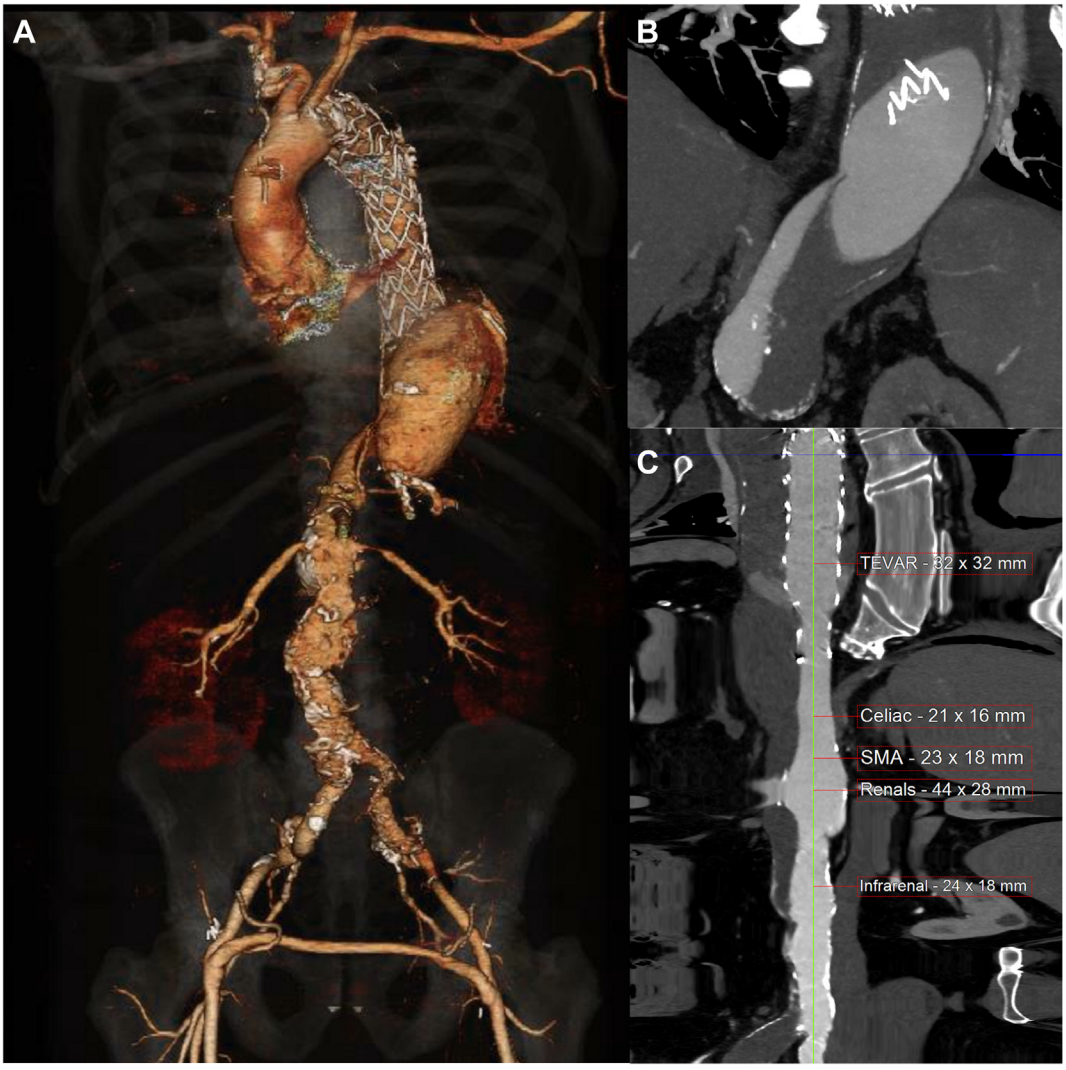

Fig 1. Preoperative images demonstrating anatomic complexity visualized during the patient's presentation with lower body malperfusion. **A,** Three-dimensional volume rendering demonstrating the distal thoracic aneurysm and severely compressed supraceliac true lumen due to stent graft-induced new entry tears from the previous thoracic endograft. **B,** Maximum intensity projection reconstruction of the severe compression of the supraceliac true lumen adjacent to the aneurysm. **C,** Measurements of the paravisceral aorta after the first-stage thoracic endovascular aortic repair (TEVAR) showing a luminal diameter of 32 mm at the distal thoracic stent graft, 32 × 4 mm at the upper edge of the compressed true lumen and 31 × 15 mm in the infrarenal aorta. *SMA,* Superior mesenteric artery.

was performed to remove gangrenous tissue and prevent the spread of infection. Two weeks later, he was brought back to the operating room, and completion endovascular thoracoabdominal aneurysm repair was performed. Given the severe compression of the paravisceral true lumen in the chronic dissection and the large size of the proximal TEVAR stent grafts, the Jotec E-Nside (Jotec GmbH) four-vessel, inner-branched device was used. It was uniquely suited to the patient's complex anatomy, because the inner branches and tapered middle segment would allow the device to fit in the fibrotic compressed true lumen of the chronic dissection. To the best of our knowledge, this represents the first use of this device in North America, which required special access permission from Health Canada for emergency compassionate use. Before surgery, a lumbar cerebrospinal fluid drain was placed by our anesthesia team, and routine hemodynamic and physiologic spinal cord protection parameters were used perioperatively. After placement of the main body through right open common femoral artery access, it was discovered that the device had landed roughly 1 to 2 cm higher than originally intended and was off rotationally by almost 45° despite diligent attempts to make adjustments and slowly deploy the device in the correct orientation. This was due to the severe tortuosity present in the common and external iliac arteries, a well-described risk factor for rotation of advanced endovascular stent grafts during deployment.[4] Although landing the device higher than intended did

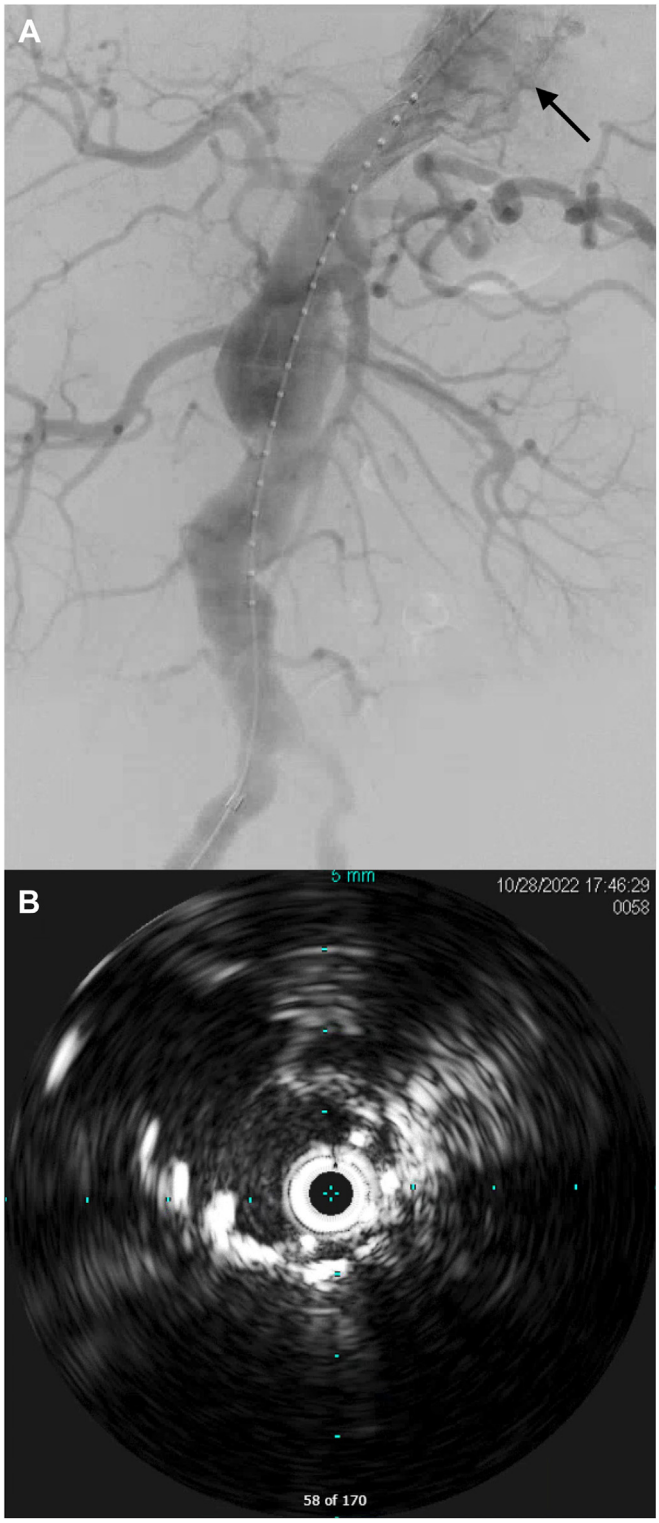

Fig 2. Completion imaging after thoracic endovascular aortic repair (TEVAR) to alleviate malperfusion demonstrating a type Ib endoleak (black arrow) visualized outside of the fabric of the stent graft on completion angiography **(A)** and graft infolding at the lower edge of the new thoracic stent graft due to oversizing relative to the compressed true lumen visualized on intravascular ultrasound **(B)**.

compensate for the rotation of the device regarding visceral target accessibility, the design of the E-Nside device also streamlined the visceral target cannulation. The combination of the precannulated delivery system and the large addressable space that can be accessed through the wide angle of the inner branches made it relatively straightforward to complete bridging from the branches to the target vessels using Bentley BeGraft peripheral plus balloon expandable stent grafts (Bentley Innomed) through open exposure of the third part of the right axillary artery. A 480-cm Nova Gold 0.018-in. wire (Boston Scientific) was placed through the precannulated inner branches of the main device and snared through the axillary access to establish through-and-through access to the inner branches. Guide sheaths were then placed through the axillary access to the inner branches, and through-and-through access was lost to facilitate advancing the guide sheath and Begraft branch stents to each target vessel. After successful stenting of each target vessel, the branched device was then extended with an Endurant (Medtronic) aorto-uni-iliac main body and iliac limb extension. The left common iliac artery was occluded using an Amplatzer AVP-2 occluding plug (Abbott Vascular) through percutaneous left common femoral artery access. Completion angiography and completion intravascular ultrasound showed no perfusion of the false lumen and well-expanded stent grafts in the residual true lumen of the dissection (Supplementary Video 2, online only). At 3 months, the patient continued to have resolution of his malperfusion and the size of the aneurysmal aorta had decreased by 2 mm in the largest component of the thoracic aorta (Fig 3).

DISCUSSION

Patients with thoracoabdominal aortic dissection requiring intervention for malperfusion or aneurysmal degeneration remain a complex population to treat with endovascular techniques. Custom-made devices, physician-modified grafts, and in situ fenestration have demonstrated technical success in this space. However, each of these solutions has disadvantages.[5] Custom-made grafts often result in a delay in treatment owing to the time required to manufacture the device. Also, the long-term durability of physician-modified devices and in situ fenestration is not yet known. A need remains for further development of off-the-shelf devices to treat patient with thoracoabdominal aortic dissections that require urgent treatment of malperfusion or rupture.

Recently, the development of inner-branched technology has expanded the anatomic suitability of branched endografts to treat extensive thoracoabdominal aortic pathology, although early iterations of this technology were still used with a custom-made device platform.[6] The off-the-shelf, four-vessel, inner-branched design of the Jotec E-Nside device has demonstrated promising short-term results for a variety of thoracoabdominal aortic pathologies as demonstrated in the INBREED (Italian branched registry of E-Nside endograft) registry.[7] The present case demonstrates the value of the

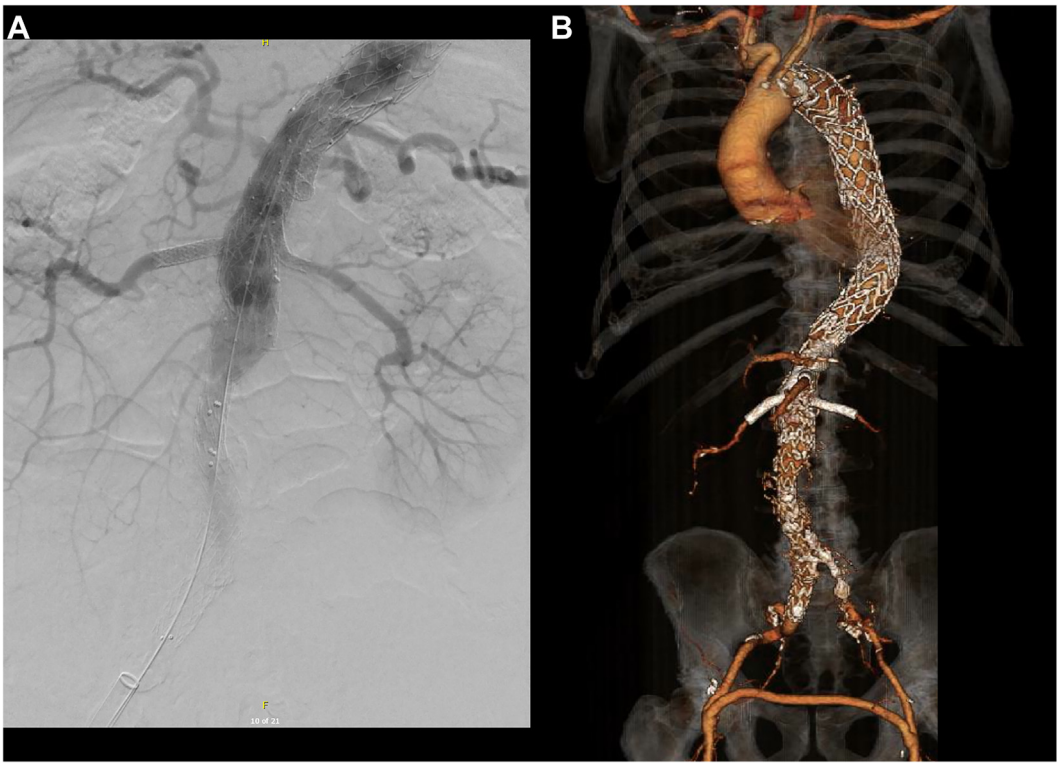

Fig 3. A, Completion angiography after placement of four-vessel inner-branched device and aorto-uni-iliac component. **B,** Three-dimensional volume rendering of 3-month postoperative computed tomography scan showing patency of all four branch vessels and no further perfusion of the aneurysm sac or false lumen.

inner-branched technology in the Jotec E-Nside device to allow for expeditious treatment of a patient with a thoracoabdominal aortic dissection with a compressed paravisceral true lumen. A recent report has demonstrated that the cumulative anatomic suitability of the currently available off-the-shelf branched grafts is far greater than any single individual device.[3] As more off-the-shelf fenestrated and branched endovascular aortic stent-grafts with different anatomic instructions for use criteria become available, we will continue to be able to treat more patients with urgent presentations and complex thoracoabdominal aortic pathology.

CONCLUSIONS

Chronic degeneration and late aortic-related events in type B aortic dissection remain a clinical challenge that often require a creative endovascular solution to solve for patients who are not suitable candidates for open surgery. We present the use of an off-the-shelf inner-branched stent graft to treat a dissection with both malperfusion and aneurysmal degeneration with good short-term results. Although this North American first required special access to facilitate compassionate use, the North American markets would benefit from access to this technology to treat patients with aortic emergencies who are not candidates for other off-the-shelf devices that currently have approval from regulatory agencies in the United States and Canada.

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