Texas Heart Institute Journal

Case Reports

# Distal Aortic Malperfusion Exacerbated by Antegrade Stent-Graft Placement During Hybrid Repair of Acute DeBakey Type I Aortic Dissection

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*We present the case of an acute DeBakey type I aortic dissection with malperfusion. The patient underwent valve resuspension, ascending aortic and partial arch replacement, debranching of the innominate artery, and placement of a small-diameter stent within the left common carotid artery, after which antegrade deployment of a stent-graft into the proximal descending thoracic aorta was performed to expand the true lumen. Distal malperfusion was exacerbated by the stent-graft's traversal into the false lumen, necessitating further endovascular repair to reestablish flow to the distal aorta. Mitigation before stent-graft placement (for example, inserting a wire within the true lumen under fluoroscopic guidance to ensure stent-graft placement in the true lumen) and prompt corrective procedures are paramount, given the grim consequences of prolonged distal ischemia.* ***(Tex Heart Inst J 2022;49(4):e217764)***

**Citation:**
Reul RM Jr, Hong JC, Coselli JS, Preventza O. Distal aortic malperfusion exacerbated by antegrade stent-graft placement during hybrid repair of acute DeBakey type I aortic dissection. Tex Heart Inst J 2022;49(4):e217764. doi: 10.14503/THIJ-21-7764

**Key words:**
Aneurysm, dissecting; aorta, thoracic/surgery; endovascular procedures/adverse effects; treatment outcome

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Acute aortic dissection is a rapidly fatal condition in which the aorta splits into 2 channels, the true and false lumens. The false lumen typically expands during the dissection process, compressing the true lumen. The lethality of acute aortic dissection affecting the proximal aorta, such as DeBakey type I, necessitates complex emergency surgical intervention, especially when the dissection process shears the commissures of the aortic valve or compromises blood flow to branching arteries. The initial operative plan is primarily guided by the patient's clinical presentation and computed tomographic imaging findings.

Initial repair may be limited to a partial arch replacement, expanded to include replacement of the entire transverse aortic arch, combined with endovascular repair to expand the true lumen within the proximal portion of the descending thoracic aorta, or combinations thereof.[1] We report extensive repair of an acute DeBakey type I aortic dissection with malperfusion related to a severely compressed true lumen.

## Case Report

This report was prepared in accordance with a clinical research protocol approved by the Baylor College of Medicine Institutional Review Board (BCM H-18095). Written informed consent was obtained from the patient.

A 34-year-old obese man (body mass index, 43) presented at another hospital with severe, tearing chest pain of 2 hours' duration progressively radiating to the lower back, left flank, and left leg. His medical history was noncontributory; however, his father had undergone repair of an aortic aneurysm at a young age. Although the patient had no clinical features of an established heritable thoracic aortic disease (such as Marfan or Loeys-Dietz syndrome), his young age was a concern.

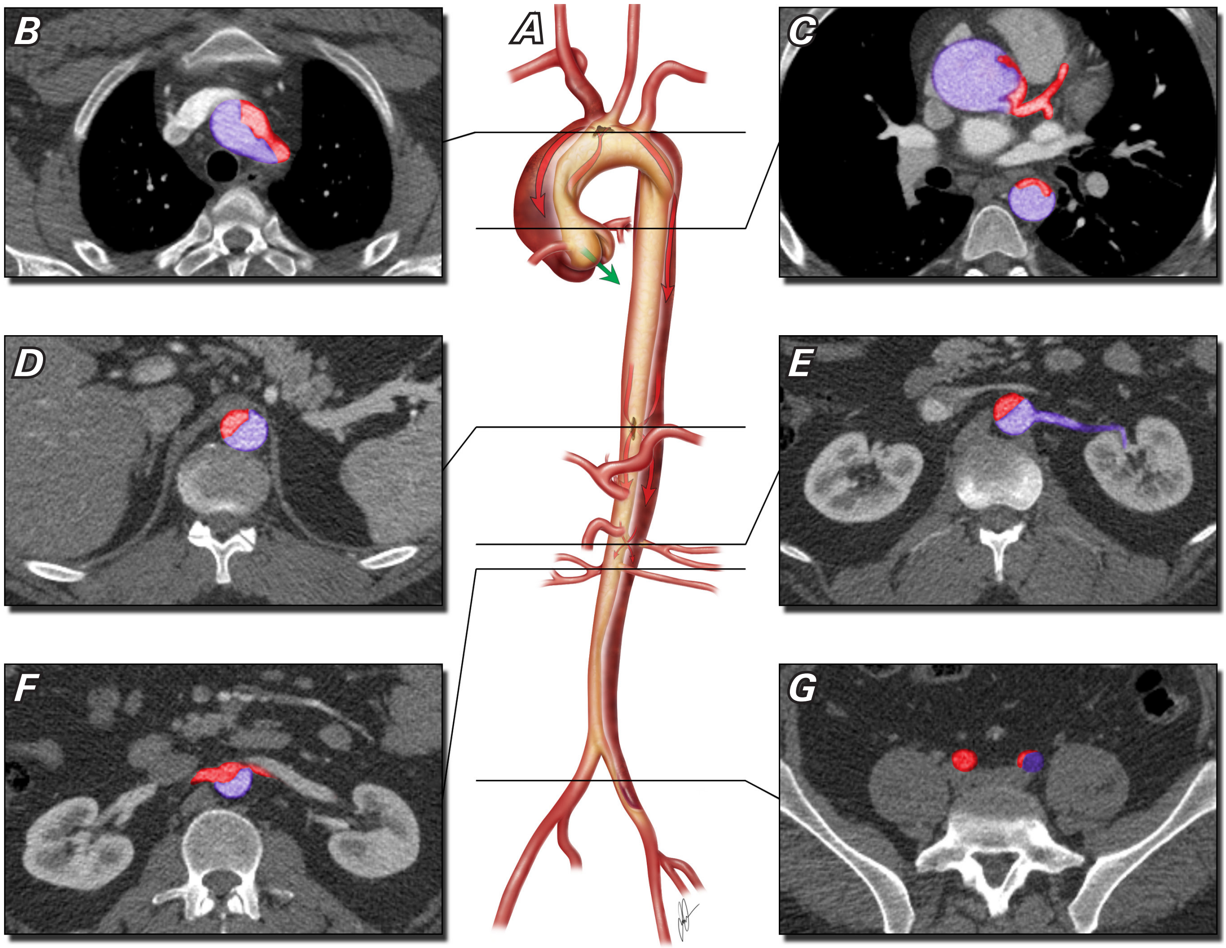


***Fig. 1*** *Preoperative illustration and correlated axial computed tomographic angiograms (CTAs) depict an acute DeBakey type I aortic dissection and the presence of 2 left renal arteries.* ***A****) The illustration shows an intimal tear originating in the aortic arch with retrograde dissection into the root and antegrade dissection down into the left common iliac artery. Fenestrations in the true lumen's septum are depicted superior to the celiac artery and at the avulsion of the upper left renal artery. Red arrows indicate blood flow; green arrow indicates aortic valve regurgitation.* ***B****) This CTA shows the originating dissection tear. Other CTAs show* ***C****) compression of the aortic valve at the level of the left coronary artery, and compression of the true lumen in the descending thoracic aorta;* ***D****) compression of the true lumen at the level of the supraceliac fenestration in the descending thoracic aorta;* ***E****) compression of the true lumen, and the upper left renal artery originating from the false lumen;* ***F****) compression of the true lumen, and the right renal artery and lower left renal artery originating from the true lumen; and* ***G****) compression of the true lumen in the left common iliac artery. In all the CTAs, the red overlay indicates the true lumen, and the purple overlay indicates the false lumen.*

A computed tomographic angiogram (CTA) showed a DeBakey type I aortic dissection extending from the aortic root to the aortic bifurcation and a tear in the aortic arch at the left common carotid artery. The patient had moderate-to-severe aortic valve regurgitation and a severely compressed true lumen, resulting in downstream aortic malperfusion. Thrombosis of the false lumen severely narrowed the left common iliac artery, threatening the health of the patient's left lower limb (Fig. 1).

The patient was transferred to our institution by air ambulance. On arrival, he was hemodynamically stable on a nicardipine drip. We found no evidence of myocardial or mesenteric ischemia or of heart or renal failure. The patient's left lower extremity was cool to the touch and had decreased pedal pulses, but was deemed viable. He was taken to the operating room for emergency surgery.

After anesthesia was induced, a transesophageal echocardiogram revealed a dissection flap prolapsing into an otherwise normal trileaflet aortic valve and a shearing of valve commissures that caused the aortic regurgitation. A 5F sheath was inserted into the right femoral artery for hemodynamic monitoring, and a median sternotomy was performed. To prepare the patient for cardiopulmonary bypass (CPB), a 10-mm graft was sutured to the distal aspect of the innominate artery to aid its cannulation as the site of arterial inflow; a venous cannula into the inferior vena cava (through the right atrium) was used for outflow. The patient was then placed on CPB and cooled to a temperature of 24 °C (moderate hypothermic circulatory arrest). Bilateral antegrade cerebral perfusion was then initiated through the innominate and left common carotid arteries, with flow rates set at 10 to 15 mL/kg/min.

Under direct vision, we performed thoracic aortic endovascular repair (TEVAR) to place a 28-mm × 15-cm Gore C-TAG endograft (W.L. Gore & Associates) in the true lumen distal to the left subclavian artery. We have pioneered this technique to enhance downstream aortic perfusion.[2-4] Because the true lumen was compressed distally in this patient, we placed the stent-graft in the proximal descending thoracic aorta to expand the true lumen.

To address dissection of the left common carotid artery, we introduced an 8 × 17-mm Express LD stent (Boston Scientific Corporation) under direct vision and balloon-expanded it within the vessel. A 26-mm Gelweave graft (Terumo Aortic) was anastomosed to the aorta proximal to the left common carotid artery, and the graft was cannulated directly to reestablish blood flow to the distal aorta. To address a tear that we discovered in the proximal aspect of the innominate artery, we performed an aortoinnominate debranching bypass procedure with use of a 10-mm graft. The ascending and proximal arch segments were replaced with the 26-mm Gelweave graft. Circulatory arrest was discontinued, and the rewarming process was initiated.

Because dissection extended into the aortic root, we repaired the noncoronary sinus with use of bovine pericardium as neomedia and BioGlue (Cryolife Inc.) to reapproximate the aortic layers. The aortic valve was then resuspended at all 3 commissures. The 26-mm graft was anastomosed end-to-end with the sinotubular junction, an anterolateral opening was created on the graft with electrocautery, and the 10-mm innominate artery graft was anastomosed to the 26-mm graft.

The patient was rewarmed to a temperature of 36.5 °C and weaned from CPB. Total CPB time was 169 minutes, and cardiac ischemia time was 123 minutes. Antegrade cerebral perfusion was given for 61 minutes.

After CPB was discontinued, the femoral arterial line was no longer pulsatile, and the right radial and right femoral arterial pressures were clearly different. Urine output was low, raising suspicion of distal aortic malperfusion; however, the patient was not acidotic, suggesting intact perfusion to the mesenteric vessels. Hemostasis was expeditiously obtained, and the surgical incision was closed. An immediate CTA revealed worsened compression of the descending thoracic aorta's true lumen, raising concern that the distal portion of the endograft had been deployed into the false lumen and was actively compressing the true lumen. In addition, the left iliac artery was now further occluded, with reconstitution of flow distally. The patient was taken to our hybrid operating room and catheterization laboratory suite for a rescue intervention.

Under intravenous ultrasonographic guidance, a femoral wire was placed in the true lumen distally. An angiogram confirmed that the endograft had been deployed into the false lumen (Fig. 2A). Removing the stent-graft would have been prohibitively risky, given the patient's fragile condition; accordingly, the wire was threaded through an existing fenestration above the celiac artery and into the endograft. Balloon septostomy was performed to enlarge the fenestration between the true and false lumens to improve perfusion to the true lumen (Fig. 2B). A 36 × 180-mm Cook bare dissection stent (Cook Medical) was placed so that it extended from the distal edge of the endograft and curved across the fenestration into the true lumen. To extend this repair to the iliac bifurcation, a second 36 × 80-mm Cook bare dissection stent was overlapped with the first. The advantage of bare dissection stents is that blood flow is not impeded. The left common iliac artery was stented with use of an 8 × 57-mm Express stent.

A completion angiogram showed improved perfusion of the true lumen (Fig. 2C–D). The femoral and radial arterial waveforms also correlated well, and the patient had palpable pedal pulses in both legs upon arrival in the cardiac intensive care unit. His postoperative recovery was complicated by acute kidney injury and paraparesis.

The patient was discharged to a rehabilitation facility 3 weeks after initial presentation. A predischarge CTA confirmed the patency of distal vessels (Fig. 3).

## Discussion

In patients with acute DeBakey type I aortic dissection not accompanied by substantial dilation of the aortic arch and an originating tear within the arch, we typically perform a limited replacement of the arch's lesser curvature (hemiarch repair). When the aortic arch is dilated or contains a large tear, we usually replace the ascending aorta and entire aortic arch, with or without endovascular extension into the descending thoracic aorta; our frozen elephant trunk technique for such repair is especially useful when there is distal aortic malperfusion.[4] When distal aortic malperfusion is present without a dilated or torn arch, we typically perform a limited replacement of the lesser curvature of the arch plus antegrade TEVAR of the descending thoracic aorta under direct vision. When we adopted this approach a decade ago, we found that antegrade stent delivery alleviated malperfusion in the downstream aorta without substantially lengthening overall circulatory arrest time[2]; midterm results of this approach indicated less of a need for subsequent intervention.[3]

Additional factors to consider when planning repair are young age; known heritable thoracic aortic disease; and dilation of the distal arch, descending thoracic aorta, or thoracoabdominal aorta, for which subsequent

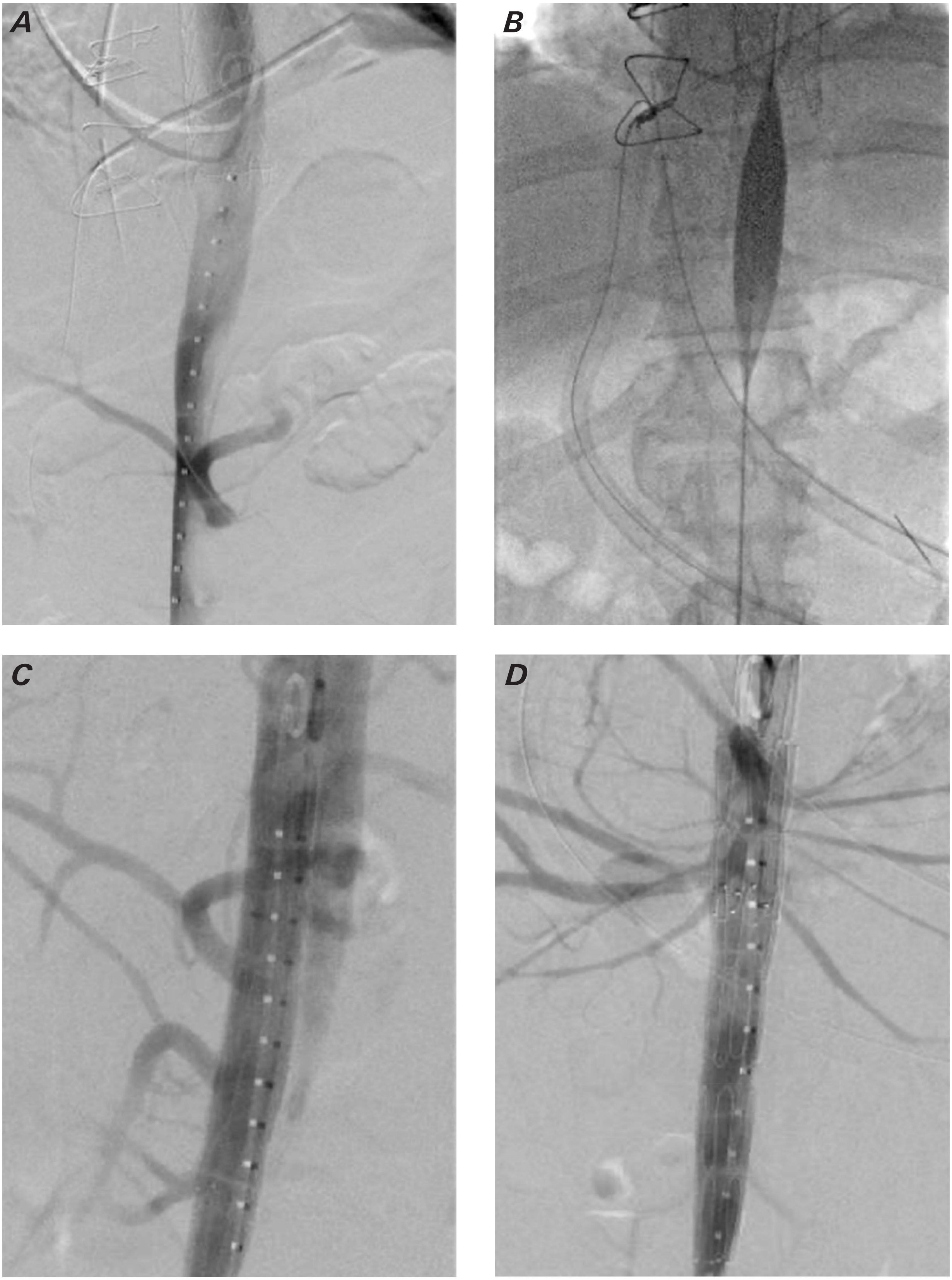


***Fig. 2*** *Angiograms show steps in the catheterization procedure.* ***A****) The thoracic aortic endograft has been deployed antegrade into the false lumen.* ***B****) Balloon septostomy is performed to increase the size of the supraceliac fenestration. Completion angiograms show improved perfusion of the thoracoabdominal aorta, with contrast readily filling both* ***C****) the true and false lumens and* ***D****) the distal aorta.*

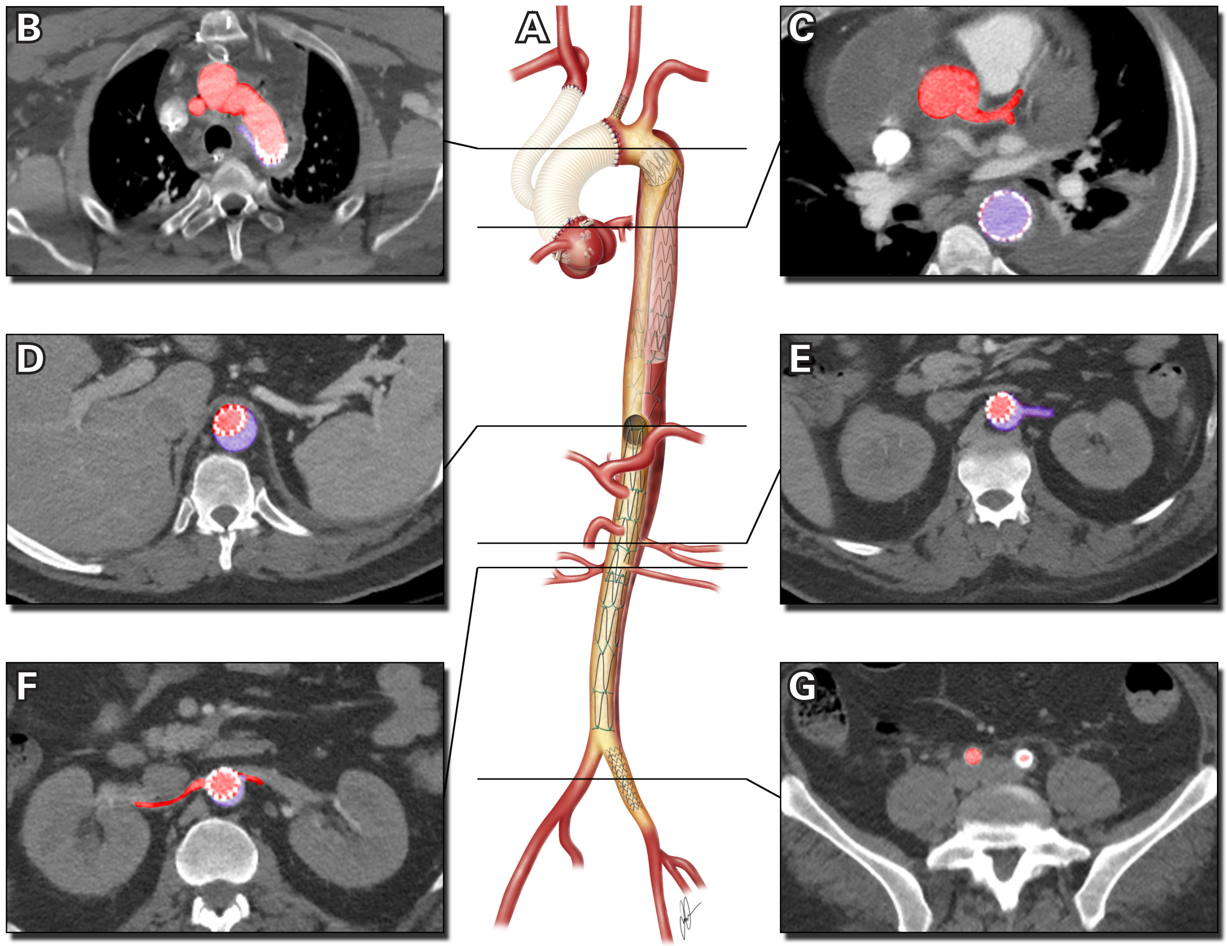


***Fig. 3*** *Postoperative illustration and correlated axial computed tomographic angiograms (CTAs) depict the index repair.* ***A****) The illustration shows plication and resuspension of the aortic valve with reinforcing felt pad sandwiched between dissected wall layers of the noncoronary sinus; ascending and proximal aortic arch replacement, along with debranching of the innominate artery with a Dacron graft; direct stenting of the proximal left common carotid artery; thoracic endovascular aortic repair (TEVAR) of the descending thoracic aorta, with its proximal end in the true lumen and its distal end in the false lumen; deployment of 2 dissection stents proximally inside the distal end of the TEVAR, traversing the supraceliac septal fenestration down to the aortic bifurcation distally; and stenting of the left common iliac artery. The CTAs show* ***B****) the proximal end of the TEVAR in the true lumen at the level of the transverse aortic arch;* ***C****) the TEVAR in the false lumen of the descending thoracic aorta;* ***D****) expansion of the true lumen by the dissection stent at the level of the supraceliac fenestration in the descending thoracic aorta;* ***E****) expansion of the true lumen by the dissection stent, and the upper left renal artery originating from the false lumen;* ***F****) expansion of the true lumen by the dissection stent, and the right renal artery and lower left renal artery originating from the true lumen; and* ***G****) expansion of the true lumen by the stent in the left common iliac artery. In all the CTAs, the red overlay indicates the true lumen, and the purple overlay indicates the false lumen.*

intervention has traditionally been necessary.[5,6] Contingency planning for foreseeable problems also is necessary. Our patient's body habitus precluded optimal exposure for a total arch replacement with elephant trunk, so we instead performed limited arch repair with directly visualized antegrade deployment of an endograft to obliterate the false lumen.

This case was further complicated by the distal end of the endograft having crossed over into the false lumen—a possibility in any type of endovascular aortic procedure.[7,8] Here, we were able to expand an existing fenestration to pass a wire into the endograft and place a stent to reestablish flow into the distal true lumen; other cases might require a needle septostomy.

During an antegrade TEVAR, we now routinely place a wire in the ascending aorta and through a femoral sheath before initiating CPB. Transesophageal echocardiography or intravascular ultrasonography can be used to confirm the wire's position within the true lumen. The endograft can then be deployed antegrade over the wire. If wire placement is not possible, a bronchoscope or angioscope can be used to inspect the endograft after deployment; such inspection might also be done fluoroscopically in a hybrid operating room and catheterization laboratory suite.

## Conclusion

Placing an endograft is an effective technique for restoring flow to the distal aorta. Nonetheless, aortic surgeons should be aware of the risks associated with each surgical maneuver and take steps to preemptively mitigate the risk of traversing an endograft into the false lumen. Early detection and prompt correction of distal malperfusion are paramount.


## Acknowledgments

Stephen N. Palmer, PhD, ELS, and Jeanie F. Woodruff, BS, ELS, of the Department of Scientific Publications at the Texas Heart Institute, and Susan Y. Green, MPH, of the Michael E. DeBakey Department of Surgery at Baylor College of Medicine, contributed to the editing of the manuscript. We thank Lindsey Johnson for creating the illustrations as part of the SMART program at Baylor College of Medicine, and Scott Weldon, MA, CMI, FAMI, for supervising the preparation of the illustrations.

**Published:** 3 August 2022

**Conflict of Interest Disclosures:** Dr. Preventza provides consultation for and participates in clinical trials with Medtronic and W.L. Gore & Associates. Dr. Coselli participates in clinical trials with and consults for Terumo Aortic, Medtronic, and W.L. Gore & Associates; and he receives royalties and grant support from Terumo Aortic. The other authors have no potential conflicts of interest with regard to the work described in this manuscript.

**Funding/Support:** Dr. Coselli's work is partly supported by the Cullen Foundation. There was no direct funding for this report.

**Meeting Presentation:** This case was presented at the Houston chapter meeting of the International Society of Endovascular Specialists (ISEVS) entitled "Aortic Challenges: From Root to Bifurcation," 22 June 2021.


## References


1. Frankel WC, Green SY, Orozco-Sevilla V, Preventza O, Coselli JS. Contemporary surgical strategies for acute type A aortic dissection. Semin Thorac Cardiovasc Surg 2020;32(4):617-29.
2. Preventza O, Cervera R, Cooley DA, Bakaeen FG, Mohamed AS, Cheong BYC, et al. Acute type I aortic dissection: traditional versus hybrid repair with antegrade stent delivery to the descending thoracic aorta. J Thorac Cardiovasc Surg 2014;148(1):119-25.
3. Preventza O, Olive JK, Liao JL, Orozco-Sevilla V, Simpson K, Rodriguez MR, et al. Acute type I aortic dissection with or without antegrade stent delivery: mid-term outcomes. J Thorac Cardiovasc Surg 2019;158(5):1273-81.
4. Preventza O, Al-Najjar R, Lemaire SA, Weldon S, Coselli JS. Total arch replacement with frozen elephant trunk technique. Ann Cardiothorac Surg 2013;2(5):649-52.
5. Poon SS, Theologou T, Harrington D, Kuduvalli M, Oo A, Field M. Hemiarch versus total aortic arch replacement in acute type A dissection: a systematic review and meta-analysis. Ann Cardiothorac Surg 2016;5(3):156-73.
6. Yamamoto H, Kadohama T, Yamaura G, Tanaka F, Takagi D, Kiryu K, Itagaki Y. Total arch repair with frozen elephant trunk using the "zone 0 arch repair" strategy for type A acute aortic dissection. J Thorac Cardiovasc Surg 2020;159(1):36-45.
7. Han SM, Gasper WJ, Chuter TAM. Endovascular rescue after inadvertent false lumen stent graft implantation. J Vasc Surg 2016;63(2):518-22.
8. Schrimpf C, Teebken OE, Wilhelmi M. Thoracic endovascular aortic repair after iatrogenic aortic dissection and false lumen stent grafting. Ann Thorac Surg 2015;99(4):1447-9.