

Aortic remodeling and competitive flow after surgical treatment of aortic dissection

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ABSTRACT

Aortic remodeling after dissection is poorly understood and remains a focus of current research. In the present report, we have described the cases of two patients with acute lower extremity ischemia related to malperfusion from aortic dissection treated with extra-anatomic axillobifemoral bypass. During long-term follow-up, aortic remodeling led to reinstitution of flow through the native aorta. This resulted in competitive flow, leading to complete thrombosis of the extra-anatomic conduits. These cases highlight the occurrence of spontaneous aortic recanalization and subsequent competitive flow, two vascular phenomena that are not well understood but can significantly affect patient outcomes. (*J Vasc Surg Cases Innov Tech* 2021;7:404-7.)

Keywords: Acute limb ischemia; Aortic dissection; Axillobifemoral bypass; Extra-anatomic bypass; Malperfusion; Recanalization

Aortic dissection can compromise perfusion to essential organs and can manifest as malperfusion. Spontaneous aortic recanalization after aortic occlusion from dissection is a phenomenon that has not been extensively reported.¹⁻³ In the present report, we have described aortic remodeling and competitive flow in two patients who had presented with malperfusion from aortic dissection. The patients were treated with emergent extra-anatomic axillobifemoral bypass. Long-term follow-up of these patients showed spontaneous recanalization of the aorta, leading to restoration of flow through the native vessel. Subsequently, competitive flow led to thrombosis of the extra-anatomic grafts. This series of events is not well understood. The patients provided written informed consent for the report of their case details.

CASE REPORT

Patient 1. A 64-year-old man had presented to the emergency department with excruciating back pain and hypotension. His medical history was notable for essential hypertension that was treated with lifestyle modifications only. On presentation, his systolic blood pressure was 178 mm Hg. A computed

tomography angiogram (CTA) revealed an acute type A aortic dissection extending to zone 9. He underwent emergent root-sparing, open, ascending aortic, and hemiarch replacement with a 28-mm Hemashield graft (Boston Scientific, Marlborough, Mass) and aortic valve replacement with a 23-mm Carpentier-Edwards biological valve (Edwards Lifesciences, Irvine, Calif) under deep hypothermic circulatory arrest.

The patient returned to the intensive care unit for recovery, where pedal Doppler signals were not detected. Emergent CTA revealed collapse of the true lumen (zones 5-8) and complete aortic occlusion (zone 9), resulting in bilateral lower extremity ischemia (Fig 1). A left axillobifemoral bypass with an 8-mm ringed Gore-Tex graft (W.L. Gore & Associates, Flagstaff, Ariz) and bilateral four-compartment fasciotomies were performed. The remainder of his postoperative recovery was notable for respiratory failure necessitating reintubation and cholecystitis-related sepsis. After recovery, the patient was discharged on postoperative day 25.

At the 1-year follow-up, the patient was ambulating well without claudication, and surveillance CTA showed gradual restoration of flow in the native aorta (Fig 2). At 1.5 years, CTA demonstrated spontaneous recanalization of the formerly occluded infrarenal aortic segment and layering thrombus within the axillobifemoral bypass graft, which was also demonstrated on duplex ultrasound (Fig 2). Despite the layering thrombus in the bypass graft, normal velocities and waveforms were found on duplex ultrasound before complete thrombosis, which had occurred after 3 years. At 5 years, the patient demonstrated continued aortic remodeling with an increase in the maximal aortic diameter (41 × 37 mm vs 37 × 36 mm initially; Fig 3). At the last follow-up, his ankle brachial index (ABI) was normal, and he continued to lead an active lifestyle without claudication or rest pain.

Patient 2. A 62-year-old man had presented to the emergency department from an unaffiliated hospital with severe lower back pain. His pertinent medical history included

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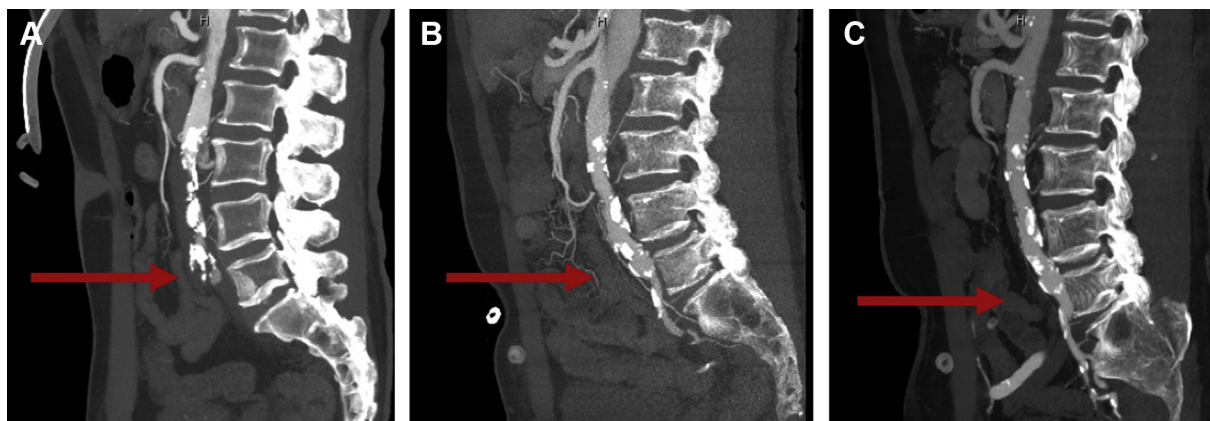


Fig 1. Computed tomography angiogram (CTA) highlighting aortic remodeling and competitive flow in patient 1. **A**, Sagittal CTA section after open ascending aortic repair showing true lumen collapse (zone 5-8) and aortic occlusion (zone 9). **B**, Corresponding sagittal section at 1 year showing aortic remodeling and gradual restoration of flow. **C**, Sagittal section of aortoiliac CTA at 5 years revealing complete restoration of native aortoiliac flow (arrow).

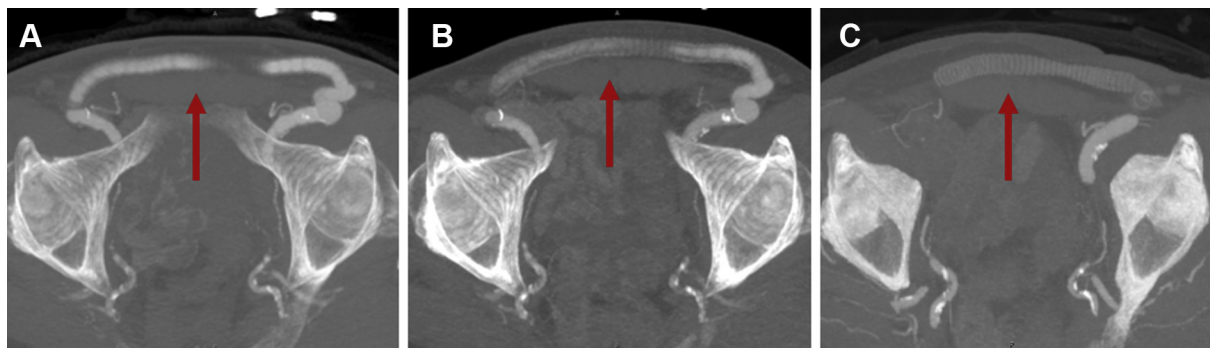


Fig 2. Computed tomography angiogram (CTA) demonstrating thrombosis of extra-anatomic bypass over time. **A**, Axial CTA section at the level of the femorofemoral limb of the axillobifemoral bypass at 1 month post-operatively demonstrating a patent bypass in patient 1. **B**, Corresponding axial CTA section at 1 year showing layering thrombus within the femorofemoral limb (red arrow). **C**, Corresponding axial CTA section at 1.5 years revealing complete thrombosis of the axillobifemoral bypass graft (red arrow).

smoking, hypertension, hyperlipidemia, previous chronic type B₃₋₉ aortic dissection, and a known small infrarenal abdominal aortic aneurysm. Before presentation, the patient had discontinued his blood pressure medications. He had presented with a systolic blood pressure of 180 mm Hg. A CTA demonstrated a new, acute type B₅₋₇ dissection tear with a narrow true lumen. The flap extended into the celiac axis, superior mesenteric artery, and right renal artery. Anti-impulse therapy was initiated for medical management.

The following night, the patient developed acute bilateral lower extremity ischemia associated with sensory and motor impairment on clinical examination. He underwent emergent left axillobifemoral bypass using an 8-mm ringed Gore-Tex graft (W.L. Gore & Associates). His recovery was complicated by left-sided surgical site bleeding at the femoral artery requiring a return to the operating room for primary anastomotic repair. He was discharged after an 11-day hospital stay.

A 9-month postoperative surveillance CTA demonstrated recanalization of the dissected lumen (zone 9), accompanied

by thrombosis of the femoral–femoral limb of the axillobifemoral bypass. At this point, the patient's ABIs were normal. At 3 years, complete thrombosis of the axillobifemoral graft had occurred with persistent inline flow through the aorta, and the patient has continued to lead an active lifestyle without claudication.

DISCUSSION

We have demonstrated the rare event of spontaneous aortic recanalization after occlusion in the setting of aortic dissection. Previously, Taguchi et al¹ reported spontaneous recanalization of an occluded descending thoracic aorta after an acute type B aortic dissection in an octogenarian with malperfusion who had been medically treated. Within 5 days, the aorta had spontaneously recanalized, and she had not experienced any sequela.¹ DeAnda et al³ reported spontaneous recanalization of an occluded aorta 6 months after axillobifemoral bypass, which remained patent at 2 years of follow-up. In their

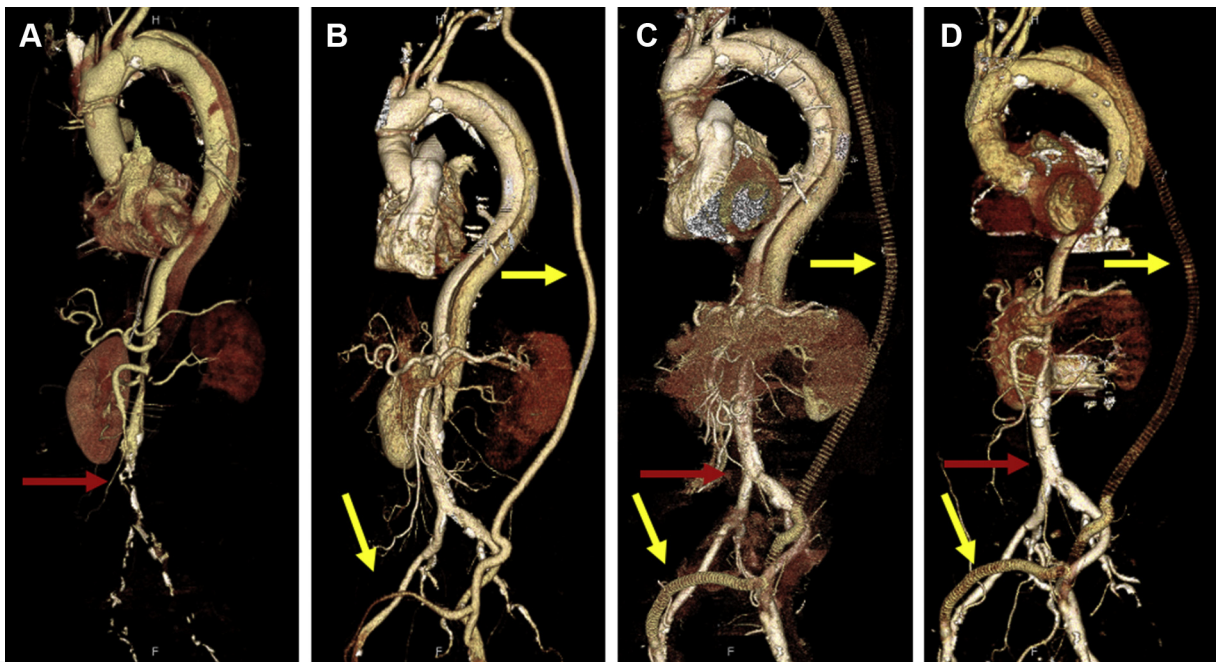


Fig 3. Three-dimensional (3D) reconstruction of computed tomography angiogram (CTA) demonstrating aortic remodeling and competitive flow over time in patient 1. **A**, 3D reconstruction after open repair of ascending aorta depicting true lumen collapse and zone 9 aortic occlusion (*red arrow*). **B**, 3D reconstruction of CTA at 1 year showing aortic remodeling and gradual restoration of flow. Also depicted is a patent left axillobifemoral bypass graft, with layering thrombus in the femorofemoral limb (*yellow arrow*). **C**, 3D reconstruction of CTA at 1.5 years showing restoration of flow within the aortoiliac segment (zones 9-12; *red arrow*) and corresponding thrombosis of the extra-anatomic bypass (*yellow arrows*). **D**, 3D reconstruction of CTA at 5 years revealing complete restoration of native aortoiliac flow (zones 9-12; *red arrow*) and thrombosis of the left axillobifemoral bypass (*yellow arrows*).

patient, the occlusion had also not resulted from an aortic dissection but from an extensive thoracic intramural hematoma.³ Finally, Choinski et al² reported an embolic occlusion of the infrarenal aorta, which had spontaneously recanalized 6 months after an axillobifemoral bypass. Similarly, the bypass graft had occluded from competitive flow after recanalization of the aorta.^{2,4} The present report adds to the limited data of spontaneous recanalization of the aorta for a longer period than previously described.

Occlusion of the axillobifemoral graft in both patients had likely resulted from competitive flow after aortic remodeling. Aortic remodeling has largely been described after thoracic endovascular repair (TEVAR), whereby reinstatement of inline flow through the true lumen leads to eventual thrombosis of the false lumen, stabilizing the aorta.^{5,6} In the present report, the dissections were not treated with TEVAR but, rather, with initial anti-impulse therapy. In patient 1, fresh aortic arch anastomoses and complete distal aortic occlusion precluded safe performance of TEVAR. In patient 2, TEVAR was precluded by the presence of a complex dissection with multiple tears and a distal aortic occlusion. In these patients, the specific mechanism of remodeling and the period required to reestablish inline aortic flow remained unclear.

In TEVAR-treated patients, aortic remodeling is often measured by true and false lumen measurements using CTA or magnetic resonance angiography; however, the surveillance methods used have been highly inconsistent.⁵ Based on the current Society for Vascular Surgery guidelines for surveillance of lower extremity revascularization using extra-anatomic bypass, we would recommend surveillance of bypass grafts using duplex ultrasound and ABI measurements at 3, 6, and 12 months after treatment, followed by 6 to 12 months thereafter.⁷

After aortic remodeling, thrombosis of the grafts was likely due to competitive flow, whereby recanalization of the native vessel leads to increased flow, creating a pressure differential between two conduits. Subsequent resistance in the smaller prosthetic conduit and the larger native vessel leads to failure of the smaller conduit.^{8,9} The phenomenon has primarily been evaluated in the context of coronary artery bypass grafting failure. Berger et al¹⁰ demonstrated that internal mammary artery grafts were more likely to occlude when the native vessels were only low-to-moderately stenosed owing to competitive flow. Another study suggested that the addition of multiple bypass grafts to a stenosed vessel could introduce more competitive flow, increasing graft failure.¹¹ Competitive flow has been less studied in larger conduits, such as axillobifemoral grafts and larger vessels

such as the aorta. A better understanding of this sequela might improve patient selection and expectations during follow-up.

CONCLUSIONS

Spontaneous recanalization can occur after an acute aortic dissection and occlusion. Extra-anatomic bypass is effective for treatment of acute limb ischemia, and competitive flow after aortic recanalization can lead to thrombosis. Further research to better understand aortic remodeling is needed.

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