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Crushing of a bridging stent during follow-up of endovascular branched aortic arch repair: A novel mode of failure

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ABSTRACT

A 68-year-old man developed aneurysmal degeneration of the aortic arch and proximal descending aorta after an open ascending graft for a type A aortic dissection. A three-branched endovascular aortic arch repair was performed with patency of all branches despite some degree of initial misalignment of the branches in relation to the target vessels. At 6 months postoperatively, an asymptomatic partial crushing of the left common carotid bridging grafts was observed on computed tomography angiography. This was treated by reinforcing the branch with a balloon-expandable endograft. The postoperative course was uneventful but a computed tomography angiography after 1 month showed recurrent asymptomatic compression. A left carotid-subclavian bypass was eventually performed. We have reported a new failure mode of an inner branch arch repair of residual type A chronic dissection. (*J Vasc Surg Cases Innov Tech* 2022;8:646-50.)

Keywords: Aortic arch repair; Inner branch; Endograft

Aortic arch pathology involving one or more of the supra-aortic vessels, given the various anatomical restraints, has traditionally been treated by open surgery.¹ A number of techniques have been described, most notably the frozen elephant trunk, which has become popular if a second stage (endovascular) procedure for the descending aorta is anticipated.² Early endeavors in total endovascular arch repair were associated with less favorable outcomes, including a significant stroke risk.³ In recent years total endovascular arch techniques have matured, showing particularly favorable result in residual dissection following an open ascending repair.⁴

As with any new treatment, new modes of failure can also arise. The aortic arch, in contrast with more distal portions of the aorta, is subject to high velocity and shear stress during the cardiac cycle, potentially making it more vulnerable. We report a case where total endovascular arch repair was complicated by crushing of one of the arch branches during follow-up. The patient provided written informed consent for the report of his case and related imaging studies.

CASE-REPORTS

A 68-year-old male patient with a history of severe hypertension underwent open repair of an acute type A aortic dissection 22 months previously with an interposition tube graft of the supracoronary ascending aorta. On the first postoperative day he was reoperated owing to a cardiac tamponade. The postoperative course was further complicated with mild renal insufficiency. His glomerular filtration rate remained stable at 51 mL/min/1.73 m² after discharge. Notably, the preoperative computed tomography angiography (CTA) showed a proximal descending aorta diameter of 44 mm. During follow-up this segment enlarged to 59 mm within 6 months. A multidisciplinary team meeting recommended endovascular treatment as the preferred option. The diameter of the true lumen at the level of the supra aortic vessels was 25 mm and a manufacturing limitation leading to a misalignment of 30 minutes in the clock position of the left carotid and its branch (Fig 1) was accepted considering that the graft tapered to 26 mm at this level (Fig 2).

The patient underwent total endovascular arch repair using a custom-made three inner branched endovascular aneurysm repair endograft (Cook Medical, Bloomington, IN),⁵ which was extended to the supraceliac abdominal aorta combined with a plug in the false lumen of the distal thoracic aorta. The procedure was performed under general anesthesia with a prophylactic spinal fluid drain and under fusion imaging guidance as previously described.⁶ Bilateral percutaneous access was used with the preclose technique using two Proglide devices (Abbott, Santa Clara, CA).⁷ Open access was used to allow clamping of the common carotid artery while deploying the bridging stent grafts. A 34-mm arch endograft with a middle segment with a diameter of

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Author conflict of interest: none.

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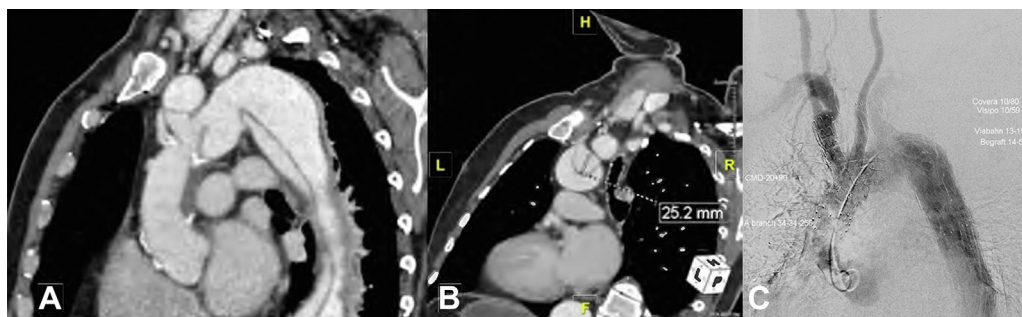


Fig 1. Preoperative computed tomography angiography (CTA) showing multiplanar reconstruction images (**A, B**) of the arch plus proximal descending aortic aneurysm and selective completion angiogram from the initial procedure showing the successful implantation of an arch stent graft with patent target vessels (**C**).

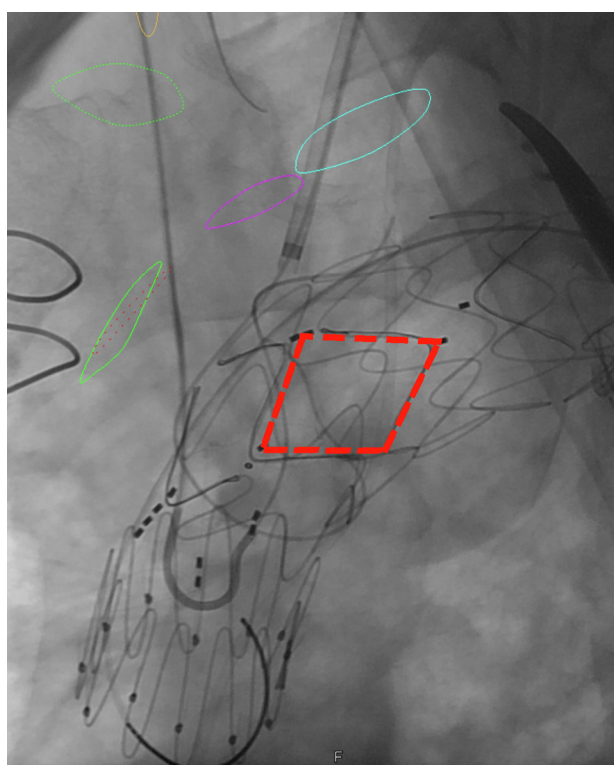


Fig 2. Fluoroscopy image with fusion markers, showing the misalignment of left common carotid (LCC) artery and its respective inner branch with diamond form (dashed red line).

26 mm was deployed in the arch and the brachiocephalic trunk was bridged with a custom endograft (20-90 mm, Cook Medical). The retrograde cannulation of the left common carotid (LCC) artery was not possible owing to the misalignment and small aortic diameter. A branch-to-branch technique was used as previously described, where the endograft was accessed from the brachiocephalic trunk branch and a wire is advanced into the LCC branch to be snared from the LCC retrograde access.⁸ A Covera (Bard, Tempe, AZ) 10- to 80-mm endograft was then placed and reinforced

proximally by a balloon-expandable stent (Visipro, Medtronic, Minneapolis, MN) of 10 to 59 mm. The left subclavian artery was bridged with a Viabahn (13-150 mm) (Gore, Flagstaff, AZ) and reinforced with a BeGraft (14-59 mm) (Bentley, Hechingen, Germany). The main endograft was then extended distally with a second endograft (ZTEC 2PT-34-197) and the false lumen was plugged distally using a 40-71 plug. Both completion angiography and on-table cone beam CT (DynaCT, Siemens, Erlangen, Germany) showed adequate positioning of the main endograft with patent branch vessels without signs of complications.

The postoperative course was uneventful except for mild hoarseness caused by local swelling of the neck, which subsided without further treatment. The first postoperative CTA scan, 1 day postoperatively, showed successful aneurysm exclusion with widely patent branch vessels. The patient spent 2 days in the intensive care unit and was discharged home on postoperative day 11 with dual antiplatelet therapy (acetylic acid 75 mg once daily and clopidogrel 75 mg once daily). The patient was readmitted twice within 30 days owing to fever and elevated inflammatory parameters. The first time, empiric antibiotic therapy was given at an internal medicine department but was discontinued after no infection was verified. An oral steroid regimen was then given with good effect. On both occasions, follow-up CTAs showed successful aneurysm exclusion with patency and integrity of the branches and no signs of extrinsic compression of the carotid bridging stent grafts, despite a slight kink that was not causing a hemodynamically significant stenosis.

A routine CTA at 6 months continued to show patency of the true lumen, including the branches, with exclusion of the false lumen and shrinkage of the aneurysm to 49 mm in the proximal descending aorta. However, the bridging endograft and balloon-expandable stent to the LCC were seen to be partially crushed (Fig 3). There were no signs of complications with regard to the other two branches and the patient was asymptomatic. A secondary intervention took place 7 months after the index

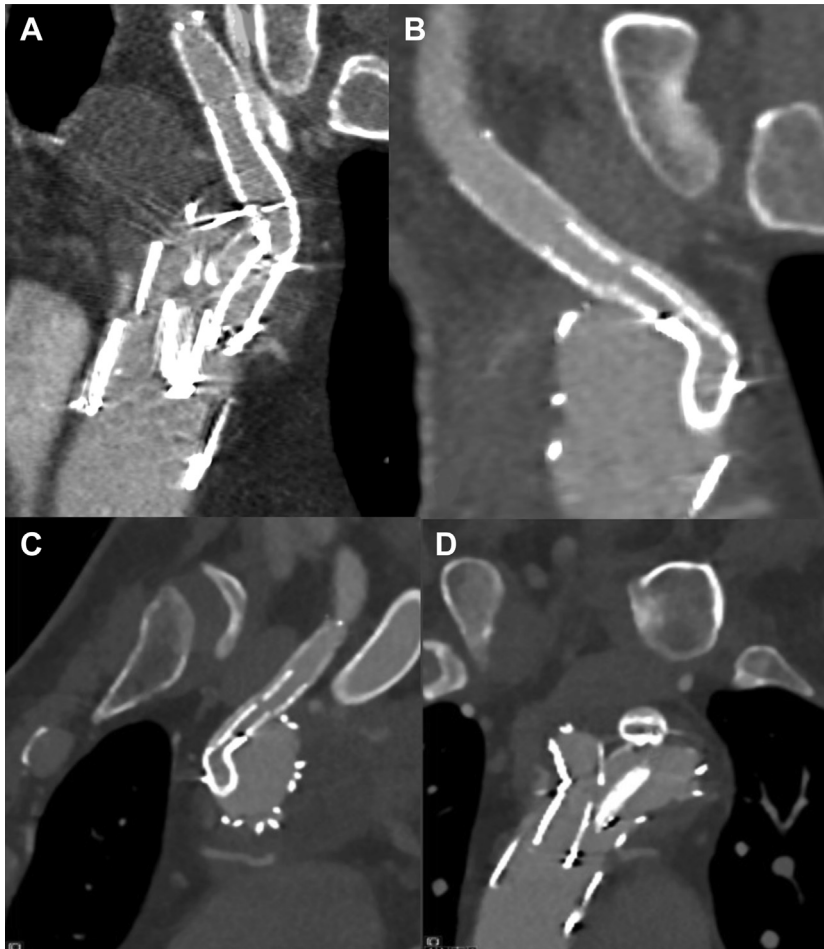


Fig 3. Postoperative computed tomography angiography (CTA) at 1 and 6 months showing kinking and crushing of the left common carotid (LCC) bridging endograft with significant narrowing of the lumen: **(A,B)** 1 month, **(C,D)** 6 months.

procedure via open access to the distal LCC under general anesthesia. The branch endograft was cannulated, even if it was difficult, in a retrograde fashion to cross the stents and a 6-mm predilatation had to be done before reinforcement with a new balloon-expandable stent (VBX 8L-79- 8mm) could be done. This was then redilated with a 8-mm high-pressure balloon up to 40 Atm. Again, the manipulation was done under surgical cross-clamping and heparinization. Completion angiography showed adequate expansion, without signs of recoil. No neurological events occurred perioperatively. The postoperative course was uneventful, and the patient was discharged home after 5 days.

A follow-up CTA performed one month after the secondary procedure showed recurrence of the branch compression (Fig 4) despite the patient remaining asymptomatic. Unhindered antegrade flow was demonstrated by a duplex in the LCC and carotid-subclavian bypass was performed 12 months after the index operation with uneventful course.

The last follow-up CTA was performed 32 months after the index procedure and showed a well-excluded aneurysm with patent true lumen, two branches, and left carotid-subclavian bypass (Fig 5).

DISCUSSION

The present case illustrates a potential complication of total endovascular arch repair for dissection. To our knowledge, this complication has not been reported before and is of interest because, as with any novel treatment, new modes of failure can be expected. Therefore, rigorous follow-up with reporting of outcomes and potential complications are paramount to further develop these techniques and devices.

This complication occurred somewhere between 1 and 6 months postoperatively, despite several maneuvers aimed to avoid it. Intraoperatively, the difficulties in catheterization caused by the small lumen and malrotation led us to preemptively reinforce the branch for the left carotid artery. This maneuver was done after our earlier

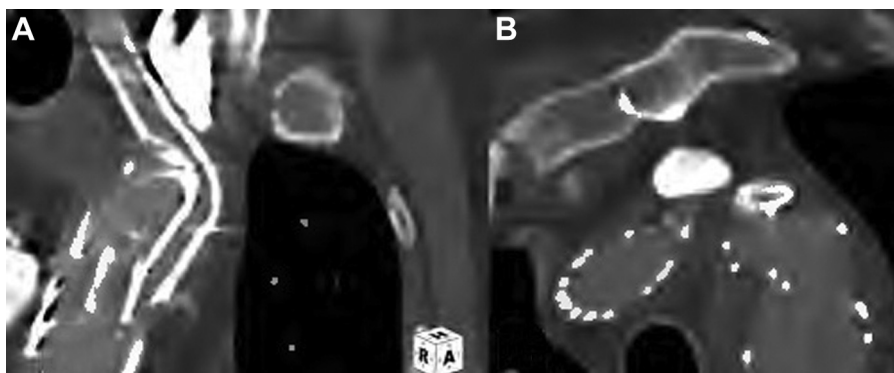


Fig 4. Postoperative computed tomography angiography (CTA) at 1 month after secondary procedure showing new compression of left common carotid (LCC) branch.



Fig 5. Postoperative three-dimensional reconstruction at 32 months showing an excluded aneurysm with patent true lumen, two branches and left carotid-subclavian bypass.

experience of possible compression of the bridging stents between the aortic wall and the main stent graft when only self-expanding peripheral stent grafts were used.⁹ Moreover, numerous quality control techniques were employed, including intraoperative cone-beam CT by the end of the procedure, to exclude any compression. This step was followed by serial CTA during follow-up showing the compression of the left carotid branch. Several factors may have contributed to this. The forces and movements on endografts in the ascending aorta and aortic arch are not extensively researched, although it has been suggested they are more pronounced compared with more distal and static portions of the

aorta,¹⁰ where these compressions had been seen.⁴ These forces may have been accentuated by the tortuous course of the branch owing to the slight misalignment during initial placement and the very fast remodeling evident on the significant shrinkage of the aneurysm in the early follow-up period. The latter, combined with the small diameter of the false lumen and misalignment between the branch and the ostium, may have led to an external compression of the branch by the dissection flap that tends to become less pliable after the first months after an acute dissection. More important, recurrence of compression may lead to the consideration of stents with high radial force at the potential compression segments. Alternatively, intentional forced disruption of the dissection membrane could be considered, but the STABILISE technique¹¹ has been mostly used in the acute setting and may prove difficult and risky in this segment. Alternatively, endovascular septectomy could also be explored.

A nonoperative approach could have been considered instead of the bypass that was ultimately undertaken. However, the antegrade flow and the proximal compression made us fear the possibility of extensive cerebral ischemia if the branch occluded.

This complication seems to be rare, given the good results after the endovascular repair of post type A dissection.⁴ However, given its potential consequences, in cases of misalignment and difficulties in catheterizing branches, it may be prudent to liberally reinforce the branches with several high-radial force stents and have a more vigorous follow-up until the remodeling of the aneurysm is verified.

CONCLUSIONS

Partial crushing of a branch is a possible complication that can occur during follow-up after total endovascular aortic arch repair of chronic dissection when there is a misalignment between the branch and target vessel combined with a small true lumen. Liberal aggressive reinforcement of the potential compression segments

with high radial force stents and rigorous follow-up are advisable in these complex cases.

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