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CASE REPORT
Coronary heart disease

Transcatheter aortic valve implantation facilitated by right common carotid cut-down and innominate artery angioplasty with simultaneous right coronary artery vein graft percutaneous coronary intervention in a patient with mid aortic syndrome: a case report

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Background Transcatheter aortic valve implantation (TAVI) is most commonly performed via the femoral approach. Small calibre ilio-femoral arteries, severe calcification and tortuosity are often prohibitive reasons for TAVI via the femoral approach. Mid-aortic syndrome is a rare condition describing congenital or acquired coarctation of the abdominal aorta.

Case summary To the best of our knowledge, this case report describes the world's first TAVI in a patient with mid-aortic syndrome with challenging vascular access that would preclude conventional TAVI access routes. A 76-year-old woman with intermittent claudication, underwent work-up for axillo-bifemoral bypass, underwent a TAVI for incidental severe asymptomatic severe aortic stenosis via right common carotid TAVI facilitated by innominate artery angioplasty achieved vascular access for TAVI. Percutaneous coronary intervention to a right coronary artery vein graft was simultaneously performed via a left brachial artery cut down.

Discussion We demonstrate that complex angioplasty to coronary artery bypass grafts and the innominate artery alongside TAVI via a variety of arterial access sites is both safe and feasible.

Keywords TAVI • Mid aortic syndrome • Complex angioplasty • Innominate artery angioplasty • Case report

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Learning points

- Transcatheter aortic valve implantation (TAVI) is a versatile procedure in which many *ad hoc* procedures can be simultaneously performed.
- Meticulous evaluation of vascular and aortic root anatomy is paramount to TAVI planning.
- Careful patient selection and multidisciplinary team decision-making are prerequisites to success in complex cases.

Introduction

Transcatheter aortic valve implantation (TAVI) is an accepted alternative to surgical aortic valve replacement in patients with severe aortic stenosis deemed to have high to intermediate operative mortality.[1] Transcatheter aortic valve implantation is most commonly performed via the femoral approach. Other vascular access routes include the subclavian and axillary arteries as well as the transaortic, transapical and most recently the transcaval approach.[2] Significant operative risk is conferred by advanced comorbidities, advanced age, poor left ventricular function, previous coronary artery bypass grafts, and pre-existing peripheral vascular disease.[3]

Mid-aortic syndrome describes coarctation of the abdominal aorta. This rare condition, with only 200 reported cases worldwide may manifest as uncontrolled hypertension, mesenteric angina, or lower limb claudication. Traditional surgical approaches have been shown to improve symptoms and to prolong life expectancy.[4] The majority of mid-aortic coarctation syndromes are congenital in origin but may also be secondary to Takayasu's arteritis. Revascularization of mid-aortic syndrome poses considerable challenges due to the fibrotic nature of the vessel wall and the involvement of the renal and visceral arteries.[5]

Timeline

Day	Event
Pre-admission	Attended vascular outpatient clinic with symptoms of intermittent right buttock and leg claudication pain Pre-operative assessments: • Computed tomography aortogram: right common femoral artery occlusion + mid aortic syndrome + innominate artery stenosis • Echocardiography: severe aortic stenosis • Carotid Doppler: 50% stenosis of left common carotid artery • Coronary angiography: right coronary artery vein graft (RCAVG) ostial lesion + diffusely diseased left internal mammary artery + 50% left subclavian stenosis
• Day 1 • Day 8 • Follow-up at 3 months	• Simultaneous angioplasty to RCASVG via left brachial artery + innominate artery angioplasty + transcatheter aortic valve implantation via right common carotid artery • Treated for pneumonia. Satisfactory echocardiographic appearance of aortic valve. Discharged home • No cardiac symptoms. Satisfactory appearance of aortic valve. Conservative management of claudication

Case presentation

A 76-year-old woman was referred for a vascular opinion regarding progressive right buttock, thigh and calf claudication pains after 100 yards on the flat, associated with nocturnal cramps. There were no symptoms of mesenteric angina. Her past medical history included hypertension and previous coronary artery bypass grafting (CABG). The grafts were left internal mammary artery (LIMA) to left anterior descending artery, saphenous vein graft (SVG) to obtuse marginal (OM), and SVG to RCA. Importantly, the patient was diagnosed with possible Takayasu's arteritis as an adolescent. However, the lack medical records meant the extent and the treatment of the arteritis were unknown. The patient was a non-smoker with medications including aspirin 75 mg o.d., atorvastatin 20 mg o.d., amlodipine 5 mg o.d., bisoprolol 1.25 mg o.d., and ezetimibe 10 mg o.d. Computed tomography aortography demonstrated occlusion of the right common femoral artery and a heavily calcified sub-total stenosis of the abdominal aorta just below the origin of the superior mesenteric artery (*Figure 1*). Clinical examination at preoperative assessment clinic revealed normal first and second heart sounds with Grade 3 ejection systolic murmur radiating to the carotids. The apex beat was not displaced. Vascular examination revealed palpable brachial pluses bilaterally, left femoral, popliteal, and pedal pulses but impalpable radial pluses bilaterally as well as impalpable right femoral, popliteal, and pedal pulses. The lower limbs were of normal colour and temperature. The carotid pulse was not slow rising nor were there any carotid bruits. Abdominal examination was unremarkable. Respiratory examination was unremarkable with a respiratory rate of 12 breaths per minute and saturations of 99% on room air. Baseline blood pressure was 151/65 mmHg with a regular heart rate of 56 b.p.m. Transthoracic echocardiography revealed severe calcific aortic stenosis of a moderately calcified tri-leaflet aortic valve. The peak and mean gradients were 85 mmHg and 47 mmHg, respectively. The peak velocity was 4.6 m/s with a valve area of 0.75cm^2. There was a jet of mild aortic regurgitation. The left ventricle was mildly concentrically hypertrophied with preserved systolic function. The right heart was normal with right ventricular systolic pressure of 20 mmHg in addition to right atrial pressure.

Carotid Doppler studies were satisfactory showing no surgical disease. The right internal carotid artery was mildly narrowed and the left common carotid artery demonstrated a 50% stenosis, which did not meet criteria for endarterectomy.

Coronary angiography via a small left radial artery highlighted a significant RCAVG ostial stenosis and diffuse disease of an atrophic LIMA graft. The SVG to the OM was occluded. The native RCA was occluded. The left main stem was normal, the left anterior descending had a moderate proximal stenosis with good run-off. The left circumflex had mild plaque burden with an 80% ostial OM lesion. There was 50% ostial left subclavian artery stenosis and a significant lesion of

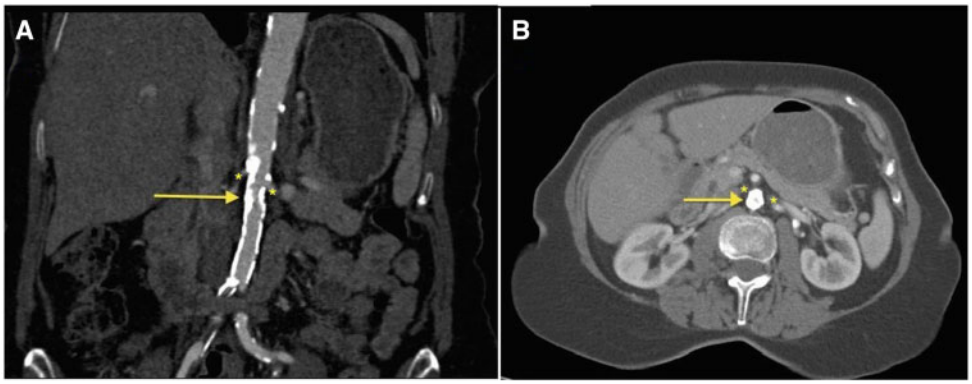

Figure 1 (*A*) Computed tomography angiogram (coronal section). Heavily calcified stenotic lesion immediately below the origin of the superior mesenteric artery (arrow) involving the renal arteries (*). (*B*) Computed tomography angiogram (transverse section). Complex mid aortic lesion (arrow) in relation with the renal arteries (*).

greater than 50% stenosis of the origin of the left common carotid. Computed tomography scanning to determine the optimal vascular access routes demonstrated a 70% stenosis of the innominate artery that would preclude the direct delivery of the 30 cm, 18-Fr Cook sheath via the minimally diseased right common carotid artery (*Figure 2*). Haemoglobin was 13.3 g/dL (12–15.5 g/dL for women) and creatinine was 77 µmol/L (45–90 µmol/L for women).

Following a joint cardiology and vascular surgery multidisciplinary team meeting, the patient's severe asymptomatic aortic stenosis was deemed preclusive of complex vascular reconstructive surgery. The patient was asymptomatic from her severe aortic stenosis because she was not able to exert herself sufficiently owing to her significant claudication pains. Transcatheter aortic valve implantation was considered preferable to surgical valve replacement. The RCASVG ostial lesion was visually severely narrowed and percutaneous coronary intervention (PCI) was deemed appropriate as this graft subtended a significant portion of myocardium. The MDT consensus was for revascularization prior to TAVI implantation. Femoral access was deemed inappropriate and angioplasty to the mid aortic stenosis would have been too high risk with a high chance of failure. A transapical approach was not considered as it was not routinely performed at this centre. The subclavian arteries would be spared for the subsequent axillo-bifemoral bypass surgery. Innominate artery angioplasty was considered to be easier via the right common carotid approach compared to the subclavian approach after discussion at the multidisciplinary team meeting. Therefore, the right common carotid approach was chosen with the aim of dilating the innominate artery stenosis prior to the implantation of the TAVI valve.

The procedure was conducted under general anaesthesia, with an experienced joint interventional cardiology and vascular surgery team. Access via a left brachial artery cut-down was achieved to facilitate PCI to the RCAVG ostial lesion. Pre-dilation with a 2.5 mm balloon and lesion modification using a 3 mm × 6 mm cutting balloon were carried out before deployment of a 3.5 mm × 15 mm Xience drug-eluting stent. A 3.75 mm × 12 mm balloon was used for post-dilation. The left brachial artery cut-down was sutured with 6.0 prolene. The left brachial route was chosen, as the radial arteries were impalpable. It was important to treat the RCAVG as it subtended a significant portion of viable myocardium (*Figure 3*).

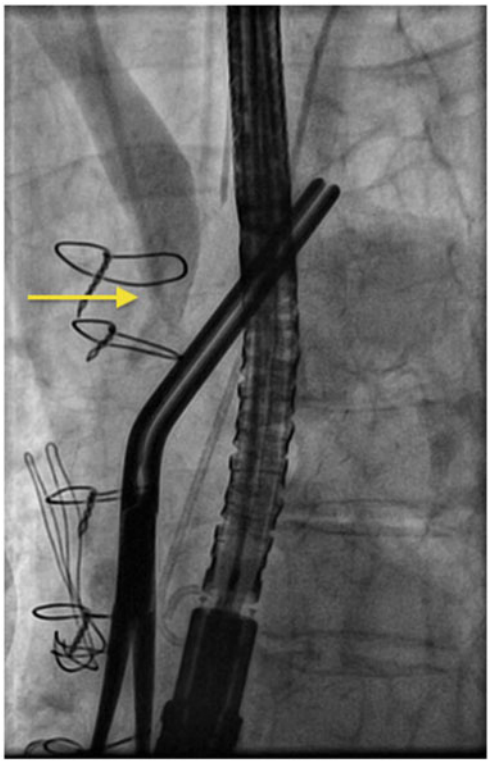

Figure 2 Innominate artery stenosis (arrow).

The right common carotid artery was then surgically exposed and angioplasty to the innominate artery using a 7 mm × 40 mm balloon at 6 atmospheres was performed via a 6-Fr sheath passed over an Amplatz super-stiff wire. The right carotid artery access was ideal allowing for simultaneous treatment of the innominate artery

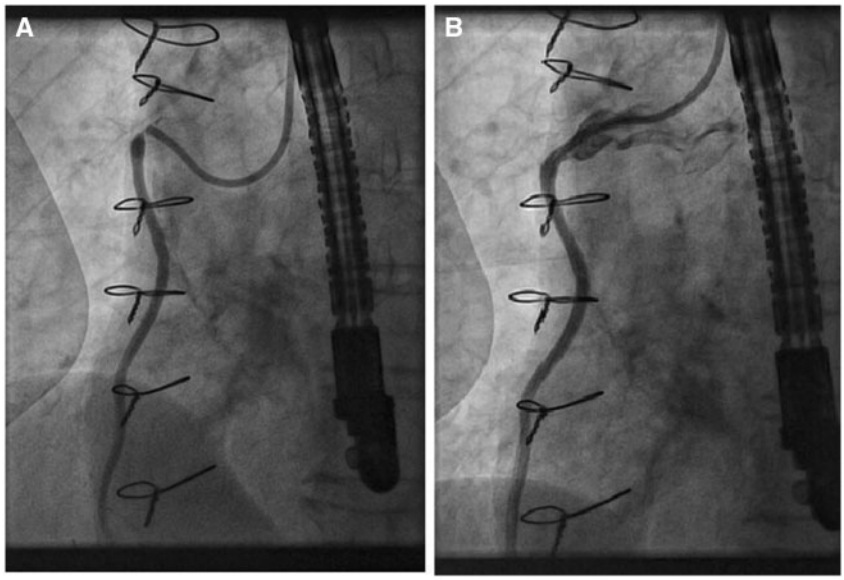

Figure 3 (*A*) Ostial right coronary artery vein graft lesion pre-angioplasty. (*B*) Ostial right coronary artery vein graft lesion post-angioplasty.

stenosis and safe delivery of the 30 cm 18-Fr Cook TAVI sheath. Continuous cerebral oximetry and transcranial Doppler were used throughout the procedure to promptly identify any sequelae from carotid artery occlusion. There were no changes throughout the procedure. The aortic valve was crossed with an AL1 catheter. Rapid ventricular pacing at 180 b.p.m. was achieved using a temporary pacing wire introduced via the right femoral vein. The next steps were dilation of the diseased aortic valve using a 20 mm Nucleus balloon and implantation of a 26 mm Corevalve at a depth of 6 mm below the annulus. An excellent result was achieved with trivial aortic regurgitation.

Haemodynamic data were as follows: pre-procedural left ventricular and aortic pressures were 176/1 and 127/37 mmHg. Post-procedural left ventricular and aortic pressures were 175/6 and 172/40 mmHg. Patent arterial haemostatsis was achieved by surgical means by the attending vascular surgeons.

The patient's convalescence was complicated by pneumonia, which responded to a 7-day course of oral levofloxacin. The patient was discharged home on Day 8. At 3 months follow-up, the patient remains free from cardiac symptoms with no evidence of valve displacement or paravalvular leakage. Echocardiographic follow-up revealed preserved left ventricular function with a peak and mean gradient across the TAVI valve of 21 mmHg and 10 mmHg, respectively. Her claudication is being managed conservatively at present with the option of an axillo-bifemoral bypass being reserved in case of critical limb ischaemia.

Discussion

Transcatheter aortic valve implantation is a well-recognized alternative to surgical aortic replacement in high-risk individuals. Transcatheter aortic valve implantation reduces cardiovascular mortality by 20% compared to medical management of severe aortic stenosis. Transcatheter aortic valve implantation is non-inferior to traditional surgical replacement in high-risk patients but is associated with higher rates of embolic cerebrovascular events at 1 year.[6] Patients with prior CABG or pre-existing renal impairment are at the highest risk of adverse events following TAVI.[7,8] Consideration to careful patient selection is crucial to success.

Equally important is the consideration of the patient's vascular anatomy. Accurate aortic root assessment and description of the relationship with the coronary ostia as well as the characterization of the central vascular anatomy are crucial pre-procedural steps in the planning of a TAVI case.[9] Conventional approaches for TAVI; transfemoral, trans-apical, trans-brachial, direct aortic, or left common carotid were precluded in this case, given our patient's very rare and complex vascular anatomy. The lack of historical medical records leaves some doubt about the aetiology of our patient's mid-aortic syndrome which is uncharacteristic of Takayasu's arteritis given the heavy calcification. However, the innominate artery and left common carotid origin stenoses would be typical for this condition.[10] It is therefore possible that our patient had prior Takayasu's disease, given the large central vessel involvement, superimposed with a more common vasculopathic process owing to the distribution of her calcific disease and the presence of clinical risk factors. Our case therefore necessitated two separate vascular access sites. The left brachial artery was chosen to perform PCI to the RCAVG and the right common carotid artery was chosen to perform innominate artery balloon angioplasty and TAVI.

Transcatheter aortic valve implantation is a versatile procedure in which many *ad hoc* procedures can be simultaneously carried out such as endovascular artery repair,[11] carotid endarterectomy[12] and coronary angioplasty.[13] In a prospective single-centre cohort study of

593 patients undergoing TAVI, Penkalla *et al.* demonstrated that single-stage PCI and TAVI was safe and feasible with early and 3-year survival rates comparable to those of patients undergoing TAVI without coronary artery disease.[14]

Conclusion

Our case demonstrates that it is possible to perform simultaneous complex angioplasty to coronary artery bypass grafts as well as other central arteries safely alongside TAVI through careful patient and vascular access site selection in the setting of a multidisciplinary team.

Lead author biography

Mina Ghobrial, Graduated medical school with honours from the university of Sheffield. A member of the Royal College of Physicians (London). Interventional cardiology specialist registrar based in the North East of the UK. Currently completing a post-graduate MD in virtual coronary physiology at the University of Sheffield. Sub-speciality interest in TAVI and CTO PCI.

Supplementary material

Supplementary material is available at *European Heart Journal - Case Reports* online.

Slide sets: A fully edited slide set detailing this case and suitable for local presentation is available online as Supplementary data.

Consent: The author/s confirm that written consent for submission and publication of this case report including image(s) and associated text has been obtained from the patient in line with COPE guidance.

Conflict of interest: none declared.

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