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CASE REPORT
Other

A case report of a transcarotid transcatheter aortic valve implantation with concomitant carotid endarterectomy

Sherif Sultan [1,2]*, Gordon Pate[3], Niamh Hynes [2], and Darren Mylotte[3,4]

[1]Department of Vascular and Endovascular Surgery, Western Vascular Institute, University Hospital Galway, National University of Ireland Galway, Newcastle Rd, Galway H91 YR71, Ireland; [2]Department of Vascular Surgery and Endovascular Surgery, Galway Clinic, Royal College of Surgeons in Ireland Affiliated Hospitals, Doughiska, Galway H91 HHT0, Ireland; [3]Department of Interventional Cardiology, Galway Clinic, Royal College of Surgeons in Ireland Affiliated Hospitals, Doughiska, Galway H91 HHT0, Ireland; and [4]Department of Cardiology, University Hospital Galway, National University of Ireland Galway, Newcastle Rd, Galway H91 YR71, Ireland

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Background Transcarotid transcatheter aortic valve implantation (TAVI) is a worthwhile substitute in patients who might otherwise be inoperable; however, it is applied in <10% of TAVI cases. In patients with established carotid artery stenosis, the risk of complications is increased with the transcarotid access route.

Case summary We report a case of concomitant transcarotid TAVI and carotid endarterectomy (CEA) in a patient with bovine aortic arch and previous complex infrarenal EndoVascular Aortic Repair (EVAR). The integrity and positioning of the previous EVAR endograft was risked by transfemoral access. The right subclavian artery was only 4.5 mm and the left subclavian was totally occluded so transcarotid access was chosen. The patient recovered well, with no neurological deficit and was discharged home after 72 h. He was last seen and was doing well 6 months post-procedure.

Discussion In patients with severe aortoiliac disease, or previous aortic endografting, transfemoral access for TAVI can be challenging or even prohibitive. Alternative access sites such as transapical or transaortic are associated with added risk because they carry increased risk of major adverse cardiovascular events, longer intensive care unit and hospital stay, and increased cost. A transcaval approach for TAVI has also been reported but was not suitable for our patient due to prior EVAR. Concomitant TAVI via transcarotid access and CEA can be successful in experienced hands. This case highlights the importance of a team-based approach to complex TAVI cases in high-risk patients with complex vascular access.

Keywords Case report • Transcatheter aortic valve implantation • Carotid endarterectomy • Transcarotid access • Bovine arch • Aortoiliac occlusive disease

Learning points

- To demonstrate the safety of concomitant carotid endarterectomy and transcatheter aortic valve implantation in a patient with both cardiac and neurological symptoms.
- To build awareness of the possibility of alternative access routes in patients with severe aortoiliac vascular disease, or previous aortoiliac stenting.
- To demonstrate that carotid access is still safe in patients with bovine aortic arch.

* Corresponding author. Tel: +353 91 720122, Fax: +353 91 720121, Email: sherif.sultan@hse.ie; vascularsultan@galwayclinic.com; sherif.sultan@nuigalway.com
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Introduction

A transcarotid approach is considered a reasonable alternative access strategy in patients with unsuitable femoral anatomy requiring transcatheter aortic valve implantation (TAVI).[1–3] Vascular complications can arise during insertion of the large-bore access sheath and in such cases, carotid endarterectomy (CEA) and repair may be required.

Timeline

Timeline	Event	Result
1999	Coronary artery bypass graft	Subsequent percutaneous coronary intervention to both saphenous vein grafts
2009	Bilateral iliac artery stenting	Temporary relief of lower limb ischaemia symptoms
2011	Aortic stent graft to treat recurrent aortoiliac occlusive disease	Relief of lower limb ischaemia symptoms
2013	Paroxysmal atrial fibrillation and left hemispheric stroke	Full neurological recovery
2019	Worsening symptoms of aortic stenosis	Institutional Heart Team declined surgical aortic valve replacement Transcatheter aortic valve implantation (TAVI) was suggested due to debilitating symptoms
2019	Multi-slice computed tomography for TAVI planning	• Heavily calcified iliofemoral vasculature with maximum lumen diameters of 4.2 mm (right) and 4.3 mm (left) • Small right subclavian artery of 4.5 mm, bovine aortic arch with left vertebral artery arising from the aortic arch, and occluded left subclavian artery • Left common carotid artery calcified with 70% left internal carotid artery stenosis
2019	Transaortic TAVI and concomitant left carotid endarterectomy	Recovered well with no neurological deficit Discharged within 72 h Continues to do well 6 months post-operatively
2020	Coronavirus disease 2019 (COVID-19) positive	Fully recovered

Case presentation

We present the case of an 87-year-old male with symptomatic severe aortic stenosis. He described progressive exertional dyspnoea (New York Heart Association Class III).

Medical history included hypertension, hypercholesterolaemia, and ischaemic heart disease with coronary artery bypass grafting and subsequent percutaneous coronary intervention to both saphenous vein grafts. He presented with paroxysmal atrial fibrillation, left hemispheric stroke in 2013, and peripheral vascular disease. He required aorto-bi-iliac kissing stents (Genesis, Cordis, Santa Clara, CA, USA) in 2009, followed by EndoVascular Aortic Repair (EVAR) in 2011 for severe aortoiliac occlusive disease using AFX (Endologix, Irvine, CA, USA). The patient lived independently with a Katz index of 6/6.[4]

On presentation, he was euvolemic without evidence of peripheral oedema. He had a loud harsh systolic murmur which peaked mid systole and radiated to the right carotid artery. He was apyrexial with a blood pressure of 119/58 and a heart rate of 69. His respiratory rate was 16 with oxygen saturation of 96% on room air.

Transthoracic echocardiography confirmed severe aortic stenosis with a mean transvalvular gradient of 65 mmHg and an aortic valve area 0.67 cm^2. Left ventricular function was preserved.

Multi-slice computed tomography was performed for TAVI planning. This revealed bilateral circumferential calcification with 4 mm luminal diameter in both external iliac arteries. A heavily calcified iliofemoral vasculature was noted with maximum lumen diameters of 4.2 mm (right) and 4.3 mm (left), a small right subclavian artery of 4.5 mm, and a bovine aortic arch with left vertebral artery arising from the aortic arch, and occluded left subclavian artery (*Figure 1*). The left common carotid artery was calcified with 70% left internal carotid artery stenosis (*Figure 2A and B*). Otherwise, the aortic root anatomy was suitable for implantation of a 29 mm CoreValve Evolut PRO (Medtronic, Minneapolis, MN, USA). The ankle-brachial indexes were 0.45 bilaterally. The patient's risk assessment demonstrated a EuroSCORE II of 17.10% and a Society of Thoracic Surgeons predicted risk of mortality of 7.9%.

The patient was discussed by the Institutional Heart Team and was declined surgical aortic valve replacement. A conservative management strategy was considered but ultimately TAVI was suggested due to debilitating symptoms.

Since transfemoral TAVI was precluded we opted for transcarotid access. Although the minimal lumen diameter of the left common carotid artery was 7.3 mm in our patient, he had a 70% stenosis of the left carotid artery with history of stroke. Hence, we opted to perform left transcarotid vascular access with the possibility to proceed to CEA in case of arterial disruption.

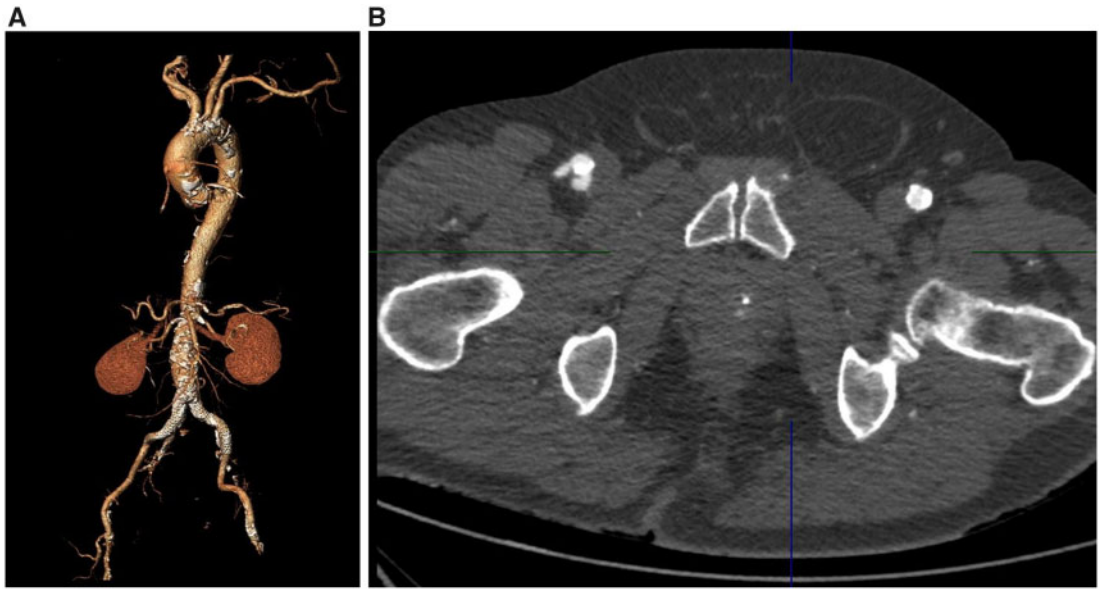

Figure 1 (*A*) Three-dimensional reconstruction of entire aorta, including the aortic valve, demonstrating previous aortoiliac stenting and calcified aortic valve. (*B*) Axial image of severely calcified iliac access.

Under general anaesthesia, cerebral regional oxygenation was monitored using the INVOS (Medtronic) Near InfraRed Spectrometry system. Right radial access was achieved and a pig tail angiographic catheter positioned in the aortic arch. The left common carotid artery was exposed through a longitudinal cervical incision along the anterior border of sternocleidomastoid (*Figure 3*). A Vessel-Clude (Medica Europe BV, Eindhoven, Netherlands) surrounded the carotid artery and a 6 Fr sheath was initially introduced and was subsequently upsized over a stiff guidewire to a 20 Fr sheath (Cook, Bloomington, IN, USA). An intravenous bolus of 5500 IU of heparin was administered to achieve an activated clotting time of >300 s and a multi-purpose angled clamp was placed on the common carotid artery, cranial to the introducer sheath, below the carotid bifurcation.

The aortic valve was subsequently crossed and a stiff guidewire placed in left ventricle (Safari, Boston Scientific, MA, USA). Balloon aortic valvuloplasty was performed due to the severely calcified nature of the aortic valve with an 18 mm NuMED balloon (NuMED Inc., Hopkinton, NY, USA) under rapid ventricular pacing. A 34 mm CoreValve Evolut Pro (Medtronic) transcatheter heart valve was positioned at a depth of 3 mm and deployed (*Figure 3C*). A 34 mm CoreValve Evolut Pro transcatheter heart valve was chosen due to its low delivery profile and its indication to treat an annulus up to 30 mm. Aortography demonstrated moderate paravalvular leak (*Figure 4A*) and hence post-dilatation was performed with a 26 mm NuMED balloon (*Figure 4B*). This resolved the paravalvular leak to trivial and the final peak-to-peak transvalvular gradient was 3 mmHg.

On removal of the vascular access sheath and closure of the arteriotomy, digital subtraction angiography (DSA) revealed no run off in the distal internal carotid artery (*Figure 2C*). Through the same longitudinal incision, a routine left CEA without shunting was performed. The carotid was dissected in a plane anterior to the internal jugular vein, preserving venous branches. The common carotid, external carotid, and internal carotid arteries were clamped in sequence and angled to lateralize the arteriotomy plane so that the closure line would lie away from the oesophagus. An arteriotomy was performed extending from the common carotid artery to the internal carotid artery as far as the termination of the carotid plaque. A plane of dissection in the vessel wall media was initiated and the plaque removed using a Watson-Cheyne endarterectomy tool. The endarterectomy plane was cleaned removing residual tissue in the axial direction. No tacking sutures were required and the arteriotomy was closed primary for fear of patch infection. The arterial clamps were removed in sequence from the external, common, and internal carotid arteries. Completion DSA showed normal blood flow to the brain without dissection flap (*Figure 2D*).

The patient was immediately extubated and transferred to the high dependency unit. A temporary transvenous pacemaker was left *in situ* for 24 h due to the presence of a new left bundle branch block (QRS duration 150 ms). The patient was discharged home after 72 h on aspirin 75 mg and clopidogrel 75 mg. He was last reviewed 6 months postoperatively and was well from both cardiac and neurological perspectives.

Discussion

Societal guidelines recommend a team-based approach to complex structural heart interventions.[5,6] Members of the Heart Team include, but are not limited to, clinical, imaging, and interventional cardiology, cardiac surgeons, anaesthesiologists, and vascular surgeons. In the current case, vascular access was particularly challenging due to the presence of severe aortoiliac disease and previous EVAR, a left

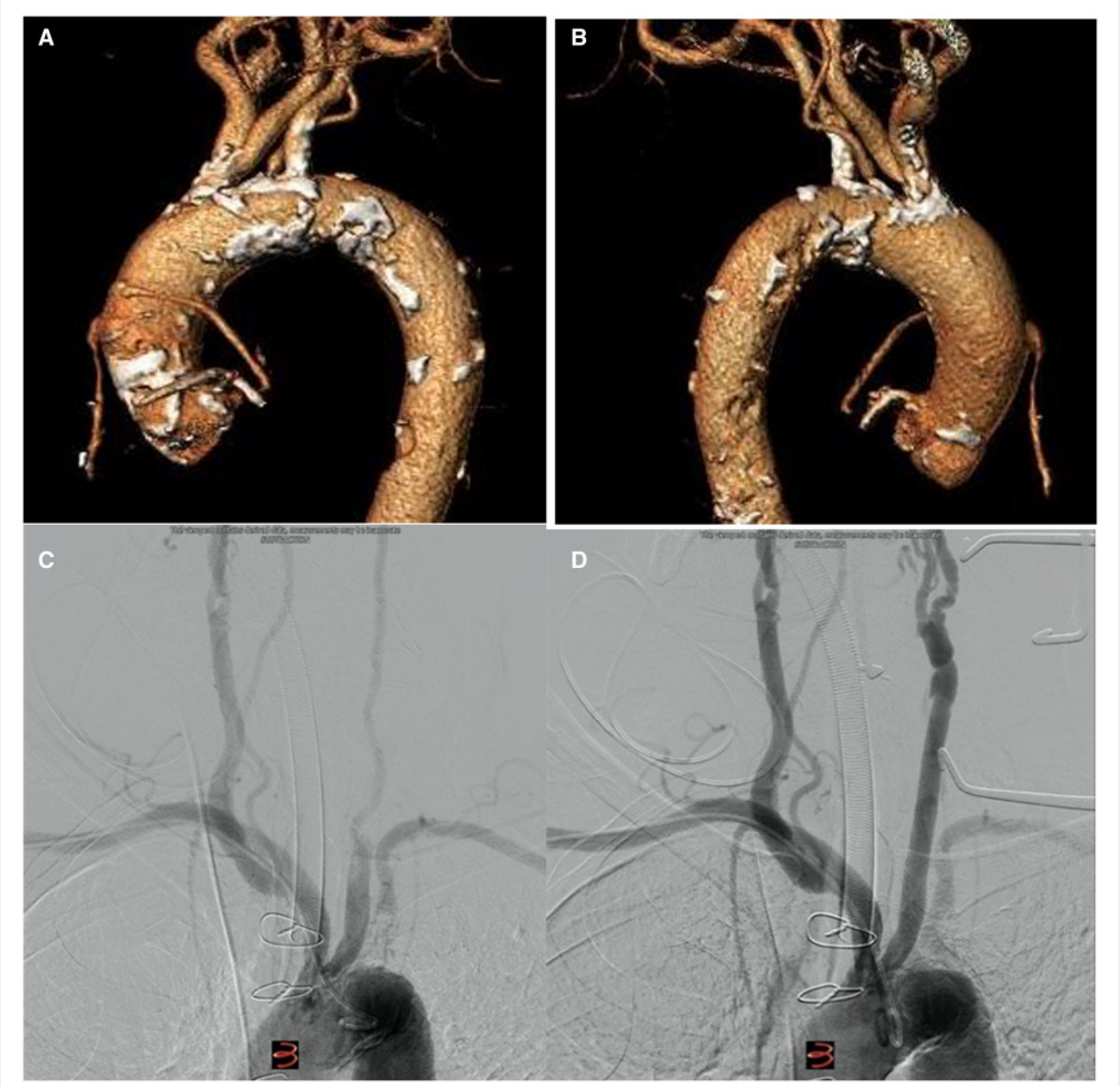

Figure 2 (*A*) Anterior and (*B*) posterior, three-dimensional reconstruction demonstrating the bovine arch with left common carotid artery having the same origin as the innominate artery, occlusion at the origin of the left subclavian artery with dense calcific plaque, left vertebral artery originating from the arch, and the two patent venous coronary bypass grafts. (*C*) Intraprocedural digital subtraction angiogram, before the carotid endarterectomy, done through a pig tail catheter from the right radial artery through innominate artery demonstrating poor run off in the left carotid artery, and totally occluded left subclavian artery as demonstrated pre-operatively. (*D*) Completion digital subtraction angiogram, post-left carotid artery endarterectomy, and primary closure, demonstrating good run off, of three out of four great vessels of head and neck.

internal carotid artery stenosis and a bovine aortic arch.[7] The team approach certainly facilitated treatment of the current patient.

Transapical or transaortic approaches are alternative access options for patients with severe peripheral arterial disease requiring TAVI. However, these 'transthoracic' options have been associated with an increased risk of major adverse cardiovascular events, longer intensive care unit and hospital stay, and increased cost compared to non-thoracic TAVI.[8] A transcaval approach for TAVI is also an emerging access strategy but was not suitable for our patient due to prior EVAR.[9]

The first case of transcarotid TAVI was reported in 2010 by Modine *et al.*[2] Allen *et al.*[10] in a retrospective study of 165 patients showed that transcarotid TAVI ($n = 84$) is associated with shorter length of stay, less blood transfusions, greater chance of discharge home, and better 2-year survival rate than either transapical ($n = 48$) or transaortic ($n = 33$) access. A meta-analysis by Stonier *et al.*[3] found

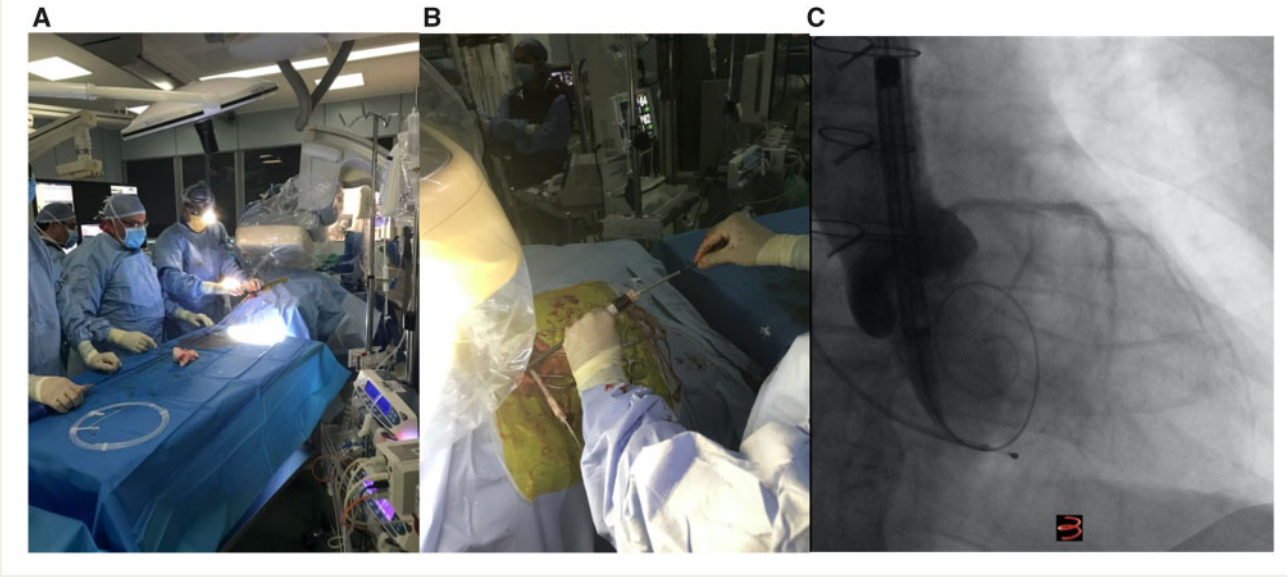

Figure 3 (*A*) Hybrid endovascular suite set up, with two long tables placed in front of the patient's head to facilitate the introduction of the long delivery system of the transcatheter aortic valve implantation. (*B*) During the whole procedure, the vascular surgeon is holding the 20 Fr sheath tight to prevent excessive movements and dislodgment, and the white vessel occlude allows distal sealing of left common carotid artery to prevent distal embolization without the need of vessel clamping. (*C*) Ascending aorta digital subtraction angiogram demonstrating the 34 mm Evolut PRO+ system (Medtronic, Santa Rosa, CA, USA), across the native aortic valve, with minimal aortic incompetence.

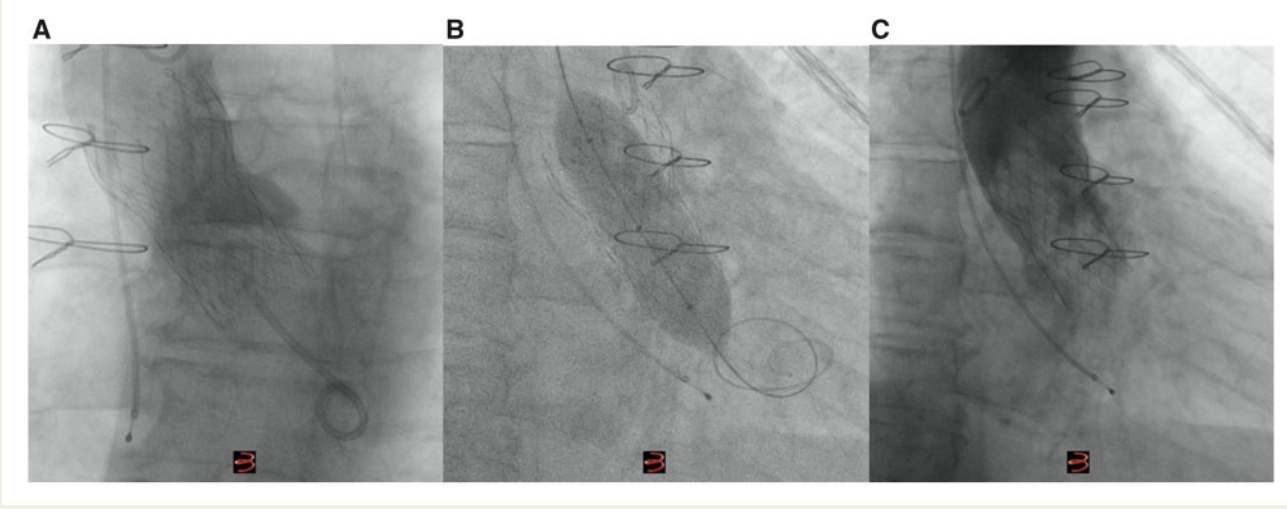

Figure 4 (*A*) Intraventricular digital subtraction angiogram, demonstrating deployed aortic valve with paravalvular leak. (*B*) Post-deployment ballooning of aortic valve stent under ventricular fibrillation at 190 b.p.m. (*C*) Completion digital subtraction angiogram in the ascending aorta, demonstrating competent post-deployment transcatheter aortic valve implantation, with no evidence of paravalvular leak or aortic incompetence.

that as a vascular approach, transcarotid TAVI is considered technically feasible and safe. Watanabe *et al.*[11] compared transcarotid with transfemoral and indicated that transcarotid was not inferior.

Parikh *et al.*[12] have described transcarotid TAVI in patients with bilateral carotid artery disease, but endarterectomy was not performed. Concomitant CEA and TAVI have been previously described, though in this small cases series ($N = 16$) all patients underwent either transfemoral or transapical transcatheter aortic valve replacement (TAVR) prior to CEA.[13] Farge *et al.*[14] successfully describe concomitant CEA and TAVI at the same operative setting in three cases. Their technique differs to ours in terms of operative sequence. They describe performing the CEA before the TAVI, and although Farge *et al.* did not report thrombosis, this is something which is undoubtedly a risk if an endarterectomized/de-endothelialized segment of artery is clamped immediately post-procedure. An added risk is disruption of the endarterectomized site by the introducer

sheaths and TAVI catheter if these are introduced through a freshly operated site. A freshly operated CEA site has a thinned out wall which makes the carotid more vulnerable to damage during the TAVI. Leaving the endarterectomy until after TAVI presents the opportunity to repair arterial damage in the rare event, albeit a genuine risk, of arterial damage.

There are few reported cases of simultaneous CEA and TAVR. The current case suggests that this may be a reasonable approach in very selected patients.

Our patient is doing well 6 months post-TAVI without any adverse cardiac or neurological sequelae. In April 2020, he tested positive for COVID-19 but has since recovered fully.

Conclusion

Transcarotid access for TAVI is a reasonable approach in patients with prohibitive iliofemoral disease. Our case suggests that this approach can be performed in the presence of internal carotid artery stenosis and bovine aortic arch.

Lead author biography

Prof. Sherif Sultan is a pioneering vascular and endovascular senior surgeon at the Saolta Hospital Group in Galway, Ireland, serving a population of more than 1 million people. He leads a world-class research team at the National University of Ireland Galway and has secured millions in research funding. He has a prolific research portfolio with over 400 international peer-reviewed publications, recognized by 36 international awards. In 2002, Prof. Sultan founded the Western Vascular Institute, a charitable research foundation committed to vascular research, technical innovation, professional and public education. Prof. Sultan is also a talented inventor and has 17 patents.

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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