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CASE REPORT
Cardiac imaging

Cardiovascular magnetic resonance facilitates entirely contrast-free transcatheter aortic valve implantation: case report

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Background Transcatheter aortic valve implantation (TAVI) is usually planned using contrast-enhanced computed tomography (CT) to determine the suitability of cardiovascular anatomy. Computed tomography for TAVI planning requires the administration of intravenous contrast, which may not be desirable in patients with severely reduced renal function.

Case summary We present an unusual case of an 89-year-old patient with an urgent need for treatment of critical, symptomatic aortic stenosis who also had severe chronic kidney disease. We judged that this posed a relative contraindication to the use of intravenous contrast. We designed and implemented a novel, contrast-free cardiovascular magnetic resonance (CMR) protocol and used this to plan all aspects of the procedure. Transcatheter aortic valve implantation was conducted successfully with zero contrast medium administration leading to an excellent clinical result and recovery of renal function.

Conclusion Contrast-free CMR appears to be a viable alternative to CT for planning structural aortic valve intervention in the rare cases where intravenous contrast is relatively contraindicated.

Keywords Case report • Magnetic resonance imaging • Aortic valve • Imaging • Intervention

ESC Curriculum 2.1 Imaging modalities • 2.2 Echocardiography • 2.3 Cardiac magnetic resonance

Learning points

- Transcatheter aortic valve implantation is a mainstream treatment for severe aortic stenosis and is usually planned using contrast-enhanced computed tomography.
- Cardiovascular magnetic resonance is an alternative technique in the unusual situation that intravenous contrast is considered contraindicated.

Introduction

Transcatheter aortic valve implantation (TAVI) is a mainstream therapy for severe, symptomatic aortic stenosis, especially when surgical risk is moderate or greater.[1–3] Transcatheter aortic valve implantation is planned with non-invasive imaging to verify adequacy of vascular access, suitability of aortic anatomy for delivery systems, to predict optimal fluoroscopic angles, and to size valve prostheses.

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Pre-procedure TAVI imaging is almost always conducted using computed tomography (CT), which provides excellent spatial imaging of the heart and vascular system.[4,5] However, TAVI CT entails the administration of contrast medium (up to 120 mL), which is well tolerated in almost all patients but carries a risk of nephropathy when renal function is severely impaired.

We present an unusual case of a patient with an urgent need for treatment of aortic stenosis who also had kidney failure creating a contraindication to intravenous contrast medium. Non-contrast cardiovascular magnetic resonance (CMR) imaging has been successfully used for TAVI planning in other centres.[6] We developed and implemented a non-contrast CMR protocol to assess anatomy and help plan the TAVI procedure.

Timeline

3 montds prior	Severe aortic stenosis, developing early symptoms, referred for assessment for intervention
Day -2	Routine cystoscopy at another hospital, developed rest angina and dyspnoea
Day 0	Arrived at our institution
Day 1	Repeat echocardiogram; progression of aortic stenosis, peak gradient 140 mmHg
Day 3	Heart team meeting
Day 4	Cardiovascular magnetic resonance scan
Day 7	Transcatheter aortic valve implantation
Day 14	Discharged
4 months later	Asymptomatic, New York Heart Association Class I

Case presentation

An 89-year-old gentleman had been referred for consideration of aortic valve intervention for severe aortic stenosis and preserved left ventricular systolic function (peak gradient 67 mmHg, aortic valve area 0.6 cm^2), and background of transitional cell carcinoma of the left ureter with a ureteric stent *in situ*, and stage 5 chronic kidney disease with baseline estimated glomerular filtration rate (eGFR) of 14 mL/min/1.73 m^2. Coronary angiography 4 years prior demonstrated moderate–severe atheroma affecting the proximal left anterior descending artery, the mid-circumflex artery, and the mid-posterior descending coronary artery. The patient had been assessed for via haemodialysis via a radiocephalic arteriovenous fistula, which had not been created. In the months prior to the admission, exercise tolerance had declined, with dyspnoea upon walking ~100 m.

Whilst awaiting aortic valve assessment, the patient attended an elective admission for routine cystoscopy and ureteric stent change (Day 0). Following the procedure, the patient experienced chest pain and electrocardiography (ECG) demonstrated bifascicular block with first degree atrioventricular (AV) block and planar ST-segment depression in the lateral leads. Troponin level rose to 835 ng/L. Renal function had deteriorated, with creatinine level of 512 μmol/L (5.8 mg/dL); eGFR 8 mL/min/1.73 m^2. The patient was transferred for consideration of aortic valve and/or coronary intervention.

Clinical signs included a slow rising pulse, a grade 3/6 ejection systolic murmur and a diminished second heart sound. Echocardiography demonstrated peak aortic gradient of 140 mmHg and mean gradient of 89 mmHg, with mild–moderate regurgitation. The case was discussed by a multidisciplinary heart team. Operative risk was deemed prohibitive. The likely diagnosis was felt to be critical aortic stenosis, leading to restricted coronary perfusion and a type II myocardial infarction (though a type I coronary event was possible). The first priority was treatment of aortic stenosis and coronary revascularization would be considered if symptoms persisted following TAVI. Balloon aortic valvuloplasty was contraindicated due to aortic regurgitation. Transcatheter aortic valve implantation was therefore offered at substantial procedural risk, quoted at a 20–30% risk of mortality. Following careful discussion of risks and benefits, the patient opted to proceed. The risk of pre-procedural contrast medium administration for CT imaging was also felt to be substantial with a high risk of precipitating haemodialysis. However, haemodialysis would lead to haemodynamic shifts likely to be poorly tolerated due to critical aortic stenosis.

Cardiovascular magnetic resonance imaging protocol for transcatheter aortic valve implantation planning

Cardiovascular magnetic resonance was performed using a Siemens 1.5 T MR system (Avanto Fit, Siemens, Erlangen, Germany) with twin 32-channel surface coils covering the aorta and femoral arteries.

Axial imaging covering the entire aorta was performed using steady state free precession (SSFP) single-shot imaging [repetition time (TR) 288 ms, echo time (TE) 1.14, slice thickness 8 mm]. Cine imaging of the left ventricular outflow tract was used to derive precise annular diameters for valve sizing (24.6 and 25.1 mm respectively, *Figure 1B*). The left coronary artery arose 11 mm above the aortic valve plane, and the right coronary artery 9 mm above. Non-contrast angiography of the thoracic aorta using respiratory and ECG gating (sequence parameters TR 274 ms, TE 1.56 ms, 320 mm × 320 mm × 110 mm) was used to predict fluoroscopic angle (LAO19 CAU12, *Figure 1C*) and to measure aortic dimensions. Cine imaging using a radial acquisition clarified aortic valve anatomy, with right and left cusp fusion with severe aortic stenosis by direct planimetry (0.6 cm^2) and flow assessment (4.9 m/s, *Figure 1E*).

We used a three-dimensional time-of-flight sequence with higher spatial resolution to assess femoral arterial anatomy, with image contrast weighted according to phase contrast from blood motion (TR 481 ms, TE 7 ms, 320 mm × 160 mm × 175 mm). This demonstrated a 9.6 mm right femoral artery suitable for primary access (*Figure 2A*), with a stenosis of the left femoral artery which was selected for secondary access. Three-dimensional reconstructions of the non-contrast angiograms of the thoracic (*Figure 1D*) and abdominal (*Figure 1E*) aorta documented tortuosity, though the aorta was patent. Total imaging time was 30 min. Gadolinium was not used.

Image analysis was performed using cvi42 5.11 (Circle Inc., Calgary, Canada).

Following imaging review, the procedural plan was to use the right femoral artery to deliver a 25 mm Lotus Edge valve.

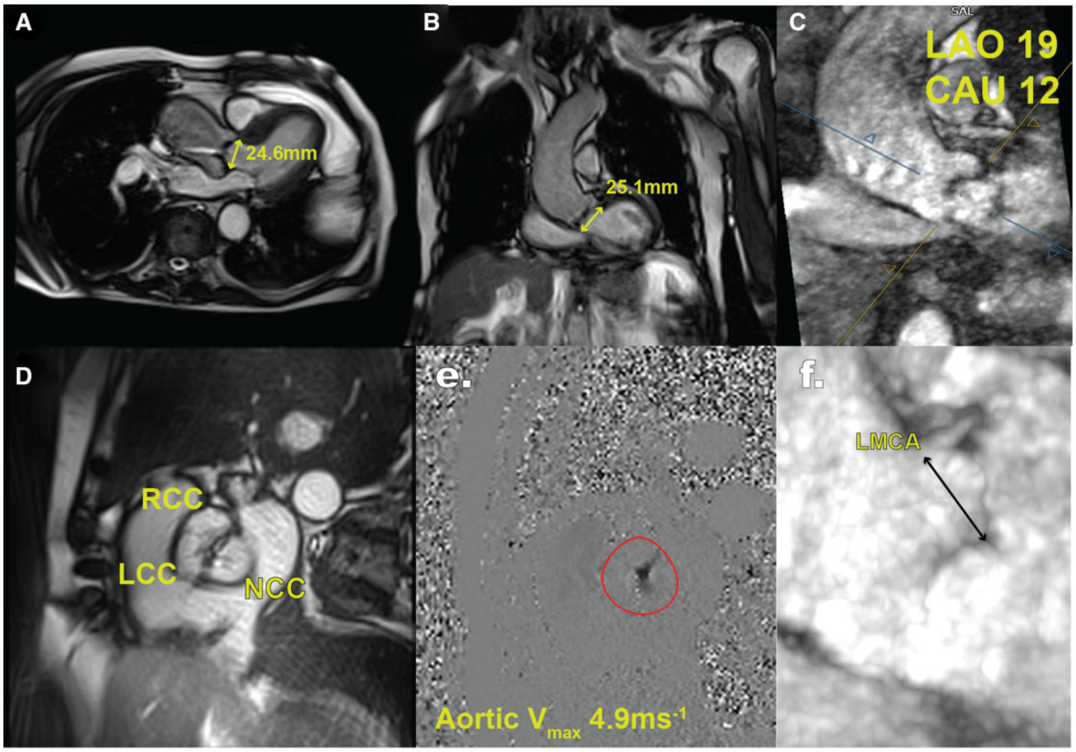

Figure 1 (*A*) SSFP left ventricular outflow tract cine view demonstrating stenotic jet of blood and aortic annular diameter. (*B*) Left ventricular outflow tract coronal view providing orthogonal view. (*C*) Prediction of optimal fluoroscopic angle using multiplanar reconstruction of the three-dimensional non-contrast angiography sequence. (*D*) Aortic valve anatomy demonstrating severe aortic stenosis and clarifying valve anatomy. (*E*) Phase contrast flow imaging confirms severe aortic stenosis with peak velocity 4.9 m/s. (*F*) Measurement of aortic valve plane to left main coronary artery distance. CAU, caudal; LAO, left anterior oblique; LCC, left coronary cusp; LMCA, left main coronary artery; NCC, non coronary cusp; RCC, right coronary cusp.

Transcatheter aortic valve implantation procedure

Under conscious sedation, access to both femoral arteries was achieved using ultrasound-guided micropuncture and a temporary transvenous pacing wire placed. The working view predicted by CMR was verified by placing a pigtail catheter in the non-coronary sinus and assessing the predicted projection to ensure visible leaflet calcification was in plane. The aortic valve was crossed and a Safari wire was advanced into the left ventricle. Valvuloplasty was performed using a 24 mm Truflow balloon. Asystole occurred and pacing was delivered via the temporary wire. A 25 mm Lotus Edge valve was positioned using fluoroscopy (*Figure 3A*) and echocardiography. Before deployment, valve position was confirmed to be fully axial with no parallax. The valve was deployed with near-normalization of the aortic valve gradient and no significant valvular or paravalvular regurgitation on echocardiography (*Figure 3D*). No contrast was used. Haemostasis was achieved using Proglides and an 8 Fr Angioseal device. A right-sided dual-chamber pacemaker was placed on account of ongoing AV block.

Post-procedural course

The patient made an uncomplicated post-procedure recovery. Following treatment of aortic stenosis, renal function improved [creatinine 512 µmol/L (5.79 mg/dL) to 383 µmol/L (4.3 mg/dL)] and the need for dialysis was avoided. He experienced no further chest pain and was discharged on post-procedural Day 7 following additional rehabilitation. At review 4 months later, the patient remained free from symptoms of angina or dyspnoea, without need for renal replacement therapy.

Discussion

Transcatheter aortic valve implantation is a mainstream therapy for aortic stenosis in suitable patients. Planning is essential for optimal procedural outcomes and is almost always conducted using contrast-enhanced CT. In this case, contrast medium was felt to be contraindicated and an alternative strategy sought.

Cardiovascular magnetic resonance offers whole-body imaging with vascular contrast created by blood motion. We devised a non-

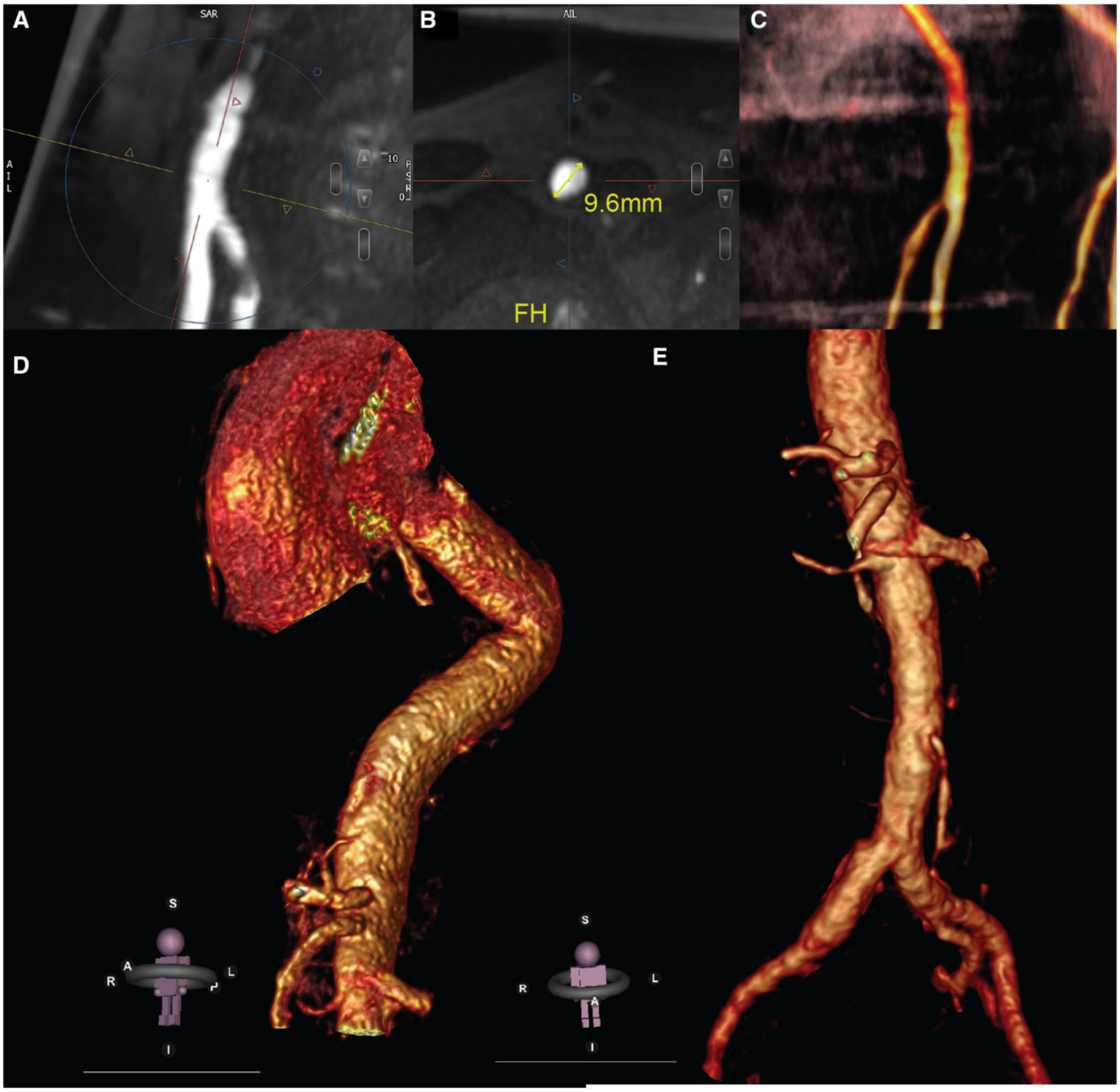

Figure 2 (*A*) High-resolution imaging of both femoral arteries using time of flight angiography. (*B*) Reconstruction to derive femoral diameter. (*C*) Three-dimensional render of femoral anatomy. (*D*) Tortuosity of the thoracoabdominal aortic junction without obstruction and dilatation of the aortic root (up to 49 mm). (*E*) Normal calibre of the abdominal aorta with no obstruction seen.

contrast CMR protocol covering the entire aorta, with high-resolution imaging of the femoral arteries, and aortic valve assessment. Although previous studies have highlighted potential to reduce the volume of intravenous contrast medium from ∼20 to ∼0 mL,[7] in this case we wished to avoid contrast entirely. The patient successfully underwent contrast-free TAVI with excellent clinical outcome.

Better biomarkers of the left ventricular response to aortic stenosis are needed to identify patients where earlier aortic valve intervention might improve outcome. Cardiovascular magnetic resonance biomarkers of ventricular decompensation for this application are being tested in clinical trials including EVOLVD9.[8] If proven, it would be straightforward to add additional CMR vascular imaging sequences to guide not just the indication, but also to plan the procedure.

In summary, we present a case of a patient requiring treatment for severe aortic stenosis, who had a contraindication to the use of intravenous contrast medium. The case illustrates that CMR and non-contrast interventional techniques can enable contrast-free TAVI. Cardiovascular magnetic resonance appears to be a viable alternative to CT for structural aortic valve intervention, in cases where intravenous contrast is not clinically desirable. Further trials to evaluate and formalize this ‘off-label’ application of CMR would be desirable.

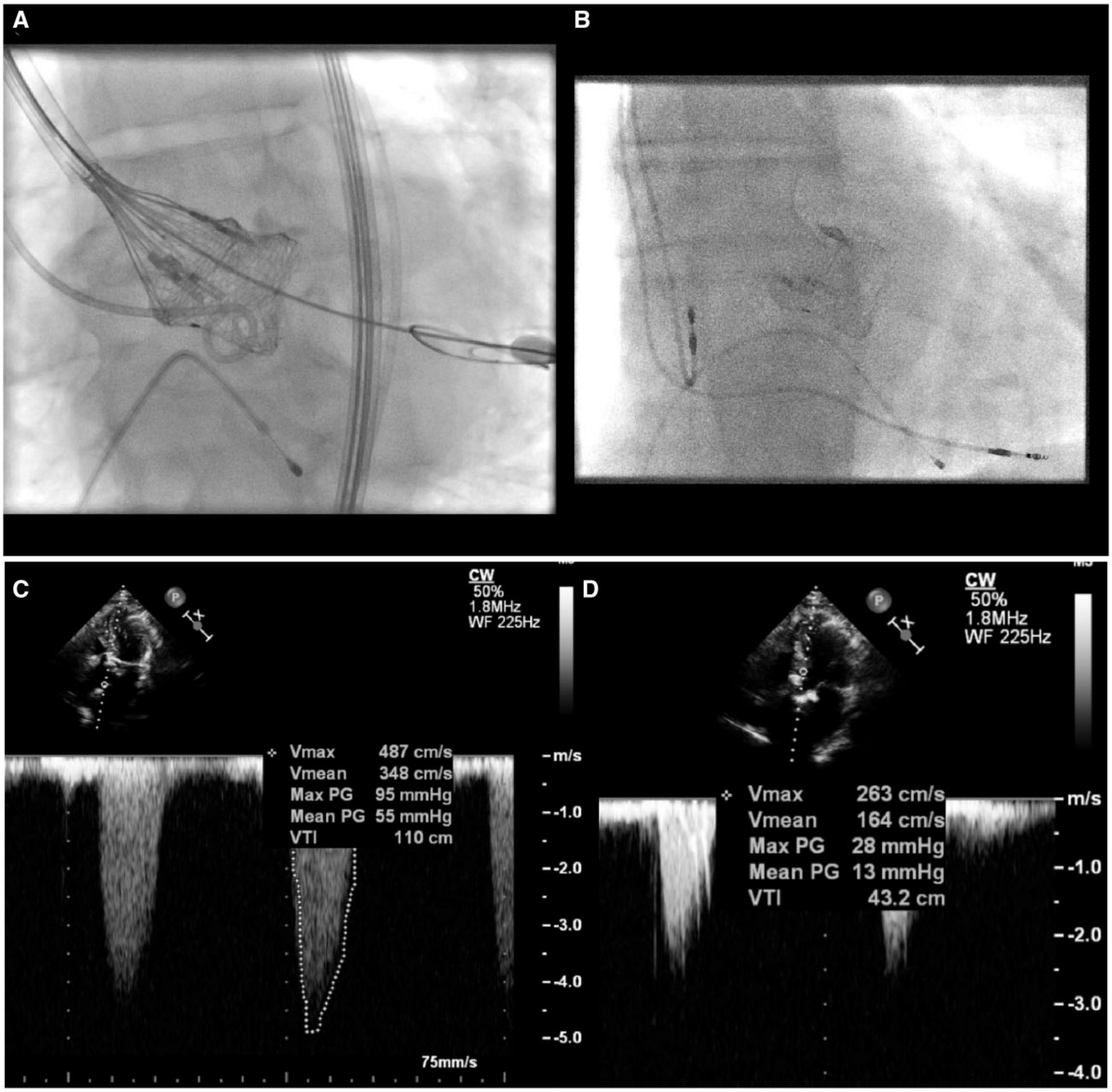

Figure 3 (*A*) Delivery of aortic prosthesis in the projected view. (*B*) Final result with dual-chamber pacemaker *in situ*. (*C*) Pre-procedural echocardiogram confirming severe aortic stenosis with peak velocity 4.9 m/s. (*D*) Echocardiography post-implant confirming reduction in peak aortic velocity to 2.6 m/s.

Lead author biography

Jonathan Raby completed pre-clinical medical training at Cambridge University, before studying clinical medicine at Oxford University. Since qualification, he has worked for Oxford and Birmingham University Hospitals Foundation Trusts. He is currently undertaking Internal Medicine Training, with an ambition to become a Cardiologist.

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 authors confirm that written consent for submission and publication of this case report including images and associated text has been obtained from the patient in line with COPE guidance.

Conflict of interest: The authors have no relevant conflicts of interest to disclose.

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