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

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All authors conceived of the case report. JR and AL drafted the manuscript. All authors contributed substantially to the drafting of the manuscript and assume responsibility for the integrity of the content.

Abstract

Background

Transcatheter aortic valve implantation (TAVI) is usually planned using contrast-enhanced computed tomography (CT) to determine the suitability of cardiovascular anatomy. CT 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 protocol and used this to plan all aspects of the procedure. TAVI 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.

Key words

Case report, magnetic resonance imaging, aortic valve, imaging, intervention

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Conflict of Interest

Jonathan Raby, Jim Newton, Sam Dawkins, and Andrew Lewis declare that they have no conflict of interest.
Learning points

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

3 months 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
CMR scan

Day 7
TAVI

Day 14
Discharged

4 months later
Asymptomatic, NYHA class I
**Introduction**

Transcatheter aortic valve implantation (TAVI) is a mainstream therapy for severe, symptomatic aortic stenosis, especially when surgical risk is moderate or greater\(^1\). TAVI 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.

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 120ml), 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**

**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 0.6cm\(^2\)), 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/1.73m\(^2\). 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 approximately 100m.

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 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/1.73m\(^2\). 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 140mmHg and mean gradient 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 revascularisation would be considered if symptoms persisted following TAVI. Balloon aortic valvuloplasty was contraindicated due to aortic regurgitation. TAVI 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 TAVI planning**

Cardiovascular magnetic resonance was performed using a Siemens 1.5T 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 SSFP single shot imaging (TR 288 ms, TE 1.14, slice thickness 8mm). 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 11mm above the aortic valve plane, and the right coronary artery 9mm above. Non-contrast angiography of the thoracic aorta using respiratory and ECG gating (sequence parameters TR 274ms, TE 1.56ms, 320x320x110mm) 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 (0.6cm²) and flow assessment (4.9 m/s, Figure 1e).

We used a 3D 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 481ms, TE 7ms, 320x160x175 mm). This demonstrated a 9.6mm right femoral artery suitable for primary access (Figure 2a), with a stenosis of the left femoral artery which was selected for secondary access. 3D reconstructions of the non-contrast angiograms of the thoracic (1d) and abdominal (1e) aorta documented tortuosity, though the aorta was patent. Total imaging time was 30 minutes. Gadolinium was not used.

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

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

**TAVI 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 LV. Valvuloplasty was performed using a 24mm Truflow balloon. Asystole occurred and pacing was delivered via the temporary wire. A 25mm 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-normalisation 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 8F Angioseal device. A right-sided dual-chamber pacemaker was placed on account of ongoing atroventricular block.

**Post procedural course**

The patient made an uncomplicated post-procedure recovery. Following treatment of aortic stenosis, renal function improved (creatinine 512µmol/L (5.79 mg/dL) to 383µmol/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**

TAVI 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 the case, contrast medium was felt to be contraindicated and an alternative strategy sought.

CMR offers whole-body imaging with vascular contrast created by blood motion. We devised a non-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 around 120ml to around 40ml\(^7\), 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. CMR biomarkers of ventricular decompensation for this application are being tested in clinical trials including EVOLVD\(^8\). 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. CMR 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 formalise this ‘off-label’ application of CMR would be desirable.
Consent
Written informed consent was provided by the patient. Research Ethical Committee review was not required.

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Figure Legends

Figure 1: Panel a; SSFP LVOT cine view demonstrating stenotic jet of blood and aortic annular diameter. Panel b; LVOT coronal view providing orthogonal view. Panel c; Prediction of optimal fluoroscopic angle using multiplanar reconstruction of the 3D non-contrast angiography sequence. Panel d; Aortic valve anatomy demonstrating severe aortic stenosis and clarifying valve anatomy. Panel e; Phase contrast flow imaging confirms severe aortic stenosis with peak velocity 4.9 m/s.
Figure 2: Panel a; high resolution imaging of both femoral arteries using time of flight angiography. Panel b; reconstruction to derive femoral diameter. Panel c; 3D render of femoral anatomy. Panel d; tortuosity of the thoracoabdominal aortic junction without obstruction and dilatation of the aortic root (up to 49mm). Panel e; normal calibre of the abdominal aorta with no obstruction seen.

Figure 3: Panel a; delivery of aortic prosthesis in the projected view. Panel b; final result with dual chamber pacemaker in situ. Panel c; pre-procedural echocardiogram confirming severe aortic stenosis with peak velocity 4.9m/s. Panel d; echocardiography post-implant confirming reduction in peak aortic velocity to 2.6 m/s.
