Zero Contrast Transcatheter Aortic Valve Replacement in Patients with Renal Dysfunction using a Novel, Multimodality Cardiovascular Imaging Approach

Ali Dakroub[1], William Chung[1], Jason Craft[1], Jaffar M. Khan[1], Ziad A. Ali[1,2,3] and Omar Khalique[1]

[1]St. Francis Hospital and Heart Center, Roslyn, New York, USA; [2]Cardiovascular Research Foundation, New York, New York, USA; and [3]New York Institute of Technology, New York, New York, USA

Correspondence: Ziad A. Ali, DeMatteis Cardiovascular Institute, The Heart Center, St. Francis Hospital and Heart Center, 100 Port Washington Blvd., Roslyn, New York 11576, USA. E-mail: ziad.ali@dcvi.org

Received 31 May 2023; revised 24 July 2023; accepted 31 July 2023; published online 5 August 2023

Kidney Int Rep (2023) **8,** 2168–2171; https://doi.org/10.1016/j.ekir.2023.07.030

INTRODUCTION

Transcatheter aortic valve replacement (TAVR) is an established therapy for patients with severe, symptomatic aortic stenosis (AS). Postprocedural acute kidney injury occurs in up to 20% of TAVR cases and is associated with increased mortality, particularly in patients with preexisting chronic renal impairment.[1,2] Chronic kidney disease (CKD) has been associated with worse clinical outcomes in patients treated with surgical aortic valve replacement[S1] or TAVR.[3] CKD promotes progression of AS[4] and increases mortality in patients with severe AS.[5] Despite the multifactorial etiology of acute kidney injury following TAVR, contrast-induced nephropathy remains a significant modifiable procedural factor.[2] Aortography using iodinated contrast agent is used during TAVR to aid in valve positioning. Alternative techniques with less contrast use may offer advantages in patients with CKD. We report a case of TAVR in a patient with severe CKD, which was carried entirely without contrast use.

CASE PRESENTATION

A 90-year-old male with severe, symptomatic AS, New York Heart Association Class III, was admitted with an exacerbation of heart failure, non-ST-segment elevation myocardial infarction, and developed acute on chronic kidney injury. Echocardiography demonstrated severe AS with a low normal left ventricular ejection fraction of 50% to 55%. Coronary angiography revealed severe diffuse left anterior descending artery disease managed with guideline-directed medical therapy. The patient was determined to be high risk for open heart surgery and transcatheter therapy was recommended. The primary comorbidity was severe stage 4 CKD with a baseline creatinine level of 2.94 mg/dl and an estimated glomerular filtration rate of 20 ml/min per 1.73 m^2. There was a history of contrast-induced acute kidney injury.

Preprocedural anatomical assessment was performed using a multimodality imaging approach. A gated, noncontrast cardiac computed tomography (CT) was acquired to assess valvular calcification (Figure 1a). There was dense, trileaflet calcification with a calcium score of 2900 Agatston Units. In order to avoid contrast-associated acute kidney injury, aortic annulus and root anatomical assessments were performed by cardiac magnetic resonance imaging (CMR). The CMR techniques used included the following: (i) free breathing T2 prep, balanced steady state free precession, 3-dimensional coronal noncontrast magnetic resonance angiography covering the entire chest using image-based navigators for motion correct and 100% scan efficiency[6] and (ii) traditional 2-dimensional steady state free-precession with slice prescribed at the level of the native aortic annulus. Annulus measurements by 3-dimensional multiplanar reconstruction included perimeter of 77.9 mm and area of 472.9 mm^2 (Figure 1b). Two-dimensional planar annulus measurements agreed with 3-dimensional measurements (Figure 1c). The coronary artery heights and sinus of Valsalva dimensions were large, predicting a very low risk of coronary obstruction (Figure 1d, e and f). A self-expanding 29 mm Medtronic Evolut FX Corevalve was

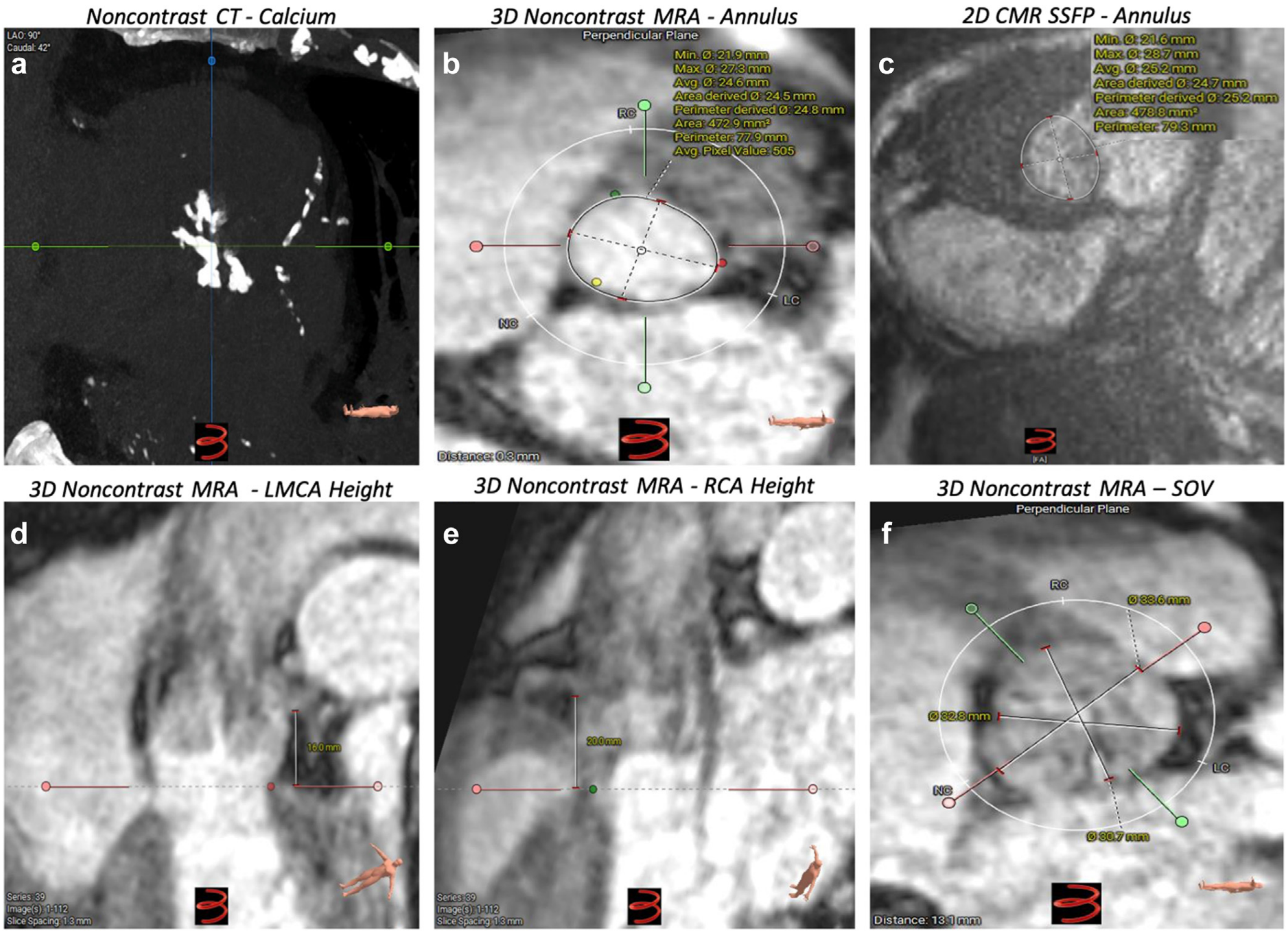

Figure 1. Preprocedural assessment of aortic annular plane using (a) gated, noncontrast cardiac CT to assess calcification; (b) 3-dimensional noncontrast MRA; (c) 2-dimensional CMR SSFP to assess annulus, and 3-dimensional noncontrast MRA to assess; (d) LMCA height; (e) RCA height; and (f) SOV dimensions. CMR, cardiovascular magnetic resonance; CT, computed tomography; LMCA, left main coronary artery; MRA, magnetic resonance angiography; RCA, right coronary artery; SOV, sinus of Valsalva; SSFP, steady-state free precession.

planned based on annular dimensions obtained by CMR (Figure 1).

TAVR was performed with general anesthesia administered using laryngeal mask airway. Catheters were inserted inside the left femoral artery and vein and a digital roadmap was performed, using CO_2 angiography, to access the right common femoral artery (Supplementary Figure S1). Three pigtail catheters were advanced from the right and left femoral artery and right radial artery to the aortic annulus. A baseline fluoroscopic implantation view was derived using the 3 pigtails catheters in the 3 respective cusps of the aorta (Figure 2). Balloon valvuloplasty was performed and a 29 mm Medtronic Evolut FX was deployed under fluoroscopic guidance without contrast use (Supplementary Figure S2). After valve deployment, the delivery system was removed, and transthoracic echocardiography used to confirm appropriate positioning without paravalvular leak. There was a 42 mm gradient across the aortic valve at baseline and 6 mm Hg gradient post TAVR (Supplementary Figure S3). The site was closed with 2 previously placed ProGlides and the patient tolerated the procedure well and was discharged home on day 2.

DISCUSSION

We describe a patient with severe renal dysfunction in whom TAVR and all preprocedural noninvasive assessments were successfully carried out without iodinated contrast use (Supplementary Figure S4). The indication for zero contrast TAVR in our patient was severe renal impairment. Importantly, this technique could also be utilized in patients with iodine allergy. TAVR treatments for patients with advanced CKD necessitate alternative options with less contrast use.

The preprocedural planning utilized a multimodality approach. Vascular access was evaluated invasively without iodinated contrast using CO_2 angiography. CMR was used for anatomical assessment and annulus sizing. Although we could have used trans-esophageal echocardiography for valve sizing, a

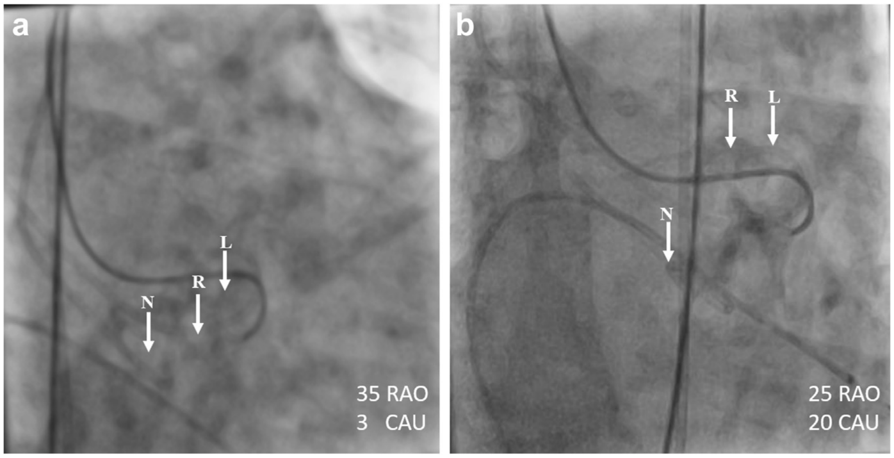

Figure 2. Fluoroscopic working view constructed using 3 pigtail catheters positioned in each aortic sinus (1 for each coronary cusp) without contrast use. (a) Coplanar View, (b) Cusp Overlap View. L, left coronary cusp; N, noncoronary cusp; R, right coronary cusp.

previous phantom study demonstrated that CMR was superior to 3-dimensional-echocardiography and CT in determining annular size.[7] Moreover, *in vivo* literature has shown no significant difference between CMR techniques and the cardiac CT gold standard for aortic annulus measurement.[8,9] Tsang *et al.*[7] showed that CMR and CT were similarly effective in sizing the annular ring diameters regardless of calcification degree. Therefore, the presence of vascular and valvular calcifications does not significantly impact the planning of TAVR via CMR when using it to determine valve size. Combining noncontrast CT with CMR as was done in our case, enhances stenosis assessment, valve sizing, and procedural planning by providing a comprehensive understanding of the patient's anatomy and disease severity.

We opted for transfemoral access after assessing iliofemoral vessels with lower extremity duplex ultrasound, and gained access to the right common femoral artery using CO_2 angiography. The use of ultrasound and CO_2 angiography instead of contrast-enhanced CT angiography provided reliable preoperative vascular evaluation and intraoperative guidance without the need for iodinated contrast. However, in cases where vascular assessment is challenging, quiescent-interval single-shot MR angiography can be used as a contrast-free transfemoral access evaluation with comparable efficacy to CT angiography.[S2] Quiescent-interval single-shot MR angiography has a greater depth of penetration and can provide a better image quality in cases where ultrasound assessment is limited. Alternatively, intravascular ultrasound may be utilized to ensure adequate vessel caliber for sheath delivery.[S3]

The major challenge in zero contrast TAVR is positioning of the valve prior to deployment. We utilized several techniques in order to accomplish this. We determined annular coaxial alignment using fluoroscopy guided by using 3 pigtail catheters with 1 catheter in each of the aortic sinuses. The pigtail catheter positioned at the base of the noncoronary sinus was used as a reference and left in place throughout the procedure. The remaining pigtail catheter in the left coronary sinus was used during valve deployment. In addition, the calcification of the native valve cusps aided in positioning of the TAVR. The radiopaque gold markers of the Evolut FX Corevalve were utilized as a reference for deployment depth and commissure location.

Conclusion

This zero-contrast TAVR technique provides a feasible, safe, and effective option to minimize contrast use in patients with renal insufficiency or iodinated contrast allergy (Table 1). CMR is a promising reasonable alternative to contrast-enhanced CT to determine annular, aortic, and coronary anatomy. In conclusion, preprocedure evaluations with noncontrast CT, transthoracic echocardiography, and CMR, combined with ultrasound and CO_2 angiography for determining vascular access, and the use of pigtail catheters and transthoracic echocardiography guidance during the procedure, can effectively address the limitations of zero-contrast TAVR.

Table 1. Teaching points

• Zero-contrast TAVR techniqueprovides a feasible, safe, and effective option in patients with chronic kidney disease or iodinated contrast allergy.
• CMR is a promising reasonable alternative to contrast-enhanced CT to determine annular, aortic, and coronary anatomy during preprocedural assessment.
• Procedural guidance strategies employed during zero-contrast TAVR include ultrasound and CO_2 angiography for determining vascular access and fluoroscopic guidance using 3 pigtail catheters and TTE to deploy valve.

CMR, cardiac magnetic resonance imaging; CT, computed tomography; TAVR, transcatheter aortic valve replacement; TTE, transthoracic echocardiography; US, ultrasound.

DISCLOSURE

WC reports being a consultant for Medtronic and Abbott. JMK reports being a consultant for Transmural Systems; and educational grants from Abbott, Boston Scientific, Edwards Lifesciences, Medtronic, and Phillips. ZAA reports institutional grant support from Abbott, Abiomed, Acist Medical, Boston Scientific, Cardiovascular Systems Inc, Medtronic Inc, National Institute of Health, Opsens Medical, Philips, and Teleflex; consulting fees from Astra Zeneca, Philips, Shockwave. Equity in Elucid, Spectrawave, Shockwave, and VitalConnect. OK reports consultant for Edwards, Abbott Structural, Triflo, Cardiac Implants, Restore Medical, and Croivalve; and is a member of a Corelab (he receives no direct industry compensation) with contracts with Ancora, Jenavalve, Atricure, and Abbott Structural and holds equity in Triflo and Cardiac Implants. All other authors declare no conflicting interest.

PATIENT CONSENT

The authors declare that they have obtained consent from the patient.

SUPPLEMENTARY MATERIAL

Supplementary File (PDF)

Supplementary References.

Figure S1. Vascular access of right common femoral artery through CO_2 angiography.

Figure S2. (A) Cusp Overlap View: assessing non-coronary cusp, (B) LAO View: assessing left coronary cusp.

Figure S3. (A) Preprocedural transthoracic echocardiography showing a baseline aortic valve mean pressure gradient of 46 mm Hg. (B) Transthoracic echocardiography after 29 mm Evolut implantation showing a mean pressure gradient of 6 mm Hg.

Figure S4. Zero contrast transcatheter aortic valve replacement multimodality cardiovascular imaging approach: Flow chart describing a multimodality cardiovascular imaging approach that can be implemented in zero contrast transcatheter aortic valve replacement.

REFERENCES

1. Ferro CJ, Chue CD, de Belder MA, et al. Impact of renal function on survival after transcatheter aortic valve implantation (TAVI): an analysis of the UK TAVI registry. *Heart*. 2015;101: 546–552. https://doi.org/10.1136/heartjnl-2014-307041
2. Scherner M, Wahlers T. Acute kidney injury after transcatheter aortic valve implantation. *J Thorac Dis*. 2015;7:1527–1535. https://doi.org/10.3978/j.issn.2072-1439.2015.06.14
3. Chen C, Zhao Z-G, Liao Y-B, et al. Impact of renal dysfunction on mid-term outcome after transcatheter aortic valve implantation: a systematic review and meta-analysis. *PLoS One*. 2015;10: e0119817. https://doi.org/10.1371/journal.pone.0119817
4. Vavilis G, Bäck M, Occhino G, et al. Kidney dysfunction and the risk of developing aortic stenosis. *J Am Coll Cardiol*. 2019;73: 305–314. https://doi.org/10.1016/j.jacc.2018.10.068
5. Patel KK, Shah SY, Arrigain S, et al. Characteristics and outcomes of patients with aortic stenosis and chronic kidney disease. *J Am Heart Assoc*. 2019;8:e009980. https://doi.org/10.1161/JAHA.118.009980
6. Bustin A, Ginami G, Cruz G, et al. Five-minute whole-heart coronary MRA with sub-millimeter isotropic resolution, 100% respiratory scan efficiency, and 3D-PROST reconstruction. *Magn Reson Med*. 2019;81:102–115. https://doi.org/10.1002/mrm.27354
7. Tsang W, Bateman MG, Weinert L, et al. Accuracy of aortic annular measurements obtained from three-dimensional echocardiography, CT and MRI: human in vitro and in vivo studies. *Heart*. 2012;98:1146–1152. https://doi.org/10.1136/heartjnl-2012-302074
8. Wang J, Jagasia DH, Kondapally YR, Herrmann HC, Han Y. Comparison of non-contrast cardiovascular magnetic resonance imaging to computed tomography angiography for aortic annular sizing before transcatheter aortic valve replacement. *J Invasive Cardiol*. 2017;29:239–245.
9. Gopal A, Grayburn PA, Mack M, et al. Noncontrast 3D CMR imaging for aortic valve annulus sizing in TAVR. *JACC Cardiovasc Imaging*. 2015;8:375–378. https://doi.org/10.1016/j.jcmg.2014.11.011