CASE REPORT

ADVANCED

CLINICAL CASE

"Gazing Into the Abyss"

Transcatheter Mitral Valve-in-Valve Implantation Through a Cavernous Left Atrium

Nicholas P. Aroney, MBBS, BSc,[a] Ronak Rajani, DM,[a,b] Tiffany Patterson, MBBS, PhD,[a] Christopher J. Allen, MBBS,[a] Harminder Gill, MBBS,[a,b] Julia Grapsa, MD, PhD,[a] Jane Hancock, DM,[a] Bernard Prendergast, DM,[a] Simon Redwood, MD[a]

ABSTRACT

We describe the case of a 73-year-old woman presenting with heart failure, a degenerating bioprosthetic mitral valve, and severely dilated left atrium, and highlight the role of multimodality imaging in planning transseptal transcatheter mitral valve-in-valve implantation. (**Level of Difficulty: Advanced.**) (J Am Coll Cardiol Case Rep 2021;3:1332–1335) Crown Copyright © 2021 Published by Elsevier on behalf of the American College of Cardiology Foundation. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

HISTORY OF PRESENTATION

A 73-year-old woman presented with New York Heart Association functional class III dyspnea. On examination, oxygen saturations were 94%, blood pressure was 110/65 mm Hg, heart rate was 65 beats/min, and peripheral edema to the knees, and on auscultation there were bibasilar crackles and a predominant systolic murmur at the apex.

PAST MEDICAL HISTORY

Her history included a surgical mitral valve repair followed by surgical bioprosthetic mitral valve replacement 9 years ago, atrial fibrillation (AF), and obstructive pulmonary disease.

LEARNING OBJECTIVES

- To identify the key steps of complex transcatheter MViV intervention.
- To understand the importance of multimodality imaging in planning patient-specific mitral valve therapies.

DIFFERENTIAL DIAGNOSIS

Symptoms could have been caused by impaired left ventricular function, exacerbation of AF, or degeneration of the mitral valve replacement.

INVESTIGATIONS

Blood results were unremarkable other than an elevated N-terminal pro-B-type natriuretic peptide of 4,900. Her electrocardiogram demonstrated rate-controlled AF. Transthoracic echocardiography showed severe bioprosthetic mitral valve degeneration (**Figure 1A**) with a mean diastolic transvalvular pressure gradient of 12 mm Hg and severe regurgitation. The left atrium was grossly dilated (volume 712 ml) and biventricular function was preserved (**Figure 1B**). Surgical risk was amplified by her multiple previous surgical interventions and comorbidities (Society of Thoracic Surgeons score 3.8%, EuroSCORE II 8.1%).

From the [a]Cardiovascular Directorate, Guy's and St Thomas' NHS Foundation Trust, London, United Kingdom; and the [b]School of Bioengineering and Imaging Sciences, King's College London, London, United Kingdom.
Purvi J. Parwani, MBBS, MPH, served as Guest Editor-in-Chief for this paper.
The authors attest they are in compliance with human studies committees and animal welfare regulations of the authors' institutions and Food and Drug Administration guidelines, including patient consent where appropriate. For more information, visit the Author Center.

Manuscript received January 20, 2021; revised manuscript received April 28, 2021, accepted May 5, 2021.

ISSN 2666-0849 https://doi.org/10.1016/j.jaccas.2021.05.007

Mitral valve-in-valve (MViV) intervention was recommended following heart team discussion.

Multiphase retrospective electrocardiogram-gated cardiac computed tomography (CT) was performed for preprocedural planning. Cinematic volume rendering (Siemens Healthineers) was used to provide enhanced visualization of the distorted cardiac geometry and severely dilated left atrium (**Figure 1C**). The CT dataset were segmented (**Figure 1D**) and postprocessed (Materialise Mimics Enlight) to determine optimal transcatheter heart valve deployment height, projected neo-left ventricular outflow tract (LVOT) area (**Figure 1E**), and optimal fluoroscopic projection angles (**Figure 1F**). The projected neo-LVOT area of 290 ml^2 determined risk of neo-LVOT obstruction was low, despite the concerning features of a perpendicular aortomitral angle and small left ventricular cavity (1). Finite element modelling predicted favorable behavioral properties of the bioprosthetic valve (**Figure 2A**, Video 1) (FeOPS) (2). Cardiac CT endoscopy (**Figure 2B**) and 3-dimensional (3D) printing (**Figure 2C**) (Materialise) allowed for pre-procedural visualization to better plan device manipulation. On the day of the procedure, CT simulations were made available to the interventional cardiologists through an interactive virtual reality headset (GE Healthcare) to assimilate all of the pre-procedural planning data onto 1 platform (**Figure 2D**, Video 2).

MANAGEMENT

The procedure was performed under general anesthesia in a hybrid operating theatre, with transesophageal echocardiography (TEE) and fluoroscopic guidance. The femoral vein was accessed with an 8-F sheath using ultrasound guidance and was preclosed with a Perclose ProGlide device (Abbott). Under TEE guidance, the interatrial septum was crossed with a Brockenbrough needle (Abbott) in an inferoposterior position as planned on 3D analysis. A large-curl Agilis steerable catheter (Abbott) directed an Amplatz left 0.75 (AL0.75) and 0.035-inch J-wire across the bioprosthetic mitral

ABBREVIATIONS AND ACRONYMS

3D = 3-dimensional

AF = atrial fibrillation

CT = computed tomography

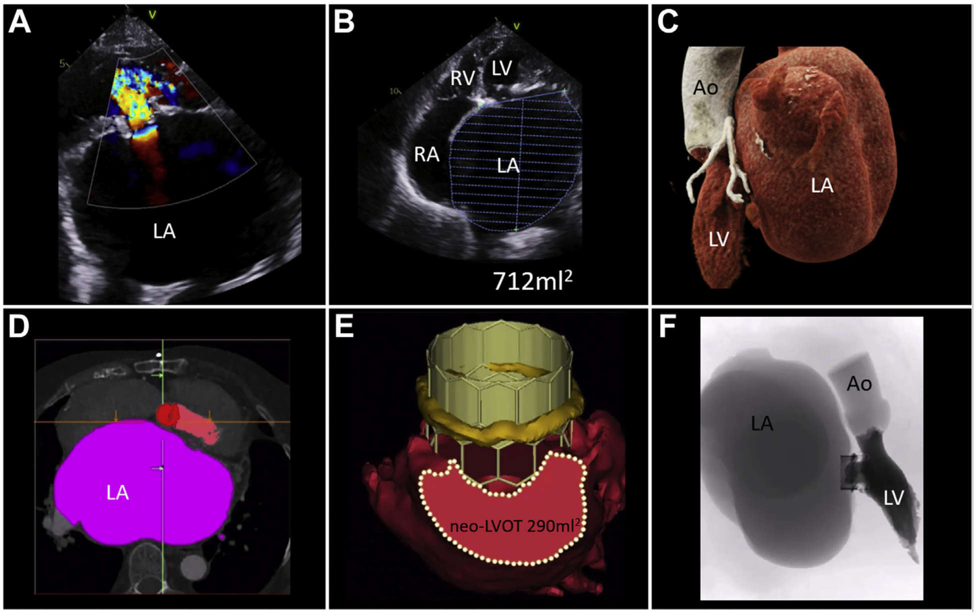
LVOT = left ventricular outflow tract

MViV = mitral valve-in-valve

TEE = transesophageal echocardiography

THV = transcatheter heart valve

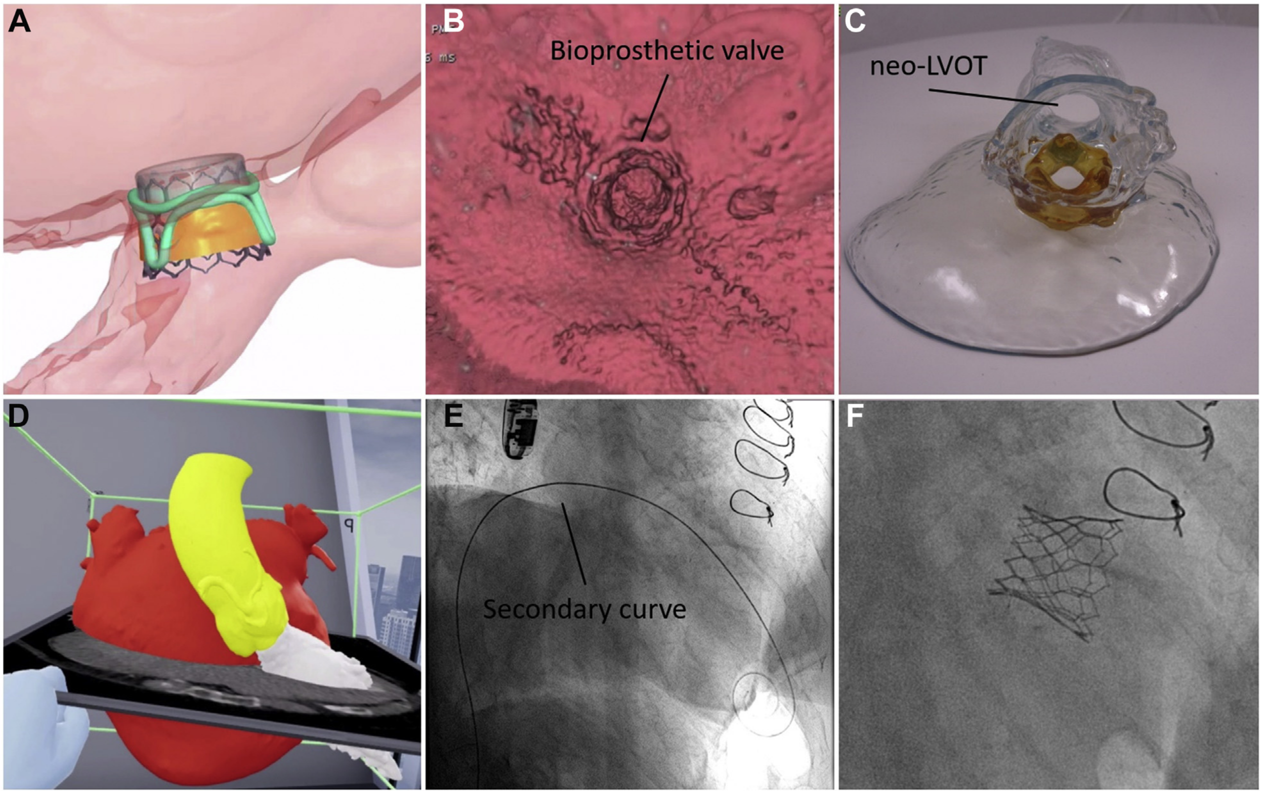
FIGURE 1 Multimodality Imaging Planning



(A) Transthoracic echocardiogram (TTE) in parasternal long-axis view showing abnormal angulation of the prosthetic mitral valve toward the interventricular septum and turbulent color Doppler flow through the prosthesis. **(B)** TTE in apical 4-chamber view showing a severely dilated left atrium (LA) (volume 712 mL). **(C)** Cardiac computed tomography (CT) cinematic 3-dimensional volume rendering showing the severely dilated LA and distorted orientation to the left ventricle (LV). **(D to F)** Cardiac CT postprocessing for transcatheter mitral valve planning. **(D)** Automated segmentation of the severely dilated left atrium; **(E)** simulated implantation of a 26-mm transcatheter heart valve and the resultant neo- left ventricular outflow tract (LVOT) area; and **(F)** the derived optimal fluoroscopic projection for mitral valve-in-valve implantation. Ao = aorta; RA = right atrium; RV = right ventricle.

JACC: CASE REPORTS, VOL. 3, NO. 10, 2021
AUGUST 2021:1332-1335

FIGURE 2 Preprocedural and Procedural Imaging



(A) Finite element analysis simulation showing the expected deformation of the existing tissue heart valve, appearance of the tissue heart valve following deployment, and impact upon the neo-LVOT. **(B)** Cardiac CT "endoscopy" to visualize the location of the tissue heart valve from the roof of the left atrium. **(C)** 3-dimensional print of the STL file obtained from the cardiac CT with different materials used for the cardiac skeleton and existing tissue heart valve. **(D)** Virtual reality projection of the cardiac CT finite element analysis simulation data set to enable anatomical manipulation of the imaging data prior to implantation by the interventional cardiologist. **(E and F)** Fluoroscopic procedural images: **(E)** the guidewire with a secondary curve; and **(F)** the final result of the THV deployment with a conical shape as predicted by preprocedural simulations. Abbreviations as in Figure 1.

valve to the left ventricular apex. A pigtail catheter and a Safari guidewire (Boston Scientific) (with a large secondary curve approximately 20 cm from the distal tip [Figure 2E] to improve stability in the left ventricle and facilitate device delivery) were used to exchange to a 14-F delivery sheath. The interatrial septum was dilated with a 14-mm VACS II balloon (Osypka) before delivery of an antegradely aligned (skirt-to-atrium) 26-mm Sapien 3 Ultra valve (Edwards Lifesciences) over the guidewire and positioning within the bioprosthetic valve, 10% above the fluoroscopic sewing ring marker. The valve was inflated under rapid pacing via the guidewire to achieve conical deployment (Figure 2F, Video 3). TEE confirmed a fall in the transmitral gradient to 6 mm Hg, no valvular or paravalvular leak, no significant neo-LVOT obstruction, and a small left-to-right interatrial shunt. Femoral venous hemostasis was achieved with an 8-F Angio-Seal (Terumo) deployed within the ProGlide.

DISCUSSION

Recent international guidelines provide a Class IIa recommendation for aortic and mitral valve-in-valve intervention for severely symptomatic patients who have high or prohibitive surgical risk (3). Although experience with MViV is more limited, registry data suggest high rates of procedural success (94.4%) and low rates of neo-LVOT obstruction (2.2%) and post-procedural regurgitation (5.6% ≥ moderate), with a 30-day and 1-year mortality of 6.2% and 14.0%, respectively (4,5). Although outcomes of trans-catheter mitral interventions in patients with a valve ring or extensive mitral annular calcification require further refinement (5,6), the data suggest that MViV intervention can be safe and effective with high-quality planning (5).

FOLLOW-UP

The patient's symptoms improved to New York Heart Association functional class II with transthoracic echocardiography demonstrating a mean transmitral gradient of 6 mm Hg and no regurgitation.

CONCLUSIONS

This case highlights the role of multimodality imaging in planning complex MViV procedures. Imaging modalities included geometric analysis of CT data sets using semiautomated platforms, finite element analysis simulation, 3D printing, and virtual reality solutions. These tools are likely to serve a greater role in improving patient outcomes by enabling better anticipation of procedural technique and patient outcomes and enhanced communication of key imaging findings among heart team members (1,7,8).

FUNDING SUPPORT AND AUTHOR DISCLOSURES

Dr. Redwood has received speaker fees from Edwards Lifesciences; and has served as an international advisory board member for Medtronic. Dr. Prendergast has received speaker fees from Edwards Lifesciences. All other authors have reported that they have no relationships relevant to the contents of this paper to disclose.

ADDRESS FOR CORRESPONDENCE: Dr Nicholas P. Aroney, Cardiovascular Directorate, St Thomas' Hospital, Westminster Bridge Road, London SE1 7EH, United Kingdom. E-mail: nicholas.aroney@gmail.com. Twitter: @drnickaroney.

REFERENCES

1. Blanke P, Naoum C, Dvir D, et al. Predicting LVOT obstruction in transcatheter mitral valve implantation: concept of the neo-LVOT. *J Am Coll Cardiol Img*. 2017;10(4):482–485.

2. Bavo AM, Wilkins BT, Garot P, et al. Validation of a computational model aiming to optimize preprocedural planning in percutaneous left atrial appendage closure. *J Cardiovasc Comput Tomogr*. 2020;14(2):149–154.

3. Otto CM, Nishimura RA, Bonow RO, et al. 2020 ACC/AHA guideline for the management of patients with valvular heart disease: a report of the American College of Cardiology/American Heart Association Joint Committee on Clinical Practice Guidelines. *J Am Coll Cardiol*. 2021;77(4):e25–e197.

4. Ye J, Cheung A, Yamashita M, et al. Transcatheter aortic and mitral valve-in-valve implantation for failed surgical bioprosthetic valves. *J Am Coll Cardiol Intv*. 2015;8(13):1735–1744.

5. Yoon S-H, Whisenant BK, Bleiziffer S, et al. Outcomes of transcatheter mitral valve replacement for degenerated bioprostheses, failed annuloplasty rings, and mitral annular calcification. *Eur Heart J*. 2019;40(5):441–451.

6. Guerrero M, Urena M, Himbert D, et al. 1-year outcomes of transcatheter mitral valve replacement in patients with severe mitral annular calcification. *J Am Coll Cardiol*. 2018;71(17):1841–1853.

7. Wang DD, Eng M, Greenbaum A, et al. Predicting LVOT obstruction after TMVR. *J Am Coll Cardiol Img*. 2016;9(11):1349–1352.

8. Sabbagh AE, Eleid MF, Matsumoto JM, et al. Three-dimensional prototyping for procedural simulation of transcatheter mitral valve replacement in patients with mitral annular calcification. *Catheter Cardiovasc Interv*. 2018;92(7):E537–E549.

KEY WORDS 3-dimensional imaging, 3-dimensional printing, computed tomography, mitral valve, valve replacement

APPENDIX For supplemental videos, please see the online version of this paper.