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Adventures across the second dimension: Predicting Left Ventricular Outflow Tract Obstruction Following Transcatheter Mitral Valve Replacement

Jaffar M Khan, BM BCh¹ and Robert J Lederman, MD¹

¹Cardiovascular Branch, Division of Intramural Research, National Heart Lung and Blood Institute, National Institutes of Health, Bethesda, MD, USA

EDITORIAL

Left ventricular outflow tract (LVOT) obstruction is a common and fatal complication of transcatheter mitral valve replacement (TMVR)(1). Predicting LVOT obstruction is important in selecting patients for TMVR, and for adjunctive procedures to prevent LVOT obstruction such as transcatheter laceration of the anterior mitral leaflet (LAMPOON)(2), trans-coronary alcohol septal ablation(3), and surgical mitral resection. The neoLVOT is the smallest cross-sectional area circumscribed by the transcatheter heart valve and the left ventricular septum, and contributes to post-procedure LVOT gradient. The neoLVOT can be predicted on multi-slice cardiac CT imaging by simulating a virtual transcatheter heart valve and measuring the projected minimal cross-sectional area(4).

The concept of predicted neoLVOT has not been validated in a sizeable patient cohort, a cut-off has not been established, and the tools for measurement have not been standardized. Therefore, the paper from Wang et al (5), attempting to validate CT-predicted neoLVOT against post-TMVR LVOT pressure gradients, is important and timely. The paper describes 38 patients who underwent TMVR over four years, including 17 valve-in-valve, 12 valve-in-ring and 9 valve-in-MAC cases. There were five catastrophic cases of LVOT obstruction, all in the valve-in-MAC arm. There were two cases with LVOT gradients marginally over 10mmHg and therefore likely inconsequential, one each in valve-in-MAC and valve-in-valve.

This work provides initial validation of one method of predicting neoLVOT from CT using semiautomated computer segmentation software. The authors found impressive correlation between predicted neoLVOT and post-procedure neoLVOT. A neoLVOT cut-off of 189mm² was sensitive and specific for a LVOT catheter gradient greater than 10mmHg. There are

ADDRESS FOR CORRESPONDENCE Robert J. Lederman, MD, National Heart Lung and Blood Institute, National Institutes of Health, Building 10, Room 2c713, Bethesda, MD 20892-1538, USA. Telephone: +1-301-402-6769. lederman@nih.gov.

EDITORIAL COMMENT

Regarding “Validating a prediction modeling tool for left ventricular outflow tract (LVOT) obstruction after transcatheter mitral valve replacement (TMVR),” by DD Wang *et al* (CCI-17-0674.R1).

COMPETING INTERESTS

NHLBI and Edwards Lifesciences have a collaboration and research agreement towards transcatheter modification of the mitral valve.

some limitations worth noting. There were no patients with LVOT gradients between 15mmHg and 70mmHg, so the imputed threshold of 189mm² may not be accurate. The paper is unclear about what was the planned implantation depth, which is important because more ventricular implantation may cause smaller neoLVOT. More important, had they used a pressure threshold of 30mmHg, a gradient considered important in hypertrophic cardiomyopathy, the resulting neoLVOT threshold would probably have been different. The report does not describe the relation between actual post-procedure neoLVOT and LVOT gradient. There was no correction for body mass or LV function. That said, the resulting threshold is close the “expert consensus” threshold (<200mm²) used to identify candidates at high risk of LVOT obstruction to participate in the LAMPOON study (NCT03015194), which will be reported in the second half of 2018.

Readers should be aware of other limitations of computer-model based predictions of LVOT obstruction. Positioning the transcatheter heart valve, both virtually on CT and actually in the catheter laboratory, is variable. Depth of implantation and canting of the valve may be difficult to control during implantation, especially via the trans-septal approach and in small ventricles. A slightly more ventricular implant, with flaring, and canting towards the septum will result in a smaller neoLVOT.

These assessments have been based on two-dimensional CT analysis of a single end-systolic phase. The next step would be 3-dimensional neoLVOT volume assessment, because the neoLVOT is a complex geometric structure. Flow is maximal in early systole but neoLVOT is typically measured in end-systole when cross-sectional area is minimal. Therefore, 4-dimensional (time-resolved) neoLVOT analysis throughout systole would account for pulsatile flow variation over time. 5-dimensional analysis would account for varying loading conditions against the neoLVOT impedance. Finally, for simplicity, the anterior mitral leaflet is oversimplified as stopping at the tip of the transcatheter heart valve. We know that for the majority of cases the anterior leaflet extends beyond the transcatheter heart valve, and Bernoulli forces may drag the leaflet towards the septum, causing LVOT obstruction. A complete assessment would involve simulation of the anterior mitral leaflet after TMVR.

Limitations aside, Wang and colleagues enhance our confidence that the predicted 2-D neoLVOT is a useful if flat guide to determine TMVR eligibility.

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Key Points

- TMVR can cause fatal LVOT obstruction, especially in the setting of valve-in-mitral annular calcification.
- A predicted neoLVOT of $<190\text{mm}^2$, measured using computer aided design models of 3-D datasets with a virtual valve implant, portends a high risk of LVOT obstruction following TMVR.
- NeoLVOT predictions may be based on different valve implantation depths, and do not account for body mass, complex neoLVOT time-varying three-dimensional geometry, flow, or anterior mitral leaflet dynamics.