Predicting LVOT Obstruction in Transcatheter Mitral Valve Implantation

Concept of the Neo-LVOT

OUTFLOW TRACT OBSTRUCTION IS A FEARED AND POTENTIALLY LETHAL COMPLICATION OF TRANSCATHETER mitral valve replacement (TMVR), mitral valve-in-valve (ViV), and valve-in-ring (ViR) procedures as well as implantation of transcatheter heart valves in calcific mitral valve disease. These procedures ultimately lead to elongation of the outflow tract into the left ventricle, whereas the pre-existing “native” left ventricular outflow tract (LVOT) confined by the most basal septum and the intervalvular fibrosa remains unchanged (Figure 1). The newly created elongation of the outflow tract is confined posteriorly by the deflected anterior mitral valve leaflet in TMVR (Figures 1 and 2), ViR, and calcific mitral valve procedures or by the deflected bioprosthetic leaflets and transcatheter heart valve struts in ViV procedures. To better discriminate from the native LVOT, we propose to refer to the newly created elongation as the “neo-LVOT” (1). Although risk factors for narrow neo-LVOT dimensions can be both device- and anatomy-related (Figure 3), we propose to perform a patient-specific assessment by means of computed tomography (CT)-based, virtual, stereolithographic device implantation. This requires segmentation of the native mitral annulus (2), the bioprosthetic sewing ring, or the annuloplasty ring, with subsequent definition of the annular plane and the annular trajectory by means of the least squares plane method to serve as anatomical landmarks for the subsequent device simulation (Figure 4) (1). With integrated device contours, the neo-LVOT can be segmented by means of a centerline technique to finally generate an orthogonal cross-sectional plane for planimetric “neo-LVOT” assessment (Figure 5). Here, we illustrate the concept of the neo-LVOT as well as the simulation and segmentation techniques essential to neo-LVOT prediction using cardiac CT (Figure 6).

Transcatheter valve implantation for native mitral valve disease and for failed surgical mitral valve replacement or repair elongate the outflow tract into the left ventricle, referred to as neo-LVOT. Pre-procedural CT-based device simulation may aid in identifying patients at an increased anatomical risk for small neo-LVOT dimensions and ultimately obstruction of the outflow tract.
FIGURE 1 Concept of the Neo-LVOT in TMVR

(Upper row) End-systolic 3-chamber view on cardiac computed tomography. (Lower row) Schematic drawing. Before TMVR, the LVOT is confined by the basal septum, the intervalvular fibrosa, and basal portion of the AML (A and D). The TMVR device deflects the AML “septally,” thereby elongating the outflow tract toward the left ventricle (B and E). This elongation is referred to as neo-LVOT, confined by the basal septum and the septally deflected AML (C and F). AML = anterior mitral valve leaflet; LVOT = left ventricular outflow tract; TMVR = transcatheter mitral valve replacement.

FIGURE 2 Cross-Sectional Imaging Planes of LVOT and Neo-LVOT

(Left) systolic 3-chamber view on cardiac computed tomography; (middle) schematic drawing; (right) cross-sectional short axis images through LVOT and neo-LVOT, with orientation indicated by red lines in the left and middle columns. (A to C) Confinements, orientation, and imaging axis of the native LVOT. After TMVR (Tendyne TMVR system, Tendyne Holdings, Roseville, Minnesota), the native LVOT at the level of the intervalvular fibrosa remains unchanged without encroachment of the device onto the native LVOT cross-sectional area (D to E). TMVR results in elongation of the outflow tract into the left ventricle, referred to as neo-LVOT (G to I). Importantly, the neo-LVOT has a different anatomical axis (yellow dashed line, H) than the native LVOT (blue line, E), thus requiring different orientation of the cross-sectional imaging planes (C and F, E). Abbreviations as in Figure 1.
**FIGURE 3** Anatomical and Device Related Factors Predisposing to Narrow the Neo-LVOT Dimension

Greater device protrusion into the left ventricle, device flaring at its left ventricular outflow, larger aorto-mitral angulation, and more pronounced septal bulging will lead to narrower/smaller neo-LVOT dimensions. Abbreviation as in Figure 1.

**FIGURE 4** Annular Segmentation and Trajectory for TMVR, Valve-in-Valve, and Valve-in-Ring Procedures

(Left) Cardiac computed tomography in functional mitral regurgitation; (middle) status post-bioprosthetic mitral valve replacement; (right) status post-mitral valve repair with closed annuloplasty ring. In native anatomy, the mitral annulus is segmented as described recently (A and D) (2). For valve-in-valve and valve-in-ring procedures, the contour of the radiopaque sewing or annuloplasty ring, respectively, are segmented on long- (B and C) and short-axis images (E and F). Segmentations allow for definition of the annular plane (G to I) and subsequently the annular trajectory, which is oriented perpendicular to the annular plane while transecting the geometric center of the annular contour (J, 3-dimensional simulation views; K, L, fluoroscopic simulation). TMVR = transcatheter mitral valve replacement.
REFERENCES


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