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Predicting left ventricular outflow tract obstruction despite anterior mitral leaflet resection - the “skirt neoLVOT”

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Transcatheter mitral valve replacement (TMVR) is a potential treatment for patients with severe mitral valve disease and high surgical risk. Pre-procedure CT is mandatory to determine the risk of 1) valve embolization, 2) paravalvular leak, and 3) left ventricular outflow tract (LVOT) obstruction. The neoLVOT area, measured using a CT-simulated valve, predicts LVOT obstruction from TMVR(1). This assumes the anterior leaflet covers any open valve stent cells. Transcatheter laceration of the anterior mitral leaflet to prevent outflow obstruction (LAMPOON, NCT03015194)(2) or surgical leaflet resection allows blood flow across uncovered stent cells, relieving LVOT obstruction. However, protruding fabric skirts on transcatheter heart valves may still obstruct the LVOT. We call the residual area after TMVR and anterior leaflet resection the “skirt neoLVOT”. Among 40 patients who underwent LAMPOON-TMVR, three had LVOT gradients >50mmHg post-TMVR and those uniquely had “skirt neo-LVOT” areas <150mm². They required emergency alcohol septal ablation despite anterior leaflet modification. We recommend measuring “skirt neoLVOT” whenever planning TMVR with anterior mitral leaflet modification, whether surgical or transcatheter. Future study, perhaps with computational fluid dynamics, is warranted to validate our cut-off.

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Figure 1. CT analysis for TMVR planning in patient 1
A 49-year-old woman with previous surgical aortic valve replacement and mitral ring annuloplasty suffered severe mixed mitral valve disease and was prepared for trans-septal TMVR. A) CT analysis suggests low risk of embolization and paravalvular leak with a 26 Sapien3 valve. B) The three-chamber view demonstrates risk factors for LVOT obstruction: a small ventricle, prominent septal bulge, and acute aorto-mitral angulation. Using 3mensio software (Pie Medical, Netherlands), a CT-simulated 26 Sapien3 valve is implanted at the predicted orientation and depth. C) The orthogonal LVOT short-axis view shows a predicted

neoLVOT of 3mm². To predict the LVOT after TMVR with anterior leaflet resection, the “skirt” neoLVOT is calculated with only the atrial skirt of the valve simulated (E), with height of 10mm as in table (D). F) Her predicted “skirt neoLVOT” was 130mm², which predicts severe LVOT obstruction despite complete anterior mitral leaflet resection.

Figure 2. Fluoroscopy and transesophageal echocardiography of the LAMPOON procedure in patient 1

The patient underwent LAMPOON TMVR. A) The fluoroscopy image shows two transfemoral catheters with exposed guidewire kink (black arrow) at the center and base of the anterior mitral leaflet. This guidewire is electrified while applying tension to both catheters to lacerate the anterior leaflet down the centerline. A deflectable sheath is positioned across the septum ready to deliver the TMVR equipment, a pacing wire is at the right ventricular apex, and a prior bioprosthetic aortic valve is present. B) The transesophageal echocardiogram after LAMPOON laceration shows the split anterior mitral leaflet (two white arrows). LA= Left atrium; LV = Left ventricle; Ao = Aorta

Figure 3. Severe LVOT obstruction in patient 1 requiring emergency alcohol septal ablation
 A) Transesophageal echocardiogram after TMVR demonstrates severe LVOT obstruction. The skirt-covered valve cells (red double-headed arrow) span the LVOT and the uncovered cells (black double-headed arrow) are against the septum (white arrow heads). There is a narrow high velocity jet between the septum and valve with a pressure drop of 114mmHg. B) Emergency transcatheter alcohol septal ablation was performed with a balloon (arrow) occluding the first septal artery. C) Transthoracic echocardiogram after emergency transcatheter alcohol septal ablation demonstrates thinning of the septum and increased distance to the transcatheter valve. D) Doppler flow is now seen through the open cells. E) On post-procedure CT her neoLVOT measures 69mm². The post-procedure “skirt neoLVOT” area is 165mm², which likely resembles the physiological LV OT following LAMPOON as blood flows through the uncovered cells, and final LVOT gradient is 20mmHg. LA= Left atrium; LV = Left ventricle; Ao = Aorta

Figure 4. NeoLVOT and skirt neoLVOT measurement in patient 2

A) A 77-year-old woman with previous transcatheter aortic valve replacement and severe mitral annular calcification and stenosis was planned to undergo trans-septal TMVR. A 29mm Sapien3 is simulated at a 70:30 ventricular depth, which would provide satisfactory seal and anchoring in this saddle-shaped annulus. B) The predicted neoLVOT from the orthogonal plane is 0mm². The overlap between implanted valve and septum is 75mm². C +D) The predicted “skirt neoLVOT” for the patient is 137mm² using a CT-simulated valve height of 12mm and diameter of 29mm. This predicts severe LVOT obstruction despite complete anterior leaflet resection.

Figure 5. CT reconstruction after LAMPOON, TMVR and alcohol septal ablation in patient 2
 A) Post-procedure CT reconstruction shows significant covered cell (small diamonds/red doubleheaded arrows) protrusion into the LVOT. Her initial LVOT gradient was 69mmHg. She underwent emergency transcatheter alcohol septal ablation causing some thinning and akinesis of the septum, seen on CT, which reduced her LVOT gradient to 41mmHg. B) Her post-implant neoLVOT was 0mm², even after alcohol septal ablation, suggesting certain death had LAMPOON not been performed. C) Her “skirt neoLVOT”, which is likely to be her physiological LVOT after anterior leaflet modification, is 150mm².

Figure 6. CT analysis and necropsy viewed from the LVOT with septum resected in patient 3
 A 76-year-old woman with severe mitral annular calcification and mitral stenosis was planned for LAMPOON-TMVR with a 29mm Sapien3 valve (E). A) Trans-septal valve positioning was predicted to be difficult because the small ventricle adversely orienting the valve during balloon inflation (large arrow), risking anterior miss and posterior paravalvular leak (small arrows). Controlling depth and co-axial alignment may have been easier with trans-apical valve delivery, but with increased morbidity. B-D) The neoLVOT was 0mm² and skirt neoLVOT (performed in retrospect) 55mm². F) The valve tilted during deployment, landing ventricular on the anterior side. The initial LVOT gradient was 100mmHg, reducing to 50mmHg following emergency alcohol septal ablation. She developed complete heart block and died post-op day 3. Necropsy shows the anterior leaflet lacerated (yellow dashed lines) and parted to the side because of LAMPOON. A significant portion of the LVOT was obstructed by the covered cells of the valve.