Complementary use of 3-dimensional intracardiac echocardiography during complex tricuspid transcatheter edge-to-edge repair

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Clinical vignette

An 86-year-old female with a history of severe aortic stenosis status post-transcatheter aortic valve replacement (TAVR; 26-mm SAPIEN 3 Ultra Resilia) was referred to the heart failure clinic for treatment of symptomatic severe tricuspid regurgitation (TR) with a tricuspid transcatheter edge-to-edge repair (T-TEER). Following TAVR, her symptoms initially improved to New York Heart Association (NYHA) Class I functional status; however, over the ensuing year, she experienced progressive clinical decline and now re-presented with NYHA Class III symptoms, consistent with American College of Cardiology (ACC)/American Heart Association (AHA) Stage C heart failure. Her medical history was notable for persistent atrial fibrillation and an inability to tolerate anticoagulation due to significant gastrointestinal comorbidities, including Crohn's disease and recurrent small bowel obstruction with prior resections and a hiatal hernia. At the time of evaluation, she reported worsening fatigue, exertional dyspnea, lightheadedness with activity, and lower extremity edema, despite optimal medical therapy. Transthoracic echocardiography demonstrated preserved biventricular systolic function with a left ventricular ejection fraction of 60%, normal functioning TAVR and severe mixed myxomatous and atrial functional TR [effective regurgitant orifice area (EROA) 0.55 cm^2 and regurgitant volume 60 mL]. Given her symptomatic deterioration, anatomic suitability, and comorbidity profile, she was felt to be an appropriate candidate for T-TEER, using the TriClip system (Abbott, Santa Clara, CA, USA) to alleviate venous congestion and improve functional status.

Surgical technique

Preparation

Comprehensive preprocedural planning was performed using transesophageal echocardiography (TEE) to define tricuspid valve anatomy and guide procedural strategy. TEE demonstrated a four-leaflet tricuspid valve (type IIIB), confirmed severe TR due to annular dilatation with majority of TR originating between the septal and posterior (P2) leaflet. The patient was admitted for diuresis pre-procedurally to obtain euvolemia and minimize leaflet coaptation gap to optimize leaflet grasping. Significant imaging limitations were also identified, including acoustic shadowing from the TAVR valve, horizontal orientation of the right heart within the chest, a hiatal hernia, and limited transgastric (TG) windows due to the patient's complex gastrointestinal history including bowel resections. Adjunctive 3-dimensional intracardiac echocardiography (3D-ICE) was planned to supplement TEE intra-procedurally as needed for optimal leaflet visualization.

Exposition

The patient was intubated in a hybrid operating room in the supine position. TEE image optimization was attempted

using a blood pressure cuff under the right shoulder (to slightly rotate the thorax leftward) along with low tidal volume ventilation to minimize respiratory motion intra-procedurally. Imaging was initiated using standard mid-esophageal TEE biplane guidance; however, despite TEE large and small wheel manipulation, TEE image quality deteriorated from expected imaging limitations (horizontal heart, acoustic shadowing from the TAVR prosthesis) impeding visualization of the tricuspid valve leaflets. Imaging guidance was therefore transitioned to a combined approach utilizing 3D-ICE with multiplanar reconstruction (MPR), integrated with the best available TG views.

Operation

The TriClip steerable guide catheter (SGC) was advanced from the left femoral vein into the right atrium (RA) under fluoroscopy and TEE guidance. The clip delivery system (CDS) was moved away from the interatrial septum by counterclockwise rotation of the SGC, then flexed and steered down towards the tricuspid valve by using the F-knob. The clip position and trajectory were optimized to align with the main TR jet using biplane imaging from the bicaval view and MPR from a 3D volume set. In the TG view, the clip was oriented perpendicular to the posterior-septal leaflet coaptation plane. It was determined that the TEE inflow view was unsatisfactory for grasping due to acoustic shadow artifact and suboptimal image quality; therefore, adjunctive 3D-ICE was introduced.

The 3D-ICE catheter was advanced from the right femoral vein and positioned in the RA to obtain right ventricular (RV) inflow view. 3D-ICE navigation was used to optimize ICE catheter positioning for the best visualization of the tricuspid valve leaflets. After acquisition of a 3D volume set, real-time MPR was used to direct the ICE catheter manipulation, including clockwise or counterclockwise rotation, advancement, and retraction, in order to align the ICE imaging plane with the TriClip XTW device (1). Once optimal alignment was achieved, leaflet grasping was performed using ICE biplane imaging at omniplane angles of –45° and 45° which provided the best ICE image resolution. The TriClip XTW was positioned at the commissural portion of the coaptation line between the posterior and septal leaflets. Both leaflets were successfully grasped, and the device was deployed. Post-deployment echocardiographic assessment using ICE demonstrated stable clip position with effective leaflet insertion, a significant TR reduction to mild, a mean transvalvular gradient of 1 mmHg, no change in RV function, and no pericardial effusion.

Completion

The procedure was completed successfully without complications, and vascular access sites were closed in standard fashion. Postprocedural TEE demonstrated preserved left ventricular systolic function and a well-seated TriClip attached to the posterior-septal leaflets, mild residual TR, with a mean transvalvular gradient of 1 mmHg at a heart rate of 87 bpm. RV size and function remained unchanged. The patient was discharged on postoperative day 6 on optimal medical therapy without anticoagulation, and follow-up transthoracic echocardiography at 30 days demonstrated stable findings.

Comments

Clinical results

T-TEER using TEE with adjunctive ICE has been associated with favorable procedural and early clinical outcomes in carefully selected high-risk patients (2-4). In this case, ICE-guided T-TEER resulted in successful clip deployment at the target coaptation zone with a significant reduction in TR to mild severity, preservation of RV function, and no procedural complications.

Advantages

Although TEE is the gold standard for T-TEER guidance, a key advantage of ICE-guided T-TEER is its ability to overcome the limitations of TEE—particularly in patients with challenging imaging windows due to gastroesophageal pathologies (e.g., hiatal hernia, prior surgery), acoustic shadowing from cardiac prostheses, native mitral annular calcification, or horizontal heart orientation. 3D-ICE provides imaging from a more proximal vantage point relative to the tricuspid valve, bypassing most TEE imaging limitations. This proximity enables more reliable leaflet visualization. When combined with MPR, 3D-ICE allows precise device orientation and leaflet grasping in complex anatomies, thereby enhancing procedural confidence and accuracy. In select patient cases, an exclusive 3D-ICE approach may obviate the need for TEE and general anesthesia, thereby potentially further reducing procedural risk in patients with gastrointestinal pathology or vulnerable RV hemodynamics.

Caveat

Despite its advantages, ICE-guided T-TEER is technically demanding and requires significant operator and imager expertise in catheter manipulation, image interpretation, and real-time integration of 3D-ICE with fluoroscopic and TEE guidance. 3D-ICE necessitates a second venous access and coordinated catheter manipulation by the proceduralist, while a separate operator (echocardiographer or company representative) manages the echo machine knobology, image processing, and acquisition, underscoring the need for precise team coordination and communication. The learning curve may be steep, particularly in patients with complex right-sided anatomy. In addition, 3D-ICE color Doppler image quality—especially when using MPR in its current version—is degraded when compared with TEE, requiring careful interpretation and limiting its use. 3D-ICE catheters are single-use and add procedural cost—this adjunctive imaging strategy may become cost-prohibitive for routine adoption in many institutions. Ongoing refinement of imaging strategies, procedural workflows, and patient selection will be essential to further optimize outcomes and expand the applicability of this approach, as previously reported by our group (2-4).

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Footnote

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Conflicts of Interest: L.M.S. has received speaker honoraria from Abbott and Medtronic Structural Heart and physician proctor for Abbott. G.H.L.T. has received speaker's honoraria and served as a physician proctor, consultant, advisory board member, TAVR publications committee member, RESTORE study steering and screening committee member, APOLLO trial screening committee member and IMPACT MR steering committee member for Medtronic, has received speaker's honoraria and served as a physician proctor, consultant, advisory board member, ENVISION trial screening committee member and TRILUMINATE trial anatomic eligibility and publications committee member for Abbott Structural Heart, has served as an advisory board member for Boston Scientific, a consultant and physician screening committee member for Shockwave Medical, a consultant for Anteris, Philips, Edwards Lifesciences, PeijaMedical and Shenqi Medical Technology. The other authors have no conflicts of interest to declare.

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