

Tricuspid valve repair using double-leaflet technique for tricuspid regurgitation with a small, displaced leaflet



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The Institutional Review Board or equivalent ethics committee of the Toranomon Hospital approved the study protocol and publication of data. The patient provided informed written consent for the publication of the study data.

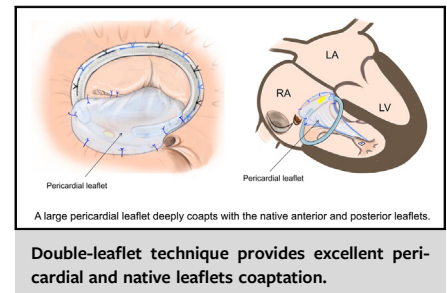
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CENTRAL MESSAGE

The double-leaflet technique demonstrates effectiveness in patients with small or displaced leaflets. By enabling deeper leaflet coaptation, it offers a promising alternative to conventional methods.

▶ Video clip is available online.

Repairing tricuspid regurgitation (TR) with severely tethered, small, or displaced leaflets is often challenging because ring annuloplasty alone may cause residual or recurrent TR.¹ Several surgical techniques are available, such as leaflet augmentation for functional TR and the cone procedure for Ebstein anomaly. However, these methods are complex due to the extensive use of sutures.^{2,3} Our previously introduced double-leaflet technique for mitral regurgitation, involving a trapezoidal pericardial patch attached to the papillary muscle, annuloplasty ring, and neighboring scallop, allows for deep coaptation with the anterior leaflet.⁴ We have successfully applied this technique to repair TR with a small and displaced septal leaflet.

CASE REPORT

A 59-year-old woman presented with drug-refractory heart failure symptoms and persistent atrial fibrillation. Echocardiography revealed massive TR with a large coaptation gap due to annular dilation (49 × 48 mm) and small septal leaflet displaced by 15 mm, not meeting the criteria for Ebstein anomaly. The right ventricular (RV) function was relatively preserved, with a tricuspid annular plane systolic excursion of 23 mm and a fractional area change of 46.4%. Totally endoscopic tricuspid valve repair, maze procedure, and left atrial appendage closure were scheduled.

A minithoracotomy was made in the fourth intercostal space with 4-cm skin incision. Cardiopulmonary bypass was initiated via the right femoral artery, femoral vein, and right jugular vein. The superior vena cava was snared via a minithoracotomy, whereas the inferior vena cava was taped but not snared. The aorta was crossclamped and cardiac asystole was obtained with antegrade cardioplegia.

A 5 × 3 cm trapezoidal pericardium piece was excised. Following the maze procedure and left atrial appendage closure, we exposed the tricuspid valve via a right atriotomy. The annulus was severely dilated, and the basal part of the septal leaflet was adhered to the ventricular septum and the distal mobile part was small. Both the anterior and posterior leaflets were morphologically normal. However, an abnormal papillary muscle was directly attached to the base of the anterior leaflet.

Initially, the abnormal papillary muscle was carefully dissected to liberate the anterior leaflet. Then, the narrower edge of the pericardium was secured to the posterior papillary muscle with a pledgeted 4-0 polypropylene mattress suture (Figure 1, A). The ring annuloplasty was performed with a 28-mm Physio Tricuspid Annuloplasty Ring

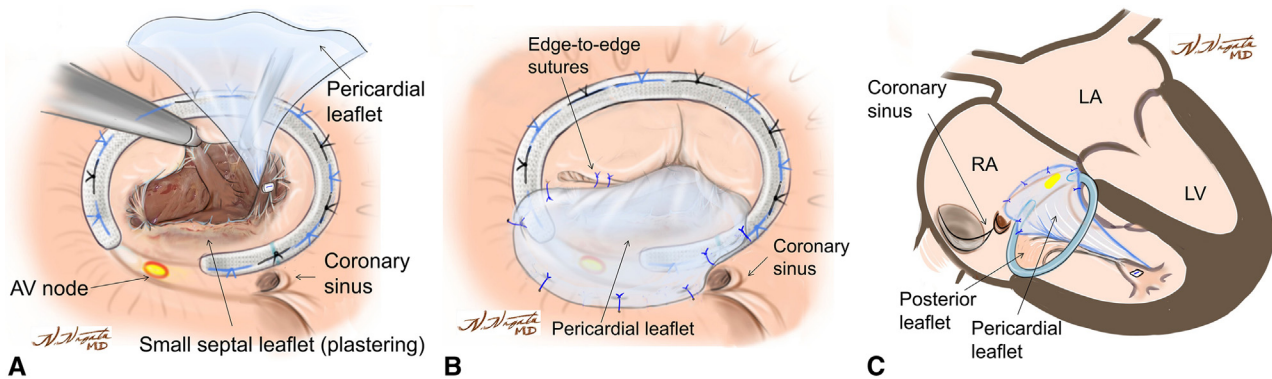


FIGURE 1. Tricuspid valve repair procedure. A, The narrower edge of pericardial leaflet was fixed to posterior papillary muscle. B, The pericardial leaflet was sewed to the septal portions of the annuloplasty band, the left edge of the septal leaflet, and the atrial septal wall. Edge-to-edge sutures were placed between the anterior and septal leaflets. C, Coaptation between the posterior and pericardial leaflets. AV, Atrioventricular; RA, right atrium; LA, left atrium; LV, left ventricle.

(Edwards Lifesciences), sized according to the size of the anterior and posterior leaflets. The pericardium was sutured to the septal portions of the annuloplasty ring, the left edge of the septal leaflet, and the atrial septal wall cranially to Koch's triangle. Two edge-to-edge sutures were added between the left sides of the anterior and septal leaflets. Finally, the additional suture was placed on the pericardium and the atrial septum close to the coronary sinus. It was placed after unclamping the aorta to prevent coronary sinus occlusion and atrioventricular block (AVB) (Figure 1, B). The pericardial leaflet covered Koch's triangle and the septal leaflet, coapting with the anterior and posterior leaflets (Figure 1, C). Intraoperative transesophageal echocardiography revealed mild TR at the anteroposterior commissure with no leakage around the septal or pericardial leaflet. The mean pressure gradient was 1.1 mm Hg.

Postoperatively, the patient was discharged on day 11 and has remained asymptomatic without diuretics for 2 years. Two-year echocardiography showed mild TR and mean pressure gradient of 1.2 mm Hg (Video 1). The patient gave written informed consent for publication of this information (institutional review board #2385; November 22, 2022).

DISCUSSION

The double-leaflet technique, proven effective in achieving profound leaflet coaptation in mitral valve repair,⁴ is now applied for the first time in TR treatment. Although annuloplasty techniques, including ring annuloplasty, De Vega's annuloplasty, and Kay's annuloplasty, are beneficial for addressing the annular dilatation associated with functional TR, their effectiveness may be limited in cases with exceptionally small leaflets or significant tethering or displacement. Adding edge-to-edge sutures or subvalvular manipulations to ring annuloplasty may not be effective when the leaflet is displaced. Leaflet

augmentation, although effective for functional TR with a severely dilated annulus or small leaflets,² does not create adequate coaptation when the leaflet is displaced. The cone procedure, commonly used for Ebstein anomaly, can be used in this case, but is relatively complex and time-consuming.³ Our technique achieves deep leaflet coaptation even in cases with small or displaced leaflets, offering a significant advantage over various other repair techniques. By creating a seamless leaflet continuum from the papillary muscle to the right atrium and providing deep coaptation, this technique could minimize the incidence of recurrent TR, even with progressive RV dilation. Compared with leaflet augmentation and the cone technique, our method offers simplicity due to fewer sutures. Additionally, it can be performed on a



VIDEO 1. Comprehensive visualization of surgical procedure and echocardiographic outcomes. This video includes preoperative echocardiography illustrating the extent of tricuspid regurgitation and the anatomical challenges, the operative procedure demonstrating the double-leaflet technique, and postoperative echocardiography showcasing the improved valve function, substantiating the efficacy of the technique. Video available at: [https://www.jtcvs.org/article/S2666-2507\(24\)00138-X/fulltext](https://www.jtcvs.org/article/S2666-2507(24)00138-X/fulltext).

beating heart, making it suitable for patients with diminished RV function. This demonstrates its versatility and broad clinical applicability.

Although tricuspid valve replacement could have been considered, it has been associated with higher in-hospital mortality and morbidity than tricuspid valve repair.⁵ Our repair technique, designed for deep coaptation, may offer enhanced durability compared with valve replacement, although long-term evaluation is needed.

Transcatheter edge-to-edge repair is valuable in high-risk tricuspid valve repair. However, its application is limited by anatomic constraints, particularly in cases with displaced leaflets or severe annular and RV dilatation, leading to significant leaflet separation. Even when feasible, transcatheter edge-to-edge repair may leave large coaptation gaps associated with residual TR.^{E1}

There are several tips for this technique. First, suturing the pericardial leaflet to the atrial septal wall cranial to Koch's triangle, rather than the annulus or prosthetic ring adjacent to the conduction system, helps avoid AVB and coronary sinus obstruction. This could create a gap between the left edges of the pericardial and septal leaflets or between the left edges of the pericardial and anterior leaflets. Therefore, edge-to-edge sutures were added between the anterior and septal leaflets. Second, the pericardial leaflet should be sutured to the atrial septal wall with the heart beating to allow immediate detection of AVB and prompt suture adjustments while ensuring the coronary sinus patency. Third, we determined the patch size based on our previous mitral valve procedures, where a 5 × 3 cm patch was effective. Although it fit well in this case, its universal applicability remains uncertain.

CONCLUSIONS

The 2-year postoperative results showing no leaflet degeneration or regurgitation are encouraging for the double-leaflet technique for TR with a small, tethered, or displaced leaflet. Further follow-up is necessary to evaluate its durability against other repair techniques or valve replacement. This technique's capacity for deep coaptation in challenging leaflet conditions highlights its potential utility in tricuspid valve repair.

Conflict of Interest Statement

The authors reported no conflicts of interest.

The *Journal* policy requires editors and reviewers to disclose conflicts of interest and to decline handling manuscripts for which they may have a conflict of interest. The editors and reviewers of this article have no conflicts of interest.

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