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

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Glossary of Abbreviations
TR, tricuspid regurgitation; RV, right ventricular; LAAC, left atrial appendage closure; CPB, Cardiopulmonary bypass; AVB, atrioventricular block; TEER, Transcatheter edge-to-edge repair
Double leaflet technique provides excellent pericardial and native leaflets coaptation.

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.
INTRODUCTION

Repairing tricuspid regurgitation (TR) with severely tethered, small, or displaced leaflets is often challenging, as 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's anomaly. However, these methods are complex due to the extensive use of sutures\(^2,3\). Our previously introduced the "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 x 48mm) and small septal leaflet displaced by 15mm, not meeting the criteria for Ebstein’s anomaly. The right ventricular (RV) function was relatively preserved, with a tricuspid annular plane systolic excursion of 23mm and a fractional area change of 46.4%. Totally endoscopic tricuspid valve repair, maze procedure, and left atrial appendage closure (LAAC) were scheduled.
A mini-thoracotomy was made in the 4th intercostal space with 4 cm skin incision. Cardiopulmonary bypass (CPB) was initiated via the right femoral artery, femoral vein, and right jugular vein. The superior vena cava was snared via a mini-thoracotomy, while the inferior vena cava was taped but not snared. The aorta was cross-clamped and cardiac asystole was obtained with antegrade cardioplegia.

A 5x3 cm trapezoidal pericardium was excised. Following the maze procedure and LAAC, we exposed the tricuspid valve via a right atriotomy. The annulus was severely dilated, and the basal part of the septal leaflet 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 1A). The ring annuloplasty was performed with a 28-mm Physio Tricuspid Annuloplasty Ring (Edwards Lifesciences, Irvine, California, USA), 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 1B). The pericardial leaflet covered Koch's triangle and the septal leaflet, coapting with the anterior and posterior leaflets (Figure 1C). 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 mmHg.

Postoperatively, the patient was discharged on day 11 and has remained asymptomatic without diuretics for two years. Two-year echocardiography showed mild TR and mean pressure gradient of 1.2 mmHg (Video 1).

The patient gave written informed consent to publication of this information (IRB #2385, November 22, 2022).

DISCUSSION

The double leaflet technique, proven effective in achieving profound leaflet coaptation in mitral valve repair, is now applied for the first time in tricuspid regurgitation (TR) treatment. While 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, though effective for functional TR with a severely dilated annulus or small leaflets, does not create adequate coaptation when the leaflet is displaced. The Cone procedure, commonly used for Ebstein's anomaly, can be used in this case, but is relatively complex and time-consuming. 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 to leaflet augmentation and the Cone technique, our method offers simplicity due to fewer sutures. Additionally, it can be performed on a beating heart, making it suitable for patients with diminished RV function. These demonstrates its versatility and broad clinical applicability.

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

Transcatheter edge-to-edge repair (TEER) is valuable in high-risk tricuspid valve repair. However, its application is limited by anatomical constraints, particularly in cases with
displaced leaflets or severe annular and right ventricular dilatation, leading to significant leaflet separation. Even when feasible, TEER may leave large coaptation gaps associated with residual TR.

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 5x3 cm patch was effective. Although it fit well in this case, its universal applicability remains uncertain.

In conclusion, the two-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.
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REFERENCES


Supplemental Reference


LEGENDS

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 (RA, right atrium; LA, left atrium; LV, left ventricle; IVC, inferior vena cava).

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.
A large pericardial leaflet deeply coapts with the native anterior and posterior leaflets.