The Egyptian Cardiothoracic Surgeon

In Press

Original Article

Tricuspid valve annuloplasty using autologous pericardial strip versus band for treatment of functional tricuspid regurgitation

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Abstract

Background: Options of tricuspid annuloplasty (TAP) for treatment of functional tricuspid regurgitation (FTR) include suture, ring, and autologous pericardium. The aim of this study was to evaluate and compare outcomes of TAP using pericardial strip versus band during left-sided heart valve surgery.

Methods: This retrospective study included adult patients who had autologous pericardial annuloplasty for FTR using pericardial strip and rolled pericardial band. The primary endpoint was residual TR (moderate or more) during 1-year follow-up.

Results: The study included 80 patients with mean age of 52.06±11.01 years and most of them were female (63.8%). Tricuspid annuloplasty was performed using pericardial strip (n=50) or band (n=30). During follow-up period, there were no re-operation for TR, severe TR, late complications, mortality, and degeneration or retraction of the pericardial patch. The incidence of residual TR was 7.5% postoperatively and 2.5% during follow-up with no significant differences between both techniques of annuloplasty. Pericardial strip showed higher incidence of postoperative mild TR than band. There were no significant differences in postoperative complications and NYHA class. Follow-up TR grade was significantly correlated with preoperative NYHA class, pulmonary artery systolic pressure, left ventricular ejection fraction, and tricuspid annular plane systolic excursion.

Conclusion: Autologous pericardial strip or band for moderate and severe FTR had similar and acceptable rates of residual TR (moderate or more) postoperatively and at 1-year of follow-up, but pericardial band had temporally lower frequency of postoperative mild TR. Further evaluation is recommended.

KEYWORDS

Tricuspid valve surgery; Tricuspid repair; Functional tricuspid regurgitation; Residual tricuspid regurgitation

Introduction

Tricuspid regurgitation (TR) is a common valvular disorder that can originate from various factors, including rheumatic heart disease, functional etiologies, or congenital abnormalities. Tricuspid annuloplasty techniques for the treatment of TR include suture repair (DeVega or Kay) and ring annuloplasty, each of which gives acceptable results. However, the ideal technique to repair the tricuspid valve remains undefined [1]. Autologous pericardial annuloplasty is considered to maintain annular structures, maintain flexibility of right ventricular pumping action, and prevent re-dilatation [2].

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The pericardium, known for its ability to regenerate and match the immune system, plays a key role in restoring the annulus to its proper size, which helps with better valve closure. Research has indicated that using autologous pericardium for annuloplasty can lead to better, more symmetrical changes in the annulus, a reduction in the severity of TR, and improved postoperative outcomes. Autologous single-layer pericardial strip annuloplasty appears to be a simple, easily reproducible, and valid option for surgical treatment of functional TR (FTR), with better outcomes than traditional suture annuloplasty and similar results to prosthetic ring annuloplasty [2, 3].

Using a flexible rolled band made from the patient's own pericardium is a modified option for pericardial annuloplasty. This approach gives the pericardium the rigidity of a band while also allowing it to be flexible and adapt to the annulus shape, without interfering with the right ventricle's movement and maintaining the dynamic flexibility of the tricuspid annulus [4]. The aim of this study was to compare outcomes of tricuspid valve annuloplasty (TAP) using autologous pericardial strip versus flexible rolled pericardial band for treatment of moderate or severe FTR during left-sided heart valve replacement.

Patients and Methods

This retrospective study included consecutive patients who had autologous pericardial annuloplasty for repair of functional TR during left-sided heart valve replacement at our institution between January 2017 and January 2023. The study included adult patients (>18 years old) of both sexes who underwent left-sided heart valve surgery and tricuspid valve repair for moderate or severe FTR. Patients with organic TR, isolated TR, redo surgery, mitral valve repair, and concomitant coronary artery surgery were excluded. According to type of the pericardial patch used for TAP, patients were divided into two groups: the first group received pericardial strip while the second group had rolled pericardial band.

All patients had standard open-heart surgery for left-sided heart valve replacement, in addition to tricuspid annuloplasty for FTR. The pericardial patch was harvested from anterior pericardium then soaked in normal saline or 0.6% Glutaraldehyde solution for 10 minutes followed by washing in normal saline for three times. Proper dimensions of the pericardial patch were determined by Carpentier Edward tricuspid sizer (Figure 1, A). In cases of autologous pericardial strip, folded over pericardial patch of 7-10 cm in length and 5-10 mm in width was used. The strip was secured to the tricuspid annulus with interrupted mattress sutures of non-absorbable 2-0 Ethibond suture, starting from antero-septal to postero-septal commissure. The distance between sutures was 2-3 mm in the pericardial patch and 5-6 mm in the tricuspid annulus. For autologous pericardial band, the pericardial patch of 7-10 cm in length and 15-20 mm was rolled around itself keeping the smooth surface outward and reinforced with Ethibond 2/0 rolled around (Figure 1, B). After annuloplasty, the competence of tricuspid valve was assessed by saline test and observed during systole and diastole (Figure 1, C and D). The size of the tricuspid valve after repair was acceptable if it could admit two fingers.

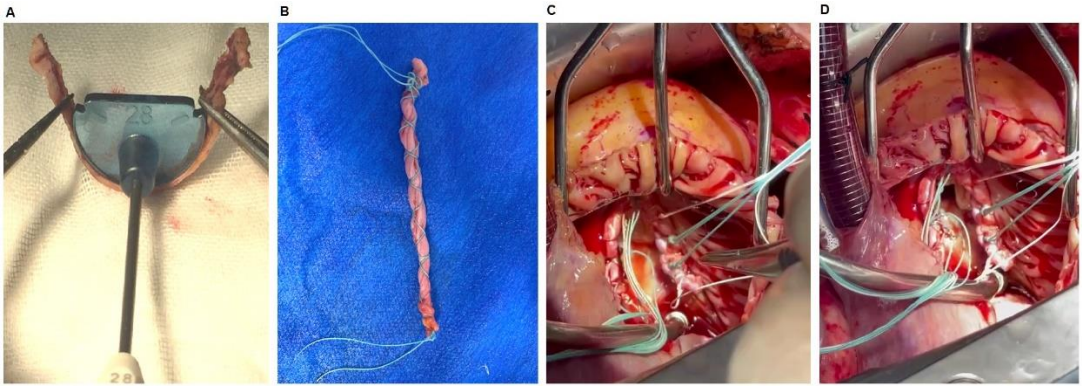

Figure 1: Intraoperative views showing: (A) Evaluation of the proper length of pericardial patch by Carpentier Edward sizer, (B) Reinforcing of rolled pericardial band by Ethibond 2/0 suture and testing the competence of tricuspid valve after fixing of the pericardial patch to the tricuspid annulus during (C) systole, and (D) diastole.

Table 1: Preoperative baseline demographic and clinical characteristics

Variables	Total (n=80)	Pericardial strip (n=50)	Pericardial band (n=30)	P-value
Age (years)	52.06±11.01	51.38±9.95	53.20±12.69	0.47
Gender (Female)	51(63.8%)	29(58%)	22(73.3%)	0.16
Obesity	17(21.2%)	14(28%)	3(10%)	0.057
NYHA III/IV	49(61.2%)	31(62%)	18(60%)	0.85
DM	19(23.8%)	10(20%)	9(30%)	0.30
Dyslipidemia	3(3.8%)	1(2%)	2(6.7%)	0.55
Hypertension	8(10%)	6(12%)	2(6.7%)	0.70
PVD	3(3.8%)	1(2%)	2(6.7%)	0.55
CVD	1(1.2%)	1(2%)	0(0%)	1
CHF	3(3.8%)	1(2%)	2(6.7%)	0.55
AF	24(30%)	17(34%)	7(23.3%)	0.31
Severe PHTN	17(21.2%)	12(24%)	5(16.7%)	0.43
PASP (mmHg)	39.50±12.07	40.48±12.21	37.86±11.84	0.26
TAPSE (mm)	17.98±1.76	18.16±1.88	17.70±1.51	0.15
LVEF (%)	59.03±5.34	58.16±5.73	60.50±4.33	0.14

NYHA: New York Heart Association. DM: Diabetes mellitus. PVD: peripheral vascular disease. CVD: cerebral vascular disease. CHD: Congestive heart failure. AF: Atrial fibrillation. HTN: Hypertension. LVEF: Left ventricular ejection fraction. PHTN: Pulmonary hypertension, PASP: Pulmonary artery systolic pressure. TAPSE: Tricuspid annular plane systolic excursion

The severity of TR was graded as none (0), trivial (I), mild (II), moderate (III), and severe (IV). On trans-thoracic echocardiography (TTE), severe TR was defined if jet area to right atrial area ratio is >40% in apical four chamber view. Preoperative, operative, and postoperative data were retrieved from the medical records and follow-up visits at outpatient clinic. The collected postoperative and follow-up data were based on clinical and echocardiographic findings. The primary endpoint of outcome was residual TR (≥ moderate grade) postoperatively and at the end of one-year follow-up. The secondary outcome included postoperative pulmonary, renal, infective or neurological complications, re-exploration for bleeding, arrhythmia, low cardiac output syndrome (LCOS), duration of ICU stay, length of hospital stay, in-hospital or late mortality, echocardiographic parameters, functional NYHA class, reoperations for recurrent TR, and any complications related to pericardial patch.

Statistical analysis

The statistical analysis was performed using IBM SPSS Statistics version 20.0 (Chicago, IL, USA). Categorical data were expressed as number and percent while continuous data were expressed as mean and standard deviation. Normality of continuous variables was examined by Shapiro-Wilk test. Comparisons were performed using Chi-square or Fisher's exact test for categorical data and t-test test or Mann-Whitney non-parametric test for continuous data. Pearson test was used to estimate correlation coefficient (R-value) between continuous variables. P-value <0.05 was considered statistically significant.

Results

The study included 80 patients who had mean age of 52.06±11.01 years (range, 26-77) and the majority of them were female (63.8%, 51/80). All patients underwent cardiac surgery for management of rheumatic mitral and/or aortic valve disease with moderate or severe FTR. Fifty patients had pericardial strip for TAP while the remaining 30 patients had pericardial band. There were no significant differences between both groups in regard to demographic and preoperative clinical data (Table 1). Also, there was no significant difference between groups in operative

Table 2: Operative data

Variables	Total (n=80)	Pericardial strip (n=50)	Pericardial band (n=30)	P-value
Bypass time (min)	85.92±34.62	89.10±34.33	80.63±35.02	0.24
Cross-clamp time (min)	51.70±35	56.50±35.20	43.70±33.73	0.057
Procedures				
MVR	73 (91.2%)	44 (88%)	29 (96.7%)	
AVR	1 (1.2%)	1 (2%)	0 (0%)	0.49
MVR+AVR	6 (7.5%)	5 (10%)	1 (3.3%)	

MVR: Mitral valve replacement. AVR: Aortic valve replacement

durations and type of procedure (Table 2).

At the end of one-year follow-up, there were no cases of re-operation for recurrent TR, residual severe TR, late complications, or mortality. Also, there was no case of degeneration or retraction of the pericardial patch. The overall incidence of postoperative residual TR was 7.5% (6/80) while the incidence of follow-up residual TR was 2.5% (2/80).

Regarding comparison of postoperative and follow-up echocardiographic grades of TR (Table 3), there were no significant differences in the incidences of postoperative residual TR (10% vs. 3.3%, P=0.40) or at the end of one-year follow-up (4% vs. 0%, P=0.52). Regarding comparisons of TR grades between both groups, pericardial strip group showed significantly higher incidence of postoperative mild TR (28% vs. 6.7%, P=0.02) with no significant difference in other grades of TR. Regarding secondary endpoints of outcome (Table 4), there was no significant differences in the incidences of LCOS, postoperative complications, echocardiographic parameters, and follow-up NYHA class.

In all patients, follow-up TR grade significant positive correlation with NYHA class (r-value=0.31, p-value=0.004) and pulmonary artery systolic pressure (PASP, r-value=0.40, p-value <0.001), while it had significant negative correlation with left ventricular ejection fraction (LVEF, r-value= -0.26, p-value=0.02) and tricuspid annular plane systolic excursion (TAPSE, r-value= -0.25, p-value=0.028) (Figure 2).

Table 3: Comparison of postoperative and follow-up echocardiographic grades of tricuspid regurgitation

Variables	Total (n=80)	Pericardial strip (n=50)	Pericardial band (n=30)	P-value
Postoperative residual TR	6(7.5%)	5(10%)	1(3.3%)	0.40
Follow-up residual TR	2(2.5%)	2(4%)	0(0%)	0.52
Postoperative TR grade				
None	37(46.2%)	21(42%)	16(63.3%)	0.32
Trivial	21(26.2%)	10(20%)	11(36.7%)	0.10
Mild	16(20%)	14(28%)	2(6.7%)	0.02*
Moderate	5(6.2%)	4(8%)	1(3.3%)	0.40
Severe	1(1.2%)	1(2%)	0(0%)	0.43
Follow-up TR grade				
None	63(78.8%)	38(76%)	25(83.3%)	0.43
Trivial	8(10%)	4(8%)	4(13.3%)	0.44
Mild	7(8.8%)	6(12%)	1(3.3%)	0.18
Moderate	2(2.5%)	2(4%)	0(0%)	0.26

TR: Tricuspid regurgitation. *Significant difference

Table 4: Postoperative and follow-up secondary outcome

Variables	Total (n=80)	Pericardial strip (n=50)	Pericardial band (n=30)	P-value
LCOS	23(28.8%)	14(28%)	9(30%)	0.84
Complications				
Re-exploration	4(5%)	3(6%)	1(3.3%)	1
Atrial fibrillation	3(3.8%)	2(4%)	1(3.3%)	1
Wound infection	1(1.2%)	0(0%)	1(3.3%)	0.37
Renal failure	1(1.2%)	1(2%)	0(0%)	1
ICU stay (days)	1.41±0.86	1.46±0.90	1.33±0.80	0.67
Hospital stay (days)	10.11±3.79	9.66±3.09	10.86±4.70	0.74
PASP (mmHg)	25.30±2.44	25.16±2.48	25.53±2.40	0.50
TAPSE (mm)	20.33±1.56	20.24±1.64	20.50±1.43	0.40
LVEF (%)	58.28±7.16	58.16±4.25	58.50±10.45	0.06
Follow-up NYHA class				
I	70(87.5%)	43(86%)	27(90%)	
II	10(12.5%)	7(14%)	3(10%)	0.73
II	10(12.5%)	7(14%)	3(10%)	

LCOS: Low cardiac output syndrome. PASP: Pulmonary artery systolic pressure. TAPSE: Tricuspid annular plane systolic excursion. *significant difference

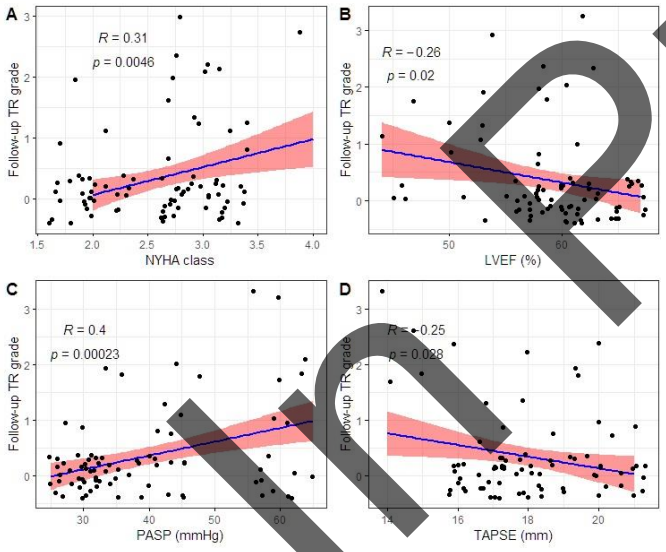

Figure 2: Linear scatter plots for correlation of follow-up grade of TR with preoperative values of: (A) Dyspnea status by New York Heart Association - NYHA class, (B) Left ventricular ejection fraction - LVEF %, (C) Pulmonary artery systolic pressure - PASP, and (D) Tricuspid annular plane systolic excursion - TAPSE

Discussion

The findings of this study confirmed that utilizing an autologous pericardium for TAP is safe and effective for treatment of moderate or severe FTR. The superiority of pericardial band over strip in terms of reducing postoperative residual TR was temporal with similar outcome of both techniques of pericardial annuloplasty at the end of one-year of follow-up. Using autologous pericardium in cardiac surgery is simple, reproducible, and inexpensive. Modifying the pericardial patch as a band by rolling it around itself and reinforcement by Ethibond suture gives it additional advantages of strength and flexibility.

At the best of our knowledge, there is no study in literature evaluating outcomes of TAP in regard to type of autologous pericardial patch whether strip or band, however the results of pericardial annuloplasty in other studies were comparable to conventional suture repair and ring annuloplasty (Table 5).

In the study by De La Zerda et al [5], tricuspid annuloplasty was durable and reproducible, using autologous pericardial strip secured to the tricuspid annulus by two rows of continuous horizontal mattress sutures. The technique of pericardial strip annuloplasty used in our study was previously described by Chang et al [2]. Those authors compared outcomes of autologous pericardial strip secured to the tricuspid annulus by interrupted mattress sutures with that of conventional suture annuloplasty and reported better long-term recurrence-free survival

Table 5: Characteristics of published studies evaluating outcome of autologous pericardial strip or band for tricuspid valve annuloplasty during left-sided heart valve surgery

Authors	Year	Technique(s)	Preoperative TR grade	Follow-up (average)	Residual/recurrent TR	Mortality
De La Zerda et al [5]	2008	-Autologous pericardial strip (n=59)	III, IV	4.4 years	Postoperative: 0% Follow-up: 1.8%	In-hospital: 1.6%.
Chang et al [2]	2008	-Autologous pericardial strip (n=217). -Suture (DeVega or Kay) annuloplasty (n=117)	I, II, III, IV	3.5 years	Postoperative: 10.8% vs. 11.8%	Operative: 1.8% after pericardial strip vs. 3.4% after suture repair.
Jabbad et al [6]	2014	-Autologous pericardial strip (n=39) -Ring annuloplasty (n=20)	III, IV	3 years	Postoperative: 7.69% vs. 10% Follow-up: 10.26% vs. 5%.	In-hospital: 1.69%.
Ettish et al [4]	2019	-Autologous flexible pericardial band (n=30) -DeVega repair (n=30)	III, IV	1 year	Follow-up: 3.3% vs. 10%.	In-hospital and follow-up: 0%
Shafeek et al [1]	2020	-Autologous flexible pericardial band (n=41) -Ring annuloplasty (n=41) -Dacron band (n=41)	IV	1 year	Postoperative and follow-up: 0%	In-hospital: 2.43% (1/41) in each group.
Nasso et al [3]	2021	-Autologous pericardial strip (n=109) -Ring annuloplasty (n=115)	III, IV	7.83 years	Follow-up: Recurrent III+/IV+ TR: 0% vs.1.8%.	In hospital: 0.9% after pericardial strip vs.s 2.6% after ring.
Agrawal et al [7]	2022	-Autologous pericardial strip (modified De Vega Annuloplasty, mDA, n=20) -Ring annuloplasty (RA, n=30)	II, III, IV	1 year	Postoperative TR: 50% vs. 43.3%. Follow-up: 10% vs. 16.6%.	In-hospital and follow-up prosthesis/valve related mortality: 0%
Helmy et al [8]	2023	-Autologous flexible pericardial band (n=50) -Suture repair (n=50)	III, IV	2 years	Postoperative (1 week): 6% vs. 12% Follow-up (6 months): 6% vs. 16%	In-hospital and follow-up mortality: 0%

following autologous pericardial strip annuloplasty. Additionally, comparable efficacy of pericardial strip to ring annuloplasty was reported by Jabbad et al [6], however, similar outcomes (survival, TR recurrence, and functional status) were reported by Nasso et al [3] and Agrawal et al [7] except for lower cost of pericardial strip annuloplasty.

Also, autologous flexible pericardial band for FTR had similar acceptable outcome as ring annuloplasty and Dacron band [1] and had no statistical differences with conventional suture repair as shown in the studies by Ettish et al [4] and Helmy et al [8]. Thus, the decision for the choice between suture, ring, or pericardial annuloplasty can be affected by the surgeon's preference and durability of each technique.

Although tricuspid valve surgery for FTR during left heart valve surgery associated with significant improvements in postoperative outcome [9], there is no unique technique for tricuspid annuloplasty. Each technique has its pros and cons. Suture repair is widely used but it is associated with higher incidences of recurrent TR and need for re-operation due to suture retraction and poor valve plasticity with respect to tricuspid orifice [10, 11]. Ring annuloplasty demonstrated superiority to suture repair in terms of survival and re-operation [12, 13], but it may interfere with the flexibility of tricuspid annulus during right ventricular pumping in addition to possibility of dehiscence and embolization [14, 15]. Autologous pericardial annuloplasty is simple, inexpensive, and offers advantages of biocompatibility, natural healing, and durability, however its long-term

results need more evaluation as it may manifest degeneration and retraction over time.

In the present study, there was no cases of pericardial degeneration or retraction after pericardial annuloplasty by strip or band during 1-year follow-up. Similar findings were reported in literature [3, 8]. Treatment of the pericardial patch in Gluteraldehyde solution gives it greater resistance to shrinking and degeneration, in addition to improved strength and low tendency to form clots [5]. However, this method can be associated with dystrophic calcification particularly when the fixation lasts more than 15 minutes [16]. Thus, fresh autologous pericardium may be a durable alternative to Gluteraldehyde-treated pericardium as reported in mitral valve repair [17].

In literature, ring annuloplasty associated with lower incidences of recurrent TR than DeVega suture repair, that indicates modification of DeVega annuloplasty to be an alternative to ring annuloplasty when rings are not available [18]. Thus, we used previously described modification of suture annuloplasty [2, 7] by applying pericardial strip or band as a large pledget secured to the tricuspid annulus by interrupted mattress sutures. In our study, overall incidences of residual TR (moderate or more) were 7.5% postoperatively and 2.5% at the end of 1-year of follow-up. There were no significant differences between group of pericardial strip and pericardial band in regard to incidences of postoperative residual TR (10% vs. 3.3%) or follow-up residual TR (2% vs. 0%). These incidences are lower than reported corresponding incidences in suture annuloplasty (range,10-35%), and nearly similar to the reported incidences in ring annuloplasty (range, 4-14%) [19-21].

Also, our incidences of residual TR (moderate or more) after pericardial strip or band are in agreement with other studies in literature. The reported incidences of postoperative and follow-up residual TR after pericardial strip annuloplasty ranged from 0 to 50% [2, 5-7] and from 0 to 10.26% [3, 5-7], respectively. On the other hand, both incidences of postoperative and follow-up residual TR after pericardial band annuloplasty ranged from 0 to 6% [1, 4, 8].

Currently, there is evidence that concomitant tricuspid valve annuloplasty for moderate or severe FTR during surgery for left-sided rheumatic heart disease does not significantly affect postoperative mortality or morbidity [22-24]. In our study, there was no in-hospital or 1-year follow-up mortality. This finding is consistent with other studies of pericardial annuloplasty which reported in-hospital and follow-up mortality rates from 0 to 1.8% [2, 3, 5-7] and 0 to 2.43% [1, 4, 8], respectively.

Regarding postoperative complications after pericardial annuloplasty, it included re-exploration for bleeding (5%) and atrial fibrillation (3.8%), wound infection (1.2%), and renal failure (1.2%) which were controlled before discharge. There were no significant differences in the incidence of postoperative complications between both techniques of pericardial annuloplasty. Similar nonspecific controllable postoperative complications were reported in other studies including re-exploration [1, 2, 6], atrial fibrillation [4, 5, 8], pericardial tamponade associated with overdose of anticoagulant [2, 4, 8], low cardiac output syndrome [1], and acute renal failure [5].

In the present study, both techniques of pericardial annuloplasty showed significant improvement in preoperative NYHA class during 1-year of follow-up. The majority of patients in both techniques had NYHA class I (87.5% of total, 86% of strip group, 90% of band group). Improvement in the functional status can be explained by improvements in TR grade, left and right ventricular functions, and pulmonary artery pressure. The significant improvement of functional status and high frequency of NYHA class I after pericardial annuloplasty have been reported in other studies. Following annuloplasty by a pericardial strip, De La Zerda et al [5] reported NYHA class I in 46.5% and Nasso et al [3] found NYHA I/II in 96.67% of patients. On the other hand, NYHA class I approximates 93% after pericardial band in the studies by Shafeek et al [1] and Ettish et al [4] at 1 year of follow-up.

Limitations

Our study is potentially limited by: (1) retrospective nature which can affect the process of patient selection and data collection, (2) small sample size, (3) single-center experience, and (4) lack of comparison to ring annuloplasty because of insufficient number of cases.

Conclusion

Tricuspid annuloplasty using an autologous pericardial strip or band is a reliable and effective alternative to suture repair or ring annuloplasty for moderate and severe FTR, showing greater early improvement in TR after the application of a rolled pericardial band. This method can be utilized in cardiac facilities with limited resources where prosthetic annuloplasty rings are not available. It is advised to assess these results in additional prospective and long-term studies.

Funding: Self-funded

Conflict of interest: Authors declare no conflict of interest.

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