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Original Article

Predictors of Failure after DeVega Repair for Functional Tricuspid Regurgitation

Hysam Abdelmohty[1], Wael Abdelaziz[1], Mohamed-Adel Elanwar[2], Ehab Abdelazeem[3], Mohamed Ali[4], Basem Abdelgawad[5]

[1] Department of Cardiothoracic Surgery, Faculty of Medicine, Mansoura University, Mansoura, Egypt
[2] Department of Cardiothoracic Surgery, Faculty of Medicine, Cairo University, Cairo, Egypt
[3] Department of Anesthesia and Intensive Care, Faculty of Medicine, Benha University, Benha, Egypt
[4] Department of Cardiology, Faculty of Medicine, Benha University, Benha, Egypt
[5] Department of Cardiothoracic Surgery, Faculty of Medicine, Benha University, Benha, Egypt

Abstract

Background: Untreated tricuspid regurgitation during mitral valve surgery may progress to severe symptomatic tricuspid regurgitation. Concomitant repair may increase the operative risk; however, re-operative tricuspid valve surgery is a high-risk procedure. This study's objective was to identify the predictors of DeVega repair failure in patients with functional tricuspid regurgitation and concomitant mitral valve surgery.

Methods: This research is a retrospective comparative study that included 140 patients who underwent tricuspid valve repair concomitant with mitral valve replacement. We divided the patients into two groups; the first group (n=106) included patients with no DeVega failure at six-months follow-up (The sustained repair group). The second group included 34 patients who developed moderate or higher TR after the DeVega and was named the failed repair group.

Results: The demographic data and comorbidities were not statistically different between both groups. The preoperative atrial fibrillation (73 (69%) vs. 30 (88%)' p= 0.027) pulmonary artery pressure (64.8±3.6 vs. 81±6.5 mmHg; p= 0.02), right ventricular dimension (4.85±0.24 vs. 5.23±0.37 cm; p= 0.03), and time between the indication of surgery and operation (8.3 ± 3.1 vs. 14.7 ± 5.4 months; p = 0.003) were higher in patients with failed DeVega repair. There was no statistically significant difference regarding the mean bypass time, cross-clamp time, ICU and hospital stay, and postoperative complications between both groups. Predictors of failure after six months were preoperative heart failure (OR: 15.4 (95% CI: 3- 92.3); p= 0.003), long time between diagnosis and surgery (OR: 12.3 (95% CI: 2.1- 84.7); p= 0.007), and postoperative severe pulmonary hypertension (OR: 24.7 (95% CI: 3.1- 199.6); p= 0.003).

Conclusions: DeVega repair is associated with a high failure rate after six months. The study of predictors of failure could change our management plans to reach the best results for repair.

KEYWORDS
Functional Tricuspid regurgitation; Tricuspid repair; De Vega annuloplasty; Mitral valve replacement

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Corresponding author: Basem Abdelgawad bassem.abdelgawad@fmed.bu.edu.eg

Introduction

Functional tricuspid regurgitation (FTR) usually occurs secondary to a left-side heart valve disease. FTR occurs in one out of three patients with rheumatic mitral stenosis [1]. Surgical correction of severe concomitant tricuspid regurgitation (TR) is recommended during left-sided valve surgery. However, the surgical treatment of mild to moderate FTR is still controversial. Some surgeons argue that FTR will regress spontaneously after treating the left side lesion [2]. On the other hand, several patients with untreated mild to moderate FTR returned because of the progression of their FTR to a severe degree [3]. Thus, it is unknown whether we should tackle mild to moderate FTR at the same sitting or be left to regress after correction of the mitral lesion. One can assume that if we repair every dilated tricuspid valve (TV) annulus, you will see less late TR on echocardiography. But, adding TV surgery could increase the risk of mitral valve surgery.

Recurrent regurgitation after DeVega annuloplasty is not uncommon. However, reoperation is rare, although many patients are symptomatic with New York Heart Association (NYHA) class III or IV. This could be attributed to the perception of reoperation as a high-risk procedure. Patients present to re-operative tricuspid valve surgery are usually older, with bad preoperative status, and a higher probability of permanent pulmonary hypertension, right ventricular dysfunction, and hepatic impairment or failure [4].

Our study aims to evaluate the outcomes of concomitant DeVega repair at the time of mitral valve operation in mild and moderate FTR and identify early failure predictors.

Patients and Methods:

This research is a retrospective comparative study that included 140 patients with mitral valve disease and FTR who underwent mitral valve replacement with concomitant DeVega repair from January 2017 to December 2018. We extracted their data from the paper charts and the computerized Cardiac surgery information registry system. We excluded patients with aortic valve lesions, coronary artery disease, re-do or emergency cases, and cases that underwent mitral repair.

We divided the patients into two groups; the first group (n=106) included patients with no DeVega failure at six-months follow-up (The sustained repair group). The second group included 34 patients who developed moderate or higher TR after the DeVega and was named the failed repair group.

Preoperative, operative and postoperative variables were extracted and recorded. We compared the need for pacemaker, liver or kidney dysfunction, dysrhythmia, prolonged need for inotropes, re-exploration, and bleeding between groups. We assessed the postoperative NYHA class and performed transthoracic echocardiography evaluation (TTE) before the operation, pre-discharge, and six-month postoperative for all patients. The degree of TR, ejection fraction (EF), left ventricular end-diastolic dimension (LVEDD), the left atrial dimensions (LAD), systolic pulmonary artery pressure (SPAP), and right ventricular dimensions (RVD) were registered and compared.

Surgical technique:

All patients had surgery through conventional sternotomy. We initiated the cardiopulmonary bypass via aorto-bicaval cannulation. Myocardial protection was maintained with intermittent antegrade blood cardioplegic solution and topical cooling every 28-35 minutes interval. Surgical exposure of the mitral valve was achieved through left atriotomy incision in the Waterston groove. The mitral valve was replaced with a mechanical prosthesis with the preservation of the posterior leaflet in most cases.

Tricuspid Annuloplasty (DeVega):

After aortic de-clamping, an oblique right atriotomy was done after snaring the cavae. Then, the DeVega annuloplasty technique was used for tricuspid valve repair. The posterior and the anterior parts of the annulus were plicated using 3-0 polypropylene or 2-0 polyester double-armed with a purse-string suture. The bites were nearly 5

mm in length and 3 mm in depth, leaving 5 mm between bites. A second Teflon was passed onto the free ends of the suture. The suture was tightened down over a sizer of 27-29 mm and, after that, hardly admitting two fingers. We tested the repair to confirm that no residual regurgitation before closing the right atrium (Figure 1 and 2). and Trans-esophageal echocardiography (TEE) assessment was done by the anesthetist after coming off bypass.

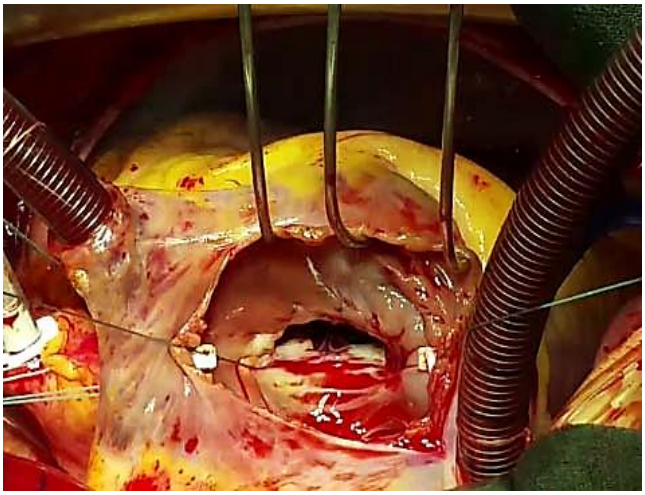

Figure 1: Placement of the first raw of the suture through the tricuspid annulus

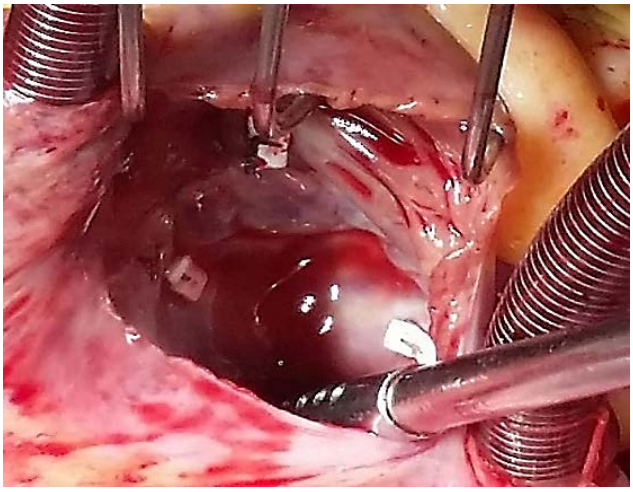

Figure 2: Saline testing and ballooning of tricuspid valve leaflets after repair

Statistical analysis:

We used the IBM SPSS statistical software version 20.0 (IBM Inc., Armonk, NY, USA) to perform the final results. The used tests were unpaired student's "t" tests; for quantitative values and the chi-square (x2) test or Fisher exact test for qualitative values. Quantitative data were expressed as the means ± standard deviation, and qualitative data were expressed as numbers and proportions. The statistical difference was considered significant if the p-value was < 0.05.

Results

Preoperative data:

The study group consisted of 140 patients. Patients' demographic and preoperative clinical data, NYHA class, and TR's degree were presented in Table 1, with no statistically significant difference between both groups. There were statistically significant differences between both groups regarding the preoperative rhythm and echocardiographic parameters (SPAP and the RV size) (Table 1).

Operative and postoperative data:

There was no statistically significant difference regarding the total bypass, cross-clamp times, operative complications, intensive care unit (ICU), hospital stay, and postoperative complications (Table 2). In the sustained repair group, 32 (30.2%) patients had trivial and mild TR, while in the failed repair group, 22 (64.7%) cases had mild TR, and 12 (35.3%) cases had moderate TR. Although the difference in other echocardiographic data was non-significant, the mean SPAP was significantly higher in the second group (66.31 ± 3.4 versus 38.5 ± 6.4 mmHg; p-value = 0.013).

The six-months follow-up:

The six-months postoperative follow-up NYHA class and echo assessment of the degree of TR and other echo data were presented in Table 3. In the failed repair group, 88.2% of patients had severe TR, which accounts for 21.4% of the patients' total number. The echo parameters were not significantly different regards the LV function or dimensions. The SPAP was higher in the second group (49.03±2.8 mmHg) versus 30.8±1.3 mmHg for the first group with a p-value < 0.001. The RV dimensions were also significantly different, with a p-value of 0.02. Regarding the NYHA class, we found 35.3% of the failed repair group with NYHA classes III and IV, while only 11.3% of the sustained repair group in these classes with p-value < 0.001.

Predictors of DeVega failure:

We compared the preoperative, operative, and postoperative data to determine the factors related to DeVega repair's failure at the follow-up period. We have compared these values of the failed repair group to those with sustained repair.

Table 1: Preoperative data. Continuous variables were presented as mean and SD and categorical variables as number and percentages

Preoperative Data	Sustained repair group (N=106)	Failed repair group (N=34)	P-value
Age (years)	43.1 ± 5.1	45.4 ± 6.71	0.847
Female	58 (54.7%)	20 (58.8%)	0.064
Body surface area (m2)	2.02	1.93	0.062
Smoking	28 (26.4%)	10 (29.4%)	0.071
Diabetes mellitus	32 (33.2%)	12 (35.3%)	0.416
Preoperative AF	73 (68.9%)	30 (88.2%)	0.027
Time between indication of surgery & operation (months)	8.3 ± 3.1	14.7 ± 5.4	0.003
NYHA Class			
Class I	18 (17 %)	4 (11.7%)	0.148
Class II	38 (35.8%)	10 (29.4%)	
Class III	40(37.7%)	14(41.1%)	
Class IV	10(9.4%)	6 (17.6%)	
TR Grade			
Mild to moderate	16(15.1%)	4(11.8%)	0.72
Moderate	42(39.6%)	14(41.2%)	
Severe	48(45.3%)	16(47.1%)	
Echocardiographic parameters			
Ejection fraction (%)	64.3±4.7	66.2±3.6	0.15
LAD (cm)	5.7±0.63	5.9±0.42	0.136
LVEDD (cm)	5.6±0.72	5.3±0.43	0.581
SPAP (mmHg)	64.8±3.6	81±6.5	0.02
RVD (cm)	4.85±0.24	5.23±0.37	0.03

AF: atrial fibrillation; LAD: left atrial dimensions; LVEDD: left ventricular end-diastolic diameter; NYHA: New York Heart Association; RVD: right ventricular diameter; SPAP: systolic pulmonary artery pressure; TR: tricuspid regurgitation

Logistic regression analysis was used to identify the independent predictors of DeVega failure (Table 4). The predictors were the persistence of severe pulmonary hypertension after surgery, the presence of preoperative heart failure signs, and the prolonged time between the indication of surgery and the time of operation.

Discussion

The debate among cardiac surgeons continues in terms of indication, timing, and the recommended surgical technique for TV repair. Recent studies have demonstrated that uncorrected significant FTR can worsen early and late outcomes due to TR and right-sided heart failure progression [4]. Therefore, it is recommended to treat FTR at the time of left-sided valve surgery. The reported progression rate of trivial or mild FTR after successful mitral valve operation to moderate to severe FTR varies between 7.7% and 33.7% [5]. Moderate tricuspid regurgitation occurred in 12 (8.6%) of our cohort early after surgery and moderate or severe in 34 (24.3%) after six months. Some cases had a recurrent regurgitation with worse functional status, while others developed higher grades than the preoperative status.

Observational data suggest that more than 85% of patients with tricuspid annuloplasty for FTR become free from moderate or severe insufficiency at their 10- year follow-up, compared with less than one-half of those patients who underwent isolated mitral valve surgery [5]. The 2012 European Society of Cardiology/European Association for Cardio-Thoracic Surgery

Table 2: Operative and postoperative data. Continuous variables were presented as mean and SD and categorical variables as number and percentages

Variables	Sustained repair group (N=106)	Failed repair group (N=34)	P-value
Cross clamp time (min)	71.3 ± 6.2	68.20 ± 9.4	0.075
Total bypass time (min)	89.3 ± 7.6	96.7 ± 8.5	0.07
Mechanical ventilation time (hours)	17.5 ± 5.4	15.3 ± 3.1	0.062
Total ICU stay time (hours)	50.3 ± 4.2	47.2 ± 6.4	0.674
Rapid atrial fibrillation	46 (43.4%)	16 (47.1%)	0.054
Transient Heart block	12 (11.3%)	4 (11.7%)	0.8
Bleeding > 600ml	14 (13.2%)	4 (11.7%)	0.470
Exploration	10 (9.4%)	2 (5.8%)	0.06
Transient renal dysfunction	6 (5.66%)	2 (5.8%)	0.8
Prolonged inotropic support	12 (11.3%)	6 (17.6%)	0.07

(ESC/EACTS) and 2014 ACC/AHA guidelines strongly encourage the surgical correction of less than severe FTR if the tricuspid annular dilation is greater than 40 mm in patients undergoing left-sided valve surgery [6,7]. Furthermore, Frater pointed out that TR is dynamic, and previously moderate or severe TR may appear only mild in the operative room, and repair is recommended if there are prior episodes of right heart failure [8].

At least 56% of patients with mitral stenosis and moderate tricuspid regurgitation are more likely to have NYHA class III or IV before mitral valve surgery [9]. There was no statistically significant difference regarding the preoperative NYHA classification between our groups. Choi and colleagues also reported the same results regarding NYHA classification in their study [10].

Table 3: Postoperative TR grade and other echo parameters at six months in both groups. Continuous variables were presented as mean and SD and categorical variables as number and percentages.

Variables	Sustained repair group (N=106)	Failed repair group (N=34)	P-value
TR grade			
No or Trivial	3 (2.8%)	0	< 0.001
Mild	103 (97.2%)	0	
Moderate	0	4 (11.76%)	
Severe	0	30 (88.2%)	
Echocardiography			
Ejection fraction (%)	63.1±3.67	62.8±3.6	0.84
LAD (cm)	5.1±0.51	5.3±0.42	0.87
LVED (cm)	4.91±0.45	5.4±0.43	0.07
SPAP (mmHg)	30.8±1.3	49.3±2.8	< 0.001
RVD (cm)	4.05±0.15	4.71±1.23	0.02
NYHA class			
class I	54 (50.9%)	10 (29.4 %)	< 0.001
class II	40 (37.7%)	12 (35.3%)	
class III	10 (9.4%)	8 (23.5 %)	
class IV	2 (1.9%)	4 (11.8%)	

LAD: left atrial dimensions; LVEDD: left ventricular end-diastolic diameter; NYHA: New York Heart Association; RVD: right ventricular diameter; SPAP: systolic pulmonary artery pressure; TR: tricuspid regurgitation

Table 4: Multivariable logistic regression for the predictors of DeVega failure

	OR	P-value	95% CI for OR	
			Lower	Upper
Heart failure signs	15.365	0.003	2.559	92.261
Preoperative AF	2.320	0.401	0.326	16.499
Preoperative dilated RV	2.871	0.235	0.505	16.336
Prolonged time between the indication of surgery and the time of operation	12.314	0.007	2.123	84.675
Preoperative severe SPAP	.673	0.717	0.079	5.753
Postoperative severe SPAP	24.741	0.003	3.067	199.556

The preoperative echocardiographic parameters in our study group revealed that the mean EF in the sustained repair group was 64.3±4.7%, and 66.2±3.6% in the failed repair group. Others reported lower EF than our study [9]. The preserved function in our study may be explained by that rheumatic mitral stenosis protects left ventricular function, and our cohort does not include any patient with other cardiac diseases as ischemia or aortic valve pathology. The LVEDD and LAD were non-significant between both groups.

The SPAP and the right ventricle dimensions were significantly different between both groups. The SPAP was higher in the failed repair group and was associated with more dilated RV than the sustained repair group. In contrast to Pradhan's group's study, their patients had PAP of 71.52 mmHg for the DeVega group vs. 48.6 for the non-repair group, and there was no statistical difference at the three-months follow-up in the SPAP or the degree of TR between the two groups [11]. Moreover, Nardi et al. reported SPAP of 60 ± 22 mmHg preoperative vs. 32 ±10 mmHg postoperative, and despite this, they reported 100% freedom of significant TR after one year [12]. This difference may be attributed to the primary pathology and other factors like the rheumatic mitral stenosis and the long time between diagnosis and surgery where the PAP and RV remodeling will be more affected.

Choi's study showed a statistically significant difference regarding the cardiopulmonary bypass time [10]. In contrast, there was no statistically significant difference in our study regarding the cardiopulmonary bypass time or the cross-clamp time in both groups. This difference may be due to our preferred technique in performing TV annuloplasty after removing the cross-clamp.

In our study groups' early postoperative course, there was no statistically significant difference between both groups regarding mechanical ventilation time, ICU complications, and ICU stay period. There was no operative or early postoperative mortality in both groups. Similarly, in Pradhan's, Hoe's, and Nardi's studies, there was no statistically significant difference between both groups regarding the early postoperative morbidity and mortality [11 - 13].

In our study, the immediate postoperative echo assessment of the grade of TR revealed that it was not significant in both groups despite the difference in the mean SPAP, which was significantly higher in the second group (66.31 ± 3.4 versus 38.5 ± 6.4 mmHg). In our study, the rate of freedom of significant TR at the six-months was 75.7%. Choi and colleagues reported 5.1% (9 patients of 174) with the early progression of less than moderate TR to moderate or more severe TR [10]. In Smid's study, there was a significant reduction in the recurrence with reported freedom from significant FTR rate of 77.4% to 100% (follow-up of between 3 and 79 months) [14]. A meta-analysis (of 2488 patients) by Kara and coworkers showed freedom from significant FTR in 77.1% to 100% of patients (n = 773) during follow-up of between 3 and 64.8 months [15].

In the present study, there was a significant improvement of the NYHA functional class at six months postoperatively among both groups compared to the preoperative NYHA class. Despite the statistical difference between both groups, this result indicates that the left-sided lesion's

correction may improve the patient's functional class. Still, there was more improvement in successfully treating the FTR. Kim's study reported the same result regarding the improvement of his patients' functional class [1]. Also, Groves's study reported that patients with functional tricuspid regurgitation after mitral valve replacement have a reduced exercise capacity, maximal oxygen consumption, and anaerobic threshold compared with patients without tricuspid regurgitation, despite having good left ventricular and prosthetic valve function [10]. Despite the relatively high incidence of recurrent tricuspid regurgitation among our patients, they functionally tolerated moderate to severe regurgitation with minimal symptoms. Still, we couldn't accurately co-relate the functional class to right heart failure symptoms and degree of recurrent regurgitation.

The logistic regression analysis revealed that the predictors of tricuspid repair failure in our case series were many factors. The most significant predictor was the persistence of severe pulmonary hypertension after surgery. Preoperative heart failure signs and the prolonged time between the indication of surgery and the operation were also considered predictors for DeVega repair failure. Other predictors included preoperative atrial fibrillation, severe pulmonary hypertension, and dilated RV. Predictors of failure of tricuspid repair in our case series were similar to other published studies. These predictive factors are not exclusive to the DeVega repair. Additional risk factors identified in other studies indicate that atrial fibrillation may cause recurrence, persistent pulmonary hypertension may have affected the suture repair and allowed the annulus to gradually dilate because of right ventricular systolic pressure did not significantly decrease during late follow-up [16,17].

Limitations

This study is retrospective, with all the drawbacks of such studies. We studied only the early outcome, and long-term follow-up is recommended.

Conclusion

Tricuspid suture annuloplasty is associated with some degree of residual or recurrence tricuspid regurgitation. The study of predictors of failure could change our management plans to reach the best results for repair.

Conflict of interest: Authors declare no conflict of interest.

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