



# Pericardiectomy and Postoperative Worsening of Tricuspid Regurgitation -Role of Radical Pericardiectomy

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## Abstract

**Background:** In pericardiectomy for constrictive pericarditis, postoperative worsening of tricuspid regurgitation (TR) is a problem to be considered. It is a focus of attention and there are several case reports and studies concerning this phenomenon.

**Aim:** The aim of this review was to examine available literature with regard to worsening of TR after pericardiectomy in order to clarify its incidence, mechanism, long-term outcome, and preventive measures.

**Results:** About one-third to half of patients experience an increase in TR postoperatively without tricuspid valve intervention. Postoperative right ventricular (RV) dilatation, tricuspid annular dilatation, together with perioperative RV dysfunction play the major role. The preoperative existence of TR increased mortality in large studies, and worsened TR postoperatively had a trend toward reduced survival. Whether tricuspid valve intervention improves outcome or not is still to be determined. At least, this intervention appears protective against long-term mortality. Radical pericardiectomy seems to have the possibility to improve the outcome related to TR than conventional pericardiectomy.

**Conclusions:** The findings of this review can be summarized as: 1. In pericardiectomy for constrictive pericarditis, preoperative TR and its postoperative worsening cannot be ignored. 2. Concomitant tricuspid valve intervention has a tendency toward improved long-term survival and should be considered especially in cases with preoperative TR. 3. Regarding TR, radical pericardiectomy seems to have more benefit than conventional pericardiectomy.

**Keywords:** Pericardiectomy, constrictive pericarditis, tricuspid regurgitation, tricuspid valve intervention, radical pericardiectomy

## Introduction

In 2013, the author (Taguchi S) published a case of conventional pericardiectomy for constrictive pericarditis [1]. In this case, preoperative mild-moderate tricuspid regurgitation (TR) worsened as severe postoperatively. The patient received tricuspid annuloplasty 18 months later. The pathogenesis of worsening TR was assumed to be right ventricular (RV) and tricuspid annular dilatation caused by the relief of pericardial constriction.

Some studies have recently focused on this worsening by referencing the author's report [2-5]. This review aims to warn surgeons planning to cope with constrictive pericarditis by simply trying to treat the pericardium especially by conven-

tional pericardiectomy.

As indicated by Busch C, et al. in 2015, there are two nationwide presentations of pericardiectomy both in 2013 from Japan (346 cases) and USA (13,593 cases) [6-8]. The former had an operative mortality of 10.0% and the latter an in-hospital mortality of 7.5%, although the latter was not limited to pericardiectomy for constrictive pericarditis. We are able to see from these studies that this operation still is highly risky, but neither of them clarified the role of TR for the risk.

## Materials and methods

This review was conducted by literature search and data extraction.

## Literature search

A literature search for relevant articles was conducted using PubMed as the following free words: Pericardiectomy, Tricuspid regurgitation. The search was performed on October 22, 2021, and records identified were 24 publications. Studies that meet the following inclusion criteria were included: clinical retrospective cohort study about pericardiectomy and tricuspid regurgitation. Studies mentioned as references in each article were also included.

## Data extraction and analysis

All data were collected from eligible studies. A single reviewer performed all data extraction to ensure consistency across the studies. Full-text reviews related to pericardiectomy, tricuspid regurgitation, and method of operation were performed. The studies included in this review are summarized in a table (Table 1).

## Statistical analysis

All the studies described the method of statistical analysis in their articles. A meta-analysis was not performed to unify the studies in this review due to the possibility of counting the patients doubly or triply from the same institutions.

## Results

Results of the analysis led the author (Taguchi S) to focus on seven subjects. They are preoperative TR, increase in TR following operation, mechanism of increase, mortality regarding TR, right ventricular dysfunction, simultaneous tricuspid valve intervention, and radical pericardiectomy.

## Preoperative TR

Calderon-Rojas R, et al. of Mayo Clinic indicated that about half of the patients were complicated with TR grade mild or more preoperatively [2,9]. Their study in 2018 reviewed records of 450 patients who underwent pericardiectomy for constrictive pericarditis and their baseline transthoracic echocardiography grade of TR were none/trivial in 51%, mild in 38%, and moderate/severe in 10% of patients [9]. Their study in 2020 reviewed the records of 518 patients [2]. Again their preoperative TR were none/trivial in 53%, mild in 37%, and moderate/severe in 10% of patients.

Tabucanon RS, et al. of Cleveland Clinic indicated in 2021 that about 40% of the patients were complicated with TR grade mild or more preoperatively [5].

The study by Mantri RR, et al. in 1993 analyzed 33 surgical cases [10]. In their study, 52% of patients were involved in TR grade mild or more. There were no preoperative clinical or hemodynamic predictors for the incidence or severity of the regurgitations.

## Increase in TR following operation without tricuspid valve intervention

The Mayo Clinic group in 2018 concluded that about one-third of patients experienced an increase in TR following operation [9]. In the study by the same group in 2020, counting the numbers of patients with TR at discharge compared to preoperative data, again about 35% of patients acquired a newly or worse TR [2]. In their studies, cases of concomitant tricuspid valve intervention were excluded.

The Cleveland Clinic group in 2021 published their expe-

**Table 1. Summary of clinical studies or cases.**

First author	(Year)	Institution/Location	Patients	Preop TR	Postop worsened TR	Radical op	Reference
Calderon-Rojas	(2020)	Mayo Clinic	N=518	47%	36%	67%	[2]
Calderon-Rojas	(2018)	Mayo Clinic	N=450	48%	35%	NR	[9]
Tabucanon	(2020)	Cleveland Clinic	N=401	NR	NR	NR	[14]
Tabucanon	(2021)	Cleveland Clinic	N=381	40%	51%	82%	[5]
Calderon-Rojas	(2021)	Mayo Clinic	N=310	35%	NR	70%	[16]
Gongora	(2008)	Mayo Clinic	N=261	20%	NR	standard	[17]
Tariq	(2015)	Cleveland Clinic	N=141	NR	NR	NR	[13]
Kumawat	(2018)	Varanasi, India	N=109	NR	NR	76%(left ant-lat)	[4]
Busch	(2015)	Leipzig, Germany	N=97	NR	NR	55%	[6]
Choi	(2019)	Seoul, Korea	N=90	5.6%	15.6%	59%	[3]
Senni	(1999)	Mayo Clinic	N=58	NR	NR	90%	[18]
Mantri	(1993)	Lucknow, India	N=33	52%	NR	NR	[10]
Johnson	(1993)	Akron City Hospital	N=2	N=2	N=2	none	[11]
Nakamura	(2008)	Osaka University	N=1	N=1	N=1	none	[21]
Taguchi	(2013)	Kawasaki, Japan	N=1	N=1	N=1	none	[1]

Percentage indicates frequency.

ant-lat: anterolateral thoracotomy, N: numbers, NR: not reported, op: operative/operation, TR: tricuspid regurgitation

riences of 381 pericardiectomy patients without tricuspid valve surgery. Among this cohort, worsened postoperative TR made up 193 (50.7%) patients [5].

There are several case reports of postoperative increase of TR [1,11]. Johnson TL, et al. reported two cases of postoperative TR increase in 1993 [11]. They demonstrated the importance of determining tricuspid valvular function prior to pericardiectomy. In their patients, severe TR was detected each on postoperative days 5 and 40, whereas in the case reported by the author (Taguchi S) in 2013, postoperative severe TR was detected on postoperative day 17 [1].

### **Mechanism of increase in TR without tricuspid valve intervention**

In the author's case presentation of 2013, it was concluded the etiology of marked increase in TR was thought to be the dilatation of the right chambers with annular dilatation of the tricuspid valve [1]. It is the same mechanism as what others mention in their reports.

Back in 1993, Johnson TL et al. described that TR deterioration postoperatively was a result of RV dilatation [11].

Conventionally, an anterior excision of the pericardium between the phrenic nerves, and the inferior pericardium is performed. This primarily relieves the surface of the right chambers and some of the left chambers, which may lead to tricuspid annular dilatation and TR increase [1].

Yu HT, et al. reported a case of transient RV dysfunction after pericardiectomy [12]. Although the role of TR is not mentioned clearly, RV dysfunction together with dilatation may be the basal factor for an eventful clinical course.

Tariq MU, et al. from the Cleveland Clinic reported a series of pericardiectomy [13]. Worsening TR was associated with a significant increase in tricuspid annular size and decrease in annular velocity. They concluded that the worsening was a result of RV dilatation post operatively with the removal of the rigid pericardium.

Tabucanon R, et al. from the Cleveland Clinic reported another series of pericardiectomy [14]. In multivariable analysis, the only independent predictor identified for the worsening TR was preoperatively reduced RV fractional area change (FAC), highlighting the importance of right ventricular function.

### **Mortality regarding TR**

In the studies of the Mayo Clinic group in 2018 and 2020, they demonstrated that patients with preoperative mild or moderate/severe TR had increased risk of mortality compared to patients with none/trivial TR [2,9].

Also, Choi MS, et al. demonstrated that late mortality was associated with preoperative grade of TR in their cohort of 90 patients including conventional and radical pericardiectomy [3].

Regarding postoperative worsening of TR, the Cleveland Clinic group studied the long-term mortality [5]. Although not significant ( $P=0.08$ ), worsened TR was associated with a trend toward lower survival during follow-up. Especially

the subgroup of worsened TR which showed no recovery of TR within the first year post operatively had a significantly ( $P=0.02$ ) worse survival than the postoperatively same / better TR group.

### **Right ventricular dysfunction**

Unai S, et al. of the Cleveland Clinic think that functional TR is seen in RV dysfunction and dilatation, which will get worse when the constriction is released and the RV and the tricuspid annulus further dilate [11,15].

In the more recent study from the Cleveland Clinic, reduced preoperative RV FAC was the factor strongest associated with postoperatively worsened TR, although not evident for mortality [5].

In the studies from the Mayo Clinic, reduced baseline and postoperative RV function was associated with an increased hazard of long-term mortality [16]. Patients who underwent tricuspid valve operation were 11 times more likely to have less than moderate TR vs moderate or severe, and 1.5 times more likely to have less than moderate RV enlargement vs moderate or severe. However tricuspid valve operation was also associated with an increased risk of RV dysfunction grade. Therefore, restoration of tricuspid valve competence does not appear to translate into an immediate benefit of RV function.

### **Simultaneous tricuspid valve intervention**

In the studies of the Mayo Clinic group in 2008, Gongora E, et al. evaluated 261 cases of constrictive pericarditis [17]. Among those with moderate/severe TR, operative mortality was similar whether or not repair was undertaken, and late survival was not impacted. Their standard pericardial resection was radical in nature.

In the studies of the Mayo Clinic group in 2018 and 2020, Calderon-Rojas R et al. commented that further study is warranted to determine if tricuspid valve intervention improves outcome [2,9]. In their very recent study of 2021, tricuspid valve intervention resulted in a reduced risk of long-term mortality, but the Kaplan-Meier estimate of survival did not differ between the tricuspid valve operation and no operation groups [16]. Their conclusion was to express that concomitant tricuspid valve operation appears protective against long-term mortality. They used radical pericardiectomy in 70% of cases.

Busch C, et al. studied their 97 consecutive patients [6]. They performed tricuspid valve repair in 39.2% of their patients. Comparing long-term mortality of pericardiectomy with or without the repair, the mortality without repair was 51.5% compared with 31% with repair ( $P=0.07$ ). Although not statistically significant, concomitant repair appeared to provide protective effect on the long-term survival. They used radical pericardiectomy in 55% of cases.

### **Role of radical pericardiectomy**

In the studies of Choi MS, et al. based on 90 patients, RV systolic pressure decreased, and pericardial thickening resolved only

in the radical pericardiectomy group [3]. Also, TR worsened after the operation more in the conventional group, and it improved over time in the radical group. Conventional pericardiectomy removed the anterior and diaphragmatic pericardium anterior to the phrenic nerves. Radical pericardiectomy additionally removed the pericardium posterior to the phrenic nerves to see the coronary sinus or pulmonary veins. Their early mortality rate was 4.4% (4/90), and all belonged to the conventional group.

Kumawat M, et al. reported their results of 109 cases in which 83 cases were performed by a left anterolateral thoracotomy enabling them to dissect the lateral and posterior walls of the LV, and diaphragmatic aspect easier [4]. Their mortality was in 2 patients only. They state that the initial hemodynamic and clinical result may not always be dramatic but continued improvement is definite because of progressive enlargement of LV dimensions.

Similarly, Senni M, et al. state that after pericardiectomy by radical pericardiectomy in 90% of cases, initial clinical and hemodynamic responses are not always dramatic and continued improvement may occur over many months [18]. This is consistent with the fact that LV dimension progressively increased, whereas systolic function remained stable.

In the studies from the Cleveland Clinic, pericardiectomy technique was not associated with worsening TR, so they continue to recommend the radical approach when indicated given improved survival and functional outcomes and lower recurrence risk than partial pericardiectomy [5].

Unai S, et al. describe the method of radical pericardiectomy in detail [15]. They describe that a unique complication following partial pericardiectomy is that severe constriction is released, and the RV is suddenly volume loaded prior to the release of LV constriction. This results in severe postoperative condition.

## Comment

From the descriptions mentioned above, the general concept of TR regarding constrictive pericarditis and pericardiectomy can be summarized. Roughly, the incidence of mild TR or more is in about half cases preoperatively. In a large study cohort, about one-third to half of patients experience an increase in TR postoperatively without tricuspid valve intervention. The mechanisms of the increase are dilatation of the right chambers and tricuspid annulus acquired by the relief of pericardial constriction. Also, RV dysfunction plays a certain role in the clinical course. Preoperative TR increased mortality in large studies and postoperative worsening of TR a trend toward lower survival. However, whether tricuspid valve intervention improves outcome or not is still to be determined. There is a certain role for radical pericardiectomy enabling the release of LV constriction together with RV.

Mitral regurgitation (MR) may worsen after pericardiectomy in the same manner [1,10]. If one is to compare the situation with MR, there are cases in which MR after pericardiectomy

subsided due to compensation and did not require reoperation [19,20]. On the other hand, there is a case report of severe MR postoperatively that required surgical management after pericardiectomy [21]. Similarly, the possibility exists that the worsened TR might regress further in the time course or requires re-intervention [1,3]. As a matter of fact, concomitant worsened TR together with MR was operated on in the latter case [21].

One important factor in thinking about post operative increase of TR is the method of pericardiectomy whether radical or conventional. This is due to the importance of post operative dilatation of the LV not only the RV. The post operative merits of relieving both the LV and RV are that in almost all cases, elasticity of the ventricles returns with total pericardiectomy; LV and RV end-diastolic pressures normalize; ventricular interdependence reduces [4]. All or part of these merits can be achieved by trying to relieve the constriction of both LV and RV.

Tricuspid annular intervention can easily be achieved by cardiac surgeons if cardiopulmonary bypass (CPB) is used. Radical pericardiectomy via median sternotomy performed under CPB with concomitant tricuspid valvular intervention is a method to be considered especially in cases with more than moderate preoperative TR [15].

## Conclusions

In pericardiectomy for constrictive pericarditis, postoperative worsening of TR is a problem to be considered. Postoperative RV dilatation, tricuspid annular dilatation, together with perioperative RV dysfunction play the major role. Even in large studies, whether tricuspid valve intervention improves outcome or not is still to be determined. Radical pericardiectomy which also relieves LV constriction seems to have the possibility to improve the outcome related to TR than conventional pericardiectomy.

## Competing interests

The author declares that he has no competing interests.

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## References

1. Taguchi S, Ishida O, Mori A and Suzuki R. Pericardiectomy for constrictive pericarditis with postoperative increase of tricuspid regurgitation. *Cardio Vasc Syst.* 2013;1:9. Available at: [www.hoajonline.com/cardiovascsyst/2052-4358/1/9](http://www.hoajonline.com/cardiovascsyst/2052-4358/1/9)
2. Calderon-Rojas R, Greason KL, King KS, Oh JK, Stulak JM, Daly RC, Dearani JA and Schaff HV. Tricuspid valve regurgitation in patients undergoing pericardiectomy for constrictive pericarditis. *Semin Thorac Cardiovasc Surg.* 2020;32:721-8.
3. Choi MS, Jeong DS, Oh JK, Chang SA, Park SJ and Suryeun C. Long-term results of radical pericardiectomy for constrictive pericarditis in Korean population. *J Cardiothorac Surg.* 2019;14:32.

4. Kumawat M, Lahiri TK and Agarwal D. Constrictive pericarditis: retrospective study of 109 patients. *Asian Cardiovasc Thorac Ann.* 2018;26:347-52.
5. Tabucanon RS, Wang TKM, Chetrit M, Furqan MM, Chan N, Pande A, Jellis CL, Cremer PC, Kwon DH, Johnston D and Klein AL. Worsened tricuspid regurgitation following pericardiectomy for constrictive pericarditis. *Circ Cardiovasc Imaging.* 2021;14:e012948.
6. Busch C, Penov K, Amorim PA, Garbade J, Davierwala P, Schuler GC, Rastan AJ and Mohr FW. Risk factors for mortality after pericardiectomy for chronic constrictive pericarditis in a large single-centre cohort. *Eur J Cardiothorac Surg.* 2015;48:e110-6.
7. Tokuda Y, Miyata H, Motomura N, Araki Y, Oshima H, Usui A, Takamoto S and The Japan Adult Cardiovascular Database. Outcome of pericardiectomy for constrictive pericarditis in Japan: A nationwide outcome study. *Ann Thorac Surg.* 2013;96:571-6.
8. Gopaldas RR, Dao TK, Caron NR and Markley JG. Predictors of in-hospital complications after pericardiectomy: A Nationwide outcome study. *J Thorac Cardiovasc Surg.* 2013;145:1227-33.
9. Calderon-Rojas R, Greason KL, Oh JK, Maltais S, Crestanello J, Bagameri G, Cicek S, Said S, Stulak J, Daly R, Pochettino A and Schaff HV. Tricuspid valve regurgitation in patients with constrictive pericarditis. *Eur Heart J.* 2018;39:Issue suppl\_1, P4582.
10. Mantri RR, Radhakrishnan S, Sinha N, Goel PK, Bajaj R and Bidwai PS. Atrio-ventricular regurgitations in constrictive pericarditis: incidence and post-operative outcome. *Int J Cardiol.* 1993;38:273-9.
11. Johnson TL, Bauman WB and Josephson RA. Worsening tricuspid regurgitation following pericardiectomy for constrictive pericarditis. *Chest.* 1993;104:79-81.
12. Yu HT, Ha JW, Lee S, Shim CY, Moon J, Cho IJ, Kang MK, Yang WI, Choi D and Chung N. Transient right ventricular dysfunction after pericardiectomy in patients with constrictive pericarditis. *Korean Circ J.* 2011;41:283-6.
13. Tariq MU, Aman W, Karwa A, Benatti R and Klein A. Right ventricular dilatation post pericardiectomy causes tricuspid regurgitation. *J Am Coll Cardiol.* 2015;65:10S,A1315.
14. Tabucanon R, Wang TKM, Chetrit M, Furqan M, Verma BR, Simsolo E, Johnston D and Klein A. Predictors of worsening tricuspid regurgitation following pericardiectomy for constrictive pericarditis. *J Am Coll Cardiol.* 2020;75:11S,1759.
15. Unai S and Johnston DR. Radical pericardiectomy for pericardial diseases. *Curr Cardiol Rep.* 2019;21:6.
16. Calderon-Rojas RD, Greason KL, King KS, Luis SA, Oh JK, Stulak JM, Daly RC, Dearani JA and Schaff HV. Outcomes of tricuspid valve operation at the time of pericardiectomy for constrictive pericarditis. *Ann Thorac Surg.* 2021;111:1252-7.
17. Gongora E, Dearani JA, Orszulak TA, Schaff HV, Li Z and Sundt TM. Tricuspid regurgitation in patients undergoing pericardiectomy for constrictive pericarditis. *Ann Thorac Surg.* 2008;85:163-71.
18. Senni M, Redfield MM, Ling LH, Danielson GK, Tajik AJ and Oh JK. Left ventricular systolic and diastolic function after pericardiectomy in patients with constrictive pericarditis: Doppler echocardiographic findings and correlation with clinical status. *J Am Coll Cardiol.* 1999;33:1182-8.
19. Buckingham RE, Jr, Furnary AP, Weaver MT, Floten HS and Davis RF. Mitral insufficiency after pericardiectomy for constrictive pericarditis. *Ann Thorac Surg.* 1994;58:1171-4.
20. Terada Y, Mitsui T and Yamada S. Mitral regurgitation after pericardiectomy for constrictive pericarditis. *Jpn J Thorac Cardiovasc Surg.* 1999;47:27-30.
21. Nakamura T, Masai T, Yamauchi T, Higuchi T, Ito H, Toyoshima Y and Sawa Y. Successful surgical management for severe mitral regurgitation unmasked after pericardiectomy for chronic constrictive pericarditis. *Ann Thorac Surg.* 2008;86:1994-6.

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