Int J Clin Exp Med 2016;9(11):22062-22068
www.ijcem.com /ISSN:1940-5901/IJCEM0038891

Original Article

Effects of mitral valve replacement concomitant with tricuspid annuloplasty on mild tricuspid valve insufficiency

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Received August 27, 2016; Accepted September 19, 2016; Epub November 15, 2016; Published November 30, 2016

Abstract: Objective: To investigate the long-term influence of mitral valve replacement (MVR) concomitant with tricuspid annuloplasty (TAP) on mild tricuspid valve insufficiency (TVI). Methods: Select 100 patients of mitral valve lesions associated with mild of functional tricuspid valve insufficiency (TVI) from January 2013 to December 2015 in our hospital, divide them into the MVR group (50 cases) and MVR+TAP group (50 cases) randomly, then record the general information and intraoperative extracorporeal circulation data of patients. Use echocardiography to evaluate patients and compare the relevant information before operation and 2-year follow-up after operation, observing the tricuspid valve annular end-systolic dimension (TVAESD), tricuspid valve annular end-diastolic dimension (TVAEDD), tricuspid annular plane systolic excursion (TAPSE), right ventricular ejection fraction (RVEF), and right ventricular fractional area change (RVFAC). At the same time, compare perioperative mortality, 2-year survival rate, improvement of cardiac function and proportion of degree of TVI in two groups of patients. Results: After 2 years' follow-up, the TVAEDD and TVAESD indexes of patients in MVR+TAP group were significantly less than those of MVR group, while RVFAC and RVEF were significantly higher than those of MVR group; the proportion of degree of TVI and improvement of cardiac function of patients in MVR+TVP group were significantly better than that of patients in MVR group; the 2-year survival rate of patients in MVR+TVP group was significantly higher than that of MVR group, and the above differences were statistically significant ($P < 0.05$). Conclusion: For patients with mild TVI, mitral valve replacement concomitant with tricuspid annuloplasty can help the recovery of right ventricular function and tricuspid valve function, and thus it is beneficial to reduce the TVI which occurs after MVR in long term.

Keywords: Mitral valve replacement (MVR), tricuspid annuloplasty (TAP), tricuspid valve insufficiency

Introduction

Mitral valve disease is the most common disease in mitral valve lesions, and among the patients with mitral valve lesions, there are about 50-60% with varying degrees of TVI [1, 2]. It is really common that TVI with exacerbation and residues after mitral valve replacement will happen. The development of TVI is slow, which will result in cardiomegaly gradually and affect the right ventricular function, leading to a congestion of systemic circulation. At present, the drug treatment of TVI is with low cure rate, long cycle and high recurrence rate. The long-term prognosis of these patients after MVR has been severely affected by the TVI [3, 4].

At present, for the functional TVI which is the subsequence from mitral valve lesions, surgical treatment is an ideal choice. But there is controversy about the choice of the time of surgery for the treatment of tricuspid valve. There exists the same opinion on treatment for mitral valve concomitant with severe TVI [5, 6]. But there are different opinions on the treatment for mitral valve concomitant with moderate TVI [7, 8]. European and American cardiology guidelines do not mention functional mild TVI. This study is to observe the effect of mild TVI in patients undergoing MVR concomitant TAP, to explore whether TAP can help prevent recurrence and progression of TVI and improve the prognosis of patients or not, and consequently, to provide experimental evidence for the clini-

cal decision of MVR concomitant with tricuspid.

Materials and methods

General information

100 patients treated in our hospital during January 2013 to December 2015 were selected. They had mitral valve lesions with mild functional TVI. Inclusion criteria: Patients who had mild TVI (echocardiography results suggest that the area of regurgitation ≤ 4 cm^2), were followed up for 2 years and with insignificant signs as well as symptoms of TVI and insignificant right ventricular dysfunction; MVR indications for surgery; exclusion criteria: Patients who had multiple organ failure (MOF), organic TVI, more than moderate TVI, and without other heart disease. The patients were randomly divided into MVR group and MVR+TAP group; there are 50 patients in MVR group, including 23 males and 27 females, with average age of (47.8±6.5) years; 50 patients in MVR+TAP group, including 25 males and 25 females, with average age of (46.6±5.7) years. There was no significant difference in preoperative clinical data, and it was comparable ($P > 0.05$). In this study, all patients signed informed consent form and it was approved by the hospital ethics committee.

Operation methods

Two groups of patients took conventional preoperative preparation and performed MVR. Patients were with median sternotomy incision, cut the pericardium and exposed heart. The ascending aorta, superior and inferior vena cava were applied with cannula to establish extracorporeal circulation with mild hypothermia, block blood supply of ascending aorta, intermittent cold blood cardioplegia perfusion for myocardial protection. Through the right atrium and atrial septal incision, mitral valve was exposed and cut off. After the area of the annulus was measured, double needle with a gasket continuous suture was applied to implant the corresponding artificial mitral valve, determining the artificial accurate implantation, ligation, inspection and washing cardiac chambers, and atrial septal incision was sutured. MVR+TAP group of patients underwent different operative methods of TAP after cardiac resuscitation, according to the characteristics of TVI: DeVega surgery or Carpentier ring fixation. After the satisfactory water injection test, conventionally exhaust, open systemic circulation, and close the right atrium incision. Reduce blood flow to the removal of extracorporeal circulation gradually. After hemostasis, place pericardial mediastinal drainage tube and close chest incision. The patients were sent into cardiac care unit after the surgery and recorded extracorporeal circulation information in surgery.

Efficacy index

Philips 7500 color ultrasound diagnostic apparatus which was with the probe frequency of 2.5 MHz adopted to performed the transthoracic echocardiography.

Dimensional echocardiographic apical four-chamber view measurements: right ventricular end-systolic area (RVESA); right ventricular end-diastolic area (RVEDA), tricuspid valve annular end-systolic dimension (TVAESD), tricuspid valve annular end-diastolic dimension (TVAEDD), tricuspid annulus plane systolic excursion (TAPSE). Calculate right ventricular fractional area change (RVFAC): RVFAC = (RVEDA-RVESA)/RVEDA × 100%.

Echocardiography was used to examine the degree of TVI: it was determined through the ratio of tricuspid valve maximal regurgitation jets area (mRJA) and right atrial area (RAA). The degree of TVI was graded as non-regurgitation, mild, mild-to-moderate, moderate, moderate-to-severe and severe according to the size of the ratio.

The echocardiography of the right ventricular ejection fraction (RVEF): calculate right ventricular end systolic volume (3DRVESV) and right ventricular end diastolic volume (3DRVEDV) through the reconstruction of the image software, RVEF = (3DRVEDV-3DRVESV)/3DRVEDV × 100%.

Record the perioperative mortality, 2-year survival rate and the improvement of the cardiac function graded by NYHA classification (grade I, II, III and IV) in two groups of patients 2 years after surgery.

Statistical treatment

SPSS12.0 software was adopted to deal with experimental data, measurement data was

Table 1. Comparison of intraoperative indicators of patients in two groups

Indicators	MVR+TAP group	MVR group
Extracorporeal circulation time (min)	105.41±25.24	99.52±26.82
Operation time (min)	200.73±36.61	193.92±30.82
Ascending aorta interrupting time	70.87±21.71	66.21±24.28
The lowest temperature of the nasopharynx after the interruption (°C)	28.16±1.38	28.27±1.78

Table 2. Comparison of two groups of patients with preoperative and postoperative right ventricular fraction area change and tricuspid function

Group	Time	TVAEDD (mm)	TVAESD (mm)	TAPSE (mm)	RVFAC (%)
MVR group	Before operation	32.92±4.6	26.4±3.4	10.84±5.8	38.81±10.4
	2 years after surgery	35.32±3.5*	29.37±3.5*	14.11±4.1	42.61±11.2
MVR+TAP group	Before operation	33.79±4.0	27.1±4.3	11.21±6.0	35.92±9.7
	2 years after surgery	29.76±4.7*,#	26.68±4.4#	13.49±4.6	47.52±5.8*,#

Note: with the same group compared with preoperative, *P < 0.05; comparison between two groups after postoperative 2 years, #P < 0.05.

presented by mean ± standard and t test was used for the group comparison; enumeration data was demonstrated by percentage and χ^2 test was applied for the group comparison. P < 0.05 was considered statistically significant.

Results

Comparison of intraoperative indicators and follow-up status in two groups of patients

50 patients in MVR+TAP group completed 2-year follow-up, but there was one lost in MVR group and the rest 49 patients completed it. There was no significant difference between the two groups of patients in the extracorporeal circulation time, operation time, ascending aorta interrupting time and the lowest temperature of nasopharynx after the interruption. It was regarded as no statistical significance (P > 0.05), see **Table 1**.

Comparison of RVFAC, tricuspid valve annular dimension and TAPSE in two groups of patients before operation and 2 years after operation

In MVR+TAP group, the TVAEDD of 2 years after operation was significantly less than that of before operation, and the RVFAC was opposite, with statistically significant difference (P < 0.05); the TVAESD of 2 years after operation had no significant difference compared to pre-operation, without statistically significant difference (P > 0.05). In MVR group, the TVAEDD, TVAESD of 2 years after operation were significantly more than pre-operation, with statistically significant difference (P < 0.05); the RVFAC of 2 years after operation had no significant difference compared to pre-operation, without statistically significant difference (P > 0.05). In 2 years after operation, the TVAEDD and TVAESD of patients in MVR+TAP group were significantly less than MVR group, and the RVFAC was opposite, with statistically significant difference (P < 0.05). In two groups of patients, the TAPSE of 2 years after operation had no significant difference compared to pre-operation, without statistically significant difference (P > 0.05). See **Table 2**.

Comparison of the degrees of TVI of patients in two groups before operation and 2 years after surgery

Two groups of patients had mild TVI preoperatively. 2 years after surgery, the proportion of the degree of TVI in MVR+TAP group is significantly better than that of MVR group, and the difference was statistically significant (P < 0.05). In the MVR+TAP group, there were 35 cases of non-regurgitation, 13 cases of mild, and 2 cases of mild-to-moderate. While in the MVR group, there were 20 cases of non-regurgitation, 21 cases of mild, 3 cases of mild-to-moderate and 6 cases of moderate. In MVR+TAP group, the proportion of the degree of TVI 2 years after surgery was significantly more improved than pre-operation, and there was statistical significance (P < 0.05); in MVR group the proportion of the degree of TVI was more

Table 3. Comparion of the degree of tricuspid regurgitation 2 years after surgery in two groups (example %)

The degree of tricuspid regurgitation	MVR+TAP group	MVR group
Non-regurgitation	35 (70)	20 (40)
Mild	13 (26)	21 (42)
Mild-to-moderate	2 (4)	3 (6)
Moderate	0	6 (12)
Moderate-to-severe	0	0
Severe	0	0

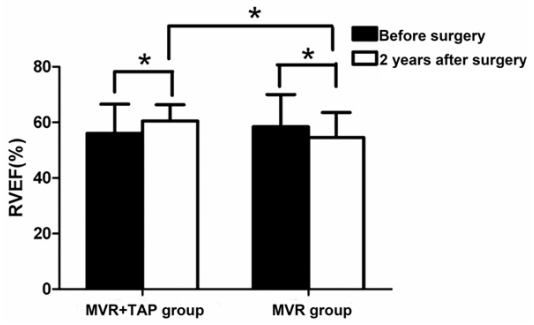

Figure 1. Comparison of right ventricular ejection fraction in two groups of patients, *P < 0.05.

deteriorated, and the difference was statistically significant (P < 0.05). See **Table 3**.

Comparison of right ventricular ejection fraction (RVEF) in two groups of patients

In MVR+TAP group, the RVEF of 2 years after surgery was significantly more increased than of pre-operation ((60.48±5.9)% vs (56.05±10.54)%, (P < 0.05); in MVR group, the RVEF of 2 years after surgery was significantly more decreased than that of pre-operation ((54.59±8.97)% vs (58.42±11.63)%, (P < 0.05)). 2 years after surgery, the RVEF of MVR+TAP group was significantly more increased than that of MVR group, and the difference between the two groups had significant meaning (P < 0.05), as shown in **Figure 1**.

Comparison of cardiac function before operation and 2 years after surgery in two groups of patients

In two groups of patients, the cardiac function NYHA of 2 years after surgery was significantly improved compared with that of pre-operation (P < 0.05). 2 years after surgery, the improvement degree of cardiac function (NYHA classification) of MVR+TAP group was significantly greater than that of MVR group (P < 0.05), as shown in **Table 4**.

Comparison of 2-year survival rate of patients in two groups after surgery

There was no death in MVR+TAP group within perioperative period, and the 2-year survival rate was 97.00% after surgery. There was no death in MVR group within perioperative period either, and the 2-year survival rate was 85.67% after surgery. The 2-year survival rate of MVR+TAP group was significant higher than that of MVR group, with statistically significance (P < 0.05), as shown in **Figure 2**.

Discussion

In recent years, there have been many reports of aortic valve and mitral valve disease, but little study of tricuspid valve [9, 10], which makes tricuspid valve become the “forgotten valves”. Current reports of tricuspid valve mainly focus on the patient’s mortality rate, survival rate, timing of surgery, comparison between different treatment and the factors that affect the TVI [11, 12]; however, there is rare report on clinical research of MVR concomitant with TAP for curing mild TVI. For patients with mitral valve disease and TVI, only dealing with the mitral valve lesions can alleviate cardiac afterload, but can’t improve the expansion of tricuspid valve annulus, alleviate preload or improve right ventricular function, either [13]. European Heart Disease Association and American Heart Association have pointed out that: severe TVI is cured when MVR is performed. Some studies have showed that, regardless of whether patients have the clinical symptoms of TVI or not, as long as they are associated with expansion of tricuspid valve annulus, they should be considered to cure tricuspid valve actively during the treatment of mitral valve surgery [14]. Through the study of follow-up, Nath showed that patients who are concomitant with significant TVI, EF < 50%, pulmonary artery pressure > 40 mmHg, right ventricle expansion or right ventricular dysfunction, were suggested to perform MVR with TAP [15]. Researches as Antunes considered that patients with moderate-to-severe TVI, who had rheumatic heart disease, right heart enlargement, tricuspid valve annulus diameter/body surface area > 21 mm/m^2,

Table 4. Comparison of patients with cardiac function before operation and 2 years after surgery in two groups (example)

Group	Time	NYHA classification			
		Grade I	Grade II	Grade III	Grade IV
MVR group (n = 50)	Before operation	2	7	35	6
	2 years after surgery	25*	17*	7*	1*
MVR+TAP group (n = 50)	Before operation	3	6	36	5
	2 years after surgery	38*,#	9*,#	2*,#	1*

Note: compared with pre-operation in same group, *P < 0.05; compared with the MVR group 2 years after surgery, #P < 0.05.

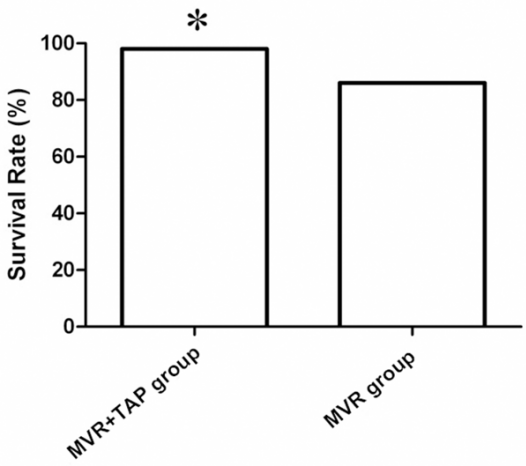

Figure 2. Comparison of the 2-year survival rate after surgery in two groups of patients, *P < 0.05.

right ventricular overload or inferior vena cava dilatation should be underwent TAP [16]. Another study showed that if patients with the expansion of tricuspid valve annulus diameter > 21 mm/m^2, tricuspid valve annulus larger than 3.5 cm prompted by transthoracic echocardiography, intraoperative measurement of the tricuspid valve annulus diameter larger than 70 mm, and rheumatic disease, atrial fibrillation (Af) or implantation pacing lead of tricuspid valve before surgery, there is no need to consider the degree of tricuspid regurgitation, but perform the tricuspid valve replacement and TAP at the same period [17]. Visibly, opinion on whether it's need to deal with the TVI still remains non-unified. In order to clarify these questions better, this study observed the effect of MVR concomitant with TAP on mild TVI.

The results showed that the changes of the right ventricular area and function of patients in MVR+TAP group were better than those of MVR group 2 years after surgery, which was reflected by the fact that the TVAEDD and TVAESD of patients in MVR+TAP group were significantly decreased, while RVEF and RVFAC were significantly increased. In addition, 96% patients in the MVR+TAP group had no regurgitation or mild 2 years after surgery.

Quantitative assessment of right ventricular function is an important indicator of heart disease. In clinical work, special attention is paid to the left ventricular function, and there is rare research on right ventricular function. RVFAC, RVEF and TAPSE are the indicators of clinical evaluation of right ventricular function. RVFAC has been proved to have a good correlation with the right ventricular ejection fraction (RVEF) measured by MRI [18]. In MVR+TAP group, RVFAC of 2 years after operation compared with that of pre-operation had significantly increased; however, in MVR group, RVFAC of 2 years after operation showed no significant difference compared to that of pre-operation, and RVFAC of patients in MVR+TAP group was significantly higher than that of MVR group. This result indicated that it was beneficial for patients who had mild TVI were adopted MVR concomitant with TAP to improve the right ventricular ejection fraction (RVEF) of 2 years after operation. In MVR+TAP group, RVEF of 2 years after operation was noticeably higher than that of pre-operation; RVEF of 2 years after operation was less than that of pre-operation; 2 year after operation, RVEF of patients in MVR+TAP group was significantly higher than that of MVR group. This result also indicated further that performing TAP at the same period can contribute to improve right ventricular function of these patients. TAPSE stands for the movement function of the long axis of right ventricular free wall, which has nice repetitiveness of measure. Some studies indicate that TAPSE is lower after coronary artery bypass grafting (CABG) or MVR [19, 20]. Its reduction may be connected with left ventricular function and right ventricular function and may be affected by them [21]. In this study, result suggested that there was no significant difference of TAPSE between MVR+TAP group and MVR group 2 years after surgery. Besides, in two groups, cardiac function (NYHA classification)

of 2 years after surgery improved significantly than that of pre-operation. The improvement degree of cardiac function of MVR+TAP group was significantly greater than that of MVR group, which suggested that MVR concomitant with TAP at can obviously postpone the progression of disease of TVI and improve the prognosis of mild functional TVI. There was no death in two groups during perioperative period, but the 2-year survival rate of patients in MVR+TAP group was higher than that of MVR group after operation, which also indicated that the effect of MVR concomitant with TAP was better than simple MVR in treatment of TVI.

The factor that influences the residues or exacerbation of tricuspid value after MVR is extremely complex. Its pathogenetic mechanism is not clear at present [22]. Pulmonary artery hypertension, right ventricular enlargement, atrial fibrillation, the increase of right ventricular preload and left ventricular function all have effects on TVI. Some studies indicate that expansion of tricuspid annulus is the independent risk factor that causes functional TVI [23], which plays an important role in the development of TVI. In recent years, the clinical work has realized the severity of residues or exacerbation of TVI after mitral valve operation. The result of this research revealed the proportion of degree of TVI in MVR+TAP group had a remarkable improvement 2 years after operation, which is better than that of MVR group. It indicated that MVR concomitant with TAP can reduce the occurrence and exacerbation of TVI after operation.

In conclusion, the effect of MVP concomitant with TAP on mild TVI is good, which has clinical feasibility. And it is helpful for recovery of right ventricular function and tricuspid value function 2 years after operation and is beneficial to reduce the residues or exacerbation of tricuspid value after operation.

There still exist some limits in this study. 2-years follow-up is comparatively short and the long-term effect of patients is supposed to be observed continuingly. In future research, the numbers of samples will be expanded, and we should follow up clinical data of patients in long term, and expand it to a multicentric research.

Disclosure of conflict of interest

None.

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