Middle and long-term outcomes of non-ring tricuspid annuloplasty in patients with mitral valve replacement

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Research article

Keywords: Mitral valve replacement, non-ring tricuspid annuloplasty, long-term observation

Posted Date: December 31st, 2020

DOI: <https://doi.org/10.21203/rs.3.rs-136778/v1>

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Abstract

Objective

To evaluate the middle-period and long-term outcomes of one-stage non-ring TVP in patients with MVR.

Methods

427 patients who received one-stage mechanical MVR and non-ring TVP from January 2005 to January 2009 at Department of Cardiovascular Surgery of West China Hospital; After screening, 400 patients were finally recruited, who reexamined by UCG 10 years after surgery and recorded UCG data.

Results

The patients were followed up for 10 years after surgery. Compared with the situation before surgery, RV(mm): 21.47 ± 3.14 vs. 22.37 ± 3.28 , TAEDD(mm): 32.18 ± 4.94 vs. 35.88 ± 4.07 and TESD(mm): 25.90 ± 4.90 vs. 28.12 ± 4.12 decreased significantly at 5 years after surgery ($P < 0.05$). However, RA(mm): 49.35 ± 13.05 vs. 50.69 ± 12.90 did not change significantly ($P > 0.05$). LVEF (%): 61.54 ± 8.23 vs. 57.38 ± 8.87 also increased significantly after surgery ($P < 0.05$). Compared with the preoperative situation, at 10 years after surgery, RA(mm) was 56.90 ± 12.90 , RV (mm) 23.12 ± 4.58 , TESD (mm) 28.80 ± 5.14 and LVEF (%) 59.81 ± 8.95 , all of which increased significantly ($P < 0.05$); however, TEDD (mm) was 35.41 ± 5.11 , which did not change significantly ($P > 0.05$). Compared with preoperative situation, the ratios of severity of TR at 5 and 10 years after surgery improved significantly ($P < 0.05$).

Conclusion

It is reasonable to use the tricuspid annular diameter in patients with mitral valve disease as an indication for one-stage TVP. The one-stage non-ring TVP is conducive to preventing aggravation of TR, so as to achieve a better long-term outcome. Besides, oral diuretics are recommended to treat TR after surgery for such patients.

Introduction

Mitral valve disease is the most common type of valvular heart disease, and about 50%-60% of the patients with mitral valve disease are combined with tricuspid regurgitation (TR) [1]. Moreover, residual or aggravating TR after mitral valve replacement(MVR) is not conducive to the short-term recovery and long-term survival of the patients. Therefore, TR remains a main challenge for cardiac surgeons [2, 3]. Whether to treat TR simultaneously as MVR and the timing and approach to treat are still a topic of controversy. So far, European Society of Cardiology (ESC) [4] and American College of Cardiology/American Heart Association (ACC/AHA) [5] seem to share similar opinions on the treatment of severe TR in MVR.

However, the opinions diverge on whether to treat mild tricuspid regurgitation simultaneously. There are also conflicting views on which surgical approach is better for tricuspid annuloplasty(TVP) [6, 7].

In the present study, tricuspid annular diameter was considered as an indication for one-stage TVP. Moreover, the one-stage non-ring TVP was performed. This study reported the long-term outcome of such a treatment strategy for the patients.

Methods

Clinical data

A total of 427 patients who received one-stage mechanical MVR and TVP from January 2005 to January 2009 at Department of Cardiovascular Surgery of West China Hospital; Within 10 years, 8 patients died , 7 patients were reoperated for severe TR, and 12 patients were reoperated for mitral valve problems. 400 patients were finally recruited, who reexamined by UCG—Ultrasonic Cardiogram—10 years after surgery. After screening, A total of 400 patients who completed 10 years of follow-up were included in the study. The UCG datas of 400 patients were analyzed retrospectively. A total of 400 patients including 91 males and 309 females, and they were aged 17-71 (46.3 ± 10.0) years old. There were 65 patients with normal sinus heart rate, 52 patients with atrial flutter, and 283 patients with atrial fibrillation. According to the NYHA classification, there were 19 cases of class I cardiac function, 289 cases of class II cardiac function and 92 cases of class III cardiac function.

Definition and classification of TR [8].

TR was defined based on the ratio of regurgitation beam area and right atrial area upon UCG as well as the width of regurgitation beam. TR severity was graded on a 0-5 scale: 0, no TR; 1, mild TR; 2, mild to moderate TR; 3, moderate TR; 4, moderate to severe TR; 5, severe TR.

Indications for TVP

(1) tricuspid annular dilation

Tricuspid annular diameter ≥ 40 mm or tricuspid annular diameter/body surface area ≥ 21 mm/m², upon intraoperative transesophageal UCG; distance from the junction between anterior and septal leaflets to the junction between anterior and posterior leaflets ≥ 70 mm; (2) no tricuspid annular dilation, but with apparent TR

No apparent tricuspid annular dilation found by preoperative or intraoperative ultrasound, but TR ≥ 1 revealed by perioperative ultrasound.

Surgical procedures

The patients took a supine position and received total intravenous anesthesia with endotracheal intubation for assisted ventilation. Full sternotomy was performed, and extracorporeal circulation was established. Myocardial protection was given by moderate hypothermia and hypothermic cardioplegia perfusion. Mitral valve and tricuspid valve surgeries were performed via the right atrium-interauricular septum pathway. After mechanical MVR and other intracardiac procedures were over, tricuspid annular dilation and leaflet alignment were examined by water injection. For patients without tricuspid annular dilation but severe TR (all 8 patients belonged to mild to moderate TR or moderate TR), 5-0 prolene suture was used for intermittent suture of leaflet defect (anterior leaflet). For 298 patients with tricuspid annular dilation and leaflet defect, leaflet repair was first performed (anterior leaflet, and junction between anterior leaflet and septal leaflet or septal leaflet also included for a few patients), which was followed by one-stage non-ring TVP: one-stage bicuspidization (2-0 double-headed MVR thread was led in from the junction between anterior and posterior leaflets and led out from the junction between the posterior and septal leaflets after interrupted suture along the valve annulus; the thread was knotted and immobilized after padding) and modified Kay's annuloplasty [9] (2-0 double-headed MVR thread was led in vertically from the junction between anterior and posterior leaflets and led out from within the valve annulus; then the needle was inserted into the valve annulus from the junction between the posterior and septal leaflets and led out from outside the valve annulus. The thread was knotted and immobilized after padding). Thus, TVP was finished. For those without leaflet defect, one-stage non-ring TVP was directly performed. Following TVP, the size of valve opening was inspected with fingers, and leaflet alignment and TR were checked by water injection. After cardiac rebeat, transesophageal echocardiography (TEE) was performed again to assess the tricuspid valve. After surgery, the patients were sent to ICU for continuous monitoring and supportive treatment.

Follow-up

Patients' gender, age, heart rate, cardiac function, date and methods of surgery were recorded before discharge along with UCG data. UCG indicators measured were as follows: Left atrium diameter (LA), left ventricle diameter (LV), right atrium diameter (RA), right ventricle diameter (RV), left ventricular ejection fraction (LVEF), tricuspid end-diastolic diameter (TEDD), tricuspid end-systolic diameter (TESD) and tricuspid regurgitation (TR). After discharge, the patients were required to receive regular follow-up at the outpatient clinic and reexamination by UCG.

Statistical

All statistical analyses were performed using SPSS 19.0 software. Measurements were expressed as mean±standard deviation ($\bar{X}(\pm S)$), and paired t-test was used for intergroup comparisons. Counts were compared between the groups by using the chi-square test. $P \leq 0.05$ indicated significant difference.

Results

The patients were followed up for 10 years. At 5 years after surgery, RA, LA and LV did not change significantly compared with the preoperative values ($P > 0.05$); however, RV, TEDD and TESD decreased

significantly, while EF increased significantly ($P < 0.05$). At 10 years after surgery, TEDD did not change significantly compared with the preoperative values ($P > 0.05$); however, RA, RV, LA, LV, TESD and EF increased significantly ($P < 0.05$). Compared with the values at 5 years after surgery, RA, RV, LA, LV, TEDD and TESD at 10 years after surgery increased significantly, while EF decreased significantly ($P < 0.05$). (Table)

The ratios of severity of TR at 5 and 10 years after surgery were considerably superior to those before surgery ($P < 0.05$). There was an apparent increase in the proportion of patients with no or mild TR, while the proportion of patients with TR of moderate or above severity decreased dramatically.(Figure)

Discussion

In spite of the remarkable progress in the diagnostic and treatment techniques for valvular heart diseases, TR may still appear or even aggravate after MVR as time goes. Even if no apparent TR is observed by intraoperative examination, patients receiving left heart valve surgery are still faced with the risk of TR in the long term [10].

There are conflicting opinions and clinical practice concerning whether TVP should be performed simultaneously with MVR. Such divergence is not only related to the use of different guidelines, but also reflects varying cognition about this issue among cardiac surgeons from different regions or countries. At present, only 7%-10% of the patients receive one-stage TVP at Mayo Clinic compared to as high as 65% at Mount Sinai Hospital [14].

Tricuspid valve has a complex structure, which consists of three leaflets (anterior, posterior and septal), chordae tendineae, muscoli papillares, tricuspid annulus, right ventricle and right ventricular muscle [3]. The tricuspid annulus is an asymmetrical saddle-shaped structure, and effective leaflet alignment requires coordination between the valve ring, leaflet, chordae tendineae, muscoli papillares and right heart function [7]. If any of them has problems, there will be hemodynamic changes leading to TR [15, 16].

It has been recognized in recent years that tricuspid annular dilation is an important mechanism involved in TR: Long-term right heart overload leads to right ventricular dilation, which further results in tricuspid annular dilation and TR [17]. In addition to tricuspid annular dilation, preload, afterload and right heart function are decisive factors related to the occurrence of TR[18–22]. Under different situations, these 3 factors can dramatically influence TR measurement. Quantitative evaluation of right heart function is of high importance for severity evaluation, decision making, efficacy and prognostic prediction, but few studies have been conducted in this respect [23]. That is an important cause of difficulty in an accurate evaluation of TR. The degree of tricuspid annular dilation is a more reliable and more constant indicator of pathological changes of the tricuspid valve [6, 22]. Tricuspid annular dilation can be considered if any of the following three conditions are present: (1) TVAEDD/BSA $> 21 \text{ mm/m}^2$ in the parasternal short axis view or apical four chamber view [24]; (2) TVAEDD $\geq 40 \text{ mm}$ in any view [7, 19, 25]; (3) the length of line connecting the junction between the anterior and septal leaflets and the junction between the anterior and

posterior leaflets ≥ 70 mm [22]. As was pointed out by Dreyfus, surgical treatment of mitral valve disease can only lower the right ventricular afterload, but does not address tricuspid annular dilation and the impact on preload or right ventricular function. One-stage TVP should be considered for mitral valve disease with tricuspid annular dilation even without TR [22].

Since 2005, we began to use tricuspid annular diameter as a surgical indication for one-stage TVP. Follow-up results of the present study indicated at 5 years after surgery, the right ventricular diameter and tricuspid annular diameter decreased significantly, while the left heart function was improved considerably; moreover, the ratio of severity of TR was also improved. After the treatment, the proportion of patients with no or mild TR increased, while that of patients with TR of moderate or above severity decreased. We believe that it is more appropriate to use tricuspid annular dilation as an indication for one-stage TVP in patients receiving MVR instead of TR for the following reasons [14, 22]: (1) It has been pointed out that the tricuspid annular diameter is independently correlated with the severity of TR [26]; (2) The measurement of tricuspid annular dilation is relatively constant, while TR severity is more greatly influenced by preload, afterload and right heart function; (3) There may be inconsistencies between the clinical situation and hemodynamic indicators of patients; (4) Residual or aggravating TR after surgery adversely affects patients' recovery.

However, which surgical technique to use for TVP is another important issue where divergent opinions exist. Duran believed that partial ring shrinkage with any technique cannot withstand the continuous stress on the annulus in severe TR. Therefore, non-ring TVP can be used for mild to moderate TR, while ring TVP should be performed for severe TR [21].

Many researchers seem to suggest that when performing non-ring TVP, the efficacy is quite uncertain and there exists the risk of residual or aggravating TR after surgery in the long term [2, 7, 13]. But there are also opposing opinions holding that non-ring TVP is easier and more effective [6, 27, 28]. Ghanta et al. [20] compared the 3-year postoperative follow-up data of 237 cases receiving non-ring bicuspidization or ring TVP. The results showed that 25% of the patients receiving non-ring TVP suffered from moderate to severe TR, while 31% of the patients receiving TVP had moderate to severe TR. We believe that (1) ring TVP is also associated with the risk of recurrence of severe TR. Secondary surgery for these patients to remove the annuloplasty ring can avoid the occurrence of degree $\geq 2^\circ$ atrioventricular heart-block to some degree; (2) Most of the patients receiving left heart valve surgery came from remote regions, and one-stage non-ring TVP was less costly, safer and easier for them. De Vega TVP was adopted at our hospital before 2003. During secondary surgery for those with postoperative severe TR, several patients were found with suture rupture near the middle part of anterior leaflet. Thus, De Vega TVP was abandoned for these patients. In this study, modified Kay's annuloplasty was chosen due to its lesser impact on the anterior leaflet and shorter suture thread after immobilization, which makes it less likely to rupture.

Therefore, one-stage TVP was expected to achieve similar long-term outcomes. The 10-year follow-up data indicated that there was a significant reduction in the left and right atrial and ventricular diameter and tricuspid annular diameter at end-systole, while the left heart function was improved dramatically.

The ratio of severity of TR was also improved effectively, with much more patients having no or mild TR after surgery and no significant increase in the proportion of patients with moderate and above TR. However, the tricuspid annular diameter at end-diastole was comparable before and after surgery. The clinical features of patients recruited in this study could be summarized as follows: (1) Predominantly rheumatic heart disease; (2) having not sought medical care until late and mostly coming from remote regions. Based on the above conditions, oral diuretics were given to those with TR revealed by UCG at 6 months after surgery and beyond. This medication was justified by the following reasons: (1) TR is a persistent and continuously aggravating pathological process [18, 22, 29]; (2) diuretics can lower the severity of hemodynamic disorder by alleviating right ventricular dilation and right atrial pressure, and spironolactone is more suitable for patients with right heart failure [30].

Conclusion

It is reasonable to use the tricuspid annular diameter in patients with mitral valve disease as an indication for one-stage TVP. The one-stage non-ring TVP is conducive to preventing aggravation of TR, so as to achieve a better long-term outcome. Because, Most of the patients receiving left heart valve surgery came from remote regions in china, and one-stage non-ring TVP was less costly, safer and easier for them. Besides, oral diuretics are recommended to treat TR after surgery for such patients.

Abbreviations

TR, Tricuspid regurgitation; MVR, Mitral valve replacement; ESC, European Society of Cardiology; ACC/AHA, American College of Cardiology/American Heart Association; TVP, tricuspid annuloplasty; UCG, Ultrasonic Cardiogram; TEE, transesophageal echocardiography; LA, Left atrium diameter; LV, Left ventricle diameter; RA, Right atrium diameter; RV, Right ventricle diameter; LVEF, Left ventricular ejection fraction; TEDD, Tricuspid end-diastolic diameter; TESD, Tricuspid end-systolic diameter.

Declarations

Acknowledgements: Not applicable

Ethics approval and consent to participate The study protocol was approved by the local ethics committee (Sichuan University West China Hospital) and the study was performed according to the Declaration of Helsinki.

Consent for publication All co-authors permit editorial amendments and the paper's publication.

Availability of data and material: All the data and material were restored in the

database of West China Hospital.

Competing interests: The authors declare that they have no conflict of interest.

Funding: This work was supported by grants from the National Key Project Program during the 13th 5-Year Plan Period of China (2016YFC1302003), and from the Major Science and Technology Project of Sichuan Province, China (No. 2017SZ0056), and the Scientific Research Project of National Clinical Research Center for Geriatrics ,West China Hospital, Sichuan University (No. Z2018B19).

Authors' contributions: Yongjun Qian and Xijun Xiao conceived and designed the study. Dou Yuan and Liping Chen wrote the paper. Tao Li, Yunfei Ling, Yongjun Qian reviewed and edited the manuscript. All authors read and approved the manuscript.

Consent to Publish: Written informed consent to publish personal or clinical details were obtained from all the study participants.

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Tables

Table.1 Comparison of preoperative and postoperative cardiac chamber size, tricuspid annular diameter, left heart function and severity of TR

UCG data	Peroperative n=400	5 years postoperative n=400	10 years postoperative n=400
RAmm	50.69±12.90	49.35±13.05	56.90±12.90
RVmm	22.37±3.28	21.47±3.14	23.12±4.58
LAmm	54.18±14.68	54.01±15.60	59.66±19.30
LVmm	47.46±6.74	47.74±6.03	49.44±8.44
TEDDmm	35.88±4.07	32.18±4.94	35.41±5.11
TESDmm	28.12±4.12	25.90±4.90	28.80±5.14
LVEF%	57.38±8.87	61.54±8.23	59.81±8.95
TR%			
0	20±5.0	107±26.7	29±7.3
1	182±45.5	177±44.3	146±36.5
2	76±19.0	44±11.0	115±28.8
3	73±18.3	53±13.3	67±11.7
4	31±7.7	8±2.0	24±6.0
5	18±4.5	11±2.7	19±4.7

Figures

Figure 1

Changes of preoperative and postoperative severity of TR