Application of Percutaneous Balloon Mitral Valvuloplasty in Patients of Rheumatic Heart Disease Mitral Stenosis Combined with Tricuspid Regurgitation

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Abstract

Background: Tricuspid regurgitation (TR) is frequently associated with severe mitral stenosis (MS), the importance of significant TR was often neglected. However, TR influences the outcome of patients. The aim of this study was to investigate the efficacy and safety of percutaneous balloon mitral valvuloplasty (PBMV) procedure in rheumatic heart disease patients with mitral valve (MV) stenosis and tricuspid valve regurgitation.

Methods: Two hundred and twenty patients were enrolled in this study due to rheumatic heart disease with MS combined with TR. Mitral balloon catheter made in China was used to expand MV. The following parameters were measured before and after PBMV: MV area (MVA), TR area (TRA), atrial pressure and diameter, and pulmonary artery pressure (PAP). The patients were followed for 6 months to 9 years.

Results: After PBMV, the MVAs increased significantly (1.7 ± 0.3 cm^2 vs. 0.9 ± 0.3 cm^2, $P < 0.01$); TRA significantly decreased (6.3 ± 1.7 cm^2 vs. 14.2 ± 6.5 cm^2, $P < 0.01$), right atrial area (RAA) decreased significantly (21.5 ± 4.5 cm^2 vs. 25.4 ± 4.3 cm^2, $P < 0.05$), TRA/RAA (%) decreased significantly ($29.3 \pm 3.2\%$ vs. $44.2 \pm 3.6\%$, $P < 0.01$). TR velocity (TRV) and TR continue time (TRT) as well as TRV $\times$ TRT decreased significantly (183.4 ± 9.4 cm/s vs. 254.5 ± 10.7 cm/s, $P < 0.01$; 185.7 ± 13.6 ms vs. 238.6 ± 11.3 ms, $P < 0.01$; 34.2 ± 5.6 cm vs. 60.7 ± 8.5 cm, $P < 0.01$, respectively). The postoperative left atrial diameter (LAD) significantly reduced (41.3 ± 6.2 mm vs. 49.8 ± 6.8 mm, $P < 0.01$) and the postoperative right atrial diameter (RAD) significantly reduced (28.7 ± 5.6 mm vs. 46.5 ± 6.3 mm, $P < 0.01$); the postoperative left atrium pressure significantly reduced (15.6 ± 6.1 mmHg vs. 26.5 ± 6.6 mmHg, $P < 0.01$), the postoperative right atrial pressure decreased significantly (13.2 ± 2.4 mmHg vs. 18.5 ± 4.3 mmHg, $P < 0.01$). The pulmonary arterial pressure decreased significantly after PBMV (48.2 ± 10.3 mmHg vs. 60.6 ± 15.5 mmHg, $P < 0.01$). The symptom of chest tightness and short of breath obviously alleviated. All cases followed-up for 6 months to 9 years (average 75 ± 32 months), 2 patients with severe regurgitation died (1 case of massive cerebral infarction, and 1 case of heart failure after 6 years and 8 years, respectively), 2 cases lost access. At the end of follow-up, MVA has been reduced compared with the postoperative (1.4 ± 0.4 cm^2 vs. 1.7 ± 0.3 cm^2, $P < 0.05$); LAD slightly increased compared with the postoperative (45.2 ± 5.7 mm vs. 41.4 ± 6.3 mm, $P < 0.05$), RAD slightly also increased compared with the postoperative (36.1 ± 6.3 mm vs. 28.6 ± 5.5 mm, $P < 0.05$), but did not recover to the preoperative level. TRA slightly increased compared with the postoperative, but the difference was not statistically significant ($P > 0.05$). The PAP and left ventricular ejection fraction appeared no statistical difference compared with the postoperative ($P > 0.05$), the remaining patients without serious complications.

Conclusions: PBMV is a safe and effective procedure for MS combined with TR in patients of rheumatic heart disease. It can alleviate the symptoms and reduce the size of TR. It can also improve the quality-of-life and prognosis. Its recent and mid-term efficacy is certain. While its long-term efficacy remains to be observed.

Key words: Apply Value; Mitral Stenosis with Tricuspid Valve Regurgitation; Percutaneous Balloon Mitral Valvuloplasty; Rheumatic Heart Disease

INTRODUCTION

Valvular heart diseases in China are still frequently-occurring diseases. Mitral valve (MV) diseases in rheumatic heart diseases are associated with tricuspid regurgitation (TR)

about 22–50%.[1] Severe TR was known to be an independent predictor of adverse outcome in the patient with rheumatic heart diseases because it contributes to increase the morbidity and mortality.[2-4]

Since 1984 Inoue introduced and developed percutaneous balloon mitral valvuloplasty (PBMV) as a logical extension of surgical closed commissurotomy, PBMV has been

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accepted as an effective method of treating hemodynamically significant mitral stenosis (MS) with favorable morphology. However, the influence of PBMV on patients with TR has seldom been evaluated. More than 4000 cases of PBMV have been carried out in our hospital since 1986. This study is to investigate the efficacy and safety of PBMV treatment in patients of rheumatic heart disease MS combined with tricuspid valve regurgitation.

METHODS

Study populations

One thousand and seven hundred cases of patients with rheumatic heart disease combined with MS and TR from our hospital were enrolled due to mitral balloon dilatation from January 2000 to December 2012, meeting the diagnostic criteria of heart valve disease diagnosis and treatment guidelines of the United States in 1998, there are obvious clinical symptoms of chest tightness, shortness of breath, left atrioventricular valve mouth area ≤ 1.5 mm^2, and have be confirmed by transthoracic echocardiography or esophagus echocardiography (America Hewlett-Packard Company Agilent 5500). Excluded severe infection, severe anemia (hemoglobin <70 g/L), severe thrombocytopenia (<50 × 10^9/L), left atrial thrombus, severe liver and kidney dysfunction, moderate to severe mitral regurgitation, severe mv calcification, merge severe aortic valve stenosis or severe regurgitation, etc. Among them, 220 cases with tricuspid valve regurgitation, aged 29–67 years old, mean age (47.5 ± 7.4) years, male 90 cases, female 130 cases, duration 3–20 years, the average (10.5 ± 5.4) years, the MV area (MVA) (0.4–1.5 cm^2), the average (0.9 ± 0.3 cm^2), TR area (TRA) (3.2–26 cm^2), the average (14.2 ± 6.5 cm^2). Sixty patients appeared different degree of double leg edema, 30 cases with liver enlargement and liver area pulsation and 120 cases with pulmonary hypertension ($\geq$25 mmHg) (1 mmHg = 1.33 kPa).

Percutaneous balloon mitral valvuloplasty

The PBMV was performed using mitral balloon catheter made in China (Jiangxi Yikang Limited Company, China), the procedure was performed by two experienced interventional cardiologist. 76% diatrizoate, or iodine Portuguese Romanian amine (Ultravist 370) (when allergy to iodine) were given to 16 ml incremental approach to expansion, each additional 0.5–1 ml, the end expansion was that the left atrial pressure (LAP) decreased by 50%, or left atrial mean pressure decreased 15 mmHg below (1 mm Hg = 0.133 kPa), diastolic rumbling noise-like from MVA disappeared or reduced significantly. After intervention atrial pressure and atrial diameter were checked and compared with that before the intervention. The patients with severe TR were combined with the use of diuretics; the urine output is maintained at more than 2000 ml of 24 h. If combined with atrial fibrillation, thrombosis was not seen in left atrial by transthoracic or transesophageal echocardiography ultrasound, urokinase of 100,000–200,000 units were conventionally given by intravenous drip, 2 times/day, a total of 3–7 day; If combined with left atrial thrombus, oral warfarin was at least given for 3–6 months, balloon angioplasty was not be completed until left atrial thrombus disappeared.

Echocardiographic evalution

Echocardiographic evaluation was performed before and after 2–3 days of PBMV; two-dimensional echocardiography and Doppler color flow imaging were performed on all patients with a Hewlett-Packard Agilent 5500 imaging system equipped with a 2.5 MHz transducer (America Company). Transesophageal echocardiography was performed on all patients to detect left atrial thrombi. The indicators as described were below: MVA, TRA, right atrial area (RAA), right atrial diameter (RAD), TR velocity (TRV), TR time (TRT), left atrial diameter (LAD), pulmonary artery pressure (PAP), and left ventricular ejection fraction (LVEF) were reviewed by thoracic echocardiography.

Clinical follow-up

The clinical follow-up ranged from 6 months to 9 years (average 75 ± 32 months), Data were obtained during visits to the outpatient clinic or by telephone interview. And at the end of the follow-up, these above indicators were reviewed by color Doppler echocardiography. The clinical cardiovascular events defined as like thrombosis embolism, heart failure, malignant arrhythmia, death, etc.

Statistical analysis

The SPSS 13.0 statistical package was used for statistics (SPSS Inc., USA); all data were expressed as mean ± standard deviation (SD), comparison of parameters between before and after therapy were investigated with the Student's t-test. A $P < 0.05$ was considered statistically significant.

RESULTS

The relationship of mitral stenosis degree and tricuspid regurgitation improvement

The TRA obviously increased with MVA decreasing, and there were negative relationship ($r = -0.8$, $t = 27.115$, $P = 0.000$) [Table 1].

Immediate hemodynamic and heart functional changes before and after percutaneous balloon mitral valvuloplasty

Mitral valve area was (1.7 ± 0.3 cm^2) of 220 patients after mitral balloon dilatation, which increased significantly compared with that of the preoperative (0.9 ± 03 cm^2)

Table 1: The relationship between MS degree and TR increase

Parameter	n	Pre-PBMV	95% CI		r	P
			Upper limit	Lower limit		
MVA (cm^2)	220	0.9 ± 0.3	25.538	31.549	−0.8	0.000
TRA (cm^2)	220	14.2 ± 6.5				

The relationship of MS degree and TR increase was very significant. *CI*: Confidence interval; MS: Mitral stenosis; TR: Tricuspid regurgitation; MVA: Mitral valve area; TRA: Tricuspid regurgitation area; PBMV: Percutaneous balloon mitral valvuloplasty.

($P < 0.01$). Postoperative TRA (average 6.3 ± 1.7 cm²) decreased significantly compared with that of the preoperative (average 14.2 ± 6.5 cm²) ($P < 0.01$), RAA decreased significantly compared with that of the preoperative ($P < 0.05$), TRA/RAA (%) decreased significantly compared with that of the preoperative ($P < 0.01$), TRV and TRT as well as TRV × TRT decreased significantly compared with that of the preoperative ($P < 0.01$). Postoperative LAD (41.3 ± 6.2 mm) significantly reduced compared with the preoperative (49.8 ± 6.8 mm) ($P < 0.01$), postoperative RAD (28.7 ± 5.6 mm) significantly reduced compared with the preoperative (46.5 ± 6.3 mm) ($P < 0.01$), and postoperative mean LAP (15.6 ± 6.1 mmHg) significantly reduced ($P < 0.01$) compared with the preoperative (26.5 ± 6.6 mmHg), postoperative right atrial pressure (RAP) (13.2 ± 2.4 mmHg) decreased significantly compared with the preoperative (18.5 ± 4.3 mmHg) ($P < 0.01$); The pulmonary arterial pressure of 120 patients with pulmonary arterial hypertension decreased significantly from preoperative pressure 60.6 ± 15.5 mmHg to postoperative 48.2 ± 10.3 mmHg ($P < 0.01$) [Table 2].

Clinical symptom, severe complications, hemodynamic and heart functional changes at the end of follow-up

Rumbling-like diastolic murmur from mv was weakened from severe to a mild degree. Systolic murmur-like hair from mv increased from the operative 0–1/6° up to 1–2/6°. The symptom of chest tightness and short of breath obviously alleviated, namely before the operation, the patients feel chest tightness and short of breath, when ascending 2–4 layer building, and after the operation, the patients feeling no obvious symptom, even boarding 4–7 layers. All cases were followed-up for 6 months to 9 years (average 75 ± 32 months), 2 patients with severe regurgitation died (1 case of massive cerebral infarction, and 1 case of heart failure after 6 years and 8 years respectively), 2 cases lost access. At the end of follow-up, MVA has been reduced compared with the postoperative ($P < 0.05$); LAD, RAD slightly increased compared with the postoperative ($P < 0.05$), but did not reach the preoperative level. TRA slightly increased compared with the postoperation, but the difference was not statistically significant ($P > 0.05$). The PAP and LVEF appeared no

statistical difference compared with that of the postoperative, the remaining patients without serious complications. Hepatomegaly and liver area pulse significantly reduced or disappeared in postoperative patients [Table 3].

DISCUSSION

Functional TR is frequently associated with severe MS, because significant MS can induce pulmonary vascular and pulmonary interstitial fibrosis and increase pulmonary resistance which results in pulmonary venous and arterial hypertension as well as right ventricular enlargement, finally resulting in tricuspid annular dilatation and right ventricle dysfunction. while there may be no problem in the valve itself.[2-5] Our study found the TRA obviously increased with MVA decreasing, and them were negative relationship $(r = -0.8, t = 27.115, P < 0.01)$. However, persistent TR contributes to increase morbidity and mortality despite adequate surgical and percutaneous intervention of the MV disease.

Table 2: Immediate hemodynamic and heart functional changes before and after PBMV

Parameters	n	Pre-PBMV	Post-PBMV	t	P
MVA (cm²)	220	0.9 ± 0.3	1.7 ± 0.3	3.8	0.001
RAA (cm²)	220	25.4 ± 4.3	21.5 ± 4.5	2.2	0.030
TRA (cm²)	220	14.2 ± 6.5	6.3 ± 1.7	3.5	0.003
TRA/RAA (%)	220	44.2 ± 3.6	29.3 ± 3.2	3.6	0.002
TRV (cm/s)	220	254.5 ± 10.7	183.4 ± 9.4	4.0	0.001
TRT (ms)	220	238.6 ± 11.3	185.7 ± 13.6	3.8	0.001
TRV×TRT (cm)	220	60.7 ± 8.5	34.2 ± 5.6	3.7	0.001
LAP (mmHg)	220	26.5 ± 6.6	15.6 ± 6.1	3.9	0.001
RAP (mmHg)	220	18.5 ± 4.3	13.2 ± 2.4	3.2	0.003
LAD (mm)	220	49.8 ± 6.8	41.3 ± 6.2	2.8	0.008
RAD (mm)	220	46.5 ± 6.3	28.7 ± 5.6	3.4	0.005
PAP (mmHg)	120	60.6 ± 15.5	48.2 ± 10.3	3.1	0.006
LVEF (%)	220	48.8 ± 4.6	50.5 ± 3.7	1.1	0.320

MVA: Mitral valve area; TRA: Tricuspid regurgitation area; RAA: Right atrial area; TRV: Tricuspid regurgitation velocity; TRT: Tricuspid regurgitation continue time; LAP: Left atrial pressure; RAP: Right atrial pressure; LAD: Left atrial diameter; RAD: Right atrial diameter; PAP: Pulmonary artery pressure; PBMV: Percutaneous balloon mitral valvuloplasty; LVEF: Left ventricular ejection fraction.

Table 3: Hemodynamic and heart functional changes at the end of follow-up

Parameter	n	Pre-PBMV	Post-PBMV	Follow-up	F*	P*
MVA (cm²)	216	0.9 ± 0.3	1.7 ± 0.3	1.4 ± 0.4*†	2.2	0.03
RAA (cm²)	216	25.4 ± 4.3	21.5 ± 4.5	22.8 ± 5.1†	0.6	0.78
TRA (cm²)	216	14.2 ± 6.5	6.3 ± 1.7	7.4 ± 1.5†	1.6	0.08
TRA/RAA (%)	216	44.2 ± 3.6	29.3 ± 3.2	32.4 ± 3.7†	1.9	0.06
TRV (cm/s)	216	254.5 ± 10.7	183.4 ± 9.4	190.6 ± 9.7†	1.1	0.45
TRT (ms)	216	238.6 ± 11.3	185.7 ± 13.6	191.5 ± 10.5†	1.1	0.45
TRV×TRT (cm)	216	60.7 ± 8.5	34.2 ± 5.6	36.5 ± 6.2†	0.9	0.53
LAD (mm)	216	49.7 ± 6.5	41.4 ± 6.3	45.2 ± 5.7*†	2.5	0.04
RAD (mm)	216	46.6 ± 6.4	28.6 ± 5.5	36.1 ± 6.3*†	2.7	0.03
PAP (mm Hg)	120	60.6 ± 15.5	48.2 ± 10.3	49.3 ± 11.2†	0.8	0.57
LVEF (%)	216	48.8 ± 4.6	50.5 ± 3.7	50.3 ± 4.7	0.7	0.65

Compared with post-PBMV, *$P<0.05$; Compared with pre-PBMV, †$P<0.05$. PBMV: Percutaneous balloon mitral valvuloplasty; MVA: Mitral valve area; RAA: Right atrial area; TRA: Tricuspid regurgitation area; TRT: Tricuspid regurgitation continue time; TRV: Tricuspid regurgitation velocity; LAD: Left atrial diameter; RAD: Right atrial diameter; PAP: Pulmonary artery pressure; LVEF: Left ventricular ejection fraction.

Tricuspid regurgitation in patients with MV stenosis (MS) may be attributable to rheumatic involvement of the valve or to functional TR, As reported in the literature, the occurrence rate of rheumatic MS with tricuspid insufficiency was 22–50%.[1] Most of them were functional TR, being a consequence of right ventricular dysfunction and the tricuspid annulus enlargement secondary to pulmonary hypertension. But the importance of significant TR was often neglected. However, TR influences the outcome of patients.

Percutaneous balloon mitral valvuloplasty has become an effective treatment way for pure, uncomplicated MS with favorable morphology,[6-9] but its merger effects in patients with TR were currently controversial, the early studies showed that after the left heart valve disease was correctly cured, the mild TR could be reversed,[2-5] however, some retrospective follow-up study found that although patients suffered from rheumatic heart disease with left cardiac valve replacement or repair. TR did not disappear with the solution of left heart valve problems after the procedure. Even some patients with TR were worsened, and TR became one of the major long-term death reasons after rheumatic heart disease valve surgery.[10-12] Sagie et al. reported that significant TR was closely associated with suboptimal immediate results and poor late outcome after PBMV.[3] They also reported that significant TR did not substantially decrease or resolve after PBMV in the majority of patient; thus, they thought surgical angioplasty was needed for treatment of tricuspid insufficiency.[13-16] However, other investigators (eg., Hannoush et al. and Song et al.) demonstrated regression of significant TR after successful PBMV in relatively young patients (mean age 25 ± 10 years) with severe MS and concomitant significant pulmonary hypertension (70 ± 22 mmHg).[2,4,17-19] In our study, we also observed obvious regression of significant functional TR with relief of the increased PAP after PBMV alone. MVA increased significantly, TRA and RAA decreased significantly, TRV and TRT as well as TRV × TRT decreased significantly compared with that of the preoperative. Postoperative LAD and RAD significantly reduced, and postoperative mean LAP and RAP as well as the pulmonary arterial pressure decreased significantly. Clinical symptom was obviously alleviated, the quality-of-life and prognosis were also been improved. Followed-up for 6 months to 9 years (average 75 ± 32 months), 2 patients with severe regurgitation died, others appeared no serious complications occurred. Therefore, TR is not a contraindication of PBMV, on the contrary, for patients with rheumatic heart disease combined with MS, which mainly caused secondary TR, PBMV is a safe and effective procedure for MS combined with TR in patients of rheumatic heart disease. It's recent and mid-term efficacy is certain while it's long-term efficacy remains to be further observed. As this research sample size was small, the result needs to be confirmed by large sample randomized parallel-group study.

REFERENCES

1. Porter A, Shapira Y, Wurzel M, Sulkes J, Vaturi M, Adler Y, et al. Tricuspid regurgitation late after mitral valve replacement: Clinical and echocardiographic evaluation. J Heart Valve Dis 1999;8:57-62.
2. Song JM, Kang DH, Song JK, Jeong YH, Lee CW, Hong MK, et al. Outcome of significant functional tricuspid regurgitation after percutaneous mitral valvuloplasty. Am Heart J 2003;145:371-6.
3. Sagie A, Schwammenthal E, Newell JB, Harrell L, Joziatis TB, Weyman AE, et al. Significant tricuspid regurgitation is a marker for adverse outcome in patients undergoing percutaneous balloon mitral valvuloplasty. J Am Coll Cardiol 1994;24:696-702.
4. Hannoush H, Fawzy ME, Stefadouros M, Moursi M, Chaudhary MA, Dunn B. Regression of significant tricuspid regurgitation after mitral balloon valvotomy for severe mitral stenosis. Am Heart J 2004;148:865-70.
5. Mahfouz RA. Impact of pulmonary artery stiffness on right ventricular function and tricuspid regurgitation after successful percutaneous balloon mitral valvuloplasty: The importance of early intervention. Echocardiography 2012;29:1157-63.
6. Oukerraj L, El Houari T, El Haitem N, Bennani R, Fellat N, Fikri N, et al. Percutaneous mitral valvuloplasty in patients with low cardiac output at high surgical risk. Int J Cardiol 2008;130:285-7.
7. Cubeddu RJ, Palacios IF. Percutaneous techniques for mitral valve disease. Cardiol Clin 2010;28:139-53.
8. Fawzy ME. Mitral balloon valvuloplasty. J Saudi Heart Assoc 2010;22:125-32.
9. Davidson MJ, White JK, Baim DS. Percutaneous therapies for valvular heart disease. Cardiovasc Pathol 2006;15:123-9.
10. Tigen K, Pala S, Sadic BO, Karaahmet T, Dundar C, Bulut M, et al. Effect of increased severity of mitral regurgitation and preprocedural right ventricular systolic dysfunction on biventricular and left atrial mechanical functions following percutaneous mitral balloon valvuloplasty. Echocardiography 2014;31:1213-20.
11. Katsi V, Raftopoulos L, Aggeli C, Vlasseros I, Felekos I, Tousoulis D, et al. Tricuspid regurgitation after successful mitral valve surgery. Interact Cardiovasc Thorac Surg 2012;15:102-8.
12. Sancaktar O, Kumbasar SD, Semiz E, Yalçinkaya S. Late results of combined percutaneous balloon valvuloplasty of mitral and tricuspid valves. Cathet Cardiovasc Diagn 1998;45:246-50.
13. Shiran A, Sagie A. Tricuspid regurgitation in mitral valve disease incidence, prognostic implications, mechanism, and management. J Am Coll Cardiol 2009;53:401-8.
14. Boyaci A, Gokce V, Topaloglu S, Korkmaz S, Goksel S. Outcome of significant functional tricuspid regurgitation late after mitral valve replacement for predominant rheumatic mitral stenosis. Angiology 2007;58:336-42.
15. Smíd M, Cech J, Rokyta R, Roucka P, Hájek T. Mild to moderate functional tricuspid regurgitation: Retrospective comparison of surgical and conservative treatment. Cardiol Res Pract 2010;2010: doi: 10.4061/2010/143878.
16. Song H, Kang DH, Kim JH, Park KM, Song JM, Choi KJ, et al. Percutaneous mitral valvuloplasty versus surgical treatment in mitral stenosis with severe tricuspid regurgitation. Circulation 2007;116:I246-50.
17. Lee SP, Kim HK, Kim KH, Kim JH, Park HE, Kim YJ, et al. Prevalence of significant tricuspid regurgitation in patients with successful percutaneous mitral valvuloplasty for mitral stenosis: Results from 12 years' follow-up of one centre prospective registry. Heart 2013;99:91-7.
18. Maoqin S, Guoxiang H, Zhiyuan S, Luxiang C, Houyuan H, Liangyi S, et al. The clinical and hemodynamic results of mitral balloon valvuloplasty for patients with mitral stenosis complicated by severe pulmonary hypertension. Eur J Intern Med 2005;16:413-8.
19. Mahfouz RA, Elawady W, Hossein E, Yosri A. Impact of atrioventricular compliance on clinical outcome of patients undergoing successful percutaneous balloon mitral valvuloplasty. Echocardiography 2013;30:1187-93.