Risk factors for posterior ventricular rupture after mitral valve replacement: results of 2560 patients

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Abstract

Objective: Posterior ventricular rupture is a rare and fatal complication of mitral valve surgery. This study is designed to define the risk factors for left ventricular rupture after mitral valve replacement and, especially, to find out if posterior leaflet preservation is protective for posterior ventricular rupture.

Methods: Between January 1996 and March 2007, 2560 patients underwent mitral valve replacement operation in our hospital. Risk factors for posterior ventricular rupture were studied with \( \chi^2 \) and logistic regression analysis.

Results: The surgery was complicated with posterior ventricular rupture in 23 (0.8%) of 2560 patients. Nineteen patients (82.6%) were female, four patients (17.4%) were male. Mean age of the patients in this group was 60 ± 10. Mortality rate of the patients with posterior ventricular rupture was 86% (20 patients). Twelve patients with posterior ventricular rupture were at the age of 60 and older. Age of 60 and above was found as a highly significant risk factor for posterior ventricular rupture (OR 4.53, 95% CI 1.98—10.38, \( p < 0.001 \)). Posterior leaflet was preserved in 513 patients (20%) and posterior ventricular rupture did not occur in these patients. Resection of posterior leaflet was also found as a highly significant risk factor (\( p = 0.008 \)) for posterior ventricular rupture. Reoperation was performed in 372 patients and posterior ventricular rupture occurred in 7 of them. Reoperation was also found as a significant risk factor (OR 2.563, 95% CI 1.03—6.34, \( p = 0.042 \)) for posterior ventricular rupture.

Conclusions: Extreme annular traction and aggressive decalcification should be avoided during mitral valve resection. Posterior leaflet of the mitral valve should be preserved, especially in the older age group to prevent posterior ventricular rupture.

Keywords: Mitral valve replacement; Posterior ventricular rupture; Posterior leaflet preservation

1. Introduction

Posterior ventricular rupture (PVR) is a rare and fatal complication of mitral valve replacement (MVR). It was first defined by Roberts and Morrow in two cases via a postmortem study in 1967 [1]. In literature, incidence of this complication is stated as 0.5—2% and its mortality as 65—75% [2—5]. Studies to prevent this fatally progressing complication have been focused on predisposal factors. In some studies with small series, it is stated that posterior leaflet preservation decreases the incidence of PVR [6,7]. In this manuscript, risk factors of ventricular rupture following MVR and, especially, the effect of posterior leaflet preservation on the incidence of PVR are studied.

2. Materials and methods

In our clinic, 2560 patients (1676 female and 884 male, with a mean age of 47 ± 28.3) who underwent MVR operation between January 1996 and March 2007 were examined. Risk factors such as older age (≥60), gender, coexisting coronary artery disease, interventions for additional valve pathologies, infective endocarditis, underlying mitral valve pathology, reoperation, calcified annulus and emergency of the operation were recorded. Also hypertension, diabetes mellitus, hyperlipidemia, smoking, chronic obstructive pulmonary disease and renal failure were recorded as demographic data.

Demographic data and clinical characteristics of the patients who underwent MVR and who developed PVR are shown in Table 1. In patients with PVR, the time and type of rupture, and repair techniques were noted (Table 2). Types of PVR were previously classified by Treasure et al. [5] and Cobbs et al. [6]. Ruptures located in the posterior atrioventricular groove were named as type I; ruptures in the posterior wall of the left ventricle at the base of the papillary muscles were named as type II; and ruptures in the
area between the atrioventricular groove and the papillary muscles (midventricular type) as type III. The complication has also been classified by time pattern of presentation; early (before sternal closure), delayed (>6 h after the sternal closure), and late (>6 h after the sternal closure) rupture [8,9].

2.1. Surgical technique

Patients were operated via median sternotomy with the standard aortic and bicaval cannulation. The heart was vented through right superior pulmonary vein. Heparin was administered with a dose of 3 mg/kg and cardiopulmonary bypass (CPB) was initiated. Myocardial protection was achieved with 28 °C systemic hypothermia, antegrade cold blood cardioplegia and intermittent retrograde cardioplegia via the coronary sinus. Operations were performed through the left atriotomy. Native mitral valves were resected; if the annulus was calcified, decalcification was performed and mechanical valves were implanted using separate 2-0 Ti-Cron 25 mm sutures (Syneture, CE). Leaflets were preserved in appropriate patients according to the intraoperative examination of the valve. In these cases, the sutures are passed both through the leaflet and the annulus.

2.2. Statistical analysis

SPSS for Windows 10.0 was used for statistical analysis. The distribution of categorical measurements was investigated according to the frequency and percentages, while the numerical parameters were described as mean and standard deviations. Chi square test and Fisher’s exact test were used in univariate assessment of the study performed by classifying numerical parameters among the study parameters. Odds ratios were calculated by estimated risk measurements. Significant parameters or parameters found to be nearly significant in univariate analysis were evaluated with logistic regression analysis among multivariate analysis for the predictors of PVR after MVR. As a result of this procedure, independent risk factors of posterior ventricular rupture after MVR were determined. The results were evaluated in 95% confidence interval and at a significance level of p < 0.05.

3. Results

Among the patients included in the study, the dominant pathology was mitral stenosis or predominant mitral stenosis in 58.4% and pure mitral failure or predominant mitral failure in 41.6%. Three hundred and seventy-two patients (14.5%) were reoperations. Leaflet preservation was applied to 513 (20%) of the cases. Posterior leaflet was preserved in 445 (17.8%) patients, both anterior and posterior leaflets in 68 (2.2%). Annular calcification was present in 120 (4.9%) of the cases. Left atrial thrombus was detected in 208 (8.1%) patients and left atrial thrombectomy was performed during the surgery.

Posterior ventricular rupture occurred in 23 patients (0.8%) among the series. Fourteen (61%) of the patients were type III, 6 (26%) were type I, and 3 (13%) were type II ventricular ruptures. Eleven (47.9%) were diagnosed before sternal closure, seven (30.4%) within 6 h after sternal closure, and five (21.7%) more than 6 h postoperatively (Table 2).

Average age in PVR group was 60 ± 10. Twelve (52%) patients were at the age of 60 and older. An age group of 60 and older was found as a highly significant risk factor for PVR (OR 4.53, 95% CI 1.98—10.34, p < 0.001) (Table 3). Reoperation was performed in 372 patients and PVR occurred in 7 of these patients. Reoperation was found as a significant risk factor (OR 2.563, 95% CI 1.03—6.34, p = 0.042) for PVR (Table 3).

Posterior ventricular rupture did not occur in any of the 513 (20%) patients with posterior leaflet preservation. Resection of the posterior leaflet was also found as a highly significant risk factor for PVR (p = 0.008) (Table 3). Other risk factors such as gender, hypertension, diabetes mellitus,
hyperlipidemia, smoking, chronic obstructive pulmonary disease, renal failure, coexisting coronary artery disease, predominant mitral stenosis, intervention for additional valve pathologies, calcified annulus, infective endocarditis, emergency of the operation and left atrial thrombectomy were not found as statistically significant (Table 3).

The sizes and types of the implanted valves and valve sizes related with PVR are given in Table 4. Mechanical valves were implanted in 2434 patients (95%) and biological valves were used in 126 patients (5%). In our series, all of the patients who were complicated with PVR in the postoperative period were in the mechanical valve group. Most commonly implanted valve sizes were 29 (n = 1031, 40%), 27 (n = 725, 28%), 31 (n = 607, 24%), 33 (n = 128, 5%), 25 (n = 67, <1%), and 35 (n = 2, <1%). Posterior ventricular rupture occurred frequently with 29 mm (n = 9, 39%) and 31 mm (n = 9, 39%) sized valves. Three patients (13%) with 33 mm sized valves and two patients (9%) with 27 mm sized valves also produced PVR. Statistical analysis showed that the size and type of the valve do not predict a significant risk for PVR.

Nineteen patients (82%) underwent surgery for PVR, four patients (18%) were diagnosed after necropsy. Among the patients who underwent surgery for PVR, both external and internal repair were applied to 11 (47.3%) patients, only external repair was applied to 8 (34.7%) patients. All of the patients with external and internal repair, and two patients with only external repair were operated on CPB. Six patients with external repair were operated without CPB.

Mortality rate of PVR in mitral valve replacement was 86% (n = 20) (Table 2). Three patients (14%) survived after the surgical intervention for PVR. Among the survivors one patient was operated with only external repair and the other two patients were operated with both external and internal repair. All of the operations were performed under CPB. During the follow-up, the functional capacity of the patients was class III according to NYHA. One patient developed a pseudoaneurysm one year after the operation; this patient was not reoperated and died 18 months after the surgery.

4. Discussion

Posterior ventricular rupture is a rare complication of MVR, generally with fatal progress. It was first defined by Roberts and Morrow via a postmortem study in 1967. In this study, papillary muscle excision and extreme traction applied on the calcified annulus were thought to be the causes for PVR [1].

The posterior annulus of the mitral valve consists of a fibrous structure and it is mobile because of the surrounding
left atrial and left ventricular myocardium; this forms the basis of annular motion. Unlike the anterior leaflet, the mitral annulus is not supported by a fibrous skeleton in the posterior leaflet. This anatomical difference accounts for the frequent incidence of ventricular rupture in the posterior leaflet after MVR.

In recent years, different studies were designed for PVR in mitral valve surgery and a variety of risk factors were focused on. Decreased tissue elasticity and increased fragility in the elderly patients participate in the formation of ventricular rupture following MVR [9–11]. In our study, age of 60 or above was found as a highly significant risk factor for PVR.

Liellehei et al. performed MVR with posterior leaflet, chordae, and papillary muscle preservation for the first time in 1962. They also claimed that decreased annular traction of the posterior leaflet, chordae preservation and under-valve structures supporting the posterior wall lower the risk for ventricular rupture [7]. Some researchers reported that posterior leaflet and chordae preservation during MVR protect diastolic dimensions and ideal geometry of the left ventricle, and that preserves the contractile functions [12–14]. Cobbs et al. presented the untethered loop theory, and stated that mural leaflet and papillary muscle excision affect atrioventricular integrity and may trigger spontaneous ventricular rupture after the operation [6]. Posterior ventricular rupture was not detected in any of our patients with posterior leaflet preservation (n = 513). In our study, resection of the posterior leaflet was found as a highly significant risk factor for PVR.

Extreme traction applied on the annulus during the excision of the native valve and implantation of the prosthesis may cause laceration and hematoma, and, in turn, may cause ventricular wall rupture [1,2]. Also, iatrogenic injuries during the manipulation of the valve, and postoperative intraventricular volume and pressure overload may contribute to the rupture [6,15]. Mitral valve and subvalvular structures should be excised carefully and extreme traction should be avoided. Carpentier et al. stated the importance of gentle manipulation on the valve and especially the preservation of tertiary chordae, and they did not face any ventricular ruptures in their large series [16].

Removal of the annular calcification, especially extending into the left ventricle may result with incomplete tears which may lead to ventricular wall rupture [6,15]. In our series, annular calcification was detected in 120 patients, but this was not found as a significant risk factor for PVR.

The location and the mechanism of the rupture may be correlated in some cases. Type I rupture generally occurs as a result of localized trauma and hematoma due to deep annular decalcification, excessive tissue debridement after bacterial endocarditis, deep subannular sutures, and upward malposition of the heart after valve implantation [8,17]. In our series, type I rupture was detected in six patients. The etiology of PVR was excessive decalcification in two patients, deep subannular suture in one patient, and mismatch of the annulus and the mechanical valve in one patient. In two patients, there were no suspected pathologies to explain the rupture. Type II rupture occurs because of excessive posterior papillary muscle resection and hypertension during the early postoperative period [17,18]. In our study, type II rupture was diagnosed in three patients; early hypertension was the etiology in one patient and a particular cause was not detected in the other two patients. Type III rupture generally occurs due to the mismatch of the annulus and the prosthesis [17,18]. This type of rupture was detected in 14 patients in our series but the common etiologic factor was detected only in 2 patients. The mechanism of the rupture was upward malposition of the heart after the implantation of the mechanical valve in two patients and hypertension in two patients. There were no diagnosed pathologies in the other eight patients. These data may show that the location and type of the rupture are not always correlated with the common etiologic factor.

The etiology for early rupture is generally a heavily calcified annulus. Delayed PVR occurs as a result of extreme traction applied on the annulus, and annulus and mechanical valve mismatch is the most common cause of late PVR. It is clear that the chances for successful intervention are much better if the chest is still open when the bleeding begins. In four of our cases, the second bleeding episode occurred after the second postoperative day. It, therefore, seems that PVR may occur later than generally reported. Another explanation for these late bleeding episodes may be early leakage with the formation of a subepicardial hematoma, which subsequently ruptures. If only this epicardial rupture is repaired, or if dense adhesions restrict the hematoma, a pseudoaneurysm may occur, as happened in one of our patients, who recovered after left ventricular rupture [18].

Although all of the patients who developed PVR were in the mechanical valve group and the implanted sizes were 29 and 31 mm in most cases, statistical analysis did not reveal any significance related to the type or the size of the valve.

Standard techniques were used for myocardial protection and valve surgery in our study. Operations were performed through left atriotomy and cold blood cardioplegia was used for myocardial protection. So, it is not possible to comment about the effect of different types of surgical techniques and myocardial protection.

Coexisting coronary artery lesions which cause papillary muscle dysfunction may also trigger PVR [13,19]. But in our study coexisting coronary artery disease was not found as a significant risk factor. Other risk factors like hypertension, diabetes mellitus, hyperlipidemia, smoking, chronic obstructive pulmonary disease, renal failure, female gender, predominant valve stenosis, surgery for additional valve pathologies, emergency of the operation and infective endocarditis were not found statistically significant.

Different surgical approaches have been previously reported to repair PVR [9,20–22]. Generally, a successful repair is expected when repair is performed on CPB. Although rare cases of successful repair have been reported when the prosthesis is kept in place, removal of the implanted mitral valve is recommended. Also, autotransplantation is one of the alternative techniques for the repair of PVR [23]. The three successfully repaired cases in our series were early types of ruptures and were operated on CPB but this was not statistically significant.

In conclusion, PVR is a rare but generally mortal complication of mitral valve surgery. Ages of 60 and above and reoperations are important risk factors for PVR. According to the results of our large series, in order to prevent PVR, posterior leaflet should be preserved in
appropriate patients, extreme annular traction should be avoided, manipulations should be done carefully in mitral valve surgery. When surgery is complicated with PVR, repair with CPB is recommended.

References


