Institutional report - Congenital

Midterm outcome of mitral valve repair for congenital mitral regurgitation in infants and children

Osami Honjo*, Kozo Ishino, Masaaki Kawada, Teiji Akagi, Shunji Sano

*Department of Cardiovascular Surgery, Okayama University Graduate School of Medicine and Dentistry, Okayama, Japan

Cardiac Care Unit, Okayama University Graduate School of Medicine and Dentistry, Okayama, Japan

Received 25 November 2005; received in revised form 24 June 2006; accepted 26 June 2006

Abstract

We analyzed the midterm results of children undergoing mitral valve repair without the use of prosthetic materials focusing on mitral annulus growth. From 1991 to 2004, 17 children (median age: 11 months) underwent mitral valve repair (grade III–9, IV–8). Regurgitation was due to prolapsed leaflet in 8 patients, annular dilatation in 4, and restrictive leaflet motion in 5. Preoperative indexed mitral valve diameter and Z-value were compared with those obtained at follow-up. There were no early or late deaths. All patients had an improved regurgitation grade after surgery. MV repair resulted in reduction in the indexed mitral valve diameter (58.2 ± 22.9 vs. 47.3 ± 18.9 mm/m², P < 0.05) and Z-value (3.3 ± 2.3 vs. 0.79 ± 2.2, P < 0.05). One patient underwent re-repair, but no patients required mitral valve replacement during the median follow-up period of 95 months. The latest regurgitation grade was absent or I in 4 patients, II in 10 patients, and III in 3 patients. Mitral valve annulus increased by 23% at 3 years and by 49% at 5 years compared with that at surgery. Mitral valve repair without the use of prosthetic materials is feasible for the majority of patients and carries an appropriate growth pattern of the mitral valve annulus after surgery.

Keywords: Congenital heart disease; Valve disease; Mitral valve

1. Introduction

Surgical management for congenital mitral valve (MV) regurgitation in infants and children has been a therapeutic challenge because of a wide spectrum of morphologic abnormalities and high prevalence of associated anomalies [1]. Since MV replacement in small children is associated with high mortality and reoperation rates [2,3], reconstructive surgery has been developed as a first-line surgical approach to patients with congenital MV lesions [4–7]. Despite recent improvement in surgical procedures, high rates of reoperation and subsequent MV replacement remains a problem, especially in small infants and children [4].

Several techniques using prosthetic materials have been utilized for MV repair in children. These techniques include annuloplasty with a prosthetic ring combined with a cusp extension technique [4] and chordal replacement with artificial chordae [8], an approach that has been widely used in adult patients. However, prosthetic rings and artificial chordae have no growth potential, and there are concerns about the use of such prosthetic materials: somatic growth of the heart may result in progressive mitral stenosis in patients with a rigid prosthetic ring, and proportional changes in the repaired valve may lead to recurrence of regurgitation in patients with artificial chordae.

To preserve growth potential of the MV in children, we have attempted to repair congenital MV regurgitation without the use of prosthetic materials. We analyzed the midterm results for 17 patients with congenital MV regurgitation who had undergone MV repair, focusing on MV annulus growth after repair.

2. Patients and methods

2.1. Patient population

We conducted a retrospective study of children who underwent MV repairs for congenital MV regurgitation from November 1991 to December 2004 at Okayama University Hospital. The Institutional Review Board approved this retrospective study and patient consent was waived for the study. Ten infants and 7 children (6 male and 11 female) underwent a total of 18 MV repairs. Patients with mitral cleft, atrioventricular septal defect, L-transposition, single ventricle, and Bland-White-Garland syndrome were excluded from this study. Age at operation ranged from 3 months to 13 years (median age, 11 months), and ten (59%) of the 17 patients were <1 year of age. Weight at operation...
ranged from 3.8 to 44 kg (median weight, 6.4 kg). Associated cardiac anomalies were present in 11 (65%) of the patients as shown in Table 1. Fifteen of the 17 patients presented with congestive heart failure, and 3 (18%) patients required mechanical ventilation prior to surgery. The MV malformations were classified according to Carpentier’s functional classification [9]: MV regurgitation associated with normal leaflet motion (type I), prolapsed leaflet motion (type II), and restricted leaflet motion (type III) (Table 2).

2.2. Mitral valve repair

Cardiopulmonary bypass was established by ascending aortic and bicaval cannulations with moderate hypothermia, and myocardial protection was obtained by antegrade crystalloid cardioplegia. The MV was approached via the vertical left atriotomy in 6 patients and through the intratrial septum in 11 patients. A list of the procedures used is shown in Table 3. Several techniques were used in the same patient. Commissuroplasty was used for repairing commissural prolapse or poor coaptation of commissures. A prosthetic ring was used in one patient who had sufficient size of the mitral annulus (31 mm). Concurrent repair of associated lesions was performed in 9 (53%) of the 17 patients.

2.3. Evaluation of mitral valve regurgitation

MV regurgitation was estimated by a semiquantitative grading according to the maximum length and width of the abnormal jet relative to the atrium: 0, no regurgitation; I, if the jet was less than one third of the length and width of the atrium; II, if the jet was one third to one half of the length and width of the atrium; III, if the jet was one half to two thirds of the length and width of the atrium; and IV, if the jet exceeded two thirds of the length and width of the atrium [10]. Postoperative evaluation was performed before discharge, and follow-up echocardiography was obtained at 3 to 6 months following surgery and every 6 to 12 months thereafter.

2.4. Evaluation of mitral valve annulus

MV annulus was measured by two-dimensional echocardiogram before and after surgery. The lateral dimension of the MV was measured from the apical or subcostal 4-chamber view. The lateral dimension of the MV annulus was considered to be the distance between the proximal attachments of the leaflets at each side of the MV annulus.

<table>
<thead>
<tr>
<th>Table 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Associated cardiac anomalies in patients undergoing mitral valve repair</td>
</tr>
<tr>
<td>Associated anomalies</td>
</tr>
<tr>
<td>Ventricular septal defect</td>
</tr>
<tr>
<td>Atrial septal defect</td>
</tr>
<tr>
<td>Left ventricular diverticulum</td>
</tr>
<tr>
<td>PAPVD</td>
</tr>
<tr>
<td>S/p CoA/VSD repair</td>
</tr>
<tr>
<td>CoA/VSD: coarctation of aorta with ventricular septal defect, PAPVD: partial anomalous pulmonary venous drainage.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classification of mitral valve lesions according to Carpentier’s functional classification</td>
</tr>
<tr>
<td>Classification</td>
</tr>
<tr>
<td>Normal leaflet motion (Type I)</td>
</tr>
<tr>
<td>Annular dilatation</td>
</tr>
<tr>
<td>Prolapsed leaflet motion (Type II)</td>
</tr>
<tr>
<td>Elongated chordae</td>
</tr>
<tr>
<td>Torn chordae</td>
</tr>
<tr>
<td>Restrictive leaflet motion (Type III)</td>
</tr>
<tr>
<td>Short chordae</td>
</tr>
<tr>
<td>Dysplastic valve</td>
</tr>
</tbody>
</table>

[11]. The largest dimension occurring during the cardiac cycle was chosen for analysis. MV annulus diameter obtained from echocardiography was compared with the predicted value calculated according to Rowlatt et al. [12]. We regarded the mean normal value of MV annulus obtained from Rowlatt’s table as 100%. MV diameter was indexed to the patient’s body surface area (Indexed MV diameter, mm/m²) and preoperative indexed MV diameter was compared with those obtained at discharge and at follow-up. Deviation of MV annulus size was evaluated by calculating Z-value of individual MV annulus [13].

2.5. Statistical methods

Survival and reoperation rates were calculated by the Kaplan–Meier method. Wilcoxon test was used for comparison of variables in two groups. Data are presented as mean ± S.D. The level of statistical significance was set at \( P = 0.05 \).

3. Results

Reconstructive surgery was possible in all patients. There were no early and late mortalities. Clinical follow-up was completed for all 17 patients. The median follow-up period was 95 months (mean, 85 months; range, 31–153 months). There were no thromboembolic events during the follow-up period. Reoperation was necessary in 1 patient two years after the initial surgery. The patient underwent initial MV repair, chordal shortening and Reed annuloplasty at 6 months of age. Intraoperative findings at reoperation showed that MV regurgitation was due only to recurrent annular dilatation, not due to chordal elongation, and the valve repair was accomplished by commissuroplasty and...
Reed annuloplasty. None of the patients required MV replacement or developed mitral stenosis during the follow-up period. Actuarial freedom from reoperation was 92% at 3 (95% confidence interval [CI]: 81–100%) and 92% at 5 (95% CI: 81–100%) years (Fig. 1). All 17 patients were asymptomatic and clinically well at last follow-up.

3.1. Mitral valve regurgitation

Preoperative MV regurgitation was grade III in 9 patients and grade IV in 8 patients. All patients had an improved MV regurgitation grade after surgery (Fig. 2). At the last echocardiography, 15 (88%) of the 17 patients maintained the same MV regurgitation grade as that obtained at discharge: absent or I in 4 patients, II in 10 patients, and III in 3 patients (Fig. 2). There was no evidence of chordal re-elongation or rupture in the 7 patients who underwent chordal augmentation.

3.2. Mitral valve annulus

Preoperative mean MV annulus diameter was $22.2 \pm 4.3$ mm (range, 14.1–31.2 mm), 146±29% of the predicted normal value. MV repair resulted in significant reduction in the mean indexed MV diameter ($58.2 \pm 22.9$ mm/m² vs. $47.3 \pm 18.9$ mm/m², $P<0.05$) (Fig. 3) and the mean Z-value ($3.3 \pm 2.3$ vs. $0.79 \pm 2.2$, $P<0.01$) (Fig. 4), respectively. Follow-up echocardiography at 3 and 5 years after surgery was obtained from 7 patients in each time point. Mean MV annulus diameter was $20.7 \pm 4.4$ mm, $117 \pm 11$% of the normal value 3 years after repair, and $24.4 \pm 3.7$ mm, $118 \pm 4$% of the normal value, 5 years after repair (Fig. 5). MV diameter increased by 23% at 3 years and by 49% at 5 years compared with that measured at immediate postoperative period (Fig. 5). There was a further decrease in the mean indexed MV diameter at 3 years, but there was no difference between the mean indexed MV annulus obtained at 3 years and that obtained at 5 years (Fig. 3). The mean Z-value has normalized further by 3 years after surgery, and remained unchanged at 5 years after surgery (Fig. 4).
leaflet enlargement in patients older than 2 years of age [4]. Other series, however, have demonstrated successful MV repairs without the use of a prosthetic ring and with a low reoperation rate [5–7]. In this series, prosthetic ring was used in only one patient who had an MV annulus of 31 mm in diameter. We agree that a prosthetic ring should be used in older children who have an MV annulus of sufficient size for the ring to be inserted. However, rigid ring insertion in the small infants may not only compromise the growth potential of the mitral annulus but also may make repair difficult. Therefore, we prefer to repair congenital MV regurgitation associated with annular dilatation without prosthetic materials for patients who have a small MV annulus.

Chordal augmentation using native chordae is still the first-line technique for repairing a prolapsed mitral leaflet in children [4,9]; however, replacement of ruptured chordae using artificial chordae versus shortening or transfer [14] has been widely used in adults. Some authors have recently used this technique in children with reasonable midterm outcome [8]. However, there is concern regarding the long-term durability of this technique following somatic growth. Finite element studies showed that shortened artificial chordae produced not only poor coaptation, but also excessive stress to the adjacent native chordae and the edge of the leaflet [15]. These studies indicate that excessive stress to the edge of the leaflet or adjacent chordae may occur as the patient grows. We prefer to use native chordae if they can be shortened or transferred, but we also do not hesitate to use artificial chordae if there is no available native chordae for transfer. The midterm results of chordal augmentation with native chordae are encouraging, and chordal repair using native tissue versus artificial chordae is expected to better preserve the proportion of the MV.

5. Conclusions

MV repair without the use of prosthetic materials is feasible and carries a low reoperation rate for the majority of patients with congenital MV regurgitation. Despite residual MV regurgitation in some patients, most patients did not develop MV regurgitation requiring reoperation and there was an appropriate growth pattern of the MV annulus during the follow-up period. We believe this strategy would have potential advantages that would attenuate early mortality and morbidity and augment long-term growth of the MV annulus in children.

References


