Echocardiographic evaluation of mitral valve in patients with pure rheumatic mitral regurgitation

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The aims of this study were to evaluate the structure of the mitral valve (MV) and subvalvar apparatus in patients with rheumatic mitral regurgitation (MR) by echocardiography and to compare the differences in morphologic abnormalities between subgroups of patients with and without mitral valve prolapse (MVP). Two-dimensional and color Doppler echocardiographic examinations were performed in 20 consecutive patients with isolated rheumatic MR and in 15 healthy subjects as controls. Annular diameter, left ventricular end-diastolic dimension, anterior leaflet length, and both leaflet thicknesses were greater in MR than those of controls. Anterior leaflet and chordal lengths were greater in severe MR than in mild or moderate MR. Sixty percent of rheumatic MR patients had nodules on the body or tip of the anterior mitral leaflet and MR was more severe in these patients. Nine of 20 patients (45%) had MVP. MR was more severe in the patients with MVP than those without prolapse. Rheumatic etiology should be suspected in patients with MR when irregular focal thickening of MV, relatively immobile posterior leaflet, eccentric regurgitant jet, and anterior MVP are found in echocardiographic study.

Key words: rheumatic carditis, mitral regurgitation, mitral valve prolapse.

In the middle of the 20th century, a dramatic decline occurred in the incidence of acute rheumatic fever (ARF) in the United States and Western Europe[1], although it remained a leading cause of heart disease in developing countries[2]. Rheumatic valvular heart disease is also a major cause of cardiovascular death during five decades of life in developing countries[3]. The mitral valve (MV) is the primary focus of endocardial involvement in rheumatic heart disease (RHD)[4,5]. Limited numbers of studies have been conducted about the echocardiographic definition of the MV apparatus in patients with RHD[6-8]. The aims of this study were to evaluate the structure of the MV and subvalvar apparatus in patients with rheumatic mitral regurgitation (MR) by echocardiography and to compare the differences in morphological abnormalities between subgroups of patients with and without mitral valve prolapse (MVP).

Material and Methods

Population

Over a three-year period, the study population consisted of 20 patients (16 female, 4 male) with pure rheumatic MR who were compared with an age- and body surface area (BSA)-matched 15 healthy children.

The age range of the patients was 7 to 23 years (mean age: 12.45±3.91 years) and of the control group was 5 to 15 years (mean age: 11.16±2.16). ARF was diagnosed according to the modified Jones criteria[9]. The follow-up period of patients ranged from 8 months to

8 years. The diagnosis of MR was based on auscultatory and echocardiographic findings. There was a period of at least eight months between the attacks of RF and echocardiographic measurements.

Echocardiographic Examination

Echocardiographic imaging was performed using commercially available echocardiographic equipment (Hewlett-Packard Sonos 5500 Cardiac Imager, Andover, Massachusetts, USA) coupled to 2.0-4.0 or 3.0-8.0 MHz transducers. Two-dimensional and Doppler echocardiographic images were obtained in standard parasternal and apical views in all patients.

Mitral regurgitation was graded with color Doppler flow according to the width and length of the regurgitant jet in the left atrium (grade 1 to 4)[5,10,11]. Jets were classified into two types as central and eccentric jets. Left ventricular end-diastolic (LVEDd) and end-systolic (LVESd) diameters and left ventricular fractional shortening (FS) were measured at midpapillary level in the standardized parasternal long-axis or short-axis positions. The diameter of MV annulus was measured at end diastole from the apical four-chamber view[12].

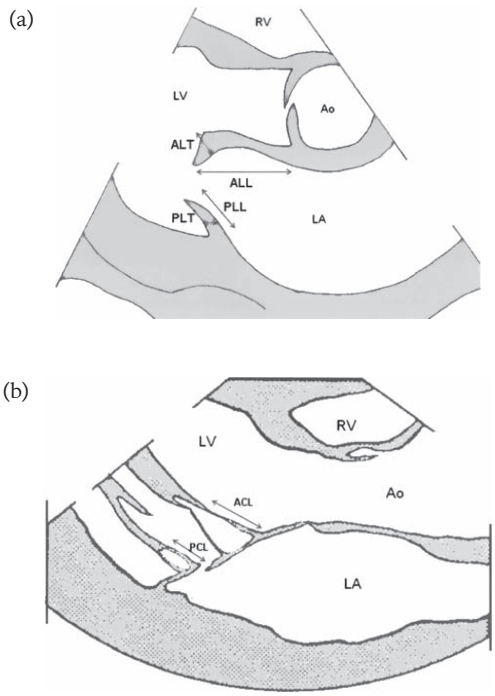

Fig. 1. a) Maximal leaflet lengths and thicknesses of mitral valve leaflets were measured in the parasternal long-axis view at end-diastole. ALL: Anterior leaflet length. PLL: Posterior leaflet length. ALT: Anterior leaflet thickness. PLT: Posterior leaflet thickness.

b) Chordal lengths were measured in the parasternal long-axis view at end-systole. ACL: Anterior chordal length. PCL: Posterior chordal length.

Valvular Apparatus

The structure of the valve and the subvalvar apparatus were imaged in the parasternal long-axis and apical four-chamber views. MV was examined for the presence of focal nodular or diffuse thickening and leaflet prolapse. Furthermore, maximal leaflet lengths and thicknesses of MV leaflets were measured in the parasternal long-axis view at end-diastole (Fig. 1a). Chordal lengths were measured in the parasternal long-axis view at end-systole (Fig. 1b). Annular and chordal measurements were indexed to BSA. Leaflet motion was graded as normal, excessive or restricted. Diagnosis of MVP was considered if systolic displacement of the mitral leaflets above the mitral annular plane in the parasternal long-axis view and similar displacement in the apical four-chamber view were present on two-dimensional echocardiography[5,8,13].

Statistical Analysis

All echocardiographic measurements were indexed to BSA and all data were shown as mean±standard deviation (SD). Statistical analyses were made with Student's t-test analysis by using SPSS 11.0 statistical package program. All reported probability values are two-sided and a probability value less than 0.05 was considered significant.

Results

Echocardiographic measurements of the study group are shown in Table I. The patients with rheumatic carditis had greater mitral annular diameter and left ventricular dimension than control cases ($p<0.05$).

Valve Regurgitation

Eight patients (40%) had severe MR and 12 (60%) had mild or moderate MR. The MR jets directed posterolaterally in most patients. Eighteen patients (90%) had eccentric jets and two patients (10%) had central jets.

Valve Morphology

Among 20 patients with rheumatic MR, 12 (60%) had more echogenic focal thickening (nodules) on the body or the tip of the anterior leaflet (Table I) (Fig. 2). Valve nodules measured from 2.5 to 6 mm in diameter (Fig. 1). It was found that the severity of MR was greater in patients with nodules than in patients without (2.60±0.83 vs 1.25±0.50; $p<0.01$). Diffuse thickening of the mitral leaflets was found in 8 patients (40%) in rheumatic MR. Restricted posterior leaflet mobility was found in 10 patients (50%) with rheumatic MR. In two of them, there was associated anterior leaflet restriction as well. The patients with rheumatic MR had greater anterior leaflet length and increased anterior and posterior leaflet thickness than control cases (respectively, $p<0.01$, $p<0.001$ and $p<0.01$) (Table I). Anterior leaflet and anterior chordal lengths and mitral annulus were greater in patients with severe MR than in patients with mild or moderate MR (respectively, $p<0.01$, $p<0.05$, and $p=0.01$) (Table II).

Evidence of anterior MVP was shown in 9 (45%) of the 20 patients. The degree of MR was greater among patients with MVP than patients without ($p<0.01$) (Table III). The patients with MVP had greater anterior and posterior leaflet length than patients without prolapse ($p=0.01$ and $p<0.05$) (Table III). Among 9 patients with MVP, 8 (88.9%) had nodules on the body or the tip of the anterior leaflet. The indexed left ventricular end-diastolic diameter (LVEDdi) was greater in patients with MVP ($p<0.01$).

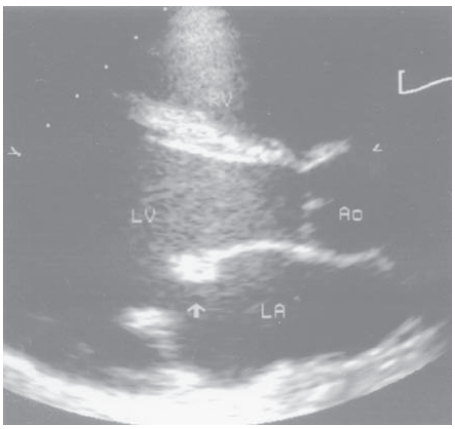

Fig. 2. Two-dimensional echocardiogram obtained from parasternal long-axis in a patient with rheumatic mitral regurgitation. Focal thickening (nodule) on the tip of the anterior mitral leaflet is indicated by an arrow.LV: Left ventricle. LA: Left atrium. Ao: Aorta.

Table I. Echocardiographic Measurements in the Study Group

	Rheumatic MR (n:20)	Control (n:15)	p
MAdi (mm)	26.27±6.28	19.92±4.86	<0.01
LVEDdi (mm)	45.39±13.31	34.93±10.00	0.01
FS (%)	35.63±5.88	36.71±5.56	0.58
EF (%)	65.73±9.26	65.31±7.63	0.89
ACLi (mm)	14.79±7.73	14.49±5.16	0.90
PCLi (mm)	12.53±3.45	10.66±2.35	0.08
ALLi (mm)	23.27±7.27	16.08±3.40	<0.01
PLLi (mm)	12.27±4.12	9.53±2.33	0.14
ALTi (mm)	4.58±2.45	1.27±0.40	<0.001
PLTi (mm)	2.63±2.17	1.07±0.38	<0.01
Valve abnormalities	n (%)		
Valve nodules	12 (60%)	0	–
MVDT	8 (40%)	0	–
MVP	9 (45%)	0	–
RLM	10 (50%)	0	–

Data are expressed as mean±standard deviation.
MR: Mitral regurgitation. MAdi: Indexed mitral annular diameter. LVEDdi: Indexed left ventricular end-diastolic diameter. FS: Fractional shortening. EF: Ejection fraction. ACLi: Indexed anterior chordal length. PCLi: Indexed posterior chordal length. ALLi: Indexed anterior leaflet length. PLLi: Indexed posterior leaflet length. ALTi: Indexed anterior leaflet thickness. PLTi: Indexed posterior leaflet thickness. MVDT: Mitral valve diffuse thickening. MVP: Mitral valve prolapse. RLM: Restricted leaflet mobility.

Table II. Echocardiographic Parameters of the Patients According to Mitral Regurgitation (MR) Severity

	Severe MR (n:8)	Mild or moderate MR (n:12)	P
MAdi (mm)	30.71±6.92	23.31±3.70	0.01
LVEDdi (mm)	55.38±14.46	38.72±7.21	<0.01
ALLi (mm)	29.30±5.38	19.24±9.36	<0.01
PLLi (mm)	13.36±4.22	10.04±3.70	0.09
ACLi (mm)	19.32±9.67	11.77±4.35	0.03
PCLi (mm)	13.98±4.19	11.52±2.58	0.15
ALTi (mm)	4.83±2.69	4.40±2.38	0.71
PLTi (mm)	3.59±2.77	1.81±1.16	0.15

Data are expressed as mean±standard deviation.
MAdi: Indexed mitral annular diameter. LVEDdi: Indexed left ventricular end-diastolic diameter. ACLi: Indexed anterior chordal length. PCLi: Indexed posterior chordal length. ALLi: Indexed anterior leaflet length. PLLi: Indexed posterior leaflet length. ALTi: Indexed anterior leaflet thickness. PLTi: Indexed posterior leaflet thickness.

Table III. Echocardiographic Measurements of Mitral Valve in Patients According to Evidence of Mitral Valve Prolapse (MVP)

	Patients with MVP (n:9)	Patients without MVP (n:11)	P
MAdi (mm)	28.89±6.90	24.13±5.05	0.09
LVEDdi (mm)	54.45±11.64	37.97±9.70	<0.01
ALLi (mm)	27.62±5.80	19.70±6.52	0.01
PLLi (mm)	13.30±3.75	9.43±3.69	0.04
ACLi (mm)	18.21±8.50	11.99±6.05	0.07
PCLi (mm)	14.10±3.80	11.14±2.56	0.08
ALTi (mm)	5.34±3.03	3.95±1.76	0.22
PLTi (mm)	3.70±2.52	1.38±0.48	0.05
Degree of MR	2.89±0.78	1.73±0.79	<0.01

Data are expressed as mean±standard deviation.
MAdi: Indexed mitral annular diameter. LVEDdi: Indexed left ventricular end-diastolic diameter. ACLi: Indexed anterior chordal length. PCLi: Indexed posterior chordal length. ALLi: Indexed anterior leaflet length. PLLi: Indexed posterior leaflet length. ALTi: Indexed anterior leaflet thickness. PLTi: Indexed posterior leaflet thickness. MR: Mitral regurgitation.

Discussion

Rheumatic heart disease is still the most important type of acquired heart disease in many developing countries. MV is the primary target of endocardial involvement, and MR is the most common finding on echocardiographic examination. Two-dimensional echocardiographic findings in rheumatic MR include thickened MV leaflets, incomplete closure of the MV, relatively immobile posterior mitral leaflet, dilated left atrium with systolic expansion, and dilated left ventricle with hyperdynamic septal and posterior wall motion[14,15]. Ventricular dilation together with leaflet restriction has been the suggested mechanism of MR both in patients with a first attack of carditis and in patients with a recurrence of carditis[8]. We also found a relation between increased left ventricular dilation and severity of MR.

Presence of varying degrees of mitral annular dilation in active carditis is well known[16,17]. Bulkley et al.[18] also determined this finding in a necropsy study of 15 patients with chronic rheumatic MR who had a 22% increase in annular circumference of MV. We also demonstrated increased annular diameter in patients with rheumatic MR. Our study also showed a relation between annular dilation and severity of MR.

Color Doppler imaging has been demonstrated to be a highly sensitive and specific non-invasive technique for the detection of MR[19]. We found the direction of MR jets most often to be eccentric, as in Vasan et al.'s study[8]. The direction of the regurgitant jet varied depending on the relative degree of restriction of mitral leaflets. We observed relatively immobile posterior MV in patients with rheumatic MR.

In active carditis, valves becomes edematous, endocardial surfaces are damaged and tiny vegetations are formed. When inflammation subsides, fibrosis with vascularization and contracture of the leaflets follow. Similar changes affect the chordae tendineae and the annulus. Chronic rheumatic MR has often been attributed to postinflammatory degenerative and fibrotic changes. These include shortening, rigidity, deformity and retraction of the leaflets, fusion of the commissures, and shortening and fusion of the chordae tendineae and papillary muscles[20,21].

Valvular thickening and chordal elongation were common in our patients with rheumatic MR by echocardiography. Although 8 patients had diffuse thickening, 12 patients had focal nodular thickening on the body or the tip of the anterior MV leaflet. We found that the severity of MR was greater in patients with focal nodules on MV than in those without. It is known that increased tension on the inflamed chordae causes their elongation[22]. Anterior leaflet and chordal lengths of the MV were closely related to the degree of valve regurgitation in our study.

Mitral valve prolapse has been observed frequently in rheumatic carditis patients as a postinflammatory sequela. The incidence of MVP had been reported as 80% in adult rheumatic patients[23]. However, Wu et al.[22] had reported that the incidence of MVP was 33% in children with isolated rheumatic MR. In our study, the incidence of MVP was found as 45% in pure rheumatic MR. MVP may be inflammatory in origin and increases with recurrent attacks as mentioned before[22,24]. The presence of marked annular dilation was reported in rheumatic patients with MVP[25], as in our study.

Weissman et al.[26] demonstrated the high prevalence of abnormal leaflet thickening in patients with MVP by two-dimensional echocardiography. We observed that the rheumatic patients with MVP had greater posterior leaflet thickness than patients without prolapse. Furthermore, the elongation of anterior and posterior mitral leaflets was demonstrated in patients with MVP[25,26]. We also found elongation of both MV leaflets in patients with MVP when compared to those without MVP. We have supported that MR is more severe in rheumatic patients with MVP, as mentioned by Marcus et al.[17]. MVP involving the anterior leaflet was also detected by echocardiography in the present study. Zhou et al.[27] had suggested that a rheumatic etiology should be suspected whenever anterior MVP exists, especially in young patients.

In conclusion, when MR in a young patient is associated with irregular thickening of MV leaflets, relatively immobile posterior leaflet, eccentric posteriorly oriented regurgitant jet, and anterior MVP, a rheumatic etiology should be strongly suspected.

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