Impact of Atrial Fibrillation on Tricuspid and Mitral Annular Dilatation and Valvular Regurgitation

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To investigate the effects of atrial fibrillation (AF) on the mitral and tricuspid valves, the corresponding annular dilatation and valvular regurgitation were compared with 2-dimensional and Doppler echocardiography in 31 consecutive patients with lone AF and 28 normal controls. Mid-systolic mitral and tricuspid annular areas were measured from 2 diameters in 2 orthogonal apical echocardiograms. Percent (%) mitral regurgitant (MR) or tricuspid regurgitant (TR) jet area to the left or right atrial area was evaluated and % MR or TR jet area >20% was considered moderate or significant. Both the mitral and tricuspid annular areas in patients with lone AF were significantly larger compared with the controls (mitral: 9.5±1.2 vs 6.6±0.9 cm², lone AF vs control, p<0.01) (tricuspid: 12.0±2.0 vs 7.5±0.9 cm², p<0.01). The % increase in the annular area relative to the mean normal value was significantly greater in the tricuspid valve (44±18 vs 60±28%, p<0.01). Moderate or severe MR was not observed and the incidence of moderate or severe valve regurgitation (% jet area >20%) was significantly higher in the tricuspid valve (0/31 vs 11/31, MR vs TR, p<0.01) in patients with lone AF. The % TR jet area showed significant correlation with tricuspid annular area (r²=0.65, p<0.001). Lone AF is associated with annular dilatation of both mitral and tricuspid valves, but the annular dilatation and valvular regurgitation are significantly greater in the tricuspid valve. (Circ J 2002; 66: 913–916)

Key Words: Atrial fibrillation; Mitral valve; Tricuspid valve; Valvular regurgitation

An annular dilatation of the atrioventricular valves promotes mitral and tricuspid regurgitation (MR and TR). Atrial fibrillation (AF) has also been shown to cause left and right atrial dilatation, potentially with dilatation of mitral and tricuspid annuli located at the inferior edge of the atrium. However, the effects of AF on the annular dilatation and regurgitation of the mitral and tricuspid valves have not been fully investigated.

The fibrous skeleton is less developed in the tricuspid annulus compared with the mitral annulus so we hypothesized that AF would potentially cause greater annular dilatation and resultant regurgitation in the tricuspid valve. Thus, the purpose of the present study was to compare the annular dilatation and regurgitation of the 2 valves in patients with lone AF, without the additional influence of other structural heart diseases.

Methods

Study Population

Between October, 1999 and September, 2000, 31 consecutive patients with lone AF, referred for 2-dimensional (D) and Doppler echocardiographic examination, were prospectively studied. Lone AF was defined as AF without other known cardiovascular diseases and no organic lesions on 2-D echocardiograms other than atrial dilatation. The control group consisted of 28 subjects with normal echocardiograms without cardiovascular disease. The subjects’ characteristics are shown in Table 1. All patients gave their written informed consent and the study was approved by the Ethical Committee of the Medical Department, Kagoshima University, Japan.

Echocardiographic Studies

All studies were performed with commercially available phased array sector scanners (Agilent Technologies Sonos 5500, Andover, MA, USA; ATL HDI 3000, Bothell, WA, USA; Toshiba SSH 380A, Tokyo, Japan; Aloka SSD 5500, Tokyo, Japan) equipped with 2–3 MHz transducers. Subjects were imaged in the left lateral decubitus position. The end-diastolic and end-systolic left ventricular volumes as

Table 1 Clinical Characteristics of the Controls and Patients With Lone Atrial Fibrillation

<table>
<thead>
<tr>
<th></th>
<th>Control group</th>
<th>AF group</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>64±12</td>
<td>72±49</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>M/F</td>
<td>16/12</td>
<td>15/16</td>
<td>NS</td>
</tr>
<tr>
<td>BSA (cm²)</td>
<td>1.6±0.2</td>
<td>1.6±0.2</td>
<td>NS</td>
</tr>
<tr>
<td>Heart rate (beats/min)</td>
<td>73±12</td>
<td>79±13</td>
<td>NS</td>
</tr>
<tr>
<td>Systolic BP (mmHg)</td>
<td>131±14</td>
<td>141±15</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Diastolic BP (mmHg)</td>
<td>78±49</td>
<td>79±49</td>
<td>NS</td>
</tr>
<tr>
<td>LVEDV (ml)</td>
<td>93±40</td>
<td>86±17</td>
<td>NS</td>
</tr>
<tr>
<td>LVESV (ml)</td>
<td>35±8</td>
<td>33±8</td>
<td>NS</td>
</tr>
<tr>
<td>EF (%)</td>
<td>63±7</td>
<td>61±6</td>
<td>NS</td>
</tr>
</tbody>
</table>

AF, atrial fibrillation; BSA, body surface area; BP, blood pressure; LVEDV, left ventricular end-diastolic volume; ESV, end-systolic volume; EF, ejection fraction.
well as the LV ejection fraction (LVEF) were obtained by the biplane Simpson’s method. The mitral annulus was visualized and its dimensions were measured from the left ventricular apex in 2 orthogonal planes including mid-systolic apical 4- and 2-chamber views (Fig 1). The tricuspid annulus was also visualized from the right ventricular apex in 2 orthogonal planes including the 4-chamber view. The mitral and tricuspid annuli were identified as the hinge points of the leaflets defined by their insertion on the left or right ventricular walls. The mid-systolic mitral and tricuspid annular area was obtained by elliptical assumption (area = d1 × d2 × π/4) (Fig 1). Color Doppler flow mapping was performed to evaluate regurgitant jet flow in the same view with the transducer position and direction slightly modified to obtain the largest regurgitant jet. The Nyquist limit of color flow mapping was set between 55 and 70 cm/s. Color flow gain was adjusted to a level immediately before artifactual color was observed. The severity of MR or TR was determined by the ratio of the color Doppler jet area to the left or right atrial area in mid-systole. The grade of MR or TR was estimated as trace, mild, moderate, or severe on the basis of ratios of >0–10%, >10–20%, >20–40%, and >40%. Continuous wave Doppler was used to obtain the TR peak velocity and systolic right ventricular pressure was calculated as 4 × v² + 10 mmHg. All the echocardiographic studies were recorded on s–VHS videotapes for subsequent off-line analysis.

Reproducibility of Measurements
Two-independent observers repeated the measurements of the mitral and tricuspid annular area in 10 patients. The difference in the measurements by the 2 observers was obtained to express inter-observer variability. The same observer repeated the measurements and intra-observer variability was also estimated.

Statistical Analysis
All values are expressed as means±SD. Comparisons between groups were done by the unpaired Student’s t-test. The relations between variables were analyzed by simple linear regression. A p value less than 0.05 was considered statistically significant.

Results
Mitral and Tricuspid Annular Size in Patients With Lone AF
Both the mitral and the tricuspid annular areas were significantly dilated in patients with lone AF (mitral annular area: 9.5±1.2 vs 6.6±0.8 cm², lone AF vs control, p<0.01) (tricuspid annular area: 12.0±2.0 vs 7.5±0.9 cm², p<0.01) (Fig 2). Compared with the mitral valve, the %
increase in the annular area in patients with lone AF relative to the mean normal control value was significantly greater in the tricuspid valve (44±18 vs 60±28%, p<0.01).

**MR and TR in Patients With Lone AF**

MR was generally absent or only mild despite significant annular dilatation and no patients with lone AF showed moderate or severe MR (Table 2). In contrast, the grade of TR was significantly more severe compared with that of MR (p<0.01). The incidence of moderate or severe TR was also significantly higher compared with that of MR (p<0.01). The % MR jet area did not show significant correlation between the mitral annular area; however, the % TR jet area was significantly correlated with the increase in the tricuspid annular area (Fig 3). Fig 4 shows a representative patient with larger annulus and greater regurgitation in the tricuspid valve compared with the mitral valve.

**Reproducibility of Measurements**

Inter- and intra-observer variabilities were 0.5±0.4 cm² or 5.1±3.6% of the mean value and 0.2±0.4 cm² or 3.3±4.7% for the measurements of the mitral annular area and 0.5±0.6 cm² or 4.1±4.2% and 0.2±0.4 cm² or 3.4±5.2% for the measurements of the tricuspid annular area.

**Discussion**

**Greater Annular Dilatation and Valvular Regurgitation in the Tricuspid Valve Compared With the Mitral Valve**

It has been reported that AF can cause significant right and left atrial dilatation⁴ so we hypothesized that AF can potentially cause mitral and tricuspid annular dilatation because the annuli are located at the inferior edge of the atrium. This hypothesis was supported by the results of the present study which showed significantly dilated mitral and tricuspid annuli in patients with lone AF. We also hypothesized that AF would cause greater annular dilatation in the tricuspid valve compared with the mitral valve, because the fibrous skeleton, which has strong resistance to elongation or dilatation, is less developed in the tricuspid valve.⁶ This second hypothesis was also confirmed by greater annular dilatation relative to the mean normal value in the tricuspid valve compared with the mitral valve in the present patients with lone AF. The lesser annular dilatation in the mitral valve was not associated with significant valvular regurgitation, whereas the greater annular dilatation in the tricuspid valve was frequently accompanied by significant regurgitation. Therefore, in addition to thromboembolism⁹,¹⁰ tricuspid annular dilatation and valvular regurgitation are important complications of AF.

**Relation to Previous Studies**

Atrial dilatation caused by AF, already demonstrated by previous investigations⁴ was also shown in the present study. The potential correlation between AF and annular dilatation has also been demonstrated and was confirmed by the present study.² The findings of the present study further demonstrated the predominant annular dilatation and valvular regurgitation of the tricuspid valve in patients with AF compared with the mitral valve. Sagie et al reported that apical displacement of the tricuspid leaflets rather than tricuspid annular dilatation is the major determinants of functional TR.²¹ In the present study, no patients showed significant apical displacement of the tricuspid leaflets. We investigated patients with lone AF without right ventricular dysfunction/dilatation whereas they examined patients with functional TR including severe TR (73%) secondary to myocardial dysfunction, left sided valve disease, pulmonary hypertension, and congenital disease, potentially leading to right ventricular dysfunction/dilatation. A dilated right ventricle can tether the tricuspid leaflets and induce their apical displacement, reducing surplus leaflets and inducing valve regurgitation. We, therefore, suggest that the differences in the study group resulted in different findings.

Recently, several studies reported isolated severe TR, characterized by AF, severe right-side heart failure with preserved left ventricular systolic function, absent pulmonary hypertension, and markedly dilated tricuspid annulus, without organic leaflet lesions in elderly patients.²²-²⁵ In the present study, moderate TR with significant annular dilatation but without organic leaflet lesions was frequently observed in patients with lone AF and may be the early stage of isolated severe TR in the elderly, suggesting AF is a potential determinant of such TR. Further studies are necessary to evaluate the progressive deterioration of TR in patients with AF.

**Clinical Implications**

The findings of the present study demonstrated that AF can potentially cause significant annular dilatation and valvular regurgitation of the tricuspid valve. Other investigations have also reported patients with isolated severe TR with annular dilatation but without organic leaflet...
lesions22–25 Together, these findings suggest that careful evaluation and follow up of tricuspid valve function is necessary in patients with lone AF. It should also be taken into consideration when determining the indications for tricuspid annuloplasty or surgical intervention in patients with mild to moderate TR.

Study Limitations
Quantification of regurgitant flow is important to evaluate the severity of valve regurgitation;26–28 but we did not quantify it and instead the severity of the MR and TR was evaluated by the % regurgitant jet area. Color Doppler regurgitant jet size has major influences from the Nyquist limit and also from Doppler gain. We, therefore, performed color flow mapping with approximately constant Nyquist limits and Doppler gain. A recent study confirmed that valve regurgitant severity by the % jet area is approximately accurate compared with quantitative methods when the regurgitation is moderate or less.29 There were no patients with severe valve regurgitation in the present study. We, thus, suggest that evaluation of regurgitant severity by the % jet area in the present study did not have major implications for the results.

Because there were no organic tricuspid valve lesions other than annular dilatation on 2-D echocardiogram and the annular dilatation can be explained by AF,30 AF with annular dilatation seems to be the cause of TR rather than TR being the cause of annular dilatation and AF. Further serial follow-up echo studies confirming preceding annular dilatation before the development of significant TR in patients with lone AF would establish the causal relationships between TR, annular dilatation and AF.

Conclusion
Lone AF is associated with both mitral and tricuspid annular dilatation, but the dilatation and valvular regurgitation are significantly greater in the tricuspid valve.

References