Abnormal Mitral Regurgitation Flow Velocity Spectra by Continuous Wave Doppler in Flail Mitral Valve

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연가량 승모판의 특징적인 도플러 심초음파도 소견

경희의대 내과학과실
배 중화

국문초록

연가량 승모판은 대개 심한 승모판 폐쇄부전증을 초래하기 때문에 급속한 심장순환을 동반하게 된다. 따라서 일반적인 승모판 폐쇄부전증을 가진 환자들의 경우가 많다. 이에 이러한 점을 고려하여 심초음파도가 많이 이용되고 있다. 그러나 경우에 따라서 심초음파도에 의한 진단이 애매할 때가 종종 있는것은 잘 알려진 사실이다.

저자들은 최근 Continuous wave Doppler 심초음파도를 실시하였던 중에 승모판 폐쇄부전을 보이는 환자중의 일부가 매우 특징적인 Doppler Spectrum을 보이는 것을 발견하였기에 이를 발표하고자 한다.

대상은 138명의 승모판 폐쇄부전증을 가지고 있는 환자이며 이들은 모두 심초음파로 진단하였고 이들 중 23명이 연가량 승모판을 가지고 있었다. 나머지 115명의 환자와 연가량 승모판을 가지고 있는 23명의 환자를 비교한 결과 매우 특징적이고 간단히 발견할 수 있는 소견을 발견하였는데(Figure 3 참조):

1) 수측시기에는 bidirectional Doppler spectrum을 보이고
2) Doppler spectrum의 peak가 거칠고 매우 불규칙한 모양을 보인다.

이러한 소견을 수치로 표식한 것이 R/A ratio이며 2.5를 기준으로 했을때 연가량 승모판을 가진 환자들은 쉽게 구분할 수 있다.

연가량 승모판을 가지고 있는 환자들이 이러한 특징적인 Doppler spectrum을 보이는 이유나 기전은 정확하게 설명하기는 매우 어려운 일이이나 주로 승모판염이 fluttering을 일으켜서 나타나는 소견임 것으로 추측할 수 있다.
INTRODUCTION

Flail mitral valve (FMV) caused by ruptured chordae tendineae usually in acute, severe mitral regurgitation and the rapid progression of congestive heart failure. Less often, flail mitral valves develop without a significant hemodynamic deterioration. With such a broad spectrum, the advent of noninvasive diagnostic methods was a practical adjunct to cardiac catheterization.

Two-dimensional echocardiography (2DE) has proved to be a reasonably sensitive method for detecting flail leaflets. Using Doppler ultrasound we have recently observed a characteristic pattern in mitral flow velocity associated with flail leaflets that should improve the diagnostic sensitivity for flail mitral valve.

METHODS

Study Population

Mitral regurgitation (MR) was diagnosed by Doppler echocardiography in 138 consecutive patients referred to noninvasive laboratory at Wadsworth Veterans Administration Medical Center for the evaluation of valvular dysfunction. All patients were male. Of these, 23 patients had the additional diagnosis of flail mitral leaflets made by two-dimensional echocardiography; 15 subjects had a flail posterior le-

Fig. 1. Apical four chamber view of two-dimensional echocardiogram showed flail posterior mitral leaflet.
aflet, 6 had flail anterior leaflet and 2 patients had both flail leaflets. FMV was diagnosed retrospectively in 10 patients and prospectively in 13 patients.

Two-dimensional Echocardiography

Echocardiographic studies were performed using commercially available equipments (either Irex System III or Meridian) with the patients in left lateral ducubitus position. M-mode and 2DE images were recorded on video tape and/or strip-chart paper using parasternal long and short axis views, apical two and four chamber views.

The echocardiographic criteria used for making the diagnosis of flail mitral valves9–12 were: 1) absence of leaflet coaptation of mitral valve leaflets during systole, 2) sudden whipping motion of a leaflet from left ventricle to left atrium, 3) chaotic fluttering of leaflets during systole or diastole (Figure 1).

Doppler Echocardiography

Phased array two-dimensional echocardiographic imaging system with simultaneous pulsed/continuous Doppler system (Irex System III or Meridian) was used for the studies. The system has a dual frequency transducer with 3.0 MHz for 2DE and 2.0 MHz for Doppler echocardiography. In addition, a dual crystal continuous wave Doppler transducer (Pedof, 2.0 MHz) was used to obtain a good Doppler
velocity profiles and were always recorded on video tape and on stripchart paper.

For the diagnosis of MR, the apical four chamber view of 2DE was first imaged. The mitral valve was positioned perpendicular to the Doppler ultrasound beam which was parallel to the long axis of the left ventricle. A systolic mitral velocity spectrum was searched for by moving the sample volume in pulsed wave Doppler mode superior to the mitral valve in the left atrium. And then the severity of MR was assessed by mapping technique of pulsed wave Doppler mode(Figure 2). The continuous wave Doppler spectra of the mitral valve was recorded from the same axis using the duplex and stand-alone transducers(Figure 3). The way we measured the amplitude was to average continuous wave Doppler velocities of the most intense peak signals in m/sec of at least 5 consecutive complexes.
RESULTS

Continuous Wave Doppler Velocity Profile of FMV

The continuous wave Doppler velocity profile of typical mitral regurgitation without FMV was recorded below the baseline represent retrograde systolic mitral flow into the left atrium and the velocity profile above the baseline represent normal antegrade flow across the mitral valve during diastole. The Doppler characteristic of typical mitral regurgitation is a spectrum of maximum velocities with a smooth, regular and easily defined peak (upper panel of Figure 3). But it is not uncommon that the antegrade Doppler velocity profile was also recorded less than 1.5 m/sec in patients without FMV (Figure 4).

In patients with FMV, the antegrade velocity profile was recorded prominently then those patients without FMV, and the retrograde velocity profile was seemed to be decreased. In addition, the margin of Doppler velocity profile was rough and irregular shape contrary to the round and smooth blackening of the peak in patients without FMV (Figure 3).

The characteristic findings of Doppler velocity profile in patients with FMV are: 1) the bidirectional systolic velocity spectra, that is, in both antegrade and retrograde directions, 2) the peaks are distinctively irregular instead of smooth and rounded.
Table 1. Data of Antegrade Doppler Velocity Profiles

<table>
<thead>
<tr>
<th>Antegrade peak Velocity (m/sec)</th>
<th>0</th>
<th>0.01</th>
<th>1.00</th>
<th>1.50</th>
<th>&gt;2.00</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mitral regurgitation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>without FMV</td>
<td>41</td>
<td>8</td>
<td>47</td>
<td>19</td>
<td>-</td>
<td>115</td>
</tr>
<tr>
<td>(%</td>
<td>(35.7)</td>
<td>(7.0)</td>
<td>(40.9)</td>
<td>(16.4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mitral regurgitation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>with FMV</td>
<td>-</td>
<td>-</td>
<td>4</td>
<td>10</td>
<td>9</td>
<td>23</td>
</tr>
<tr>
<td>(%</td>
<td>(17.4)</td>
<td>(43.4)</td>
<td>(39.2)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

FMV: Flail mitral valve

Table 2. Data of Retrograde Velocity Profiles

<table>
<thead>
<tr>
<th>Retrograde peak velocity (m/sec)</th>
<th>&lt;2.99</th>
<th>3.00</th>
<th>4.00</th>
<th>&gt;5.00</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>MR without FMV</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MR with FMV</td>
<td>11</td>
<td>5</td>
<td>5</td>
<td>2</td>
<td>23</td>
</tr>
<tr>
<td>(%)</td>
<td>(47.8)</td>
<td>(21.7)</td>
<td>(21.7)</td>
<td>(8.8)</td>
<td></td>
</tr>
</tbody>
</table>

MR : Mitral regurgitation
FMV: Flail mitral valve

Table 3. Ratio Between Retrograde Peak Velocity and Antegrade Peak Velocity

<table>
<thead>
<tr>
<th>No. of patients</th>
<th>Retrograde peak velocity</th>
<th>Antegrade peak velocity</th>
<th>R/A Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>MR without FMV</td>
<td>74</td>
<td>4.87 ± 0.73</td>
<td>1.28 ± 0.27</td>
</tr>
<tr>
<td>MR with FMV</td>
<td>23</td>
<td>3.19 ± 1.39</td>
<td>1.92 ± 0.62</td>
</tr>
<tr>
<td>P Value</td>
<td>NS</td>
<td>NS</td>
<td></td>
</tr>
</tbody>
</table>

MR : Mitral regurgitation
FMV: Flail mitral valve

Table 4. Distribution of R/A Ratio

<table>
<thead>
<tr>
<th>R/A Ratio</th>
<th>&lt;1.50</th>
<th>1.51</th>
<th>2.01</th>
<th>2.51</th>
<th>&gt;3.00</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>MR without FMV</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>74</td>
</tr>
<tr>
<td>MR with FMV</td>
<td>9</td>
<td>7</td>
<td>6</td>
<td>1</td>
<td>-</td>
<td>23</td>
</tr>
<tr>
<td>(%)</td>
<td>(39.1)</td>
<td>(30.4)</td>
<td>(26.1)</td>
<td>(4.4)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

MR : Mitral regurgitation
FMV: Flail mitral valve
Amplitude of Continuous Wave Doppler Velocity

In patients without FMV, 41 (35.7%) out of 115 did not have antegrade velocity at all. And 8 (7.0%) patients had less than 1.0 m/sec, 47 (40.9%) in 1.0 - 1.49 m/sec and 19 (16.4%) in 1.50 - 1.99 m/sec. In patients with FMV, 4 (17.4%) out of 23 had antegrade velocity in 1.0 - 1.49 m/sec, 10 (43.4%) in 1.50 - 1.99 m/sec, 5 (21.8%) in 2.0 - 2.49 m/sec, 2 (8.7%) in 2.49 - 2.99 m/sec and 2 (8.7%) had more than 3.0 m/sec. Thus 55 (74.3%) out of 74 patients without FMV and 4 (17.4%) out of 23 patients with FMV had the antegrade velocity less than 1.5 m/sec (Table 1).

The similar analysis was made of the relation between the retrograde systolic velocities and flail leaflets and there was considerably more overlap (Table 2).

Table 3 summarizes the means for retrograde and antegrade velocities for the two. Mitral regurgitation associated with flail mitral leaflets tended to have lower retrograde velocities (toward the left atrium) and higher antegrade velocities (toward left ventricle) than mitral regurgitation without flail leaflets. However, neither of these differences were significant. When the amplitudes are expressed as a ratio of retrograde to antegrade velocities, the means of ratio are significantly different.

The distribution of a ratio of antegrade to retrograde velocities (R/A Ratio) was disclosed in Table 4. In patients with flail mitral leaflets, the R/A Ratio showed
the tendency lower than in patients without FMV.

The plots in Figure 5 showed the distribution of retrograde to antegrade ratios in patients with mitral regurgitation, with and without flail leaflets. The broken line is an R/A ratio of 2.5. In the presence of flail leaflets, 96% of the patients fall below 2.5. In patients without flail leaflets, 97% lie above 2.5.

Figure 6 showed the relation of maximum velocities in patients with and without flail leaflets which is significantly different ($p < 0.001$).

**DISCUSSION**

Although two-dimensional echocardiographic findings in patients with flail mitral valve are well known\(^a\)\(^{-}\)\(^d\) and have a reasonably good statistical accuracy\(^b\), it is difficult to detect flail mitral valve and to assess the degree of mitral regurgitation. In addition it is unable to find flail mitral valve in patients with poor two-dimensional echocardiographic window.

In our echocardiography laboratory, we had experienced particular Doppler tracings among those patients with mitral regurgitation which was quite different from most of the patients. So we reviewed all Doppler tracings of mitral regurgitation and found 10 patients which showed same Doppler tracings. And also we reviewed two-dimensional echocardiography which showed flail mitral valve.

After reviewed those Doppler tracings retrospectively, we planned prospective study which showed the same results in 13 patients. In 10 patients studied retrospectively, 4 patients had poor window and difficult to find flail mitral valve esaily by two-dimensional echocardiography.

The characteristic findings of continuous wave Doppler tracing for flail mitral valve is bidirectional mitral systolic flow with rough and irregular peak. These findings are caused by the systolic fluttering of flail mitral leaflets causing chang of red blood cell direction, and the turbulence of systolic blood flow itself.

In patients with flail mitral valve, the degree of mitral regurgitation was severe in most of the patients by the Doppler mapping technique and Doppler tracings were distinct even in patients with poor two-dimensional echocardiographic window. But using pulsed wave Doppler system we could not detect the bidirectional systolic flow because of limitation of velocity. We could find the characteristic finding by the continuous wave Doppler system easily, especially with stand-alone transducer.

**CONCLUSION**

Using echo-Doppler technique, we have described a new observation for detecting flail mitral leaflets in patients with mitral regurgitation. In addition to the systolic retrograde velocity spectra directed toward the left atrium usually seen with mitral regurgitation, flail leaflets are associated with antegrade systolic velocities. These bidirectional signals also differ from normal antegrade flow and regurgitant flow velocities by having distinctively irregular contours and peaks.
REFERENCES


