Aortic Regurgitation with Dove-coo Murmur with Special References to the Mechanism of its Generation Using Dual Echocardiography

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SUMMARY
Triphasic dove-coo murmur in a patient with aortic regurgitation was studied as to the mechanism of its generation using simultaneous recording phonocardiography and dual echocardiography. The murmur arose coincident with the coarse regular fluttering of aortic posterior wall during the opening of mitral valve and decreased coincident with the protrusion of mitral valve anterior leaflet into the left ventricular outflow tract. Thus the murmur might occur, provided that normal mitral valve opening and closure was maintained. It may well explain why the murmur hardly occurs in aortic regurgitation of rheumatic origin in which rheumatic lesion often is thought to involve mitral valve, restricting mitral opening during diastole and thereby inhibits aortic root vibrations.

Additional Indexing Words:
Dual echocardiography    Dove-coo murmur    To and fro murmur

BEFORE echocardiography was introduced in clinical use, the origin and mechanism of dove-coo murmur, a diastolic musical murmur in aortic regurgitation, were only studied pathoanatomically.1)-3) McKusick1) regarded it as the vibration of deformed aortic cusp, but showed no real evidences. Recently we had a chance to investigate the origin of the murmur in a patient with aortic regurgitation using echocardiography. The patient was studied with both phonocardiography and dual echocardiography, and it provided a new finding as to the mechanism of the dove-coo murmur generation.

METHODS
Simultaneous recording of phonocardiography and dual echocardiography were performed with phonocardiographic microphone HMS-4 (Toshiba), a line from the Second Department of Internal Medicine, Fukuoka University School of Medicine, Fukuoka 814, Japan.
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scan recorder FR-06 (Toshiba), a dual echo unit (Toshiba), and two echo-transducers (Aerotech) of 2.0 MHz with a focal length of 5.0 cm and a diameter of 10 mm. The aortic and mitral echocardiograms were obtained simultaneously at the third and fourth left sternal borders respectively. The phonocardiogram was recorded at the third left sternal border. All investigations were done in supine position.

**CASE REPORT**

A 39-year-old man was referred to Fukuoka University Hospital in September 1979 because of exertional dyspnea and hemosputum. Physical examination revealed a state of congestive heart failure due to aortic regurgitation. He had never suffered from any diseases such as rheumatic fever, syphilis, or bacterial endocarditis, except for chronic tonsillitis at 12 years in age. He had never drunk and smoked.

Physical examinations, on admission, revealed blood pressure of 176/50 mmHg, regular heart rate of 76/min, bounding carotid pulse, moist rales in the bilateral lungs, and a diastolic musical murmur of grade 5 all over the precordium. There was a left parasternal heave. There was no evidence of hepatomegaly or pretibial edema. Labolatory data were unremarkable. The chest X-ray revealed cardiomegaly with the cardiothoracic ratio of 59%, and slight pulmonary congestion. The phonocardiogram, as shown in Figs. 1 and 2, revealed the dove-coo murmur consisted of sine wave configuration, which began 80 msec after an aortic second

![Carotid pulse wave and phonocardiogram at the fourth left sternal border.](image-url)
Fig. 2. Phonocardiogram at the apex showing the dove-coo murmur which begins 0.03-0.04 sec after pulmonary second sound (P2). A2 = aortic second sound.

sound and was superimposed on to-and-fro murmur induced by aortic regurgitation. The dove-coo murmur showed three wax and wane phases corresponding to early, mid, and end-diastole respectively, ending before mitral component of the first sound. The murmur was composed of a frequency of 160 cps initially and in end-diastole of a frequency of 110 cps. Carotid pulse wave showed pulsus bisferiens and flattening of dicrotic notch.

The intensity of dove-coo murmur decreased during inspiration, as well as in response to amyl nitrite inhalation. It remained, however, unchanged or slightly decreased in response to a bolus injection of angiotensin II.

In dual echocardiographic examination, aortic echogram revealed coarse regular flutterings of both aspects of the aortic valve and wall in diastole, as shown in Fig. 3. There were some differences, however in the flutterings, that is, that of posterior wall was more intense and of shorter duration coincident with points D’ to C of mitral echogram, whereas that of aortic valve was weaker and longer, lasting from aortic closure (AC) to aortic opening (AO). The flutter of aortic anterior wall was similarly observed as seen in Fig. 4, but it was less dominant in intensity in comparison with that of posterior wall.

The echogram of mitral valve anterior leaflet showed fine and irregular flutterings in diastole. The simultaneously recorded phonocardiogram showed that
the dove-coo murmur arose with the beginning of flutter of the aortic posterior wall, that is, point D', and disappeared together with the end of flutter, that is, point C. Moreover, two constricted parts of the triphasic murmur were seen nearly coincident with both points E and A in mitral echogram as shown in Fig. 5. Echocardiographic data are shown in Table I. Cardiac catheterization, as shown in Table II, demonstrated no significant abnormalities except for high aortic pulse pressure of 95 mmHg. Coronary angiography revealed no significant abnormality, but left ventriculography showed diffuse hypokinesis. In aortography, grade 3 aortic regurgitation was evident.

Later the patient had surgical replacement of his aortic valve in May, 1980. The aortic cusp was markedly deformed, there were tiny perforations on the marginal portions of both right and noncoronary cusps, and the left cusp was hypertrophied and everted (Fig. 6).

Histological examination of the valve demonstrated that the right cusp was involved by moderate fibrosis with focal myxoid changes, and the left cusp also showed marked fibrosis with fibrinous degeneration on the surfaces. However, neither rheumatic nor syphilitic lesion was found.

**DISCUSSION**

The dove-coo murmur has been described to be attributed to the vibrations of aortic cusp and its surrounding structures. Present study seemed to
Fig. 4. The expanded echocardiogram of aortic root. Regular flutters of both the aortic valve and wall are seen clearly. There is apparent difference in duration of flutters between aortic cusp and posterior wall. The flutter of aortic posterior wall does not occur in isometric relaxation time (IRT) and isometric contraction time (ICT). AC=aortic closure; AO=aortic opening; MO=mitral opening; MC=mitral closure.

Fig. 5. Serial recording of simultaneous phonocardiogram and echocardiogram. Paper speed 50 mm/sec. The dove-coo murmur diminished coincident with the projection of the mitral valve anterior leaflet to left ventricular outflow tract showing triphasic appearance. IVS=interventricular septum; MV=mitral valve.
Table I. Echocardiographic Data

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>DDR (diastolic descent rate of the mitral valve)</td>
<td>42 mm/sec</td>
</tr>
<tr>
<td>LVDd (left ventricular diastolic dimension)</td>
<td>62 mm</td>
</tr>
<tr>
<td>LVDs (left ventricular systolic dimension)</td>
<td>47 mm</td>
</tr>
<tr>
<td>FS (fiber shortening)</td>
<td>24%</td>
</tr>
<tr>
<td>IVS (interventricular septum)</td>
<td>8 mm</td>
</tr>
<tr>
<td>LVPW (left ventricular posterior wall)</td>
<td>12 mm</td>
</tr>
<tr>
<td>RVD (right ventricular dimension)</td>
<td>13 mm</td>
</tr>
<tr>
<td>AR (aortic root)</td>
<td>39 mm</td>
</tr>
<tr>
<td>LAD (left atrial dimension)</td>
<td>25 mm</td>
</tr>
</tbody>
</table>

Table II. Cardiac Catheterization Data

<table>
<thead>
<tr>
<th>Location</th>
<th>Pressure (mean) mmHg</th>
<th>O$_2$ Sat. %</th>
</tr>
</thead>
<tbody>
<tr>
<td>RA</td>
<td>(0)</td>
<td></td>
</tr>
<tr>
<td>RV</td>
<td>20/1</td>
<td></td>
</tr>
<tr>
<td>MPA</td>
<td>15/5 (9)</td>
<td>69.5</td>
</tr>
<tr>
<td>PAW</td>
<td>(4)</td>
<td></td>
</tr>
<tr>
<td>LV</td>
<td>150/7</td>
<td></td>
</tr>
<tr>
<td>AO</td>
<td>150/55 (85)</td>
<td>96</td>
</tr>
</tbody>
</table>

Cardiac Output 6.21 l/min (Thermo); Cardiac Index 4.09 l/min/m²

Fig. 6. Surgically excised aortic valve with perforation in both right and non-coronary cusp (black arrows).
add some more new findings as to the origin and mechanism of the murmur. The dove-coo murmur did not arise coincident with coarse regular fluttering of aortic valve, but with that of aortic posterior wall (Fig. 7). Moreover, the beginning point of the murmur was coincident with point D' in the mitral echogram. In other words, as mitral valve began to open, aortic wall might

![Diagram](image_url)

**Fig. 7.** A schematic diagram of the phono-echographic data. M1 = mitral first sound; A1 = aortic first sound; A2 = aortic second sound.

![Diagram](image_url)

**Fig. 8.** A schematic presentation of the proposed mechanism of dove-coo murmur. In the period of isometric relaxation and contraction time, aortic cusp flutter does not transmit to aortic posterior wall because aortic root is fixed by mitral closure, and the sympathetic resonance does not occur. As mitral valve opens, aortic cusp flutter transmits to aortic posterior wall because aortic root becomes free relatively, and the sympathetic resonance occurs. The regular flutter of aortic anterior wall may not be due to the transmission of aortic cusp flutter but the sympathy of whole aortic wall.
resonate with the precedent flutter of aortic valve and produce the murmur. Hence, as mitral valve closed, aortic wall might quit resonance (Fig. 8).

These findings suggest that the opening of mitral valve may induce the resonance of aortic wall and the production of the dove-coo murmur. Why does the mitral opening induce resonance of aortic wall? As the mitral valve opens and the anterior and posterior leaflets of the mitral valve separate, the aortic posterior wall, being a continuation of the anterior leaflet of mitral valve anatomically, may become more free and be facilitated to resonate with the flutter of aortic cusp. The vibration of aortic wall may be transmitted to cause the resonance of aorta producing musical murmur, or the dove-coo murmur, just like a wind instrument. It stopped vibrating with the mitral closure probably because aortic root may become more rigid, and impossible to produce the murmur.

The theory that the aortic valve vibrated as a reed to produce the dove-coo murmur was previously proposed. Present study suggested that the dove-coo murmur might be produced by not only vibrations of the reed but also consequential resonance of pipe. The loud murmur which was of grade 5 in the present case might be related to the phenomenon of resonance.

Intensity of the dove-coo murmur was decreased twice, just coinciding with points E and A in the mitral valve anterior leaflet, which protruded into the left ventricular outflow tract at the points E and A and might prevent the regurgitant flow which vibrated the aortic cusp, resulting in the decrease in intensity of the murmur. The mitral valve anterior leaflet might play a role like a mute of the wind instrument.

Perforation and eversion of the aortic cusp may not be related primarily to the dove-coo murmur generation, but might be one of the contributing factors in producing murmur.

It has been well known that the musical murmurs in aortic regurgitation of rheumatic origin are extremely rare in comparison with those of syphilitic and bacterial endocarditis. Taking account of the findings in the present case, it may be reasoned that rheumatic lesion involves mitral valve more frequently, therefore, the mitral valve and surrounding structures may become adhesive and sclerotic, resulting in mitral stenosis, which may bring about mitral closing effect to fix aortic root and wall tightly. As for the etiology of aortic regurgitation in the present case there were no pathological evidences for rheumatic fever and the mitral valve was intact.

Thus the mechanism of dove-coo murmur generation may well be explained by that of a wind instrument as is shown in Fig. 9. Aortic regurgitation may correspond to the stream of air arisen by blowing a wind instrument, aortic valve to the reed, aorta to the tube, and mitral valve to the mute.
MECHANISM OF DOVE-COO MURMUR

Fig. 9. Analogy of the dove-coo murmur to a wind instrument.

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REFERENCES