Echocardiographic Recognition of the Mitral Valve–Posterior Aortic Wall Relationship

By Brian L. Strunk M.D., Stephen B. Guss, M.D., Richard E. Hicks, M.D., and Morris N. Kotler, M.D.

SUMMARY
Aortic-mitral valve discontinuity has previously been described in double outlet right ventricle, endocardial cushion defect, single ventricle, tetralogy of Fallot, and prolapse of the mitral valve. We are reporting two additional examples of aortic-mitral valve discontinuity including 15 cases of gross left ventricular dilatation and a case of acute pneumococcal bacterial endocarditis with a large subannular erosion. While nonspecific, aortic-mitral valve discontinuity is a clinically important sign that should be sought with slow-M-mode scanning and strip chart recording.

Additional Indexing Words:
Mitral-semilunar valve discontinuity
Slow M-mode scanning
Congestive cardiomyopathy
Ultrasound

THE ANTERIOR MITRAL LEAFLET (AML) is anatomically continuous with the posterior aortic wall (PAW) as these two structures lie at the same depth from the anterior chest wall during systole. Formerly this relationship was best defined on a lateral or left anterior oblique left ventricular angiogram, and continuity assured the origin of the aorta from the systemic ventricle. Echocardiography can now be employed to demonstrate aortic-mitral continuity or discontinuity when the ultrasonic transducer is swept along the aortic-mitral valve axis. For example, in double outlet right ventricle the echocardiogram demonstrates disruption of the normal aortic-mitral continuity, with the AML displaced posterior to the plane of the PAW.1 This paper reports our experience with echocardiography in the study of the PAW-AML relationship and shows that aortic-mitral discontinuity can be found in conditions other than double outlet right ventricle, endocardial cushion defect,2 single ventricle,3 tetralogy of Fallot,4 and prolapse of the mitral valve.5

Materials and Methods

Three groups of patients were studied. Group 1 consisted of 30 normal subjects. Group 2 consisted of 15 patients with left ventricular enlargement (table 1): there were two

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Received June 7, 1974; revision accepted for publication December 9, 1974.

594 Circulation, Volume 51, April 1975
Table 1

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<th>LV posterior wall thickness (cm)</th>
<th>Septal thickness (cm)</th>
<th>AML displaced post. to PAW (cm)</th>
<th>Septum displaced anterior to ant. aortic wall (cm)</th>
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Abbreviations: Dd = end-diastolic dimension; Ds = end-systolic dimension; LV = left ventricular; AML = anterior mitral leaflet; PAW = posterior aortic wall.

*Coronary artery disease.
†Rheumatic heart disease.

tion of the mitral valve and left ventricular wall were identified. By recording continuously while slowly rotating the ultrasound beam, a continuous scan was obtained.

The left ventricular dimension at end-diastole (Dd) and end-systole (Ds) was measured (to the nearest 0.1 cm) from the endocardial echo of the posterior wall to the left side of the interventricular septal echo. Dd was measured at the peak of the R wave of the simultaneously displayed electrocardiogram and Ds at the time of maximal anterior movement of the posterior left ventricular wall. The ventricular volumes were estimated by the regression equation of Teicholz,*

\[ V = (7.0/2.4 + D) \times D^2 \]

where \( V \) = volume (ml) and \( D \) = diameter (cm). The mean ventricular volume of the control group (group 1) was 119 ml. The ventricular volumes for the group with gross left ventricular dilatation (group 2) ranged from 179 ml to 393 ml with a mean of 262 ml. The interventricular septal and posterior left ventricular wall thicknesses were measured at end-diastole. The measurement of PAW-to-AML displacement was taken at the transition zone from well-defined posterior aortic wall motion to the onset of well-defined anterior mitral valve motion. Aortic-to-mitral valve displacement was measured from the mitral valve closure (C point) to the posterior edge of the PAW at end-diastole. Septal-to-aortic wall displacement was measured from the right side of the septum to the anterior edge of the anterior aortic wall at end-diastole.

Results

Group 1

The amount of posterior displacement of the AML from the PAW was negligible, ranging from 0 to 3 mm with a mean of 1 mm (fig. 1).

Group 2

In all patients with gross left ventricular dilatation, echocardiographic evaluation of the aortic-mitral sweep demonstrated discontinuity between the PAW and the AML with posterior displacement of the AML and no cases of anterior displacement (fig. 2). The degree of posterior displacement of the systolic portion of the AML from the PAW varied between 1.0 cm and 2.8 cm (mean 1.8 cm) as shown in table 1. Six of the 15 patients also demonstrated anterior displacement of the septum in relation to the anterior aortic wall. The degree of anterior septal displacement varied between 0.5 and 2.0 cm.

Four of the 12 patients with congestive cardiomyopathy underwent cardiac catheterization. The cardiac indices ranged between 1.5 and 1.9 L/min/m², and the left ventricular end-diastolic pressures (LVEDP) varied between 12 and 39 mm Hg. All had significantly increased left ventricular end-diastolic volumes (313–550 ml) and end-systolic volumes (217–264 ml). Two of the four patients had minimal mitral regurgitation. The two patients with rheumatic heart disease had significant mitral regurgitation. In both of these patients the LVEDPs were modestly elevated at 15 and 20 mm Hg, and the cardiac indices were 3.0 and 3.43 L/min/m². End-diastolic volumes were 182 and 107 ml. The patient with coronary artery disease had no angiographic evidence of mitral regurgitation. The LVEDP measured 33 mm Hg, cardiac index 4.1 L/min/m², end-diastolic volume 280 ml, and end-systolic volume 200 ml.
Group 3

The preoperative echocardiogram as well as an artist’s view of the surgeon’s findings in the patient with acute pneumococcal endocarditis and aortic insufficiency are shown in figure 3. With the onset of ventricular diastole the mitral valve barely opened to the E point and there was premature closure well before the QRS complex, a previously well-described finding in acute aortic regurgitation. An unexpected but important echocardiographic finding was the AML-to-PAW discontinuity with the systolic portion of the AML displaced 4 mm anterior to the PAW (fig. 3 left). In addition there was absence of recordable echoes and a distinct echo-free zone between the base of the anterior mitral leaflet and the posterior aortic wall suggesting destruction of supporting tissue. This was confirmed by the surgical findings (fig. 3 right). Postoperatively, the echocardiogram demonstrated normal PAW-AML continuity.

Discussion

During M-mode scanning the direction of the transducer is changed minimally while continuous recordings are displayed on a strip chart recorder. One of the most important and fundamental landmarks in echocardiography is the aortic-mitral sweep or axis. The importance of demonstrating anatomic continuity of the posterior left ventricular wall with the atrioventricular ring and left atrium in the diagnosis of pericardial effusion has previously been emphasized. Normally, the anterior mitral leaflet is attached to the mitral ring, which is contiguous with the posterior aortic wall. During systole when the anterior and posterior leaflets have coapted, the anterior mitral leaflet lies at the same depth from the transducer as the posterior wall of the aorta (fig. 1). We are using the term discontinuous to mean an abrupt change in distance from the transducer while going from the PAW to the AML while not necessarily meaning a complete separation of the structures, although this was obviously the case in the patient with pneumococcal endocarditis and in certain congenital heart defects.

Discontinuity between an atrioventricular valve and the posterior wall of an outflow vessel has previously been documented in double outlet right ventricle, endocardial cushion defect, single ventricle, tetralogy of Fallot, endocardial fibroelastosis, and prolapse of the mitral valve. This paper adds two more conditions, left ventricular enlargement and
MITRAL-SEMILUNAR VALVE DISCONTINUITY

Figure 3

Left) Echocardiographic recording as the transducer is angled in a superior and cephalad direction from the mitral valve (AMV) toward the aorta in the patient with acute aortic insufficiency secondary to bacterial endocarditis. The arrow points to discontinuity and absence of echoes between the mitral valve (which is now anterior) and the posterior wall (PAW). LPW = left ventricular posterior wall, LA = left atrium, AAW = anterior aortic wall. Right) Artist's impression of the surgeon's findings in the same patient. There is a large subannular ring-shaped erosion extending beneath the non-coronary cusp and separating the anterior leaflet of the mitral valve from the attachment to the annulus. Fenestration of the non-coronary cusp and vegetations on all the cusps are clearly shown.

destructive endocarditis of the aortic valve, in which this discontinuity is also found (figs. 2 and 3).

Our examples of left ventricular enlargement consisted of cardiomyopathies and rheumatic valvular disease. The echocardiographic features of congestive cardiomyopathy have previously been well described.10-12 These include increased left ventricular internal dimensions, increased left ventricular outflow tract dimension, and reduced excursion of septal and posterior left ventricular wall motion. Diminished amplitude of motion of the mitral valve10 and abnormal mitral valve motion have been reported in those patients with elevated left ventricular end-diastolic pressures.13

This paper documents the additional findings of posterior displacement of the AML relative to a normally positioned PAW, which was observed in all 12 of our patients with congestive cardiomyopathy. The exact mechanism of this discontinuity is not clear. It is possible that the observed phenomenon may be artificially produced by the sudden rotation of the transducer during the recording of the aortic-mitral valve echoes. This phenomenon can be produced to some extent in normals if the transducer is placed more cephalad than usual, for example in the second intercostal space, and rotated rapidly. When the transducer was placed in the third or fourth intercostal space along the left sternal border and rotated slowly from a superior and medial position to an inferior lateral position, negligible discontinuity between the PAW and AML was observed in every normal control. Thus the PAW-AML displacement simply reflects gross left ventricular enlargement secondary to various etiologies rather than any specific disease process. In patients with left ventricular dilatation, the position of the papillary muscle with its chordal attachments may play a role in producing the discontinuity (fig. 4). The tension developed in the normally situated papillary muscle maintains the closed mitral leaflets in an almost continuous plane with the posterior aortic wall. However, in the dilated left ventricle the abnormal cephalad and lateral position of the papillary muscles may have a tendency to pull the leaflets in a more posterior direction. It is important to realize that the posterior displacement of the mitral valve was seen not only with congestive cardiomyopathy, but also when the left ventricle was enlarged as a result of rheumatic valvular or ischemic heart disease.

In the patient with bacterial endocarditis, the AML was displaced anteriorly to the PAW, as a result of erosion of the attachment of the anterior mitral leaflet to the aortic ring subsequent to acute pneumococcal endocarditis (fig. 3 right). The loss of echoes between the AML and PAW was caused by the large subannular ring-shaped erosion extending beneath the non-
coronary cusp and separating the anterior leaflet of the mitral valve from its attachment to the aortic annulus. Because of the extensive pathologic destruction of the aortic annulus, the mitral valve was free to assume an anterior position. Buchbinder and Roberts have recently emphasized the invasive and destructive nature of acute pneumococcal endocarditis involving the aortic valve and described semilunar aortic valve destruction with the subanular erosion. This preoperative echographic finding was of clinical importance to our patient since it alerted the surgeons to the possibility of mitral valve repair as well as aortic valve replacement.

Thus, this report emphasizes the potential value of careful echocardiographic study of the PAW-AML relationship in patients with left ventricular cavity dilatation, in patients with a variety of complex congenital cardiac disorders, and in patients with bacterial endocarditis.

Acknowledgment

The authors gratefully acknowledge the help of Mr. Wayne Parry and Mrs. Patricia Tocei in the preparation of the manuscript.

References

Echocardiographic recognition of the mitral valve-posterior aortic wall relationship.
B L Strunk, S B Guss, R E Hicks and M N Kotler

*Circulation.* 1975;51:594-598
doi: 10.1161/01.CIR.51.4.594

*Circulation* is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
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Print ISSN: 0009-7322. Online ISSN: 1524-4539

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