FIGURE 3. Aortogram showing the course of the anomalous right aortic arch. The arrows indicate the looped cervical position.

region, at the site of the palpable thrill; and (2) the demonstration of a large smooth curved posterior impression on the barium-filled esophagus suggestive of an anomalous aorta crossing the midline behind the esophagus.

It is conceivable that arteriovenous malformations, subclavian artery aneurysms, or very vascular tumors in the supraclavicular region could cause a supraclavicular thrill and a pulsating echo-free space or both when scanned ultrasonically. Such conditions might therefore, in this respect, mimic a cervical aortic arch; however, none of them would be associated with a barium swallow appearance indicating a retroesophageal aorta.

REFERENCES


Effect of Mitral Regurgitation on the Murmur of Pulmonic Regurgitation*

Dennis Enomoto, M.D.; Paul E. Fenster, M.D.,†
Gordon A. Euy, M.D.; and Neal Salomon, M.D., F.C.C.P.

We evaluated auscultatory findings in a 67-year-old man with acquired pulmonic and mitral regurgitation. During inspiration, the murmur of pulmonic regurgitation decreased in intensity prior to surgery, but increased in intensity after mitral valve replacement. Inspiration reduces the volume of mitral regurgitation, thereby reducing the volume and murmur of pulmonic regurgitation.

Pulmonic valvular regurgitation has several different auscultatory presentations. The variability in the auscultatory findings may be related to the presence or absence of pulmonary hypertension or right heart failure, the etiology of the pulmonary regurgitation, the configuration of the chest wall, and the relationship of the cardiac structures to the chest wall. We had the opportunity to care for a patient with acquired pulmonic and mitral regurgitation due to staphylococcal endocarditis. Auscultatory findings were carefully documented before and after replacement of the mitral valve. The murmur of pulmonic valvular regurgitation markedly decreased in intensity with inspiration prior to surgery, but definitely increased in intensity with inspiration after mitral valve replacement.

CASE REPORT

A 67-year-old man with no prior cardiac history presented to another hospital with fever, chills, and confusion two weeks after he sustained a puncture wound. Endocarditis was diagnosed based on the presence of a new systolic murmur, an M-mode echocardiogram showing mitral valve vegetations, and blood cultures positive for Staphylococcus aureus. He was treated with methicillin and chloramphenicol. His hospitalization was complicated by atrial fibrillation, congestive heart failure, renal failure, septic emboli, and an elevated white blood cell count in the spinal fluid. He improved following six weeks of antibiotic therapy and was transferred to University Hospital for consideration of mitral valve replacement.

Physical findings at the time of admission were a resting heart rate of 120/min; bibasilar rales; normal carotid and jugular venous pulsations; and an inferolaterally displaced left ventricular apical impulse. On auscultation a grade 4/6 holosystolic murmur was present, loudest at the apex and radiating to the axilla. A short diastolic murmur was heard along the left sternal border and at the apex. The chest roentgenogram was normal. Electrocardiogram showed sinus tachycardia and nonspecific ST and T wave changes. Echocardiographic findings were consistent with a flail posterior mitral valve leaflet and a thick anterior leaflet. The hemodynamic findings at cardiac catheterization are shown in Table 1 (first catheterization). Left ventricular angiography revealed moderate mitral regurgitation. The coronary arteries were normal. The patient was discharged to be followed up with medical therapy.

*From the Section of Cardiology, Department of Internal Medicine, and the Cardiovascular Section, Department of Surgery, University of Arizona, Tucson.
†Supported by an American Heart Association Clinician-Scientist Award.


Reprint requests: Dr. Fenster, Cardiology Section, University Hospital, Tucson 85724

Murmur of Pulmonic Regurgitation (Enomoto et al)
The patient was readmitted three months later because of new physical findings. He denied having significant cardiovascular symptoms. Cardiac examination revealed the previously noted inferolaterally displaced left ventricular impulse and a new systolic impulse at the left sternal border. A diastolic thrill was palpable in the second and third left intercostal spaces. A grade 5/6 harsh systolic and a loud diastolic murmur were present at the left parasternal area. The diastolic murmur was loudest at the apex. With inspiration, the intensity of the diastolic murmur markedly decreased (Fig 1). The previously noted 4/6 apical holosystolic murmur of mitral regurgitation also was present. Chest roentgenogram showed mild congestive heart failure and prominent pulmonary arteries. Two-dimensional echocardiographic findings were consistent with a flail posterior mitral leaflet and an enlarged left atrium and left ventricle. One leaflet of the pulmonic valve was visualized and appeared normal. Hemodynamic findings at repeated cardiac catheterization are shown in Table 1 (second catheterization). Note the decrease in both the pulmonary and regurgitant CV wave pressures with inspiration. There was no significant change in the simultaneously recorded left ventricular end-diastolic pressure with inspiration. Left ventriculography revealed severe mitral regurgitation. Aortic root angiography revealed no evidence of aortic regurgitation.

The patient was taken to surgery. The mitral valve was found to be severely destroyed, and a Hancock porcine valve was inserted. When cardiopulmonary bypass was discontinued, a diastolic vibration was noted over the right ventricular outflow tract. The pulmonary artery was therefore opened and the pulmonary valve inspected. Two leaflets were normal; however, the third leaflet demonstrated multiple small perforations without vegetations. The pulmonic valve was not replaced.

Postoperatively, the pulmonary artery diastolic pressure was normal. Physical examination revealed absence of the mitral regurgitation murmur. The systolic ejection murmur and the diastolic murmurs were still present along the left sternal border. However, they were markedly decreased in intensity. In contrast to the preoperative examination, the intensity of the diastolic murmur no longer decreased with inspiration, but increased with inspiration (Fig 2). Postoperatively, the chest roentgenogram showed a decrease in heart size and clearing of the pulmonary congestion. The pulmonary arteries returned to a normal roentgenographic appearance.

**DISCUSSION**

The murmur from pulmonic regurgitation associated with pulmonary hypertension is usually described as a high-pitched, early diastolic decrescendo murmur. Murmurs of pulmonic regurgitation secondary to pulmonary hypertension rarely change in intensity with inspiration. The murmur of pulmonic regurgitation in patients with normal pulmonary artery pressures is typically a low-frequency early- to mid-diastolic crescendo-decrescendo murmur located in the left second and third intercostal spaces.6,8 These murmurs usually increase in intensity with inspiration.4,7,8 Criscitiello and Harvey4 emphasized that the detection of an inspiratory increase in the intensity of diastolic murmurs is of great value, since this finding points to a right-sided cardiac origin. These authors reported that in three of four patients with congenital pulmonic regurgitation, the murmur increased in intensity with inspiration. Bacterial endocarditis of the pulmonic valve is another cause of pulmonic regurgitation with normal pulmonary artery pressures, and thus one would expect this murmur to increase in intensity with inspiration. In contrast, our patient initially had a prominent inspiratory decrease in the intensity of the murmur (Fig 1). However, the respiratory variation of the murmur changed dramatically with mitral valve replacement. Postoperatively, the murmur increased with inspiration (Fig 2). Although an effect due to postoperative changes in intrathoracic anatomy cannot be excluded, a more likely explanation involves the changes in pulmonary artery hemodynamics with respiration before and after mitral valve replacement. In our patient, inspiration

**Table 1—Hemodynamic Findings at Cardiac Catheterization**

<table>
<thead>
<tr>
<th></th>
<th>Right Atrium, mm Hg (mean)</th>
<th>Right Ventricle, mm Hg</th>
<th>Pulmonary Artery, mm Hg (mean)</th>
<th>Pulmonary Artery Wedge, mm Hg</th>
<th>Left Ventricular Ejection Fraction, %</th>
<th>Cardiac Index, L/min/m²</th>
</tr>
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<tr>
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<td></td>
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<td></td>
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<tr>
<td>Inspiration 1</td>
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<td>23/0</td>
<td>15/3</td>
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<td>Inspiration 2</td>
<td>4</td>
<td>33/6</td>
<td>25/14</td>
<td>30</td>
<td></td>
<td></td>
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<tr>
<td>Second catheterization</td>
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<tr>
<td>Inspiration 1</td>
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<td>47/0</td>
<td>47/15</td>
<td>25</td>
<td></td>
<td>63</td>
</tr>
<tr>
<td>Inspiration 2</td>
<td>5</td>
<td>60/8</td>
<td>58/20</td>
<td>35</td>
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</table>
Figure 2. Simultaneous ECG and phonocardiogram following mitral valve replacement. The diastolic murmur increases in intensity during inspiration (open arrow) and decreases during expiration (closed arrow).

caused a 10 mm Hg decrease in the height of the regurgitant CV waves, a decrease in the pulmonary artery systolic and diastolic pressures. Thus, inspiration reduced the diastolic pressure against the pulmonic valve, perhaps accounting for the preoperative decrease in the intensity of the murmur with inspiration.

Another contributory factor could be a decrease in regurgitant blood volume with inspiration. In patients with acute severe mitral regurgitation, retrograde flow from the pulmonary veins to the pulmonary arteries can occur in systole. This retrograde flow may decrease with inspiration, thereby decreasing the volume in the pulmonary arterial bed and the regurgitant flow across the pulmonic valve.

Mitral valve replacement was followed by normalization of pulmonary artery pressures. Consequently, the usual right-sided inspiratory augmentation of venous return produced the expected increase in the intensity of the murmur of pulmonic regurgitation.

Exercise-Induced ST Segment Alternans*

Victor S. Wayne, M.B., B.S.; Richard L. Bishop, M.D.; and David H. Spodick, M.D., F.C.C.P.

We report a rare electrocardiographic finding occurring in previously undescribed circumstances in which a 61-year-old man undergoing exercise testing developed striking ST segment elevation on the ECG characterized by electrical alternans of the ST segments. The significance of electrical alternans is briefly discussed in the light of this event.

Widespread exercise testing has led to recognition of a range of electrocardiographic responses to myocardial ischemia. While ST-segment depression is the most common finding, ST-segment elevation (regarded as representing probable transmural myocardial ischemia) also occurs. We report the unusual finding of alternation of exercise-induced ST-segment elevations.

Case Report

A 61-year-old man was referred for exercise testing following a five-year history of intermittent exertional chest pain, with one episode of pain at rest. Physical examination was unremarkable, and the resting ECG revealed sinus rhythm with T wave inversion in lead aVL and partial T wave inversion in leads V3, V5, and V6.

The patient was exercised according to a modified Bruce protocol. After three minutes at 2 mph and 3.5 percent grade, he complained of mild retrosternal chest discomfort. The ECG revealed marked ST segment elevation in the precordial leads whereupon exercise was promptly terminated.

The ST segment elevation peaked at 7 mm with concomitant ST segment depression in the inferior leads. The striking feature of the ST segment elevation was that within 20 seconds of its development, the ST segments displayed electrical alternans (Fig 1). There was no

References


*From the Cardiology Division, St. Vincent Hospital and the University of Massachusetts Medical School, Worcester, MA.

Reprint requests: Dr. Spodick, St. Vincent Hospital, Worcester, MA 01604