Diastolic Murmurs in Apparently Normal Children

By Jerome Liebman, M.D., and Santosh Sood, M.D.

SUMMARY

Diastolic murmurs have always been considered abnormal, but this report presents nine apparently normal children with high-frequency, early, diastolic murmurs confirmed by intracavitary phonocardiography to arise within the left ventricle. Each child (aged 5 to 15 years) was referred for evaluation of a systolic murmur at the lower left sternal border, but an additional finding at the initial examination was a grade I to III/VI high-pitched diastolic murmur, thought to be decrescendo, at the third and fourth intercostal space at the left sternal edge. The murmurs were best heard when the patient was supine. Cardiac x-rays, including four views with barium, were all clearly normal, as were eight of the nine electrocardiograms and the Frank and McFee vectorcardiograms. Multiple parameters of right and left heart catheterizations were normal in all.

Additional Indexing Words:
Intracavitary phonocardiography
Crescendo-decrescendo early diastolic murmur
Barium titanate phonocatheter

Diastolic murmurs have always been considered abnormal, but this report presents nine apparently normal children with high-frequency, early diastolic murmurs, confirmed by intracavitary phonocardiography.

Methods

The group studied consisted of five girls and four boys, ranging in age from 5 to 15 years. Each was referred for evaluation of a systolic murmur at the lower left sternal border, but an additional finding at the initial examination was a grade I to III/VI high-pitched diastolic murmur, thought to be decrescendo, at the third or fourth intercostal space at the left sternal edge (table 1). The earliest age that any systolic murmur was recognized in the group was at age 3 years, and the latest was at 13 years. Except for three children with prominent systolic retractions just inside the nipple line and thought possibly to have an abnormal left ventricular impulse, all would have been considered normal on examination, if not for the newly heard diastolic murmur. Cardiac roentgenograms (four views with barium) were normal, as were eight of the nine electrocardiograms. One of the electrocardiograms, from a child with a possibly abnormal left ventricular impulse, had unusually prominent Q waves in the left chest leads (fig. 1). Admission to the hospital for right and left heart catheterization studies was then recommended to rule out aortic regurgitation or anomalous left coronary artery with retrograde flow. During the hospitalization, other studies included external phonocardiography and Frank and McFee vectorcardiography, as well as right and left heart catheterization with cineangiography and intracavitary phonocardiography (table 2). External phonocardiograms were done using a Cambridge 1 MB 1000 four-channel photographic recorder equipped with a Leatham type low-pass filter and special Cambridge peaking filters. During the cardiac catheterization, the external phonocardiograms were made with a Sanborn 550 M photographic recorder and a 350-1700 B heart sound preamplifier. The intracavitary phonocardiograms were made simultaneously with a second 350-1700 B heart sound preamplifier and a barium titanate phonocatheter.2 Each child had the sounds recorded and listened to from within the root of the aorta and left ventricle. In three children, the phonocatheter was
<table>
<thead>
<tr>
<th>Patient</th>
<th>Sex</th>
<th>Age (yr)</th>
<th>Age (yr) when systolic murmur heard</th>
<th>Blood pressure (mm Hg)</th>
<th>Cardiac impulse</th>
<th>Systolic murmur</th>
<th>Diastolic murmur</th>
</tr>
</thead>
<tbody>
<tr>
<td>L.M.</td>
<td>F</td>
<td>5</td>
<td>4</td>
<td>105/56</td>
<td>Normal LV</td>
<td>Grade II ejection, LLSB, poor transmission</td>
<td>Grade II early short, high freq., 2-3 LIS</td>
</tr>
<tr>
<td>C.H.</td>
<td>F</td>
<td>5</td>
<td>5</td>
<td>104/60</td>
<td>Normal LV</td>
<td>Grade III vibratory ejection, LLSB → to apex, axilla, and neck</td>
<td>Grade II early short, high freq., LLSB</td>
</tr>
<tr>
<td>M.M.</td>
<td>M</td>
<td>12</td>
<td>11</td>
<td>120/72</td>
<td>(?) Abnormal LV with systolic retractions</td>
<td>Grade II vibratory ejection, LLSB → to apex and axilla</td>
<td>Grade II early short, high freq., LLSB</td>
</tr>
<tr>
<td>D.Z.</td>
<td>M</td>
<td>5½</td>
<td>5</td>
<td>90/60</td>
<td>Normal LV</td>
<td>Grade II ejection, LLSB → to apex</td>
<td>Grade II early short, high freq.</td>
</tr>
<tr>
<td>J.D.</td>
<td>F</td>
<td>15</td>
<td>13½</td>
<td>118/60</td>
<td>Normal LV</td>
<td>Grade II ejection, ULSB → to left shoulder. Grade II high-pitched, late systolic at apex, heard at age 14 yr. Not heard at time of study</td>
<td>Grade II early short, high freq., LLSB</td>
</tr>
<tr>
<td>D.D.</td>
<td>F</td>
<td>8</td>
<td>8</td>
<td>98/60</td>
<td>Normal LV</td>
<td>Grade II ejection, LLSB → to ULSB</td>
<td>Grade II-III early short, 3 LIS</td>
</tr>
<tr>
<td>J.N.</td>
<td>F</td>
<td>14</td>
<td>11</td>
<td>104/70</td>
<td>Normal LV</td>
<td>Grade II short systolic ejection ULSB</td>
<td>Grade II early short, medium to high freq., ULSB</td>
</tr>
<tr>
<td>R.F.</td>
<td>M</td>
<td>7</td>
<td>3</td>
<td>90/60</td>
<td>(?) Abnormal LV with systolic retractions</td>
<td>Grade II ejection, ULSB</td>
<td>Grade II early short, high freq., 3 LIS</td>
</tr>
<tr>
<td>R.B.</td>
<td>M</td>
<td>12</td>
<td>Newborn</td>
<td>122/68</td>
<td>(?) Abnormal LV with systolic retractions</td>
<td>Grade III systolic ejection, ULSB</td>
<td>Grade III early short, medium to high freq., LLSB and apex</td>
</tr>
</tbody>
</table>

Abbreviations: LV = left ventricle; LLSB = lower left sternal border; ULSB = upper left sternal border, and LIS = left interspace at sternal edge.
## Table 2

<table>
<thead>
<tr>
<th>Patient</th>
<th>ECG</th>
<th>VCG</th>
<th>Cardiac catheterization (all normal hemodynamically, including ascorbic acid curves)</th>
<th>Intracavity phonocardiography: Ejection systolic murmur maximal at root of aorta in all diastolic murmurs</th>
</tr>
</thead>
<tbody>
<tr>
<td>L.M.</td>
<td>TWNL</td>
<td>Normal</td>
<td>Cine-PA, aorta, LV</td>
<td>Early crescendo-decrescendo diastolic in LV; early ejection systolic in MPA &gt; RVO†</td>
</tr>
<tr>
<td>C.H.</td>
<td>TWNL</td>
<td>Top normal posterior QRS projection</td>
<td>Cine-aorta, LV</td>
<td>Early crescendo-decrescendo diastolic in LV</td>
</tr>
<tr>
<td>M.M.</td>
<td>TWNL</td>
<td>Normal</td>
<td>Cine-aorta, LV, Isuprel → no gradient in systole from LV → aorta</td>
<td>Early crescendo-decrescendo diastolic in LV</td>
</tr>
<tr>
<td>D.Z.</td>
<td>TWNL</td>
<td>Top normal leftward QRS projection</td>
<td>Cine-aorta, LV</td>
<td>Early crescendo-decrescendo diastolic in LV and root of aorta</td>
</tr>
<tr>
<td>J.D.</td>
<td>TWNL</td>
<td>Normal</td>
<td>Cine-aorta, LV</td>
<td>Early crescendo-decrescendo diastolic in LV</td>
</tr>
<tr>
<td>D.D.</td>
<td>TWNL</td>
<td>Normal</td>
<td>Cine-aorta, LV</td>
<td>Early crescendo-decrescendo diastolic in LV and root of aorta</td>
</tr>
<tr>
<td>J.N.</td>
<td>TWNL with occasional ectopic ventricular beats</td>
<td>Normal</td>
<td>Cine-PA, aorta, LV</td>
<td>Early crescendo-decrescendo diastolic in LV; early ejection systolic in MPA &gt; RVO</td>
</tr>
<tr>
<td>R.F.</td>
<td>Deep Q V₅, V₆, Dx: “left septal hypertrophy”</td>
<td>Large initial rightward anterior projection</td>
<td>Cine-aorta, LV, Isuprel → no gradient in systole from LV → aorta</td>
<td>Early crescendo-decrescendo diastolic in LV</td>
</tr>
<tr>
<td>R.B.</td>
<td>TWNL</td>
<td>Normal</td>
<td>Cine-PA, aorta, LV</td>
<td>Early crescendo-decrescendo diastolic in LV; early ejection systolic in MPA &gt; RVO</td>
</tr>
</tbody>
</table>

*Tracing within normal limits.
†MPA > RVO = main pulmonary artery greater than right ventricular outflow tract.
Figure 1
Standard electrocardiogram of 7-year-old boy. Note the very prominent initial force to the right and anterior interpreted as being due to left septal hypertrophy.

Figure 2
External phonocardiogram at lower left sternal border of a 5-year-old girl with grade III vibratory systolic ejection murmur at the lower left sternal border. The diastolic murmur could not be demonstrated on the external phonocardiogram, though it was easily heard by many auscultators.

also placed in the right atrium, right ventricle, and pulmonary artery (table 2).

Results
In the hospital, it became clear that the diastolic murmurs were variable, and occasionally even disappeared. The one murmur that had been described as grade III became a shorter grade I. The upright position not only did not increase the intensity of any murmur, but it usually made it softer, and in one child made it disappear. There was either no variation with respirations or an increase with expiration. Though the diastolic murmurs were heard by many auscultators, external phonocardiography, using the Cambridge apparatus with both peaking and low-pass filters1 on the day before catheterization and a Sanborn apparatus using high-pass filters during the catheterization, could not definitely demonstrate the murmurs. This was the situation even when the intracavitary phonocatheter had been passed retrograde across the aortic valve into the left ventricle. The systolic ejection murmurs were stable and easily recorded (fig. 2).

The vectorcardiograms were quantitatively and qualitatively analyzed and were all found
to be normal except in the one child with prominent left chest Q waves in the standard electrocardiogram. A large initial rightward anterior vector, considered possibly to be due to left septal hypertrophy, was demonstrated.

Oxygen saturation and pressure data in the right heart and retrograde left heart catheterizations were all normal. The left atrium was not entered. In each case, in order to rule out tiny left-to-right shunts, ascorbic acid dye-dilution curves were performed. With the platinum-tipped catheter in the pulmonary artery, injections were made directly through the pulmonary artery catheter, as well as through the retrograde catheter, into the left ventricle or root of aorta. In no case could a left-to-right shunt be detected. Intracavitary electrocardiography was performed on the right side and was always normal. In no case was there a systolic pressure gradient across a semilunar valve, and in two children where an abnormal left ventricular impulse was questioned, no gradient was produced even after isoproterenol infusion.

In all nine children, cineangiograms from the root of the aorta in the left anterior oblique and right anterior oblique projections were normal, as were left ventricular angiograms. There was no aortic regurgitation, the valve always had three cusps, and the coronary arteries were normal. The ventricular contractions appeared normal, as did the papillary muscles and mitral valve. In the three children in whom pulmonary artery angiograms could be done without catheter reflux or valve distortion by the catheter, there was no pulmonary regurgitation.

Intracavitary phonocardiography was performed on the left side in all and on the right side in three children. No diastolic murmurs were found in the right side, though the typical ejection murmurs, maximal in the

Figure 3

Intracavitary phonocardiogram from the root of aorta (same child as in fig. 1). Note the very prominent systolic ejection murmur, but no diastolic murmur.
Intracavitary phonocardiogram from the body of the left ventricle from the same child as figures 1 and 3. Note the prominent diastolic murmur, just as loud as the systolic ejection murmur. It is early, but diamond-shaped rather than decrescendo.
Intracavitary phonocardiogram from root of aorta of the same child as figure 5. Note that the early diamond-shaped diastolic murmur is present here as well. Gain is less than in figure 5, but when gain is unchanged on pullback tracing, systolic murmur is louder, and diastolic murmur is softer.

**Figure 6**

Intracavitary phonocardiogram from root of aorta of the same child as figure 5. Note that the early diamond-shaped diastolic murmur is present here as well. Gain is less than in figure 5, but when gain is unchanged on pullback tracing, systolic murmur is louder, and diastolic murmur is softer.

main or right main pulmonary artery, were present. In all nine children, the typical normally prominent aortic systolic ejection murmur was found, maximal at the root (fig. 3). In addition, each child had a clear-cut diastolic murmur, which was easily recorded and heard. It was always present in the body and outflow tract of the left ventricle (figs. 4 and 5) and in the two children in whom it was also present in the root of the aorta (fig. 6), the murmur was maximal in the left ventricular body. The area of the ventricle where the murmur was loudest was high in the body, but below the outflow tract. It often disappeared at the apex. The murmur began just after aortic closure or even as late as pulmonary closure and was not de crescendo. It was always crescendo-decrescendo and it was present not more than through one third of diastole. Left-sided intracavitary phonocardiography has been performed in our laboratory on other children (with mitral regurgitation or suspected left ventricular cardiomyopathy) without demonstration of a diastolic murmur. A diastolic murmur in the left ventricle is expected, however, in the presence of aortic regurgitation.

**Discussion**

A search of the literature revealed that diastolic murmurs in normal children or adults have not been documented, though Luisada and associates mentioned diastolic murmurs in two of 500 normal children. In the presence of large left-to-right shunts and normal atrioventricular valves, mid-diastolic rumbling murmurs are well known. Similar flow murmurs have also been well documented in children with the severe hemolytic anemia of sickle cell disease, presumably due to increased cardiac output, and in many other pathological states. High-pitched early diastolic murmurs in the presence of presumably normal aortic valves have been noted in systemic hypertension and with presumably normal pulmonary valves in pul-
monary hypertension. Levine and Harvey have also described early diastolic murmurs in severe anemia.

Murmurs similar to those of the present study have been heard but not documented by intracavitary phonocardiography in children after infancy with an anomalous left coronary artery arising from the pulmonary artery with retrograde flow. In such children, coronary flow mainly or entirely originates in the right coronary artery and in one such child the diastolic thrill at surgery could be obliterated by compressing the right coronary artery.

Since the diastolic murmur occurs during peak coronary blood flow, the timing, location, and character suggest that it could represent normal coronary artery flow. Obviously, however, we have done no studies to prove this hypothesis. One could also suggest that the murmur is due to normal flow across the mitral valve, but mitral flow murmurs are expected to be of low rather than high frequency.

**Addendum**

Since acceptance of this paper for publication, three other children, with virtually identical clinical findings, have been studied. The same results have been documented. It is thus the opinion of the authors that such children no longer need a cardiac catheterization in order to diagnose a normal heart.

**References**

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