EVALUATION OF TRANSIENT HEART MURMUR RESEMBLING PULMONARY ARTERY STENOSIS IN TERM INFANTS BY DOPPLER AND M-MODE ECHOCARDIOGRAPHY

TOSHIHARU MIYAKE, M.D. AND TATSUO YOKOYAMA, M.D.

Four term infants with transient murmurs resembling that of pulmonary artery stenosis were examined. A grade 3/6 systolic ejection murmur was transmitted clearly to the entire precordium and the back. This murmur was first detected 7 days after birth in 1 infant and at a 1-month medical check in the other 3. The murmur continued for 7 to 22 weeks, with an average of 12 weeks. It gradually localized in the region of the left sternal border, and eventually disappeared. At the first medical examination, peak velocities of over 2.0 m/s, in the left or right pulmonary artery, were detected by a pulsed Doppler. The diameter of the right pulmonary artery was small (mean, 58±8%; range, 46 to 64% of predicted normal). When the heart murmur disappeared, the diameter of the right pulmonary artery (mean, 97±28%; range, 70 to 126%) had increased significantly (p<0.05). Peak velocities in the right pulmonary arteries had decreased significantly (2.22±0.37 m/s vs 1.13±0.10 m/s, p<0.01). We suggest that hypoplasia of pulmonary artery branches, in relation to the main trunk, is the main cause of the murmur resembling pulmonary artery stenosis.

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LOW-BIRTH-WEIGHT infants frequently have transient heart murmurs resembling pulmonary artery stenosis for about 2 weeks after birth. Term infants also occasionally have such murmurs. Rowe¹ has termed this condition “functional pulmonary artery stenosis”. As the infant grows, the murmur gradually becomes less intense, and finally disappears altogether. We encountered 4 term infants in whom this type of murmur eventually disappeared. However, their murmurs lasted longer than those of low-birth-weight infants. In this study we observed changes in the branches of the pulmonary artery using pulsed Doppler and M-mode echocardiography.

METHODS

Patients
The subjects consisted of 1 female and 3 male infants with heart murmur who were between 25 and 36 days old (average: 32 days). Their mothers did not have a history of abnormal pregnancy or delivery and no infant had experienced asphyxia at birth. None of the mothers of our cases developed rubella during pregnancy, and no evidence of Williams syndrome was found in any of the patients. The gestation period varied from 39 to 40 weeks. The birth weight ranged from 2,230 to 3,465 grams (average:

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Key words:
- Blood velocity
- Heart murmur
- Infant
- Pulmonary artery branch

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2,937 grams). The heart murmur was first detected 7 days after birth in 1 infant, and at a routine 1-month medical check in the other 3. The second heart sound had a normal respiratory split. The pulmonary component of the second heart sound was neither accentuated nor diminished. A grade 3/6 systolic ejection murmur was transmitted clearly to the entire precordium and the back (Fig. 1). The murmur was most pronounced in the second left intercostal space. No cardiomegaly was found on chest X-ray examination, and the electrocardiograms of all 4 infants were normal.

Methods
A commercially-available Doppler color flow imaging system (Toshiba SSH65A) was used. All 4 infants were studied under sedation (trichlorehyl phosphate monosodium) in the supine position. Using a real-time color flow imaging system, pulmonary artery branch flows in the left and right pulmonary arteries were examined in the parasternal short axis view. The presence of any additional abnormal color signals were noted. Using a pulsed Doppler echocardiogram, the velocities in the left and right pulmonary arteries were recorded just distal to the pulmonary artery branches in the parasternal short axis view. The velocities at the pulmonary valve were also obtained in the parasternal right ventricle outflow tract view. Doppler flow velocity signals were obtained using sample volume sizes of 2 mm. No attempt was made to apply an angle correction to the velocities because all velocities were recorded with an intercept angle, formed by the ultrasound beam and the direction of blood flow, of less than 20°. The diameter of the pulmonary artery anulus was measured at end-diastole at the beginning of Q wave in the high parasternal right ventricle outflow tract view on an M-mode echocardiogram. We also measured the diameter of the right pulmonary artery at end-diastole in the suprasternal coronary view (Fig. 2). Three consecutive measurements were made and averaged.

Controls
As controls, the diameters of the pulmonary artery anulus and the right pulmonary artery were analyzed with an M-mode echocardiogram in 36 children (mean age of 5 years 1 month; range 20 days to 15 years)
Fig. 2. A: Measurements of PVD and RPAD by M-mode echocardiogram. B: Correlation between BSA and PVD. C: Correlation between BSA and RPAD. BSA = body surface area; PVD = pulmonary valve annulus diameter, RPAD = right pulmonary artery diameter.

Fig. 3. Pulsed Doppler tracing in the proximal right pulmonary artery. AO = aorta; L = left pulmonary artery; MPA = main pulmonary artery; R = right pulmonary artery.
TABLE I  CLINICAL FEATURES AND ECHOCARDIOGRAPHIC MEASUREMENTS

<table>
<thead>
<tr>
<th>variable</th>
<th>patients (n=4)</th>
<th>control (n=4)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (days)</td>
<td>31.5±5.1</td>
<td>35.5±10.5</td>
<td>NS</td>
</tr>
<tr>
<td>Birth weight (g)</td>
<td>2,938±571</td>
<td>2,900±348</td>
<td>NS</td>
</tr>
<tr>
<td>Gestational age (weeks)</td>
<td>39.5±6.0</td>
<td>38.8±5.5</td>
<td>NS</td>
</tr>
<tr>
<td>Body surface area (m²)</td>
<td>0.24±0.01</td>
<td>0.24±0.03</td>
<td>NS</td>
</tr>
<tr>
<td>Heart rate (l/min)</td>
<td>148±6</td>
<td>141±5</td>
<td>NS</td>
</tr>
<tr>
<td>PV velocity (m/sec)</td>
<td>0.85±0.11</td>
<td>0.76±0.03</td>
<td>NS</td>
</tr>
<tr>
<td>RPA velocity (m/sec)</td>
<td>2.22±0.37</td>
<td>1.20±0.12</td>
<td>&lt;0.005</td>
</tr>
<tr>
<td>LPA velocity (m/sec)</td>
<td>1.98±0.34</td>
<td>1.13±0.24</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>PV diameter (mm)</td>
<td>7.5±1.5</td>
<td>8.4±1.1</td>
<td>NS</td>
</tr>
<tr>
<td>RPA diameter (mm)</td>
<td>3.7±0.5</td>
<td>5.9±0.8</td>
<td>&lt;0.005</td>
</tr>
</tbody>
</table>

Abbreviations: LPA=left pulmonary artery; PV=pulmonary valve; RPA=right pulmonary artery.

who had no evidence of cardiac disease and a mean body surface area of 0.74 (range 0.20 to 1.76). Due to the age-dependence of flow velocity in the pulmonary artery, 4 infants from among the 36 controls were matched for age to the patients at the time of the first medical examination.

Statistical Analysis
Results were reported as the mean±1 standard deviation. The data were analyzed using the Student's t test. A p value <0.05 was considered significant.

RESULTS
Neither valvular nor supravalvular pulmonary stenosis was found on a two-dimensional echocardiogram. Color flow signals characteristic of patent ductus arteriosus, ventricular septal defect or atrial septal defect were not recorded in any patient. The blue-coded color signal suddenly changed into a mosaic pattern at the branch of the left and right pulmonary arteries, where the blood flow velocity, as determined by pulsed Doppler, increased. Table I shows clinical features and echocardiographic measurements at the first medical examinations. The flow velocities in the left and right pulmonary arteries were 1.50 to 2.23 m/s (1.98±0.34 m/s) and 1.76 to 2.67 m/s (2.22±0.37 m/s), respectively, and were significantly faster than those of the age-matched control infants (p<0.01 and p<0.005 for the left and right pulmonary arteries, respectively). The spectrum of the flow velocities in the left and right pulmonary artery branches on pulsed Doppler (Fig. 3) was slightly broad, but not turbulent. Changes in the maximum velocities in the right pulmonary arteries of the 4 patients are shown in Fig. 4. The heart murmur transmitted to the back lasted for 7 to 22 weeks (mean 12 weeks). It gradually localized in the region of the left sternal border, and eventually disappeared. The flow velocities at the first medical examination (mean 32 days of age) and at approximately the age when the murmur disappeared (mean 17 months; range 13 months to 23 months) were compared to changes in the velocities, as determined by pulsed Doppler, in the pulmonary valve annulus and in the left and right pulmonary artery branches (Fig. 5). The velocities in the bilateral pulmonary artery branches.

Fig.5. Changes of pulsed Doppler velocities in the left, right, and main pulmonary arteries. "+" shows that the characteristic systolic murmur is present. "−" shows that the murmur is absent. LPA = left pulmonary artery; PV = pulmonary valve; RPA = right pulmonary artery.

Fig.6. Changes of RPAD (A) and PVD (B) derived from M-mode echocardiogram. "+" shows that the characteristic systolic murmur is present. "−" shows that the murmur is absent. BSA = body surface area; PVD = pulmonary valve annulus diameter, RPAD = right pulmonary artery diameter.

decreased significantly, while that in the pulmonary valve annulus did not. Curves representing the normal values for the diameters of the pulmonary valve annulus and the right pulmonary artery at end-diastole as determined by M-mode echocardiography, are shown in Fig.2. The M-mode echocardiographic data were expressed as a percentage of the predicted normal values using body surface area. The ratio of the subjects' size to predicted normal values was followed during the clinical course (Fig.6). The diameter of the right pulmonary artery was small (mean 58 ± 8%; range, 46 to 64% of predicted normal values) at the first medical examination, but subsequently increased significantly (mean 97 ± 28%; range 70 to 125% of predicted normal values) (p < 0.05). The change in the diameter of the pulmonary valve annulus was insignificant: from 84 ± 16% (range 65 to 104%) to 93 ± 18% (range 75 to 117%).

**DISCUSSION**

Patten reported that, in the term fetus immediately before birth, the internal diameters of the main pulmonary artery and left and right pulmonary arteries average 6.7, 3.7, and 3.9 mm respectively. Until the infant reaches a few months of age, the size of the main pulmonary artery does not increase, although cardiac output rises. However, both the left and right branches of the pulmonary artery enlarge to approximately three-fourths of the size of the main pulmonary artery by the age of 3 to 4 months. Heart murmurs during this period are believed to be due, at least in part to the fact that blood flows at an acute angle from the main pulmonary artery to the left and right pulmonary arteries. Functional or physiologic heart murmurs are frequently heard during the neonatal period. However, heart murmurs which are widely transmitted to the precordium and the back, are less frequent in term infants than in low-birth-weight infants. This suggests that the angle plays a less important role in the heart murmur of term infants. It is also believed that blood flow velocities markedly increase in the left and right branches of the pulmonary artery when they are considerably smaller than the main pulmonary artery. This phenomenon might also cause the heart murmurs found in low-birth-weight infants. Because of the poor lateral resolution of the apparatus used, we did not measure the diameter of the pulmonary artery branches just distal to the bifurcation. Instead, since stable measurement could be obtained in the right pulmonary artery, we measured its diameter, as being representative of the
hypoplastic pulmonary artery branch. As the heart murmur weakened and eventually disappeared, the blood velocities at the branches of the pulmonary artery gradually decreased, and the diameter of the right pulmonary artery increased to a normal size. Therefore, we believe that the increase in blood velocity at the branches of the pulmonary artery due to their delayed adaptation or expansion after birth is the primary cause of this transient heart murmur. The heart murmur is not found during the early neonatal period. It becomes apparent only during the late neonatal period due to the increase in blood velocity in the left and right pulmonary arteries. This increase is partially due to the increase in cardiac output resulting from the physiologic decrease in pulmonary vascular resistance.

Congenital rubella syndrome and Williams syndrome both involve hypoplasia of the peripheral pulmonary arteries. Tang et al⁸ have reported that only a few cases in the rubella syndrome show slight intimal thickening, which they attribute to primary growth failure in the regional pulmonary artery branches. Wasserman et al⁹ have suggested that the state of the pulmonary artery in congenital rubella syndrome and that in physiologic hypoplasia of the branches of the pulmonary artery are distinguishable. Giddins et al⁵ have reported that hypoplasia of the left and right pulmonary arteries in Williams syndrome gradually improves. However, the timing of the return to normalcy in hypoplastic pulmonary arteries differs from that in our cases.

Several researchers have reported heart murmurs in patients with pulmonary artery stenosis. Perloff et al⁹ have reported many cases of pulmonary artery stenosis, in which the murmur has its maximal point at the second left sternal border and transmits widely to the precordium, axilla and back. The murmurs in our cases were similar to those of Perloff's cases. They also report, based on intracardiac phonocardiography, that the systolic murmur starts from the branch of the pulmonary artery and transmits widely to the peripheral pulmonary arteries. The area in which the systolic murmur begins coincides with the site of the blood velocity increase, as determined by pulsed Doppler. However, during the first medical examination, it is difficult to judge how the hypoplastic pulmonary artery branches will grow. We believe that true or organic pulmonary artery stenosis may be present when the characteristic murmur continues for more than 2 or 3 months. The transient heart murmur in the late neonatal period reported by Kato¹⁰ is similar to that found in our cases: the timing of the appearance and disappearance of the murmur coincides, as does the maximal point of the murmur, which became localized at the left second sternal border. However, the murmur described by Kato is not transmitted widely, as it is in our cases. When the flow of blood passing through the pulmonary valve increases, such as in cases of atrial septal defect, the blood velocity at the pulmonary valve increases¹¹ but our cases had normal velocities at the pulmonary valve (less than 1.0 m/s). Therefore, we believe that changes in blood flow velocity in the main pulmonary artery are not the main cause of this transient heart murmur.

REFERENCES

2. PATTEN BM: The changes in circulation following birth. Am Heart J 1930; 6: 192—205

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Murmur Resembling Pulmonary Artery Stenosis
