Dysplasia of the Systemic and Pulmonary Arterial System with Tortuosity and Lengthening of the Arteries

A New Entity, Diagnosed During Life, and Leading to Coronary Death in Early Childhood

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SUMMARY
This article describes the case of a boy, 1 year and 5 months old, with generalized tortuosity and lengthening of all major arteries, including the coronary arteries and the pulmonary artery. The early death of the patient was attributed to coronary insufficiency and multiple severe peripheral pulmonary stenoses.

The pathological changes were confined to the elastic arteries and the first part of the muscular arteries. The wall of the aorta was thickened and there was an increase of the elastic fibers. The same changes were present in the main pulmonary artery. In the large muscular arteries, the characteristic changes were thickening of the intima with hyperplasia of the elastic fibers and degenerative fragmentation of the internal elastic membrane. The walls of the coronary arteries were thickened and their lumina were narrow.

Additional Indexing Words:
Degenerative arterial hyperelastosis
Coronary insufficiency in infants

TORTUOSITY of a single artery has been described in the literature. In the majority of these cases, elongation and tortuosity occurred in elderly patients due to hypertension or atherosclerosis. In some patients kinking of a single artery or of the aorta simulated aneurysms, or coarctation, or tumors. Diffuse tortuosity and lengthening of the systemic arteries in a girl dying at 10 years of age has recently been described by Ertugrul. His case was characterized by generalized tortuosity and lengthening of the aorta and all its major tributaries. There was also a diffuse aneurysm of the ascending aorta and aortic regurgitation. Involvement of the coronary and pulmonary arteries was not mentioned by the author. Biopsy of the peripheral artery was interpreted as showing fragmentation of the internal elastic membrane and a considerable decrease in elastic fibers in the media.

Early in 1967, we examined a 17-month-old boy with tortuosity and lengthening of the systemic and pulmonary arteries, including the coronaries. We presume that the patient had the same disease that Ertugrul's patient had, although, there are some differences in the clinical picture.

Report of Case
D. K., born October 1, 1965, had had daily episodes of dyspnea since the age of 6 months, with
admissions to a hospital on three occasions. These attacks eventually were thought to be episodes of coronary insufficiency, and he was referred to the Department of Pediatric Cardiology of the Hospital of the University of Göttingen on March 2, 1967.

On admission the child appeared healthy. A grade II continuous murmur, which was loudest in the second left intercostal space and in the back on both sides of the vertebral column, was heard. The roentgenogram showed cardiac enlargement with a cardiothoracic ratio of 62%. The electrocardiogram was diagnosed as showing right axis deviation, right ventricular hypertrophy with strain, and myocardial infarction (fig. 1). Episodes of coronary insufficiency occurred several times a day and increased in duration during the hospital period of 4 weeks. The patient would suddenly cry out with pain, become restless, pale, and begin to sweat.

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Figure 1

Electrocardiogram. Right ventricular hypertrophy with strain and myocardial infarction.
Right and left heart catheterization was carried out. The pulmonary artery was not entered. No intracardiac defect was demonstrated. The pressure in the right ventricle was 105/5 mm Hg, and in the left ventricle 100/5 mm Hg (Table 1).

Right ventricular angiocardiography (Fig. 2) showed a large right ventricle and a dilated main pulmonary artery with pulmonary stenosis at the

Table 1

<table>
<thead>
<tr>
<th>Level</th>
<th>Oxygen Saturation (%)</th>
<th>Pressure (mm Hg)</th>
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</thead>
<tbody>
<tr>
<td>Inferior vena cava</td>
<td>51.5</td>
<td></td>
</tr>
<tr>
<td>Superior vena cava</td>
<td>59.0</td>
<td></td>
</tr>
<tr>
<td>Right atrium, high</td>
<td>56.5</td>
<td></td>
</tr>
<tr>
<td>Right atrium, middle</td>
<td>50.0</td>
<td>10/4 (6)</td>
</tr>
<tr>
<td>Right atrium, low</td>
<td>51.5</td>
<td></td>
</tr>
<tr>
<td>Right ventricle, middle</td>
<td>53.0</td>
<td>105/5 (38)</td>
</tr>
<tr>
<td>(3 samples)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left pulmonary vein</td>
<td>94.0</td>
<td></td>
</tr>
<tr>
<td>Left atrium</td>
<td>93.5</td>
<td>13/3 (6.3)</td>
</tr>
<tr>
<td>Left ventricle</td>
<td>92.0</td>
<td>100/5</td>
</tr>
<tr>
<td>Radial artery</td>
<td>93.0</td>
<td>95/65</td>
</tr>
</tbody>
</table>

Figure 2

Right ventricular angiocardiogram, anteroposterior-view. Peripheral pulmonary stenoses are evident.

Figure 4

Left ventricular angiocardiogram. The coronary arteries are also tortuous.

Figure 3

Angiogram of right brachial artery. See abnormal tortuosity and lengthening of the arteries.
Left ventricular angiocardiography was done a few days later, the left ventricle being entered through the patent foramen ovale. This showed abnormal tortuosity and lengthening of the aorta and all its tributaries and marked tortuosity of both coronary arteries (fig. 4).

Pseudoxanthoma elasticum was excluded on histological examination of skin biopsies taken from the left side of the neck and the left upper arm.

**Figure 5**

Scars in the inner part of the right ventricular wall.

bifurcation. The smaller pulmonary arteries were tortuous and showed peripheral pulmonary stenoses.

The right radial artery when exposed for retrograde aortography appeared similar to a stretched telephone cord. A catheter could only be introduced for about 8 cm. Retrograde angiography showed tortuosity of all the arteries which filled (fig. 3). Biopsy of the radial artery revealed fragmentation of the internal elastic membrane, a thickening of the intima, and an increase in elastic fibers.

**Figure 6**

(A) Cross-section of the main pulmonary artery and opened pulmonary artery showing peripheral stenosis at the bifurcation (above). Thick wall. Cross-section of ascending aorta (below). (B) Pulmonary artery of elastic type with a thick wall and narrow lumen beside a small peripheral bronchus. Elastic-van Gieson staining; × 120.

**Figure 7**

(A) Renal artery separated from the aorta. (B) Common carotid artery and subclavian artery fixed under pressure.
TORTUOSITY AND LENGTHENING OF MAJOR ARTERIES

Figure 8
(A) Cross-section of right coronary artery 1 cm from its origin. Considerable thickening of the intima with hyperplasia of elastic fibers. No internal elastic membrane. I = intima; M = media. Elastic-van Gieson staining, × 120.
(B) Cross-section of right coronary artery 1 cm from its origin from a normal child of the same age. M = media. Elastic-van Gieson staining, × 120.

Postmortem Examination
At autopsy there was marked right ventricular hypertrophy with widespread scars (fig. 5). Scars were also present in the wall of the left ventricle and in the papillary muscles. The maximal wall thickness of the right ventricle was 13 mm. The left ventricle was smaller than the right ventricle.

The pulmonary artery was dilated and its wall was thicker than that of the aorta (fig. 6A). Severe stenosis at the bifurcation of the pulmonary artery was confirmed (fig. 6A). Some small intrapulmonary thick-walled arteries of the elastic type with a narrow lumen extended far into the periphery (fig. 6B). Occasional aneurysmatic dilatations with a thinner media were present in muscular pulmonary arteries.

The aortic arch, the abdominal aorta, and the common carotid arteries were tortuous. The wall of the aorta was twice as thick as normal and on histological examination the elastic lamellae were about twice as large as normal and fragmented. The structure of the large arteries of the elastic type was the same as that of the aorta.

Changes were also present in the large arteries of the muscular type. Both coronaries were very tortuous. The renal arteries appeared similar to cork-screws (fig. 7A). The common carotid artery has been perfused with a pressure of 120 mm Hg and then fixed with formalin (fig. 7B). Figure 7A shows the tortuous renal artery separated from the aorta.

The wall of the coronary arteries was thickened and the lumen was narrow. Histological examination showed a marked thickening of the intima. In the proximal portions of both coronary
arteries, no internal elastic membrane was present. In the distal portions, this membrane could be seen only in a few locations. Elastic fibers were present in the intima. Some of these fibers were running in a longitudinal direction, some in a cross-direction. In a cross-section of the right coronary artery 1 cm from its origin, there were considerable intimal proliferations with hyperplasia of elastic fibers and no internal elastic membrane (fig. 8A). The media was thickened. The borderline between the media and the intima was diffuse. There was derangement of the increased number of elastic fibers. Figure 8B shows a cross-section of a normal right coronary artery of a child of the same age, 1 cm from its origin. Changes in the iliac arteries in our case were similar to those in the coronary arteries (fig. 9).

In the renal arteries, the transitional zone from an elastic to a muscular artery was longer than normal. The thickness of the media was different in various parts of these vessels (fig. 10). Thickening of the intima, fragmentation of the internal elastic membrane and differences in the thickness of the media were seen. Many elastic fibers were present in the broad adventitia. Some of these extended into the media.

The peripheral arteries of the systemic circulation in the main organs have been examined. The structure of these vessels was normal.

**Discussion**

There may be a very broad clinical spectrum in these patients, depending upon the degree of coronary involvement and the severity of peripheral pulmonary stenoses. Ertugrul's patient is still living. Fragmentation of the internal elastic membrane has been described in both patients. However, the elastic fibers are not decreased but increased, also there is a considerable derangement of these fibers and a thickening of the media and the intima. In the disease described herein the pathological changes in the arterial system are confined to the arteries of the elastic type and to the first part of the muscular arteries.

We believe that we are dealing with a congenital malformation of the arterial wall. Calcification of the arteries with coronary calcification can be excluded. Occlusive fibroelastosis of the proximal segment of the coronary arteries, as recently described by MacMahon and Dickinson, is also different from the changes seen in our patient.

**References**

3. **Parkinson, J., Bedford, D. E., and Almond,**

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