An Unusual Late Complication of Pulmonary Artery Banding

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CONGESTIVE HEART FAILURE\textsuperscript{1, 2} develops in approximately 10 to 15\% of infants born with a ventricular septal defect, and this proves refractory to medical management in a significant number. Circumferential banding of the main pulmonary artery has been widely used as a palliative procedure in such cases.\textsuperscript{3-7} This report concerns a previously undescribed complication of this useful operative procedure. Approximately 22 months after an apparently successful banding procedure, a thrombus developed in the main pulmonary artery and produced almost complete occlusion of the lumen beneath the band.

Report of Case

J.A.F. was the apparently healthy male product of a normal pregnancy and delivery. A cardiac murmur was first heard at 6 weeks of age, but he remained well until the age of 4 months when cardiac failure developed and prompted hospitalization. After his condition had stabilized, cardiac catheterization was carried out (table 1). A 50\% left-to-right shunt was demonstrated at the ventricular level. Because his response to the usual medical regimen was not considered satisfactory, the main pulmonary artery was banded elsewhere when he was 5 months old. A cotton umbilical tape was used to decrease the arterial diameter to about one sixth of its preoperative size, and this resulted in a fall in pulmonary artery pressure from approximately 85/30 to 35/10 mm Hg. Subsequently, the child improved and when examined 1 year after operation, growth and development were normal and cyanosis was absent.

He remained well until 25 months of age when cyanosis and decreased exercise tolerance were noted. On one occasion, he fainted during energetic play. Because of these symptoms, he was referred to Brooke General Hospital and was first examined by us when he was 27 months old. He was deeply cyanotic and there was questionable early clubbing of the fingers and toes. A marked parasternal lift and a grade I/VI systolic pulmonary ejection murmur were present. Chest roentgenograms and an electrocardiogram showed marked right ventricular and right atrial enlargement and decreased pulmonary vascularity.

Cardiac catheterization was accomplished shortly after admission (table 1). A right-to-left shunt at the ventricular level was confirmed by indocyanine-green indicator dilution curves, and estimated to be 28\% of systemic flow by the forward triangle method. Systemic pressure was found in the right ventricle and proximal main pulmonary artery, but 1.5 cm distal to the pulmonary valve, the systolic pressure abruptly fell to 20 mm Hg. A right ventricular cineangiogram demonstrated the expected, severe narrowing of the main pulmonary artery, but in addition disclosed a smooth filling defect proximal to the narrowed segment (fig. 1).

Following these diagnostic studies, the child had several episodes of respiratory distress and hypotension. Emergency surgical relief was undertaken 12 hours following catheterization. Cardiac arrest occurred during induction of anesthesia. An attempt to unbend the pulmonary artery to permit more adequate resuscitation was hindered by extremely dense scar tissue about the cotton umbilical tape. A rapidly established bypass during massage resulted in great improvement in cardiac action. When opened, the residual lumen in the main pulmonary artery was found to be almost completely occluded by a firm 2 by 1 by 1 cm white thrombus (fig. 2). The marked intrinsic changes in the wall of the pulmonary artery made the insertion of a pericardial gusset necessary to restore an adequate lumen. The septal defect was closed by patch repair. Postoperatively, the child remained comatose and expired after 6 hours despite intensive efforts with assisted ventilation, vasopressors, and correction of acidosis.

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Table 1

Cardiac Catheterization Data

<table>
<thead>
<tr>
<th></th>
<th>April 9, 1963</th>
<th>February 4, 1965</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% Saturation</td>
<td>Pressure (mm Hg)</td>
</tr>
<tr>
<td>Superior vena cava</td>
<td>79</td>
<td>—</td>
</tr>
<tr>
<td>Inferior vena cava</td>
<td>74</td>
<td>—</td>
</tr>
<tr>
<td>Right atrium</td>
<td>76</td>
<td>9/3(5)*</td>
</tr>
<tr>
<td>Right ventricle</td>
<td>87</td>
<td>118/6</td>
</tr>
<tr>
<td>Proximal pulmonary artery</td>
<td>88</td>
<td>112/60</td>
</tr>
<tr>
<td>Distal pulmonary artery</td>
<td>88</td>
<td>112/60</td>
</tr>
<tr>
<td>Left atrium</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Left ventricle</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Aorta</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Ear oximeter</td>
<td>97.5</td>
<td>—</td>
</tr>
</tbody>
</table>

*Mean pressures are in parentheses.

Postmortem examination confirmed the adequacy of the repair. Microscopic sections from the area beneath the band where the thrombus had been attached showed almost complete loss of the integrity of the vessel wall (fig. 3). The elastic tissue of the media had been completely replaced by connective tissue containing an inflammatory infiltrate which consisted of lymphocytes, plasma cells, and histiocytes. The internal elastic membrane was absent in this area and connective tissue extended out into the thrombus.

Discussion

During preliminary evaluation of the banding procedure, it was feared that a degree of pulmonary artery narrowing appropriate for infancy might prove to be excessive and result in severe cyanosis as growth occurred. Subsequent experience has shown this to be an infrequent problem. Though the gradual onset of mild cyanosis has occasionally been noted,8,9 severe cyanosis has rarely been reported.10 Consequently, the reason for the late appearance of severe cyanosis and syncope with exercise in our patient was not appreciated, even after the hemodynamic studies had been obtained. It was not until the cineangiocardiogram demonstrated a filling defect in the main pulmonary artery that the presence of an intravascular thrombus was suspected.

Figure 1

Cineangiocardiogram showing severe narrowing of the main pulmonary artery and a smooth filling defect proximal to the narrowed segment.

Figure 2

Firm white thrombus in main pulmonary artery.

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The thrombus arose proximally from the damaged endothelium immediately beneath the band, where moderately dense connective tissue had replaced the arterial wall. Similar changes in the arterial wall beneath a circumferentially constricting cotton band have been reported by King and Mandelbaum in dogs. They suggested that necrosis resulted from the ischemia which followed occlusion of the vasa vasorum by the band. Focal intimal excrescences were also noted, which were apparently similar to those found by Dahl and associates following removal of the adventitia from an arterial segment in the dog. Such lesions appeared to underlie small, traumatic breaks in the internal elastic membrane. The presence of fibrin in one such lesion suggested that it originated from a small mural thrombus.

Thrombotic occlusion of the pulmonary artery has been reported only once previously, in a recent abstract by Lynfield and associates. It is somewhat surprising that it has not been encountered more frequently. In preparing the artery, considerable adventitia may be removed, and with it the principal blood supply to the outer two thirds of the arterial wall. A circumferential band would be expected not only to produce occlusion of the remaining adventitial vessels but also to interfere seriously with reestablishment of adventitial circulation. Should intimal thickening occur as a consequence of the forceful ejection of blood through the narrowed segment, the blood supply to the inner third of the arterial wall would also be compromised, and ischemic necrosis of the arterial segment would occur. The propagation of a thrombus in the lumen beneath the damaged segment might be expected in the sluggish, turbulent pulmonary stream.

The possible role played by tissue reaction to the cotton tape used in this patient is unknown. It would appear desirable, however, to use a nonreactive material for banding to facilitate removal at a later date and to avoid

Figure 3

Complete loss of integrity of vessel wall beneath the band where thrombus was attached.
the possibility of an excessive fibrous reaction producing unintentional further narrowing of the artery. For these reasons, we have routinely employed a wide, nonreactive Teflon tape to constrict the pulmonary artery.

**Summary**

An unusual case is reported in which severe cyanosis developed many months following banding of the pulmonary artery. The obstruction resulted from a thrombus which originated beneath the band and eventually almost completely occluded the main pulmonary artery. The late onset of severe cyanosis following a banding procedure should suggest this rare complication and prompt definitive hemodynamic and angiographic studies.

**References**


**Roger Bacon on the Errors of Physicians (Circa 1652)**

Bacon, assured in his own mind that all these things are capable of verification, that they can by experiment acquire the virtue of certitude, sums it up in the pregnant final sentence—Neither the voice of authority, nor the weight of reason and argument are as significant as experiment, for thence comes quiet to the mind.

The *De Erroribus Medicorum* may belie the boisterous promise of its title, but medicine, pharmacy and science are the better for its purposeful illumination.—Sir John Charles: *Roger Bacon on the Errors of Physicians*. Med Hist 4: 281, 1960.
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