A Clinical Profile of Paroxysmal Hyperpnea in Cyanotic Congenital Heart Disease

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The development of paroxysmal hyperpnea is a somewhat alarming complication seen in patients with cyanotic congenital heart disease with diminished pulmonary blood flow. These paroxysms are also called hypoxic spells, "anoxic" spells, blue spells, and syncopal attacks. These episodes may lead to death or permanent brain damage. Surprisingly little clinical information is available concerning the patients subject to these spells, such as the relationship of these attacks to the severity of cyanosis, the time of day when they occur, and the precipitating factors. We have made a retrospective survey of a large group of patients with cyanotic congenital heart disease and diminished pulmonary blood flow and also reviewed a smaller current group of patients to obtain a clinical profile of the patients and their spells.

Material

All available records of children requiring Blair-Taussig or Potts anastomoses at the Children's Hospital of Los Angeles (CHLA) in the 10-year period from 1954 to 1963 were reviewed. Of 190 such patients, 73 or 38 per cent had well-documented histories of hypoxic spells. Four additional patients are included who died during this period with hypoxic spells but who did not have surgery. All 77 patients with hypoxic spells had cyanotic congenital heart disease with diminished pulmonary blood flow. The anatomic diagnoses are shown in Table 1. Fifty-four patients had tetralogy alone, and an additional eight patients had tetralogy with pulmonary atresia.

Twenty-four patients evaluated at the University of Washington Hospital (UWH) in the last 4 years were reviewed. Thirteen patients had hypoxic spells (nine of 18 with tetralogy, two of two with pulmonary atresia, and two of four with tricuspid atresia).

Results

The hypoxic episodes were characterized by paroxysmal hyperpnea and increased cyanosis. Often limpness developed, and generalized stiffness and rolling back of the eyes were common. Many patients slept following the spells, several became unconscious, and three infants had spells that terminated in convulsions. There were eight cerebral vascular accidents, and six patients died during attacks.

The age at onset of hyperpneic spells in

Table 1

Anatomic Diagnosis in 194 Children's Hospital of Los Angeles Patients with Cyanotic Congenital Heart Disease

<table>
<thead>
<tr>
<th></th>
<th>Total number patients</th>
<th>Tetralogy of Fallot</th>
<th>Tetralogy with pulmonary atresia</th>
<th>Pulmonary atresia with intact ventricular septum</th>
<th>Tricuspid atresia</th>
<th>Transposition with pulmonary stenosis</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>No hypoxic spells</td>
<td>117</td>
<td>94</td>
<td>3</td>
<td>0</td>
<td>15</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Hypoxic spells</td>
<td>77</td>
<td>54</td>
<td>8</td>
<td>1</td>
<td>14</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
the CHLA patients is shown in figure 1. The peak incidence was at 1 to 3 months of age. The UWH group had no occurrences before 2 months nor any patients with onset after 1 year. Information regarding the time of day at which spells occurred was available in only 15 of the CHLA patients. Spells occurred primarily in the morning (usually related to awakening) in 11, and in the evening in four patients. In the UWH group, six had spells exclusively in the morning soon after awakening, although the more severely cyanotic patients had spells at almost any time.

The duration of the hyperpneic episodes ranged from less than a minute to several hours, with the majority lasting 15 to 60 minutes. The frequency varied from several spells per day (approximately 25 per cent of the patients) to less than one a week (10 per cent), whereas the majority had one to several spells per week. In most of the patients the occurrence of spells was terminated by surgery; six patients, however, had spontaneous regression of spells without therapy at ages ranging from 2 to 6 years.

Information regarding the precipitating factors was available in 31 of the CHLA patients. Crying was said to initiate spells in 16, eating in seven, defecation in four, hot weather in two, and "exercise" in two patients. In the UWH patients, bowel movements were implicated in seven, crying in six, feeding in two, and coughing paroxysms in one.

Hematocrit or hemoglobin determinations were available in all but one patient. Six patients had a hematocrit value of less than 50 per cent; five had values in excess of 70 per cent. Several patients had amelioration of hyperpneic paroxysms after iron therapy for relative anemia.

Oxygen saturations obtained in 30 CHLA patients subject to spells ranged widely from 15 to 82 per cent; saturations obtained during paroxysmal hyperpnea in three patients were 15, 24, and 33 per cent (fig. 2). Arterial saturations were obtained in 18 UWH patients, nine of whom were subject to spells and nine who were not (fig. 3). None of the saturations was obtained during a hyperpneic episode. The occurrence of spells in two patients with 93 and 98 per cent saturation is remarkable, and, conversely, one patient with 44-per cent saturation had had no spells.

**Discussion**

In patients with cyanotic congenital heart

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**Figure 1**

Age of onset of spells: 77 patients from the Children's Hospital of Los Angeles.

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**Figure 2**

Oxygen saturations: 13 patients subject to hypoxic spells from the Children's Hospital of Los Angeles.
disease and diminished pulmonary blood flow the published incidence of paroxysmal hyperpnea varies from 20 per cent in older patients\textsuperscript{2} to 35 per cent of the patients requiring surgical relief,\textsuperscript{1} and 70 per cent of autopsied cases.\textsuperscript{1}

No numerical data are available on precipitating events, although two general statements are helpful. Taussig\textsuperscript{8} reported that “attacks of severe paroxysmal dyspnea are common in infants who suffer from anoxemia. The attacks may be precipitated by nursing, crying, or by a bowel movement or they may occur without any apparent cause.” Nadas\textsuperscript{4} found that “anoxic spells usually do not follow severe exertion, but, rather, occur in the morning after a good night’s sleep. Often they are associated with bowel movements or feeding; at other times they cannot be attributed to any single environmental factor.”\textsuperscript{4}

Although relatively few parents could state a definite time of day at which the spells occurred, there was a marked tendency for these spells to occur in the morning, which agrees with Nadas’ report. This suggests that a prolonged period of rest paradoxically heightens the susceptibility of the child to these paroxysms.

The precipitating events found in our patients were similar to those reported by Taussig and Nadas: crying, defecation, and feeding. All three, of course, increase oxygen demands and would elevate the arterial pCO\textsubscript{2}, and lower the pH and pO\textsubscript{2} of the systemic venous and arterial blood. Crying and defecation are roughly equivalent to a Valsalva maneuver, which would tend to increase resistance to pulmonary flow and increase right-to-left shunting. It is reasonable to assume that the resulting alterations in the arterial pCO\textsubscript{2}, pO\textsubscript{2}, and pH might stimulate hyperpnea and initiate an attack.

The most surprising finding in our present series of patients was the lack of correlation between the severity of cyanosis and the occurrence of paroxysmal hyperpnea. Two patients with resting arterial saturations in the normal range had unequivocal spells, and quite severely cyanotic patients had no recognizable spells. One patient with an arterial saturation of 44 per cent and a markedly diminished pulmonary blood flow had no paroxysms of marked hyperpnea, although he appeared to have chronic, mild hyperpnea, a finding previously reported.\textsuperscript{5} (Perhaps the absence of spells in such severe cases reflects the absence of cycles of relative oxygen balance, i.e., they are continuously hypoxic.)

**Summary**

A large series of patients with cyanotic congenital heart disease and inadequate pulmonary blood flow who required a systemic to pulmonary artery anastomosis was reviewed, along with a small current series of patients unselected as to surgical intervention.

Thirty-eight per cent of 190 patients in the first group had definite spells consisting of paroxysmal hyperpnea and increased cyanosis, frequently progressing to loss of consciousness. In the current group, 13 of 24 had spells. In the combined groups, there were three convulsions, eight cerebral vascular accidents, and six deaths due to the spell.

Age of onset varied from 1 month to 2 years, with the peak incidence between 2 to 3 months of age. The time of day at which spells occurred was recorded in only 15 patients in the large series: 11 occurred in the morning and four in the evening. In the smaller series, the patients who had only occasional episodes had them exclusively in the morning, whereas the severely affected patients had attacks at almost any time.

Precipitating factors, in order of over-all frequency, were crying, defecation, and feeding.

The most surprising finding was the lack of correlation of hyperpneic spells with resting arterial desaturation, although all arterial saturations obtained during attacks were quite low. Two patients with observed, typical paroxysms had arterial saturations under sedation of 93 and 98 per cent, in contrast to a patient with a 44-per cent saturation who had had no spells.
Acknowledgment

We gratefully acknowledge the assistance of Dr. Benjamen Landing and Dr. John Jones in this study.

References


Coronary Thrombosis

The syndrome of thrombosis of the coronary arteries, long included in angina, has quite recently been isolated, though Harvey's description of Sir Robert Darcy's case, in his second Disquisition to J. Riolan, in which the wall of the left ventricle was ruptured apparently as the result of "an impediment to the passage of the blood from the left ventricle into the arteries," has now been recognized as an early example. The syndrome, first described in 1910 by Obrastzow and Strachesko and again in 1912 by J. B. Herrick, is, now that its characteristic features have been pointed out, obviously a frequent event. Isolated cases had been reported in 1884 by Leyden and even diagnosed by Hammer in 1878, and it is easy to wonder why coronary occlusion, long recognized pathologically, had not been correlated earlier with a clinical picture.—Sir Humphry Davy Rolleston. The Harveian Oration. Great Britain, Cambridge University Press, 1928, p. 92.
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Circulation. 1965;31:66-69
doi: 10.1161/01.CIR.31.1.66
Circulation is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
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Print ISSN: 0009-7322. Online ISSN: 1524-4539

The online version of this article, along with updated information and services, is located on the World Wide Web at:
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