Cyanosis, Cardiomegaly, and Weak Pulses

A Manifestation of Massive Congenital Systemic Arteriovenous Fistula


Large systemic arteriovenous fistulas are usually considered a form of acyanotic heart disease characterized by bounding pulses and cardiomegaly. This report deals with a cyanotic infant whose pulses were so weak that blood pressure was unobtainable either by the auscultatory or flush method. Although the infant died before hemodynamic studies were completed, we believe the cyanosis was due to a large central right-to-left shunt. On the basis of the frequency of cyanosis reported in other cases of gross congenital systemic arteriovenous fistula producing congestive heart failure in early infancy, and a consideration of the hemodynamic changes caused by large experimental fistulas in animals, it is suggested that such cyanosis is practically a mandatory hemodynamic and clinical manifestation of the disease. Previous authors have often described cyanosis and the "mistaken diagnosis of cyanotic heart disease" without attempting to explain the mechanism of the cyanosis.

Case Report

A 2-day-old Negro female infant was referred to Walter Reed General Hospital because of cyanosis, gross cardiomegaly, a loud murmur, and mild respiratory distress. Following an uneventful pregnancy, delivery was complicated by two loops of cord about the infant's neck. Because of immediate respiratory distress positive-pressure oxygen was used to initiate breathing. Following this, the infant was noted to be cyanotic and was placed in oxygen. At 24 hours of age, she was described as having a harsh precordial systolic murmur of maximum intensity over the left chest but was not thought to be in respiratory distress. Chest x-rays showed a superior mediastinal mass, massive cardiomegaly (cardiothoracic ratio 0.80), and normal vascular markings. The infant was transferred to Walter Reed General Hospital at 48 hours of age.

Physical examination revealed a well-developed and well-nourished Negro female infant with a respiratory rate of 80 per minute. Moderate cyanosis was evident and increased when the infant was out of oxygen. Minimal respiratory retraction was present. There was no visible precordial bulging but pulsatile distention was visible in the left supraclavicular area. A rough continuous thrill was palpable over this area and over the upper chest. A pulsatile vessel was palpated behind the left clavicle above the first rib. Deep pressure in this area caused the thrill to disappear. A grade-VI continuous murmur of maximum intensity in the left supraclavicular area was heard over the entire chest. The murmur obscured the aortic and pulmonic second sounds. The lungs were clear to auscultation. The liver was felt 3 cm. below the right costal margin. The extremities were cold and cyanotic with weak peripheral pulses and intense peripheral vasoconstriction. Blood pressure was unobtainable by the auscultatory method. The extremities remained blanched for a protracted period following the application of pressure. This delayed capillary filling precluded blood pressure determination by the flush method.

The electrocardiogram revealed right axis deviation, right ventricular hypertrophy, and right atrial enlargement (fig. 1). Admission hemogram revealed a hematocrit level of 65 with 20 grams per cent of hemoglobin and a white blood count of 31,000 with 70 per cent polymorphonuclear cells. Chest films revealed marked cardiomegaly, normal vascular markings, and a superior mediastinal mass considered consistent with the "snowman" appearance of total anomalous pulmonary venous return (fig. 2).

Cyanosis progressed during the first few hours in spite of continuous oxygen therapy. Respiratory distress became more manifest by increasing respiratory rate with retraction. Hepatomegaly increased. Rapid digitalization produced little
change in the clinical state. Preparations were made to perform an emergency cardiac catheteri-
ization and angiocardiogram. However, at 60 hours of age the infant suddenly ceased breathing and resuscitative procedures were unsuccessful.

The anterior superior mediastinum was filled by several large dilated venous channels. These consisted of the greatly dilated superior vena cava and innominate veins. The left innominate vein had a large, widely patent (0.8 cm.) communication with the left subclavian artery at a point approximately 2 cm. from the aortic arch. Proximal to the abnormal communication, the subclavian artery was equal in size to the aorta, but became almost atretic distal to the fistula, with an internal diameter of less than 1 mm. (fig. 3). The entire right heart, particularly the right atrium, was markedly dilated. The right ventricle was hypertrophied and the ductus arteriosus was widely patent. The foramen ovale was patent, the inter-
ventricular septum was intact, and cardiac structures were normal except for marked cardio-
megaly. The diameter of the aorta decreased distal to the origin of the left subclavian artery creating the appearance of mild preductal coarctation. The right ventricle measured 4 to 6 mm. in thickness, the left ventricle, 2 to 3 mm. The valve circum-
ferences were normal: tricuspid, 55 mm.; pul-
monic, 31 mm.; mitral, 40 mm.; and aortic 23 mm. Microscopic sections from the area of the fistula revealed a smooth transition from arterial to ven-
ous wall structures.

There was atelectasis of both lower lobes of the lungs with some focal atelectatic areas in other lobes. Edema fluid was generally present in the alveoli and blood vessels were engorged. Focal inflammatory exudate was present in some of the alveoli. There were multiple areas of recent focal subpleural hemorrhage.

Discussion

It was recognized that this infant had an arteriovenous fistula prior to death. In fact,
the fistula could be obliterated by firm pressure in the left supraclavicular area. In view of the marked cyanosis and extremely weak arterial pulses, it was assumed that this arteriovenous fistula was merely an incidental finding in a patient with severe cyanotic congenital heart disease. Unfortunately, the fact that a systemic arteriovenous fistula could be the cause of severe cyanosis was not appreciated and the effect of prolonged compression of the fistula was not observed. At necropsy the systemic arteriovenous fistula proved to be the primary cardiovascular lesion.

Review of reports of other large congenital arteriovenous fistulas leading to congestive failure in infancy made it apparent that other authors too, had frequently erred in diagnosing cyanotic congenital heart disease. Levick and Rubie\(^2\) reported in 1953, “The association in a young infant of persistent central cyanosis, increased by crying and feeding, with a systolic murmur heard all over the precordium, almost always indicates congenital heart disease. In the present case the existence of those features led to this diagnosis, yet the necropsy failed to reveal such a lesion. In fact the infant suffered from a hemangioendothelioma of the liver.” Experimental arteriovenous fistulas in animals lower the mean systemic arterial blood pressure, whereas pul-

monary arterial and right atrial mean pressures are increased. The larger the fistula, the more striking is this increase.\(^9\) Large experimental aortocaval fistulas in the dog were observed by Rowe and associates\(^9\) to increase cardiac output 172 per cent, to lower mean aortic pressure 39 per cent, to elevate mean right atrial pressure 60 per cent, to elevate pulmonary artery pressure 73 per cent, and to lower systemic resistance 79 per cent so that left ventricular work increased only 67 per cent while right ventricular work increased 433 per cent.

Most clinicians tend to consider the hemodynamic alterations of a patent ductus arteriosus comparable to that of a systemic arteriovenous fistula—and fail to recognize that a patent ductus increases, primarily, the work of the left ventricle whereas a systemic arteriovenous fistula increases cardiac output in the presence of a marked reduction in sys-

**Figure 2**

Chest film taken at 2 days of age reveals marked cardiomegaly—cardiothoracic ratio 0.80. The superior mediastinal mass suggested the diagnosis of total anomalous pulmonary venous return. There is slight rotation of the chest to the right.

**Figure 3**

Note the marked enlargement of the heart, particularly the right atrium and right ventricle. The left subclavian artery continues into the arteriovenous fistula with a diameter approaching that of the proximal aorta. The distal left subclavian artery is minute. Sub. a., subclavian artery; A-V Anas., site of AV fistula; L. Com. Car. a., left common carotid artery; Inn. c., innominate vein; Inn. a., innominate artery; SVC, superior vena cava; Dis. Sub. a., distal subclavian artery.
neic resistance with no reduction in pulmonary resistance. This results in the right ventricle bearing the brunt of the increased cardiac work. Pulmonary vascular resistance in the newborn is high, the foramen ovale is patent, and frequently, as in our patient, the ductus arteriosus remains open. In such a setting, a large systemic arteriovenous fistula will markedly increase systemic venous return to the right atrium, will strikingly elevate right atrial pressure above left atrial pressure, and cause massive right-to-left shunting through the foramen ovale. The low systemic resistance will also cause unoxygenated blood to stream readily from the high pressure pulmonary artery through the ductus into the low pressure, low resistance aortic circuit. We believe this is the mechanism of the striking cyanosis in our patient and of the cyanosis frequently associated with large congenital systemic arteriovenous fistulas in the newborn. If the ductus is closed, the right-to-left shunt will occur only at the atrial level. Likewise, weak pulses should not be an unexpected finding, since large experimental systemic arteriovenous fistulas cause a marked reduction in both the pulsatile and mean arterial pressure distal to the fistula.10

Silverman et al.1 reported two cyanotic infants thought to have congenital heart disease with gross cardiomegaly and congestive failure who had large cerebral arteriovenous fistulas at necropsy. Levine and associates8 reported hemodynamic studies on an 11-month-old infant before and after ligation of a cerebral arteriovenous fistula whose flow exceeded that of the systemic capillary bed. Prior to ligation of the fistula there was an unexplained 91-per cent saturation of arterial blood. Following closure of the fistula arterial blood was 98 per cent saturated. Glatt et al.4 reported two patients with cerebral arteriovenous fistulas who developed congestive failure in infancy. The patient who died at 32 hours was overtly cyanotic, had a blood pressure of 60/30, and at necropsy, like our patient, had a patent ductus and patent foramen ovale. Their second case had a less extensive arteriovenous fistula and was thought to show evidence of congestive failure at 6 days. This patient was stated to be acyanotic, yet oximeter readings were 91 and 92 per cent and rose to 100 per cent with administration of oxygen. A retrograde aortogram via the left brachial artery at 6 days of age showed slight narrowing of the aortic isthmus. A ductus was stated not to be present; when the infant died from obstructive hydrocephalus at 5 months of age, however, he had a ductus that admitted a 1-mm. probe. Failure to visualize this ductus with retrograde aortography at 6 days of age must have been due to reverse shunting through the ductus. This patient was mildly cyanotic, perhaps from modest right-to-left shunting of blood both at the level of the ductus and the foramen ovale. Oxygen administration would reduce pulmonary resistance, with lowering of pulmonary artery and right atrial pressures leading to temporary closure of the foramen ovale, disappearance of reverse shunting through the ductus and explain the oximeter readings increasing from 91 to 100 per cent.

Glass et al.5 reported a cyanotic infant with a massive arteriovenous fistula between the left internal mammary artery and the ductus venosus. Their patient, like ours and others who have a large fistula proximal to the ductus, had a narrow aortic isthmus resembling a mild preductal coarctation. These authors assumed, “The lowered pressure in the aorta beyond the origin of the subclavian artery provided no stimulus for the aortic isthmus to enlarge thus leading to the coarctation.” We suggest that reversal of flow through the ductus distal to the aortic isthmus would further decrease the stimulus for the isthmus to enlarge.

The most common sites of massive congenital arteriovenous fistula leading to congestive failure in the newborn are reported in the brain and liver, but may be located elsewhere.1–8 A precordial systolic murmur has often been the only murmur described. Probably more careful auscultation over the body of such patients would have revealed the presence of a continuous murmur. Silverman et al.1 proposed that congenital cerebral ar-

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arteriovenous aneurysms should be included in the differential diagnosis of newborn infants with marked cardiomegaly and congestive failure. We suggest that massive systemic arteriovenous fistula should be ruled out as a possible cause of cyanosis, cardiomegaly, and congestive failure in infancy. Early diagnosis and corrective surgery may be life-saving.

**Summary**

An infant was seen at 2 days of age with cardiomegaly, congestive failure, cyanosis, and weak pulses. The primary cardiovascular lesion was a massive arteriovenous fistula between the left subclavian artery and innominate vein.

Review of the literature indicates that most newborn infants with large systemic arteriovenous fistulas leading to congestive failure have been cyanotic. The hemodynamic alterations incident to large experimental systemic arteriovenous fistulas affords an explanation for this cyanosis.

It is suggested that massive systemic arteriovenous fistula in the newborn lowers systemic resistance to a fraction of the high pulmonary resistance present at this age. The right ventricle bears the brunt of the increased cardiac work. Right ventricular failure associated with a marked increase in systemic venous return to the right atrium elevates right atrial pressure above that in the left atrium and almost inevitably leads to cyanosis with right-to-left shunting of blood through the foramen ovale.

Failure to realize that massive systemic arteriovenous fistula in the newborn may present as cyanotic heart disease can cause fatal delay in recognizing this correctable form of heart failure.

**References**

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