Two Cases of Total Anomalous Pulmonary Venous Return of the Supracardiac Type with Stenosis Simulating Infradiaphragmatic Drainage

By Shirley L. Kauffman, M.D., Celia N. Ores, M.D., and Dorothy H. Andersen, M.D.

TOTAL anomalous pulmonary venous return has been classified into four types: cardiae, supracardiac, infracardiac, and mixed, depending on the route by which blood is conveyed by the anomalous vein to the right side of the heart.¹ A simplified classification has recently been suggested based on the known physiologic effect of infradiaphragmatic drainage, namely pulmonary venous obstruction.² On this basis only two types of drainage are given, the supradiaphragmatic, without obstruction, and the infradiaphragmatic with obstruction. The association of obstruction with infradiaphragmatic drainage appears to be constant, as pulmonary veins entering below the diaphragm join either the ductus venousus or portal vein, and in both cases the venous blood will meet hindrance to flow.

The statement has been made that total anomalous pulmonary drainage below the diaphragm forms a distinct clinical entity³ with characteristic x-ray findings.⁴ Although all instances of infradiaphragmatic drainage have been associated with pulmonary vein obstruction, there may also be obstruction in some patients belonging to other groups. We have recently seen two patients who presented with symptoms of such obstruction and were found at autopsy to have stenosis of an anomalous vein at the supracardiac level.

Case Reports

Case 1

A 3-day-old white male infant was admitted to the Babies Hospital on August 16, 1960, because of cyanosis and bilateral pneumothorax.

The infant was born to a 28-year-old, gravida II, para 1, woman after an uncomplicated full-term pregnancy. At birth he was cyanotic, and chest x-rays taken within the first 2 days showed bilateral pneumothorax. Chest tubes were inserted and later chest films showed expanded lungs. The infant could not tolerate oral feedings and vomited brownish mucoid material several times before admission.

Physical examination showed a well-developed infant who was cyanotic and had substernal retractions. His breath sounds were poor, and rhonchi were heard throughout both lung fields. The heart rate was 120 per minute and regular. A grade-II, low-pitched systolic murmur was best heard at the apex with the infant lying on his back. The pulmonic second sound was louder than the aortic second sound. The liver was 2.5 to 3.0 cm. below the right costal margin; the spleen was not palpable. The remainder of the physical examination was normal.

Chest x-rays (fig. 1) taken on the third and fourth days of life in lateral and frontal projections revealed a partial pneumothorax on the right side. A thoracostomy tube was present on the left and the left lung appeared expanded. The heart was of normal size. Each lung showed severe reticular densities suggesting a marked degree of pulmonary vascular congestion with pulmonary edema. A film taken 24 hours later, revealed reexpansion of the right lung. The appearance of marked pulmonary venous congestion was again noted.

An electrocardiogram consisting of six extremity leads and three precordial leads (V₁, V₂, and V₃) was obtained on the fourth day of life. There were normal sinus rhythm, rate 125, a P-R interval of 0.12 second, and right axis deviation. The P wave in lead II measured 1 mm. The right precordial leads showed tall R waves, and small S waves associated with upright T waves. The electrocardiogram was considered within normal limits for the age of the patient. The upright T waves were equivocal evidence of abnormality. Respiratory distress and cyanosis continued.
Cultures of the nose, throat, and blood were negative. The infant was treated with penicillin and chloromycetin. His condition continued to deteriorate and he died on the second hospital day at 5 days of age. Digitalis had not been administered. The clinical diagnosis was congenital heart disease, pneumonitis, and question of sepsis.

Postmortem examination: The infant was well developed and poorly nourished, weighed 2450 Gm., and measured 46 cm. in length. The lips and nailbeds were cyanotic. There was no peripheral edema or effusion into the body cavities.

The heart was normally shaped and not enlarged; it weighed approximately 13 Gm. The right ventricle formed two thirds of the anterior surface of the heart and the apex was made up of both right and left ventricles. The right atrium and ventricle were dilated and hypertrophied, and had a capacity three or four times that of the left heart. The right atrium received the dilated superior vena cava, the inferior vena cava, and the coronary sinus. The foramen ovale measured 1.0 cm., the septum primum was absent. The right ventricle measured 3 mm. in thickness near the septum posteriorly. The tricuspid and pulmonary valves were normal and measured 3.6 cm. and 2.1 cm. respectively. No pulmonary veins entered the small left atrium. The mitral and aortic valves measured 2.7 cm. and 1.2 cm. in circumference respectively. The ductus arteriosus was patent and measured 1.1 cm. in circumference. The pulmonary veins joined posterior to the pericardium to form a common pulmonary vein (fig. 2). From the left superior aspect of this common chamber an anomalous vein arose and passed superiorly; it measured 1.1 cm. in circumference. One-half centimeter from its origin, the vein passed posterior to the left pulmonary artery, between it and the left main stem bronchus. At this point there was marked narrowing of its lumen to a circumference of 0.3 cm. The vein continued anteriorly and then upward as a persistent left superior vena cava, and joined the left subclavian and internal jugular veins to form the innominate vein. Between the point of constriction and the entrance into the innominate vein there was an aneurysmal dilatation of the vessel that measured 1.2 cm. in circumference.

The common pulmonary chamber from which the anomalous vein arose had a sacular dilatation on its superior surface measuring 0.8 by 0.7 cm.; this ended blindly on the posterior wall of the left atrium within 2 mm. of the atrial septum and 8 mm. above the coronary sinus.

The lungs showed congestion, patchy atelectasis, interstitial edema, and prominent, dilated, blood-filled lymphatics in the interlobular septa.
Rubella in the first trimester. Although the infant appeared vigorous and normal at birth, 6 to 8 hours later she developed tachypnea.

On admission she was well developed and well nourished and had generalized moderate cyanosis. The pulse was 140 per minute and the respirations were 44 per minute with mild substernal retractions. A grade-III systolic murmur was heard along the left sternal border, loudest in the fourth left interspace without significant radiation. The second pulmonic sound was louder than the second aortic sound. The liver was palpable 3 to 4 cm. below the right costal margin, and the tip of the spleen was just felt.

Films of the chest on the day of admission (fig. 3) showed a heart of normal size. The vascular pattern in the lung was markedly abnormal, with prominent venous congestion. The diagnosis of anomalous pulmonary venous drainage below the diaphragm was suggested by the radiologist.

An electrocardiogram (fig. 4) was obtained on the fifth day of life, prior to digitalization. There were normal sinus rhythm, heart rate of 166 per minute, P-R interval of 0.10 second, and right axis deviation. The P wave in lead II measured 1.5 mm. The T waves were inverted in leads II, aV_{R}, V_{5}, and V_{6}. The precordial tracings showed tall R waves in right-sided leads and deep S waves in left-sided leads. The electrocardiogram was considered probably abnormal for the age of the patient, showing evidence of right ventricular enlargement.

On the second hospital day (age 6 days) the infant was considered to be in congestive failure, and digitalis was administered. That evening the infant was noted to tire during feedings. The following day she had an acute episode of cyanosis, restlessness, and sweating during a feeding. Penicillin therapy was begun. The infant appeared to be doing well until the fifth hospital day when the liver increased in size, pretibial edema developed, and the respiratory rate rose to 102 per minute. She died suddenly the same afternoon at the age of 9 days. The clinical diagnosis was congenital heart disease, cyanotic, probably total anomalous pulmonary return below the diaphragm.

Postmortem examination: The infant weighed 3,540 Gm. and measured 47 cm. in length. The lips and fingertips were cyanotic, and there was generalized subcutaneous edema. The right pleural cavity contained 15 ml. and the left 30 ml. of serosanguineous fluid. The mesentery and retroperitoneal tissues were edematous, and the peritoneal cavity contained 15 ml. of free serous fluid.

The heart was normal in contour and weighed 20 Gm. Approximately 75 per cent of the anterior surface was occupied by the right ventricle, and the apex consisted of both right and left ven-

**Case 2**

A 5-day-old female infant was admitted to the Babies Hospital on October 7, 1960, because of poor color and rapid respiration since 6 to 8 hours of age.

The infant was born to a 36-year-old, gravida IV, para III, woman whose pregnancy was uncomplicated. There was a history of exposure to
The right atrium and ventricle were hypertrophied and dilated, whereas the left atrium and ventricle were hypoplastic. The left heart was estimated to have less than 25 per cent of the volume of the right heart. The greatly dilated right atrium received the superior and inferior venae cavae and the coronary sinus. The superior vena cava was dilated and had an unusually wide orifice. The foramen ovale was partially covered by the septum primum but admitted a probe of 1.2 cm. in diameter. Both the trabecular muscles and the crista supraventricularis were hypertrophied. The tricuspid and pulmonary valves were normal and measured 4.5 cm. and 2.3 cm. respectively. No pulmonary veins entered the left atrium. The mitral and aortic valves were normal and measured 3.5 cm. and 1.5 cm. respectively. The ductus arteriosus was patent and had a circumference of 0.6 cm.

The pulmonary veins from each lung joined posterior to the pericardium to form a common pulmonary vein (fig. 5). A large vein arose from the left superior wall of this chamber and almost immediately gave off a small branch to be described later. The main anomalous vein measured 1.0 cm. in circumference at its origin. Six millimeters distal to its origin it passed between the left pulmonary artery and the left main stem bronchus and was narrowed to 3 mm. in circumference at this point. It then passed upward to join the innominate vein. Between its emergence from behind the pulmonary artery and its entrance into the innominate vein, there was an aneurysmal dilatation of the vessel that
Case 2. Postmortem angiogram. Contrast media outlines the aneurysmal dilatation of the persistent left superior vena cava, the constricted segment, and pulmonary veins. The right atrium and portal system are filled through an accessory anomalous vein.

The lungs were strikingly congested and many lobules were outlined by large dilated lymphatics containing blood. Microscopically the interlobular veins as well as lymphatics were congested and alveolar walls were thickened because of edema and capillary engorgement. The liver, spleen, kidneys, and gastrointestinal tract were congested. No other malformations or other significant changes were present.

A postmortem angiogram is shown in figure 6. A clamp has been placed on the innominate vein and the left jugular and left subclavian veins have been tied. A needle is inserted into the aneurysmal dilatation of the persistent left superior vena cava and contrast material injected. This has outlined the dilatation, the constricted segment, and the pulmonary veins. In addition, the accessory anomalous vein leading from the main anomalous trunk is seen. Through it, the contrast media has spread to the right superior vena cava, aygos vein, right atrium, and portal system.

Anatomic diagnoses: Total anomalous pulmonary venous return, supracardiac, via two routes: A. Anomalous vein posterior to left pulmonary artery, leading to left superior vena cava and left innominate vein; B. Accessory anomalous vein leading from “A” to the right superior vena cava; stenosis of anomalous vein “A,” localized, between left pulmonary artery and left main stem bronchus; poststenotic dilatation of left superior vena cava; patent foramen ovale; patent ductus arteriosus; congestion and edema of lungs; congestion of abdominal viscera; anasarca.

Discussion

Harris, Neuhauser, and Giedion mentioned two patients in their group who, by clinical and x-ray signs, were thought to have infra-diaphragmatic drainage, but at autopsy were...
found to have supracardiac drainage. Since
the complete autopsy findings were not given,
it is not clear whether there was stenosis in
the supracardiac circuit as in our cases.

Only one case similar to ours has been
found in the literature. Didion (case 2) de-
scribed a 4-month-old boy who had dyspnea
beginning in the third week of life. He de-
veloped cyanosis on slight provocation and
died suddenly with bronchopneumonia. On
postmortem examination, a common pulmo-
mary vein 3.2 cm. in circumference was seen
to pass between the left pulmonary artery
and the left main-stem bronchus. Distal to
this, it entered a sacular dilatation that
joined the innominate vein. No other anom-
alias of the heart or vessels were described.

Appreciation of the existence of a group of
cases with obstruction at the supracardiac
level, has led us to review the literature in
search of anatomic variants that occur in
pulmonary venous return via the persistent
left superior vena cava.

Illustrations from specimens usually show
the left superior vena cava anterior to the
left pulmonary artery. Occasionally, a dia-
grammatic sketch or a reconstruction from
an angiocardiogram indicates the vein poste-
erior to the left pulmonary artery. Though
the latter arrangement may prove to be more
common than is now apparent, in the great
majority of cases the anomalous vein lies
anterior to the left pulmonary artery.

An explanation for the common anterior
position of the persistent left superior vena
cava is given by the embryologic origin of
the veins. Figure 7 shows the embryologic
relationships of the splanchnic plexus, car-
dinal and common pulmonary veins. The fore-
runner of the left superior vena cava, the left
anterior cardinal vein, is always anterior to
the left pulmonary artery while only the veins
of the splanchnic plexus are posterior to it.
Consequently, we believe that a true persist-
ent left superior vena cava is always anterior
to the left pulmonary artery. In our cases,
the proximal part of the anomalous channel
was probably derived from the primitive
esophageal plexus and not the anterior car-
dinal vein. The point of stenosis, where the
left pulmonary artery crosses the anomalous
vein, represents the point of communication
between the channel derived from the splan-
chnic plexus and the cephalic portion of the
left anterior cardinal vein (fig. 7). There-
after, the anomalous vein assumes an anterior
position as a persistent left superior vena
cava.

An additional point of interest is the pres-
ence, in case 1, of a dilatation of the common
pulmonary vein that is attached by a cord to
the left atrium in the area of the embryologic
site of budding of the atrial component of
the common pulmonary vein. Occlusion of
the vein at its exit from the atrial wall at an
early stage of development may be inferred.

Summary

Two patients who died during the neonatal
period with congestive heart failure and
marked pulmonary congestion were found at
autopsy to have total anomalous pulmonary
venous return of the supracardiac type with
stenosis of the pulmonary vein. The narrow-
ing was the result of an unusual course of
the vein, which passed between the left pul-
monary artery and left main bronchus and
was stenosed at this point. It is emphasized
that the clinical and x-ray findings were in-
distinguishable from those of total anomalous
pulmonary drainage below the diaphragm.

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As to your method of work, I have a single bit of advice, which I give with the earnest conviction of its paramount influence in any success which may have attended my efforts in life—Take no thought for the morrow. Live neither in the past nor in the future, but let each day's work absorb your entire energies, and satisfy your widest ambition. That was a singular but very wise answer which Cromwell gave to Bellevire—"No one rises so high as he who knows not whither he is going," and there is much truth in it. The student who is worrying about his future, anxious over the examinations, doubting his fitness for the profession, is certain not to do so well as the man who cares for nothing but the matter in hand, and who knows not whither he is going!—Sir William Osler. *Aphorisms From His Bedside Teachings and Writings.* Edited by William Bennett Bean, M.D. New York, Henry Schuman, Inc., 1950, p. 71.
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