Syndrome of Congenital Absence of the Spleen with Associated Cardiovascular and Gastroenteric Anomalies

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Survey of 27 cases in the literature and the authors' 3 cases reveals a characteristic syndrome of congenital absence of the spleen with certain cardiovascular and gastrointestinal abnormalities. The hematologic and other findings permit a presumptive antemortem diagnosis. More accurate prognosis is made possible and valuable information is afforded the cardiac surgeon, since the cardiac anomalies often follow a predictable pattern.

Congenital absence of the spleen is rare. When it does occur, it appears to be associated with a characteristic group of anomalies of the cardiovascular and gastroenteric systems. Recent case reports suggest a method for diagnosing splenic agenesis hematologically. It becomes important, therefore, to determine with what degree of accuracy one can predict the presence of other associated anomalies, particularly those affecting the cardiovascular system. To this end, the authors have reviewed the anatomic findings in all cases of splenic agenesis appearing in the literature and have added 3 cases of their own, with special attention to the cardiac anomalies.*

Review

Twenty-seven cases of splenic agenesis have been reported, usually with associated anomalies involving other organ systems.

The first well-documented case is that of a 1 1/2-month-old female, reported by Martin1 in 1826. The stomach was on the right and the first part of the duodenum was on the left, while the liver occupied both hypochondria and was divided into 2 equal lobes. Many of the abdominal arteries were abnormal in course and distribution. The heart was enlarged, and there was transposition of the great vessels with a left-sided descending aorta. The atria intercommunicated throughout their entire extent posteriorly, and there was a single ventricular cavity. Right and left venae cavae were present.

In the case of splenic agenesis in the early literature from Germany, only 2 of the usually associated anomalies were reported in each. Robert's case2 (1842) was that of a 3-day-old female with a rudimentary left forearm, wrist, and hand. The stomach was a short, narrow tube with a small saclike outpouching in the region of the cardia. The pancreas was incompletely developed, and the omentum was absent. The transverse colon was suspended by a long mesentery. The stomach and duodenum, on the other hand, were retroperitoneal. There was, however, no situs inversus, and the heart and lungs were normal. The 15-week-old female in Arnold's case3 (1868) had dextrocardia with a right-sided aortic arch, a single ventricle, and a single arterial outflow trunk. The right and left pulmonary arteries arose from the ductus arteriosus. The main pulmonary artery was a cordlike structure extending between the bifurcation of the ductus and the ventricular wall. Additional cardiovascular anomalies included a large interatrial defect, pulmonary venous drainage into the portal system, and vena caval drainage into the left atrium. Accessory lobes of the lungs were described.

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* Only acceptable infantile cases are considered. The authors believe that adult cases reported in the literature do not represent unquestionable examples of splenic agenesis.
The abdominal viscera were normal in position and mesenteric attachment.

The case reported by Birch-Hirschfeld in 1871 was that of a newborn male whose liver filled the entire hypochondrium, the left lobe being a mirror image of the right. Except for a patent foramen ovale, the heart was normal, and no other abnormalities were described.

The case reported by McLean and Craig (1922) was that of a 3-month-old male who had a levoposition of the liver and gallbladder. The enlarged heart had a widely patent foramen ovale and a large, high, interventricular septal defect. The pulmonary veins emptied into the right atrium, and the venae cavae into the left. Both lungs had supernumerary lobes. The gastrointestinal tract was described as normal, although the cecum and mesocolon were freely movable.

Hu reported (1929) the case of a 7-month-old Chinese male who had situs inversus of all abdominal organs with the gallbladder in the midline. Mobility of the ascending and descending colon was increased because of abnormal mesenteric attachments. The pancreatic duct opened separately into the duodenum, and each lung had 3 lobes. The enlarged heart had a single ventricle. There were 2 interatrial septal defects separated by a narrow band of tissue. The pulmonary artery and valve were atretic, and the great vessels were transposed. The vena caval drainage was anomalous, and the pulmonary veins emptied into the portal system. Many of the other large vessels showed anomalous origin or distribution.

Only 2 cases of splenic agenesis without additional anomalies were included in Polhemus and Schafer's survey. One was that of an 8-month-old boy described by Peterman; the other was the case of a 14-month-old male reported by Nelson and Venable.

In 1939 Taussig reported the case of a 2-month-old male whose heart was enlarged with a large atrial septal defect. The fused mitral and tricuspid valve opened into a common ventricle. In the region normally occupied by the pulmonary conus, a small thick-walled chamber, separated from the common ventricle by a muscular ring, gave off the transposed aorta and pulmonary artery.

Lightner (1939) reported the case of a 6-month-old female with situs inversus of the jejunum, ileum, and colon, supernumerary lobe of the left lung, and numerous cardiovascular malformations. The heart was a cor biloventriculare commune. The common A-V valve had 5 leaflets. The pulmonary artery was atretic at its takeoff and hypoplastic distally, with the left pulmonary artery receiving a widely patent ductus arteriosus. The right coronary artery was absent. The left atrium received the inferior vena cava, 3 right pulmonary veins, the right innominate vein, and the coronary sinus, while the left innominate vein and 2 left pulmonary veins emptied into the right atrium.

The 9½-month-old male of Rossman's case (1942) had a single atrial cavity, with the venae cavae entering the right side and the pulmonary veins the left. The common atrioventricular orifice was guarded by 4 wrinkled, nodular leaflets and opened into a single ventricular chamber in which the septum was represented only by a muscular ridge along the posterior wall. There was complete transposition of the aorta and pulmonary artery. The pulmonary artery was atretic, being represented by a thin cord, the cardiac end of which was lost in the tissues about the posterior surface of the aorta. The distal end entered the right pulmonary artery, which, together with the left, arose from the bifurcation of the ductus arteriosus. The other findings included incomplete rotation of the intestine, situs inversus of the upper abdominal visera (stomach, duodenum, foramen epiploicum, pancreas, liver, and gallbladder), accessory lobes of the left lung, bilateral indirect inguinal hernias, and cervical spina bifida.

In the 2 cases reported by Durie and Wyndham (1942) the lungs were normal but other anomalies characteristically associated with absence of the spleen were present. In the first case a 2-day-old female had dextrocardia and a double aortic arch. The left aortic arch, after giving off the left common carotid and subclavian arteries, bifurcated to form the left and right pulmonary arteries. From this point to the base of the aorta, the cordlike vestigial pulmonary artery, patent only in its distal
portion, coursed between the ductus and the ventricular wall. The ventricles were incompletely separated, the septum membranaceum being absent, and the single arterial trunk arose from the left ventricle. The left atrioventricular opening was guarded by a deformed 3-cusped valve; the right opening could not be seen. The atrial cavities communicated freely, with only a narrow band of tissue separating the large superior and inferior septal defects. There were 2 superior venae cavae, 1 entering each side of the common atrial cavity, the right superior vena cava receiving all the pulmonary veins. There was a persistence of the dorsal mesentery from the distal end of the gullet to the rectum.

The second case was that of a 1-month-old male with maldevelopment of the dorsal mesentery and absence of the omentum. In addition, the large bowel lay entirely within the left lower quadrant, with the ileocecal junction in the left iliac fossa. The enlarged heart was rotated to the right, and the aorta and pulmonary artery were transposed. The superior vena cava emptied into the left atrium, the pulmonary veins and inferior vena cava into the right. The lower portion of the interatrial septum was absent, and the foramen ovale was patent and traversed by several narrow membranous strands. The interventricular septum was incomplete superiorly, so that all 4 chambers of the heart were in communication through a common AV orifice, surrounded by 5 deformed leaflets.

Colome's case14 (1945), as tabulated by Polhemus and Schafer,7 showed only absence of the spleen and partial situs inversus of the viscera.

Conn, Clark, and Kissane16 (1950) reported 4 cases of cor biloculare, 1 of which showed an associated absence of the spleen, situs inversus of the stomach, liver and gallbladder, and intestinal tract, and abnormal mesenteric attachments. This 3-year-old male had an enlarged heart with a single ventricle. The atria were separated only by a very narrow band of muscle tissue, and the right atrium was much larger than the left with the venae cavae emptying into the latter. The atrioventricular opening was encircled by the fused mitral and tricuspid valve. The aorta and pulmonary artery were transposed. A small stenotic pulmonary valve marked the takeoff of the otherwise normal pulmonary artery.

Leikin's case16 (1951) was primarily a report of partial situs inversus with congenital heart disease, similar to those reported by Forgacs,17 Thomson,18 Young and Griswold,19 Robinson and Garfinkle,20 and others.21-26 However, this 4-month-old Negro male had an accessory lobe of the left lung and absence of the spleen. The heart had a single ventricle with only a rudimentary septum, and a single arterial trunk, the aorta, which had a normal arch and a patent ductus arteriosus uniting with the left pulmonary artery. The vestigial pulmonary artery was represented by a fibrous cord originating posterior to its normal position and to the left of the aorta. The pulmonic valve was completely atretic. The atria communicated through incompletely separated large septal defects, the lower representing a persistent ostium primum and contributing to a common atrioventricular chamber, which was ringed by a large tricuspid valve. There was a persistent left superior vena cava and the inferior vena cava drained into the left atrium, while the pulmonary and right hepatic veins emptied into the right atrium. There was situs inversus of the stomach, duodenum, and pancreas, and the right and left lobes of the liver were of equal size with the gallbladder on the right and the inferior vena cava located to the left of the quadrate lobe.

In all 4 cases reported by Polhemus and Schafer,7 abnormal mesenteric attachments and accessory lobes of the lungs were present. In the first case, a 23-month-old male had an enlarged heart with large communicating interventricular and interatrial septal defects, through which passed a fused mitral and tricuspid valve. The foramen ovale was patent. The pulmonary artery was stenotic, and its valve was an irregular nodular mass. The ductus arteriosus was obliterated, and there was dextroposition of the aorta. There was situs inversus of the liver, gallbladder, and intestine, and the pancreatic duct opened separately into the duodenum.

The second case was that of a 1-year-old
male whose heart had 1 ventricle and incompletely separated atria with a single 3-cusped atrioventricular valve. The stenotic pulmonary artery arose from behind papillary muscles on the right side of the common ventricular chamber and had only a rudimentary valve. The aorta descended on the right. An elongation of the mesentery gave the cecum unusual mobility.

In the third case, a 6-week-old female with splenic dysgenesis had a persistent atrioventricularis communis, partial situs inversus of the abdominal viscera, and a Meckel’s diverticulum. Transposition of the great vessels was associated with marked stenosis and atresia of the pulmonary artery and valve. The atrioventricularis communis was represented by a rudimentary interventricular septum, a common atrioventricular valve with 3 poorly defined cusps, and communicating atrial chambers. The patent ductus arteriosus arose from the right subclavian artery and entered the right pulmonary artery. The right and left lobes of the liver were similar in size and shape, and the gallbladder was midline.

The 10-day-old male of the fourth case showed incomplete atrial and ventricular septa and a common atrioventricular 3-cusped valve. The pulmonary valve and artery were atretic. The patent ductus arteriosus bifurcated into the right and left pulmonary arteries. The liver and stomach were transposed, and the cecum was described as high.

Boggs and Reed\(^27\) (1953) reported 2 cases, one of a 12-day-old female, the other of a 2-month-old female, both of whom had absent spleens, marked pulmonic stenosis, and persistence of the dorsal mesentery of the ascending colon. In addition, one had an anomalous drainage of the pulmonary and azygos veins into the superior vena cava, 4 distinct lobes of the left lung, situs inversus of the stomach and first 2 parts of the duodenum, and a rightsided pancreas suspended within the peritoneal cavity by an elongated mesentery. The second had no other abdominal abnormalities, but showed large interatrial and interventricular septal defects and right and left superior venae cavae.

The 12-day-old male of Adler and Van Slyke’s case\(^27\) (1953) showed a heart with a single ventricle without the rudiment of a septum and an atrium divided only by a transverse band of tissue, resulting in an interconnecting atrioventricular canal whose valve had 2 leaflets. There was no pulmonary valve or infundibulum, and the stenotic pulmonary artery originated blindly. A widely patent ductus arteriosus bifurcated to form the right and left pulmonary arteries. There was only 1 coronary ostium. The left lung had an accessory lobe. The right and left lobes of the liver were similar in size and shape, and the tail of the pancreas was mobile. A thoracic spina bifida was demonstrated radiographically.

The case report of Millar and Garrow\(^28\) (1953) concerned a 6-week-old Indian female whose right-sided aorta passed anterior to the trachea and back over the right tracheobronchial angle. The enlarged liver was transposed. No other anomalies were described.

The most recent case report, by Bush and Ainger\(^29\) (1955), concerned a 2-year-old boy with transposition of the liver, stomach, and pancreas, bilateral double ureters, 3 lobes to both lungs, and an enlarged heart with a complete transposition of the aorta, atresia of the pulmonary orifice, and hypoplasia of the pulmonary artery with a patent ductus arteriosus. Interaltrial and interventricular septal defects were present, and the foramen oval was patent. The pulmonary veins entered the right atrium and the venae cavae the left. The mitral valve was tricuspid. The patient, in addition, had hematologic abnormalities similar to those found after splenectomy.

Gasser and Willi\(^30\) reported 2 cases of cor biloculare, one in a newborn female, the other in a 14-day-old boy, both of whom had congenitally absent spleens. One had a truneus arteriosus with a hypoplastic pulmonary artery, the other a right-sided aortic arch and pulmonary artery atresia. Both had abnormal mesenteric attachments, but only one showed situs inversus of the abdominal viscera and accessory lobes of the lungs. These authors, emphasized the hematologic findings of splenic agenesis, as did Bush and Ainger.
CASH REPORTS

Clinical Summary

This 20-month-old white female was first admitted to the University of California Hospital on October 6, 1953, with the chief complaint of persistent cyanosis. She was the product of an uncomplicated pregnancy, normal labor, and spontaneous delivery, and weighed 4 pounds 9 1/2 ounces at birth. There was one older, apparently normal sibling. No cyanosis was noted following birth, but a heart murmur was heard. At 1 week of age the infant was observed by the mother to have a dusky color when crying, and these cyanotic spells became progressively prolonged. X-ray films showed an enlarged heart of unusual contour and situs inversus of the abdominal viscera. Electrocardiograms were interpreted as showing right ventricular hypertrophy. The patient was admitted for diagnostic study including cineangiography.

On physical examination, marked cyanosis and clubbing of the fingers and toes were observed. The heart was enlarged both to the right and to the left, with the cardiac impulse in the sixth left intercostal space at the anterior axillary line. A harsh grade 3 systolic murmur was present, heard best in the fourth and fifth left intercostal spaces and transmitted to the axilla and the back. The liver was palpated only in the left hypogastrum.

Complete blood count on admission showed 22.3 Gm. of hemoglobin, a red blood count of 10 million/mm.² and a white cell count of 13,550, with 18 polymorphonuclear cells, 2 eosinophils, 72 lymphocytes, and 7 monocytes. The red cells revealed some hypochromia, and a few target cells were present. There was 1 nucleated red cell/100 white cells. Platelets were normal. Packed cell volume was 73.

Cineangiographic studies performed on October 7, 1953, showed a functional single ventricle with immediate filling of the aorta and with only a small amount of blood passing into the pulmonary artery.

That afternoon the patient became comatose and extremely cyanotic, with pupils widely fixed, a pulse rate of 200, and shallow respirations of 48/min. Oxygen was administered, but the respirations became increasingly shallow. The heart rate slowed but continued regular until the patient died 1 hour later.

Pertinent Autopsy Findings

General. Cyanosis was present, and clubbing of the fingers and toes was noted.

Heart and Great Vessels. The heart (fig. 1) was enlarged and had a peculiar globoid outline. From its anterior aspect, the smooth surface of a single ventricle, an anterior enlarged aorta, and 2 equally prominent auricular appendages were apparent. The pulmonary artery was obscured by the aorta. From its posterior aspect, the atrium received the venae cavae in a normal manner.

The opened heart showed the atria communicating through a large interatrial septal defect, 19 mm. in diameter, which had a sharp crescentic free upper border. Superiorly, the septum was attached anteriorly to the atrioventricular opening. It was thin and membranous but imperforate. The pulmonary veins entered the superior vena cava through a common orifice well above the atrial cavity. Both cavae entered the right side of the atrial cavity.

The common atrioventricular valve had 4 deformed, thickened cusps, which were nodular and wrinkled. The single thick-walled ventricle showed no septal formation. The dilated aorta arose anteriorly, and the aortic valve was relatively normal. A stenotic pulmonary conus arose from a split-like opening between hypertrophic muscle bundles in the lateral ventricular wall, somewhat inferior to the left cusp of the aortic valve. The conus terminated in a funnel-shaped stenotic pulmonary valve having 2 incompletely formed, thickened, and sclerotic cusps. The small pulmonary artery divided almost immediately into right and left trunks. The ductus arteriosus entered the left pulmonary artery and was obliterated in its central portion.

The aorta gave off its great vessels and descended on the left in a normal manner. The coronary ostia were normal in position.

Lungs. Both lungs had 3 main lobes with well-developed fissures. The left lower lobe had in addition 2 incompletely separated smaller lobes, while the right lower lobe had 1 additional rudimentary lobe.

Liver. The liver weighed 270 Gm. and extended across the entire hypogastrium, with equally divided right and left lobes. Two oddly shaped lobes, presumably the quadrate and caudate, issued from its posterior surface.

Gallbladder. The gallbladder lay in the interlobar fissure in an approximate midline position. The cystic and common ducts were patent.

Spleen. The spleen and its vessels were entirely absent.

Gastrointestinal Tract. There was situs inversus of the stomach, duodenum, and pancreas. The stomach lay posterior to the liver in the right hypochondrium. The first part of the duodenum was on the left, while the remainder was mobile with an elongated mesentery. The remainder of the gastrointestinal tract was in normal position.

Pancreas. The pancreas was intraperitoneal and mobile, with a discrete mesentery. Its head was in the duodenal curvature and its tail was directed toward the right.

Autopsy Diagnoses. Congenital cyanotic heart disease (with atroventricularis communis, trans-
Fig. 1. Case 1. A. Schematic diagram of heart and great vessels, with arrows indicating direction of blood flow. B. Heart, posterior view, with atrium opened widely to show large, interatrial septal defect (persistent ostium primum), anomalous pulmonary venous return, and common atrioventricular valve. C. Heart, anterior view, showing single ventricle and aortic outflow tract. Heavy black arrow indicates slitlike opening into the infundibulum. Figure at right illustrates this rudimentary pulmonary outflow tract enlarged to show detail of structure. Stenotic bicuspid valve guards a small pulmonary artery that bifurcates abruptly.
position of aorta and pulmonary artery, infundibular stenosis, hypoplasia of pulmonary artery with stenotic bicuspid pulmonary valve, and anomalous pulmonary venous return); partial situs inversus involving liver, pancreas, stomach, and duodenum; abnormal mesenteric attachment of pancreas and duodenum; accessory lobes of the lungs; and agenesis of the spleen.

Case 2

Clinical Summary

This 3-month-old Chinese male entered the University of California Hospital for the first time on February 4, 1954, with the chief complaint of progressive cyanosis. The infant was the product of a full-term uneventful pregnancy, normal labor, and delivery, and was the only offspring of a 41-year-old mother and 43-mother-old father. Cyanosis was first noted on the fourth day, and the parents were told that the child had heart disease. He gained weight well for the first 2 months but not during the month prior to entry. He ate poorly and had daily episodes of cyanosis and dyspnea lasting about 30 min., and episodes of coughing while asleep.

Physical examination upon admission revealed a very cyanotic, semistuporous, extremely dyspneic infant. There was a marked precordial bulge. A systolic murmur, loudest in the third intercostal space at the left sternal border, was heard on one occasion. During other examinations, no murmurs were heard, but a tic-tac rhythm was noted. P₂ was much greater than A₂. Clubbing was marked. Electrocardiogram showed marked right axis deviation with peaked P waves in leads I and II. X-ray examination suggested absence of the right ventricle; the lung fields were undervascularized. The clinical impression was that of a single ventricle with pulmonary stenosis.

Complete blood count on admission showed 12.5 Gm. of hemoglobin, a red cell count of 6 million/mm³, and a white count of 12,650 with 86 polymorphonuclear cells (42 filamentous, 42 nonfilamentous, and 2 metamyelocytes), 10 lymphocytes, and 4 monocytes. The red cells showed anisocytosis and poikilocytosis, moderate hypochromia, and polychromatophilia, and a considerable number of target cells were present. The platelets were normal.

An exploratory thoracotomy on February 5, 1954, revealed a right-sided aorta with a left innominate artery; a small left pulmonary artery, with increased hilar collateral circulation; and possibly a trilocular heart. The left subclavian artery was anastomosed to the left pulmonary artery, the proximal stump of which was sutured closed. The immediate postoperative course was excellent, with marked decrease in cyanosis. On the second postoperative day the child had several episodes of cyanosis with Cheyne-Stokes respirations, following one of which there was a left-sided Jacksonian seizure involving the arm, leg, and face. The patient died on February 7, 1954.

Pertinent Gross Findings

Heart and Great Vessels. The heart was enlarged, weighed 30 Gm., and had a globoid shape. The aorta arose from the central anterior superior aspect of the ventricle, arching forward and descending on the right. The pulmonary artery and valve were absent. The left subclavian artery had been anastomosed to the distal portion of the left pulmonary artery, the proximal portion having been ligated. The ductus arteriosus arose from the aorta just opposite the right subclavian artery and divided into right and left pulmonary arteries. The arteries taking origin from the aortic arch were, from left to right, the innominate, right common carotid, and right subclavian.

The interatrial septum was markedly incomplete, with both a persistent ostium primum and a patent foramen ovale. Between these defects, narrow muscular bars, divided by a slitlike space, 6 by 3/4 mm. in size, ran from the base of the common atrioventricular valve anteriorly to joint a thin abortive septal ridge projecting from the posterior aspect of the atrial cavity. The superior interatrial defect was 8 mm. in diameter. The lower interatrial defect Communicated with a high interventricular septal defect.

The superior vena cava received the pulmonary veins and emptied into the right atrium. The inferior vena cava emptied into the left atrium. The common atrioventricular valve was well above the free border of the incompletely formed interventricular septum. This septum partially divided the inferior portion of the ventricle into 2 unequal chambers, the larger and anterior of which gave off the single arterial trunk, which bore a tricuspid valve 2 cm. in circumference. The coronary ostia were in their normal position above the cusps of this valve. The smaller chamber was posterior; there was no pulmonary outflow tract.

Lungs. The right lung weighed 32.5 Gm., the left 35 Gm. Both had 3 lobes and were mirror images of each other.

Liver. The liver weighed 158 Gm. and was predominantly left-sided. The right and left lobes were of approximately equal size.

Gallbladder. The gallbladder lay to the left of the midline. The cystic and common ducts were patent, the latter crossing anterior to the pylorus and entering the anterior aspect of the duodenum.

Spleen. There was no spleen or major splenic vessels.

Pancreas. The head of the pancreas lay in the loop of the left-sided duodenum.

Gastrointestinal Tract. The stomach was on the right and the duodenum on the left of the hypochondrium. No other abnormalities of position or
Fig. 2. Case 2. A. Schematic diagram of heart and great vessels, with arrows indicating direction of blood flow. B. Heart, posterior view, with atrium opened widely to show persistent ostium primum with other septal defects and interventricular septal defect. Fused mitral and tricuspid valves pass through this common atrioventricular orifice above free border of interventricular septum. C. Heart, anterior view, showing truncus arteriosus, with pulmonary arteries arising from ductus arteriosus. Note right-sided aortic arch. Again fused mitral and tricuspid valves can be seen passing through common atrioventricular septal defect.
SYNDROME OF CONGENITAL ABSENCE OF SPLEEN

Fig. 3. Case 3. A. Schematic diagram of heart and great vessels, with arrows indicating direction of blood flow. B. Heart, posterior view, with atrium opened widely to show markedly incomplete interatrial septum and large septal defects, anomalous pulmonary venous return, and common atrioventricular valve. Note thin membranous strands traversing perforations in anterior superior portion of interatrial septum. C. Heart, anterior view, showing at left the single ventricle with aortic outflow tract. Note thick muscular ridge inferior to right aortic valve cusp, with heavy black arrow indicating circular opening into stenotic pulmonary conus. Figure at right shows detailed structure of the stenotic conus. Note abruptness of take-off and abnormal placement of left and right pulmonary arteries, with patent ductus arteriosus distal.
mesenteric attachment of the remainder of the enteric tract were noted.

**Autopsy Diagnoses.** Congenital cyanotic heart disease (with atrioventricular communis, atresia of the pulmonary artery and valve, truncus arteriosus, multiple interatrial septal defects, and anomalous systemic and pulmonary venous return); right-sided aortic arch with left-sided innominate artery; partial situs inversus involving stomach, duodenum, liver, and pancreas; accessory lobe of left lung; and agenesis of spleen.

**Clinical Summary**

This 5-day-old Chinese female was born on September 3, 1954, after a full-term pregnancy. The first and second stages of labor were rapid, and the baby was delivered with Simpson forceps as a posterior presentation with difficulty. She cried at once but was mildly cyanotic and continued to give spontaneous spasmodic cries. There were bilateral basal rales posteriorly. The heart sounds were normal, and the remainder of the physical examination was negative. The hemoglobin was 17.4 Gm. per cent.

On September 4 there were rales at the right base, and x-ray examination showed a questionable diaphragmatic hernia. Another film on September 6 showed a segment of stomach and a loop of colon in the right pleural space. The infant had marked cyanosis on crying or eating, and surgical correction of the hernia was deemed imperative.

On September 7 a combined exploratory laparotomy and right thoracotomy was performed, at which time the stomach and a segment of large bowel were found in the chest, and there was a lack of rotation of the bowel. The right diaphragmatic hernia was repaired, the infant appearing to withstand the procedure fairly well. However, the left chest did not aerate well, despite suction and Alevaire and the patient died on September 8, 1954, after a tracheotomy proved ineffective in restoring respiratory mechanics. A loud systolic murmur was heard in the final hours of life.

**Pertinent Autopsy Findings**

**Heart and Great Vessels.** The heart was 1 3/4 times normal size and had a relatively normal external configuration. A single atrial chamber occupied the upper posterior aspect of the heart, which the venae cavae entered in a normal manner. The common atrial chamber was the product of 2 large septal defects. The inferior defect, representing a persistent ostium primum, formed the superior part of an atrioventricular orifice. Above this defect and separated from it by a narrow fibromuscular band was a high interatrial defect, representing a patent foramen ovale.

The single atrioventricular valve was 4 cm. in circumference and bore 4 irregular redundant cusps with wrinkled nodular free edges. The large single ventricle was without a vestige of a septum. The ventricle gave off the aorta anteriorly, while the aortic valve leaflets and coronary ostia were normal. From the posterolateral aspect of the ventricle arose a stenotic pulmonary conus. This rudimentary outflow chamber gave off the pulmonary artery, into which the widely patent ductus arteriosus entered immediately distal to the branching of the pulmonary artery.

A coarctation of the aorta narrowed the lumen between the takeoff of the left subclavian artery proximally and of the ductus distally to less than 2 mm. in that region.

The pulmonary veins entered the superior vena cava at the level of the aortic arch.

**Lungs and Pleural Cavities.** In the posterior portion of the left pleural cavity there was a reherniation of the stomach through the recently repaired defect. The trachea and bronchi contained a large amount of hemorrhagic mucoid material. The right lung had 4 lobes, and the left had 3. Both lungs showed scattered areas of atelectasis and hemorrhagic discoloration.

**Liver.** The liver was enlarged and filled the entire hypochondrium. Its configuration was abnormal, with the right and left lobes of approximately equal size. The caudate and quadrate lobes were absent. A very small accessory lobe, high on the posterior surface of the right main lobe, extended down along the right adrenal gland.

**Gallbladder.** The gallbladder lay along the undersurface of the left lobe of the liver. The cystic and common ducts were patent.

**Gastrointestinal Tract.** There was situs inversus of the entire gastroenteric tract associated with failure of rotation of the bowel, so that the entire small intestine distal to the ligament of Treitz was on the left and the entire colon on the right, each with a discrete mobile mesentery.

**Spleen.** There was complete absence of the spleen.

**Pancreas.** The head of the pancreas lay to the left, behind the stomach, and the body and tail ran along the posterior portion of the stomach and into the diaphragmatic hernia.

**Autopsy Diagnoses.** Congenital cyanotic heart disease (with atrioventricular communis, infundibular stenosis, and anomalous pulmonary venous return); coarctation of the aorta; right diaphragmatic hernia; complete situs inversus of abdominal viscera with malrotation and abnormal mesenteric attachments of the abdominal viscera; accessory lobes of the lung; and absence of the spleen.

**Discussion**

Recently it has been noted that certain hematologic abnormalities are associated with congenital absence of the spleen. Gasser and
Willi,30 in 1952, were the first to make a presumptive antemortem diagnosis of splenic agenesis, on the basis of persistent erythrocyte inclusions that they identified as Heinz bodies. The associated erythroblastosis, however, they ascribed to anoxemia secondary to the congenital heart disease. Bush and Ainger,29 in 1955, published the second report of antemortem diagnosis of splenic agenesis, based on the association of cyanotic congenital heart disease, situs inversus of the abdominal viscera, and certain hematologic abnormalities. These abnormalities, similar to those found after splenectomy, were target cells, decreased osmotic fragility, Howell-Jolly bodies, transient normoblastemia, sideroblastosis, and leukocytosis. Thus, these hematologic findings should afford a reliable diagnostic tool in future cases.

The presence of agenesis of the spleen presents extremely valuable information to the cardiovascular surgeon, especially since the cardiac anomalies often follow a predictable pattern. Having demonstrated partial situs inversus of the abdominal viscera in a case showing the hematologic abnormalities cited above, one should then strongly suspect the associated congenital heart disease to be of the cor biloculare type, with an atroventricular communis, anomalous venous return to the heart, and pulmonary stenosis or atresia. Less frequently there will also be present abnormalities of the great vessels, such as transposition, truncus arteriosus, and a right-sided aortic arch. The occasional inconstancy of these and the other anomalies should be borne in mind, however, and definitive diagnostic studies such as cardiac catheterization should be carried out prior to operation. Evidence of impaired pulmonary blood flow occurred in 19 of the 27 cases; pulmonary atresia was present in 11 cases and pulmonary stenosis in 7 cases. Chest roentgenograms demonstrate poor vascularization of the lungs in the great majority of cases of splenic agenesis. Consideration of a shunt operation to increase pulmonary blood flow may be entertained in the management of these cyanotic infants.

Embryologically, the association of the anomalies can be related to developmental arrest and malformation initiated during the fifth week of gestation. At this time the splenic primordia develop in the dorsal mesogastrium, the heart separates incompletely into 2 chambers, the definitive pulmonary lobes are forming with the bronchial buds branching to form the larger conductive tubules, and the intestine, previously freely movable within the scope of its restraining mesentery, begins its definitive rotation and attachment.

Summary

A review of 27 cases of splenic agenesis reported in the literature, in addition to 3 new cases, demonstrates a characteristic association of multiple congenital anomalies: (1) septal defects, particularly atroventricularis communis; (2) anomalous venous return to the heart; (3) pulmonary stenosis or atresia; (4) transposition of the great vessels; (5) accessory lobes of the lungs; (6) partial situs inversus of the abdominal viscera; and (7) abnormal mesenteric attachments. Recently, emphasis has been placed on the antemortem diagnosis of splenic agenesis by hematologic means. Such a diagnosis, coupled with a foreknowledge of the high constancy of the associated anomalies, should lead to a more definitive approach and estimate of prognosis. Should operative intervention be considered, the surgeon must expect to encounter serious if not uncorrectable defects, as attested by the fact that in 20 of the 27 collected cases, the patients died before they reached 1 year of age.

Summario in Interlingua

Es presentate un revista de 27 casos de agenese splenic que es reportate in le litteratura. In combination con le presentation de 3 nove casos, le revista exhibi un association characteristic de multiple anomalías congenite. Istos es (1) defectos septal, specialmente communitate atroventricular; (2) anomalía del retorno venose al corde; (3) stenosis pulmonar o atresia; (4) transposition del vasos major; (5) lobos accessori del pulmones; (6) partial sito inverse del visceres abdominal; e (7) anormal attachamentos mesenteric. In recente temporos on ha prestate grande attention al diagnose ante morte de agenese splenic per medios hematologic. Un tal diagnose,
combine with the nunc establisite constatation de alte grados de constantia in le occurrencia del anomalias associate, deberea permitter un attitude clarificate in le maneamento del condition e meliorate estimationes prognostic. In cases in que un intervention chirurgic es prendite in consideration, le chirurgo debe esser preparate a incontrar serie e possibilemente incorrigibile defectos. Iste observation es corroborate per le facto que in 20 del 27 casos hice colligite, le patientes moriva ante que illes habeava attingit un etate de 1 anno.

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